AN EVALUATION OF ECOSYSTEM RESTORATION AND MANAGEMENT OPTIONS FOR THE CALHOUN AND GILBERT LAKE DIVISIONS OF TWO RIVERS NATIONAL WILDLIFE REFUGE

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MARK TWAIN NATIONAL WILDLIFE REFUGE COMPLEX
QUINCY, ILLINOIS

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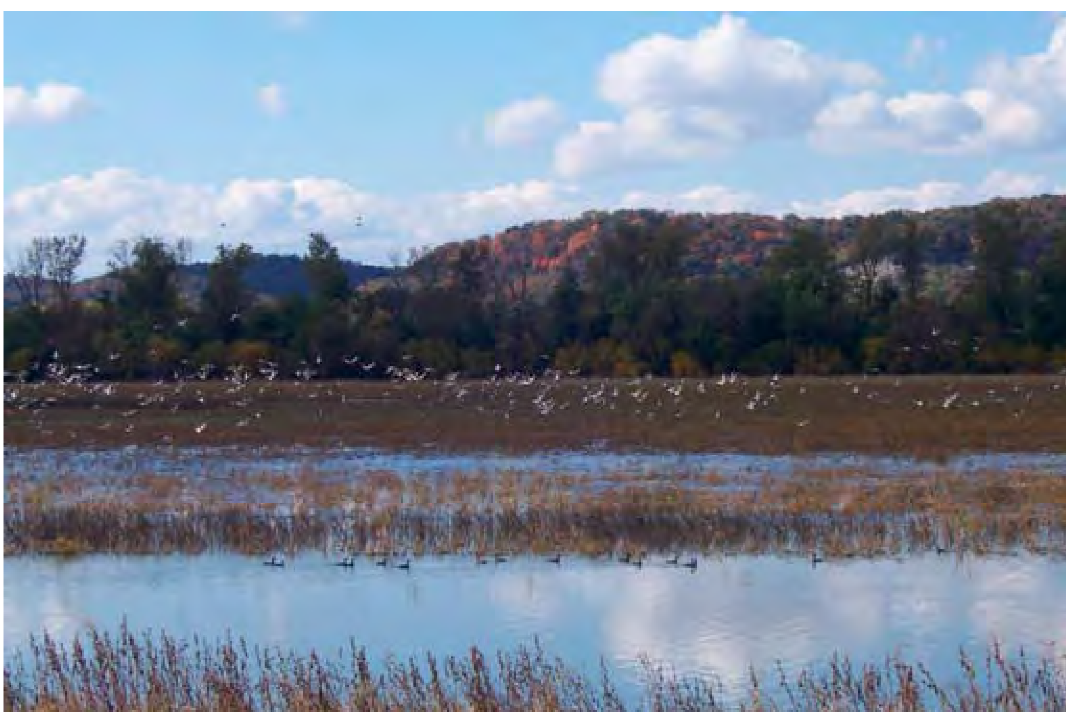

EXECUTIVE SUMMARY

The Calhoun and Gilbert Lake Divisions (DV) of Two Rivers National Wildlife Refuge are located adjacent to the Illinois River near its confluence with the Mississippi River. This confluence area contains diverse land forms, hydrology, and ecological communities created by historic fluvial dynamics. Bottomland lakes are major features of the area and include Swan Lake on Calhoun DV and Gilbert Lake on Gilbert Lake DV. These lakes have been severely degraded because of altered hydrology, sedimentation, and topography. The most dramatic change to the region was construction of Lock and Dam 26 across the Mississippi River near Alton, Illinois in 1938. After Lock and Dam 26 was built, water levels in the Illinois River and in Swan and Gilbert lakes were raised and stabilized. Prolonged flooding ultimately killed less water tolerant trees in floodplains and enlarged the bottomland lakes. Additionally, these lakes were rapidly filled with sediments and became more turbid with less aquatic vegetation present.

In the late 1990s and early 2000s, the Swan Lake Habitat Rehabilitation and Enhancement Project (HREP) attempted to restore certain ecological attributes of the confluence area. Specific developments included: 1) riverside dikes and water-control structures along Swan Lake, 2) a cross-levee to divide Swan Lake into three compartments, 3) water and sediment retention traps, 4) pumps to seasonally remove water from Swan Lake, 5) island wind beaks, and 6) deepwater overwintering fish habitat. Generally, the effectiveness of HREP developments in controlling water levels has not been established, nor have management plans been developed for annual or long-term operation of water-control structures, pumps, and other infrastructure. More importantly, uncertainty still exists in what the ultimate “desired state” is, or can be, for habitat composition, distribution, and ecological processes within Calhoun and Gilbert Lake DV. This report evaluates ecosystem restoration and management options to address these issues. Objectives of the report are to: 1) identify the presettlement, and pre-Lock and Dam 26, ecosystem condition and ecological processes; 2) evaluate changes in the area from presettlement, and pre-Lock and Dam 26, condition; and 3) identify restoration and management options and ecological attributes needed to restore specific habitats.

The present location of the Illinois and Mississippi rivers, and the geomorphic land forms in the confluence region, reflect numerous channel changes and deposition/scouring events caused by fluvial dynamics and glacial events in the Quaternary period. The current Illinois River occupies the much wider former channel of the ancient Mississippi River below Hennepin, Illinois and its discharge and river slope are lower than the old channel capacity. This situation created a labyrinth of channels, natural levees, point bar ridges and swales, and bottomland lakes in the lower Illinois River Valley including the complex of Swan, Stump, and Gilbert lakes in the confluence region. The floodplain in the confluence region is bounded by limestone bluffs on the east side of the Illinois River and by the Deer Plain Terrace on the west side.

Climate and long-term data from Illinois River levels at Grafton, Illinois indicate a strong seasonal pattern of increasing precipitation and river flows from January through April followed by gradually declining levels to lows in September or early October. This strongly seasonal pattern of precipitation and flooding is superimposed on a relatively regular long-term pattern of alternating wet and dry periods on about a 20-year periodicity.

Elevations on Calhoun and Gilbert Lake DV historically ranged from 410-412 feet above mean sea level in the lowest depressions of Swan Lake to about 435 feet on the Deer Plain Terrace. Elevation maps prepared in the late 1800s and early 1900s provide information on topography and water depths prior to large changes in land use and hydrology that occurred in the 21st century and identify locations of floodplain natural levees, bottomland lakes, river sloughs, point bars, and terraces. They also provide insight into locations and elevations where Illinois River flows entered and exited Swan and Gilbert lakes during flooding and drying periods.

Most regular and frequent entry of flood water into these lakes was from slower backwater flooding at downstream ends of the lakes.

The low natural levee points where Illinois River water historically flowed into and out of Swan and Gilbert lakes were about 412 and 417 feet, respectively. In the late 1800s, prior to major man-made changes in flows in the Illinois River, extended drying (> 3 months) of Swan Lake occurred in about 7 of every 10 years during dry periods and about 5 of every 10 years in wet periods. During dry periods, Gilbert Lake was nearly completely dry for > 3 months every year and in wet periods it dried during summer nearly 80% of the years. This seasonally dynamic flooding and drying pattern was the primary ecological process that controlled plant and animal distribution and composition in the region.

The lower Illinois River Valley historically contained 9 major habitat types distributed across elevational and hydrological gradients. They included: 1) the main Illinois River channel and islands, 2) backwater sloughs and chutes, 3) natural levee "riverfront" forests, 4) bottomland lakes, 5) shrub/scrub, 6) bottomland forest, 7) bottomland "wet" prairie, 8) mesic prairie, and 9) upland forest. Many diverse resources were provided in these habitats and were used seasonally by a wide diversity of animals.

A hydrogeomorphic (HGM) matrix was prepared to characterize the soil, topography, geomorphological surface, and hydrological position of each habitat on Calhoun and Gilbert Lake DV prior to major alterations in the system. Open water in Swan Lake was present < 412 feet elevation. The edges of the lake had seasonal herbaceous vegetation on mudflats 412-414 feet during drying periods. Bottomland forest was present on natural levees and floodplain surfaces 414-419 feet in the Swan Lake area and up to 420 feet at Gilbert Lake. A narrow band of shrub/scrub habitat occurred around the upper edges of bottomland lakes between herbacous and bottomland forest vegetation. A transition zone of savanna developed at the upper edges of bottomland forest and graded into bottomland prairie, which was present at 417-422 feet. Bottomland prairie transitioned into mesic prairie above 422 feet and upland forest was present on higher terrace, upland hill, and bluff locations. In the late 1800s, the confluence area contained about 56% bottomland forest and 41% prairie.

Changes to regional landscapes in the confluence area were minimal until the late 1800s, when increased European settlement occurred and significant areas of bottomland forest and prairie were converted to agricultural production. Water levels and flows in the Illinois River also were altered from historical condition at this time when large volumes of water were diverted into the Illinois River from the Chicago River and Lake Michigan through the Chicago Sanitary and Ship Canal. These diversions increased the rate of spring flood rise in the Illinois River by 22%. By 1920, over 35 drainage and levee districts were formed in the Illinois River Valley and increased flood stages and prolonged flooding.

Lock and Dam 26 was built near Alton in 1938 and water in the lower Illinois River near Calhoun and Gilbert Lake DV immediately rose and permanently inundated low elevations. This prolonged flooding caused extensive mortality of remnant bottomland forest. Water management of Pool 26 has attempted to maintain a 419.5 minimum summer pool level, which is 8-9 feet higher than historic summer levels. Surface water of Swan Lake increased from 462 acres in 1903 to 2,873 acres in 1969 and Gilbert Lake increased from 96 acres to 232 acres over the same time period.

Sediment levels and sedimentation rates increased in the Illinois River and its floodplains following clearing of upland watersheds for agriculture, construction of levee and drainage districts, increased diversion of water into the river, and slow impounded flows after locks and dams were built. Historically, the source of sediments in the Illinois River and subsequent deposition in bottomland lakes was 62% from valley slopes and tributary rivers and 38% from local upland erosion, mostly from nearby agricultural fields. Following construction of the Swan Lake HREP projects, the relative importance of sediment inputs to Swan Lake was estimated to shift to 50% river and 50% local hillside contributions. From 1903 to 1978, sedimentation rates in Swan Lake averaged about 0.33 inches/year and reduced storage capacity by 42%. Natural topographic contours in Swan and Gilbert lakes have been moderated or eliminated as depressions filled with sediment and flattened the bottom contour.

Changes in hydrology, turbidity and sedimentation, vegetation communities, and seasonal dynamics of resources have caused many changes to biota of the Illinois River and habitats in the Calhoun and Gilbert Lake DV. Invertebrate, fish, and waterbird populations all have changed and generally declined over time.

Calhoun and Gilbert Lake DV are administered and managed under a revised agreement between the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers. This agreement supports active restoration and ecosystem management including the aforementioned Swan Lake HREP. Since the HREP was completed, Middle Swan Lake was nearly completely drained in summer 2001, 2002, and 2005 and partly drained in summer 2000, 2003, and 2004. In 2002, Lower Swan was 90% drained in summer for the first time since Lock and Dam 26 was closed in 1938. A second draw down was attempted in 2006, but only about 50% drainage occurred because of pump problems. Gilbert Lake is at a higher elevation than Swan Lake and water levels naturally declined during summer even after Lock and Dam 26 was built. In the early 1960s, a low levee was built between Gilbert Lake and the Illinois River and a pump station was installed to reflood the lake following drawdowns. Since 1965, nearly complete drainage of Gilbert Lake occurred during summer 1971, 1977, 1983, 1989, 2000, 2003, and 2005.

The following general management and restoration objectives are recommended for Calhoun and Gilbert Lake DV: 1) emulate a more “natural” seasonally- and annually-dynamic water regime in bottomland lakes and floodplain habitats; 2) control and reduce sedimentation rates in bottomland lakes and restore at least some natural topography in floodplains that have become highly silted in; 3) restore and maintain the diversity, composition, distribution, and regeneration of floodplain and terrace vegetation communities in relationship to topographic and geomorphic landscape position and current Illinois River management; and 4) provide natural patterns of resource availability and abundance including nutrient cycling; seasonal energy flow; and key food, cover, reproductive, and refuge resources for endemic animal species.

Specific recommendations are made for management and restoration of Calhoun and Gilbert Lake DV areas. For Swan Lake, important recommendations include: 1) maintain existing levees and water-control structures on the Illinois River side to drain the lake to at least 10-20% water cover in summer when draw downs are scheduled; 2) attempt to at least partly drain edges of Swan Lake during summer in all dry years and in over half of wet years. A 2-3 year schedule to completely drain Middle and Lower Swan compartments is proposed; 3) extend drainage of Lower Swan to two consecutive years in the near future; 4) open water-control structures between Swan Lake and the Illinois River in non-drawdown years and seasons; 5) continue annual summer drainage of Upper Swan Lake on Fuller Lake WMA whenever possible; 6) control excessive expansion of early successional forest species into Swan Lake bottoms; 7) restore and maintain some natural topographic features within the silted-in lake bottom; 8) control and reduce sedimentation in the lake bottom, preferably through soil conservation practices in the adjacent upland watershed; and 9) use several federal and state incentive programs to help reduce erosion from agricultural lands in the Swan Lake watershed.

For Gilbert Lake important recommendations include: 1) attempt to partly drain Gilbert Lake each summer and completely drain the lake for at least 3 months in about 3 of every 5 years; 2) control excessive woody vegetation encroachment into the lake bottom and sustain a shrub/scrub community around its edges; 3) maintain silt basins on the north side of Gilbert Lake and restore natural topographic depressions and sloughs; 4) restore topographic variation in the edges of the lake; and 5) reforest the natural levee along the Illinois River and in elevations > 419.5 feet. A mixed savanna/prairie community could be restored in the Duncan Farm alluvial fan area.

Recommendations for the Calhoun Point-Bar Terrace south of Swan Lake include: 1) restore bottomland prairie or a mixed prairie/savanna community on higher elevation ridges; 2) manage moist-soil impoundments for a mix of annual and perennial vegetation and encourage inclusion of wet prairie species; 3) manage swales as seasonal herbaceous emergent wetlands with a border of shrub/scrub or bottomland forest around them; 4) restore bottomland forest on the higher natural levee on the southeast side of Swan Lake and in the transition zone where the terrace slopes down into Calhoun Point WMA; and 5) maintain some agricultural fields that have traditional high use by wintering waterfowl.

Only a small amount of the Deer Plain Terrace occurs on Calhoun DV but restoration recommendations include: 1) reforest higher elevation to upland forest and 2) restore prairie and savanna to lower terrace elevations.

The ultimate success of restoring parts of the historic Illinois River floodplain communities and their ecological functions and values will depend on: 1) how well infrastructure and management strategies can emulate natural water regimes in Swan and Gilbert lakes and the adjacent natural levees and floodplains, and 2) if sedimentation rates can be reduced. Many of the Swan Lake HREP project features are very beneficial to managing water levels, but uncertainty exists about the most effective spatial and temporal pattern of emulating natural drainage of Swan and Gilbert lakes. Future management using recommendations and options identified in this report can be done in an adaptive management framework where predictions (e.g., improved consolidation of bottom sediments and increased aquatic vegetation) about specific management actions (e.g., regular summer drainage) are made and then select abiotic and biotic variables are monitored to determine ecosystem response and to suggest future changes or strategies in the management actions taken. Monitoring is especially needed to determine aspects of: 1) flooding and drying regimes in Swan and Gilbert lakes, 2) sediment loading and rates of deposition, 3) revegetation of Swan and Gilbert lakes, and 4) restoration of prairie and bottomland forest.

INTRODUCTION

The Calhoun and Gilbert Lake Divisions (DV) of Two Rivers National Wildlife Refuge (NWR) are located adjacent to the Illinois River near its confluence with the Mississippi River (Fig. 1). The Calhoun DV contains 4,836 acres along the west bank of the Illinois River from about river mile (RM) 5 to RM 10 in Calhoun County, Illinois (Fig. 2). It is bounded by the Fuller Lake Wildlife Management Area (WMA), administered by the Illinois Department of Natural Resources (IDNR) on the north. Fuller Lake WMA includes the northern leveed compartment of Swan Lake, which is a large bottomland lake, and dominant landscape feature, in the southeastern part of the Calhoun DV. The Gilbert Lake DV contains 736 acres along the east bank of the Illinois River south and east of Pere Marquette State Park in Jersey County, Illinois (Fig. 2). As the name implies, the dominant feature of this DV is the 250-acre bottomland Gilbert Lake. The U.S. Army Corps of Engineers (USACE) owns most lands within Calhoun and Gilbert Lake DV and they have transferred management authority for fish and wildlife purposes to the U.S. Fish and Wildlife Service (USFWS) as General Plan (GP) lands (USFWS 2004). A small portion of Gilbert Lake DV is owned by the state of Illinois and is managed by the USFWS through a cooperative agreement. Two Rivers NWR is part of the larger Mark Twain NWR complex that contains NWR divisions along the Mississippi River from the Quad Cities in Iowa to the mouth of the Ohio River. Originally named the Brussels District of the Mark Twain NWR, it was renamed Two Rivers NWR in 2000.

The area near the confluence of the Illinois and Mississippi rivers, where the Calhoun and Gilbert Lake DV occur, contains diverse land forms, soils, hydrology, and ecological communities created by historic fluvial dynamics of these two large rivers (Hajic 2000a,b). Calhoun and Gilbert Lake DV each contain large bottomland lakes that are remnant abandoned channels of the Illinois River. They also contain a mosaic of floodplain forest, bottomland prairie, seasonal herbaceous wetland, and river slough and chute habitats. Historically, bottomland lakes were seasonally connected with the Illinois River and contained a diversity of depths

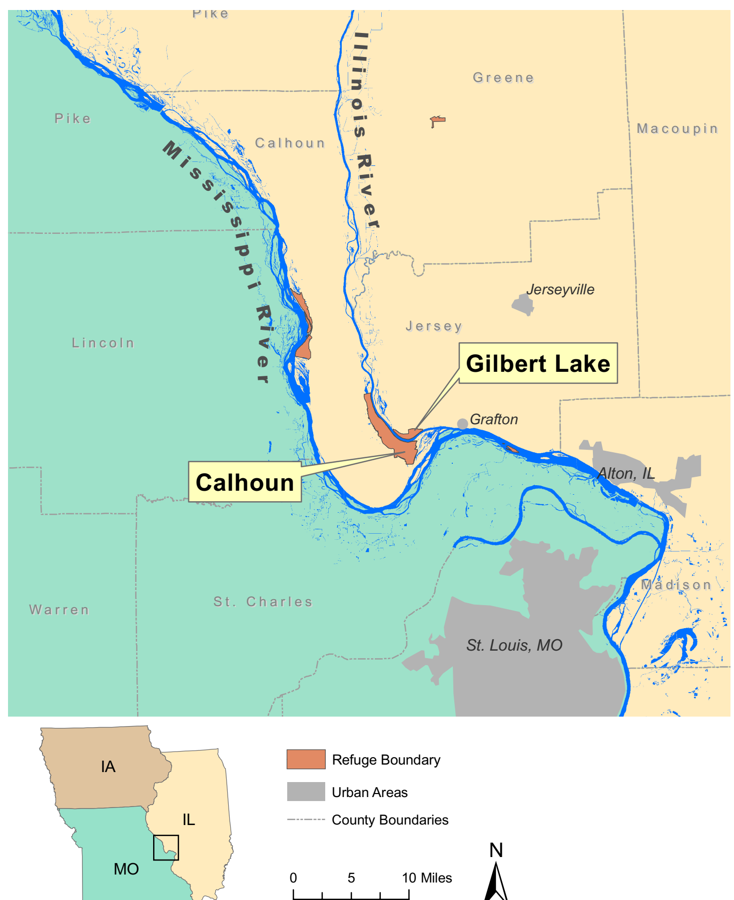

Figure 1. General location map of Calhoun and Gilbert Lake Divisions of Two Rivers National Wildlife Refuge.

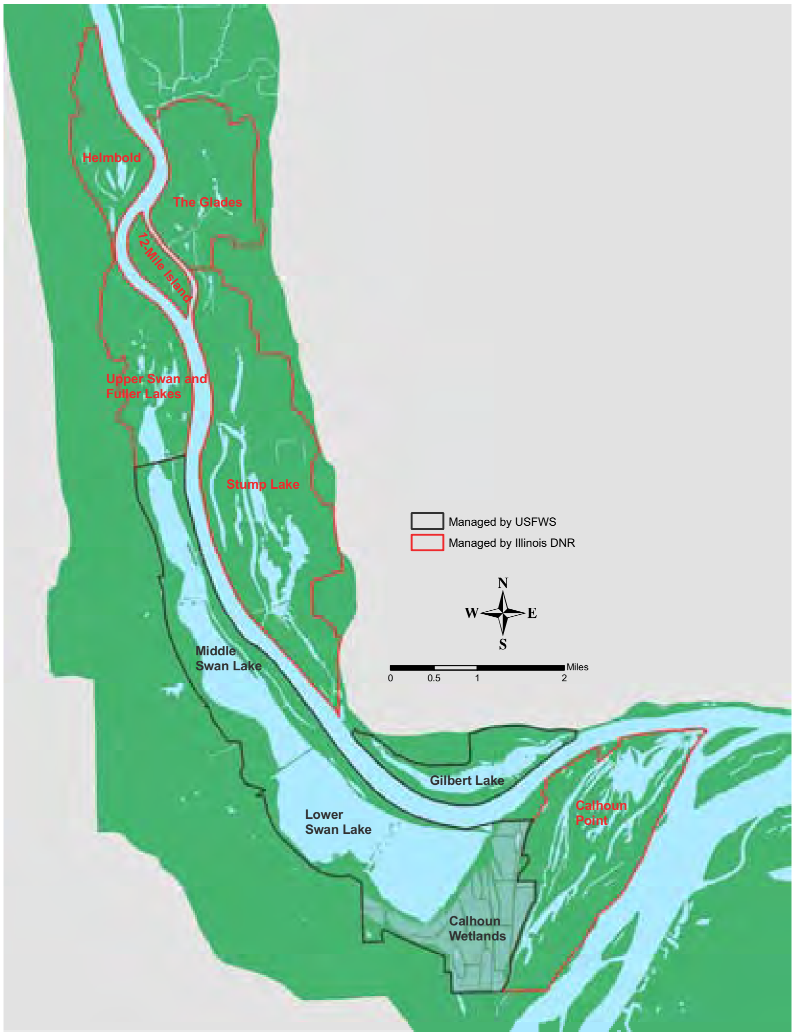

Figure 2. Major bottomland lake and wetland areas in the Illinois-Mississippi River confluence area.

that supported rich aquatic and herbaceous vegetation communities (Starrett 1972, Sparks et al. 1988). Sediments carried by the Illinois River moved into, and sometimes out of, bottomland lakes and adjacent floodplains depending on river velocity and stage. Sediments gradually filled these lakes, but also imported nutrients and created fertile substrates that sustained rich plant and animal communities (Sparks 1995a).

Many changes have occurred in the Illinois-Mississippi River confluence area since the early 1900s and floodplain habitats and their ecological functions and values now are degraded (Mills et al. 1966, Sparks 1995a,b, Yin and Nelson 1996). The most dramatic change was construction of Lock and Dam 26 across the Mississippi River near Alton, Illinois. Completed in 1938, Lock and Dam 26 impounded water to improve navigation and created Pool 26 about 40 miles upstream of the lock and dam in the Mississippi River and Alton Pool about 80 miles upstream in the Illinois River to a lock and dam at LaGrange, Illinois. After Lock and Dam 26 was constructed, water levels in the Illinois River near the confluence area were raised and became more stabilized. Prolonged flooding of floodplains ultimately killed less water tolerant trees in bottomland forests and enlarged bottomland lakes (Yeager 1949, Bellrose et al. 1983, Yin and Nelson 1996)). For example, Swan Lake on the Calhoun DV (and Fuller Lake WMA) was about 988 acres in the early 1900s, but was enlarged to > 2,700 acres after construction of Lock and Dam 26. In addition to prolonged flooding, the timing, depth, and duration of Illinois River water levels and flood events changed and in some cases permanently connected bottomland lakes, such as Swan Lake, to the river (Sparks et al. 1998). Land use changes throughout the Illinois River Valley also increased erosion and sediments in the Illinois River, which caused high sedimentation rates and rapid filling of bottomland lakes including Swan and Gilbert lakes.

In the late 1990s and early 2000s, the Swan Lake Habitat Rehabilitation and Enhancement Project (HREP) attempted to restore certain ecological attributes of the Illinois River floodplain between RM 5 and RM 13 in the confluence area (USACE 2000). The HREP project area covered about 4,600 acres and included several structural developments that attempted to improve water and sediment management with the goals of: 1) restoring aquatic macrophyte and associated invertebrate communities for migratory waterfowl; 2) providing deep water winter habitat for fish; and 3) providing summer habitat for spawning and rearing fish. Specific developments included: 1) riverside dikes along Swan and Fuller lakes and two large water-control structures that separate Swan Lake from the Illinois River, 2) a cross-levee to divide Swan Lake into three individually managed compartments (Lower and Middle Swan on Calhoun DV and Upper Swan on Fuller Lake WMA), 3) water and sediment retention traps and agricultural practices to reduce erosion and sediment runoff from the upland watershed that drains into Swan Lake, 4) pumps to seasonally remove water from Swan Lake, 5) construction of island wind breaks in the Lower and Middle Swan compartments, and 6) dredging for deepwater fish habitat.

HREP developments on Swan Lake have been constructed but their effectiveness and efficiency in controlling water levels have not been established, nor have specific management plans been developed or implemented for annual or long-term operation of water-control structures, pumps, and other infrastructure. More importantly, uncertainty still exists in what the ultimate "desired state" is, or can be, for habitat composition, distribution, and sustaining ecological processes within Calhoun and Gilbert Lake DV. Additionally, few practices have been implemented on private lands in the upland watershed adjacent to Swan Lake, and consequently, sediments still are being deposited in Swan Lake at a high rate. A comprehensive habitat management plan is needed for Calhoun and Gilbert Lake DV that: 1) uses information on geomorphology, soils, and hydrology to develop appropriate and realistic habitat-based objectives; 2) seeks to emulate natural water regime patterns and dynamics of the historic Illinois River system where possible; 3) understands, complements, and at least partly mitigates negative impacts of alterations to the Illinois River and surrounding lands; 4) incorporates "state-of-the-art" scientific knowledge of floodplain ecological processes and requirements of key fish and wildlife species; and 5) identifies important monitoring needs of abiotic and biotic features.

This report evaluates ecosystem restoration options (e.g., Heitmeyer and Fredrickson 2005, Heitmeyer et al. 2006) and helps develop a comprehensive habitat management plan for Calhoun and Gilbert Lake DV to address the above issues. Objectives of the report are to:

1. Identify the Presettlement, and pre-Lock and Dam 26, ecosystem condition and ecological processes in the area.

2. Evaluate changes in the area from the Presettlement, and pre-Lock and Dam 26, condition 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 area.

THE HISTORIC ILLINOIS-MISSISSIPPI RIVER CONFLUENCE ECOSYSTEM

GEOLOGY, SOILS, TOPOGRAPHY

The present location of the Illinois and Mississippi rivers and the geomorphic land forms in the confluence region reflect numerous channel changes and deposition/scouring events caused by fluvial dynamics and glacial events in the Quaternary period (Willman 1973, Simons et al. 1975). During preglacial times about 1 million years before the present (BP), the Iowa River occupied the current Mississippi River floodplain from about Muscatine, Iowa to Grafton, Illinois and the Mississippi River flowed south from Minnesota to Hennepin, Illinois where it then flowed through the current Illinois River valley. During the Kansas continental glaciation, much of the western drainage area of the current Upper Mississippi River watershed was diverted by ice through the current Illinois River valley and enlarged the valley greatly. Following the Kansas glaciation, the drainage reestablished a preglacial pattern with the ancient Mississippi River occupying the Illinois Valley and the ancestral Iowa River occupying the present Mississippi River Valley.

During the Illinoian glaciation the glacial ice sheet advanced from the northeast and forced the ancient Mississippi River west; a lobe of ice advanced west and partly blocked the Mississippi Valley at St. Louis (Simons et al. 1975). This ice dam formed a large glacial lake in the current Mississippi/Illinois River confluence area and caused extensive deposition of alluvial material in the region. Following retreat of the Illinoian ice during the Sangamonian interglacial period the Mississippi River reoccupied the Illinois Valley and the Iowa River again passed through the present Mississippi River Valley.

The final advance of the Wisconsin ice sheet through the northern half of Illinois forced the Mississippi River into its present valley. The Illinois River, now draining a much reduced area, occupied the valley formed by the ancient Mississippi River. During the retreat of the Wisconsin ice about 13,000 to 18,000 BP, major glacial outwash and floods moved through the Illinois Valley as ice dams failed and glacial lakes drained from the Chicago area. This flood water formed the Des Plaines and Kankakee rivers which joined near Channahon, Illinois and created the current northward extent of the Illinois River. By the end of the Wisconsin glaciation, the current drainage patterns of the Upper Mississippi and Illinois rivers were established.

Even after the retreat of the Wisconsin glaciers, the Mississippi River was strongly influenced by remnant ice sheets to the north. Large quantities of glacial debris and melt water moved through the river channel, causing extensive deposition in the valley and backing water up the Illinois Valley. When the northern ice sheets retreated further north, the reduction in sediment loads caused the Mississippi River to incise to depths of 50-75 feet. Subsequent channel widening and development of floodplain valleys and terraces occurred in the post-Wisconsin glacial time. The remnants of the ice age are wide floodplain valleys partly filled by glacial outwash sands and gravels. In the confluence area, the Mississippi River valley floor is about 5-6 miles wide with a slope of about 0.5 feet/mile. In the lower Illinois River, the valley floor is about 4 miles wide and slopes about 0.25 feet/mile. Deposition has caused the floodplain in the lower Illinois River Valley to be higher than it is immediately upstream.

Because the current Illinois River occupies the much wider former channel of the ancient Mississippi River below Hennepin, its discharge and river slope are much lower than the old channel capacity (Willman 1973). Consequently, this relatively low river discharge and velocity over a wide floodplain created a unique “braided” pattern of sediment deposition and river channel connectivity. This braided channel geo-

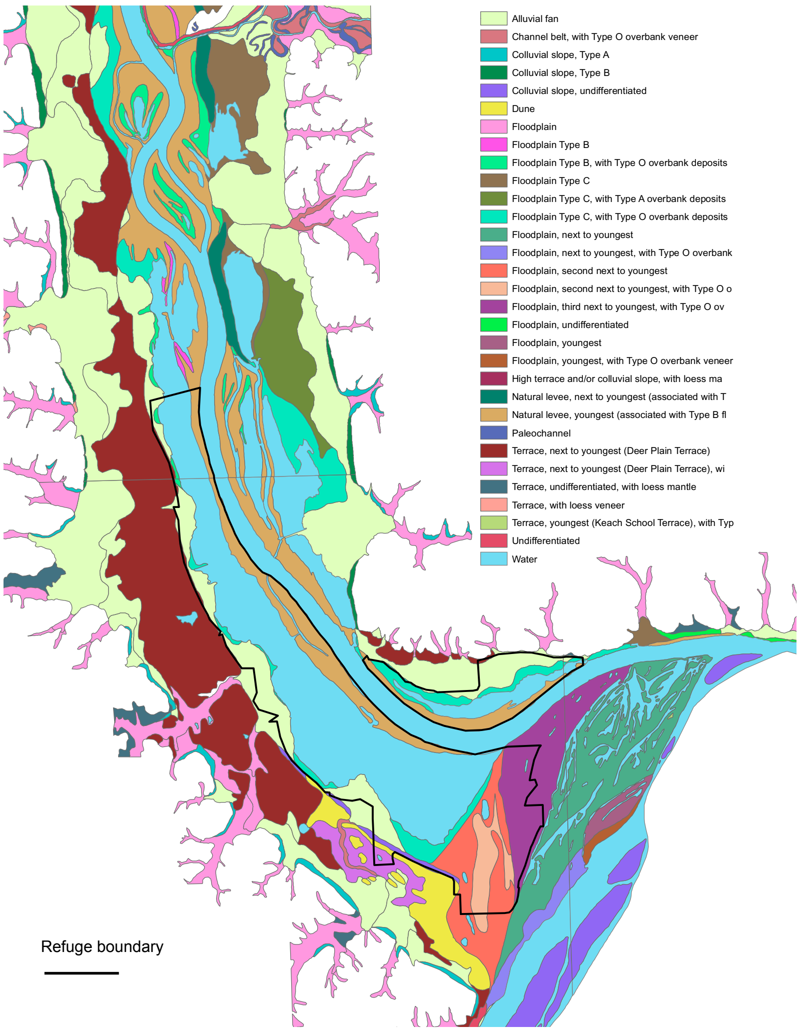

Figure 3. Geomorphological surfaces of the Illinois-Mississippi River confluence area (from Hajic 2000a,b).

Savanna (Deer Plain) Terrace on the west side of Calhoun DV and by valley margin alluvial fans on the east side of Gilbert Lake (Fig. 3).

The Deer Plain Terrace is mostly > 430 feet above mean sea level (amsl) and is the highest terrace adjacent to the Illinois River floodplain that does not have a significant eolian cover (Hajic 2000a). Other upland and terrace hills in Calhoun County have 20-50 feet loess deposits. The Deer Plain Terrace has a reverse slope because a sediment dam formed across the mouth of the Illinois River Valley by outwash aggradation in the Mississippi Valley about 13,300 to 12,000 BP. This dam caused a lake (Lake Calhoun) to form in the lower Illinois River Valley and inundated all of the Calhoun and Gilbert Lake DV lands and the Deer Plain Terrace. The Deer Plain Terrace formed mainly in these lake deposits and evidence of lake edge "beach-ridge" topography is evident on the west side of Calhoun DV south of the current Two Rivers NWR headquarters. Locally, much of this terrace is buried beneath younger Holocene-aged alluvial deposits dating from 2,500 to 9,500 years BP (Hajic 2000b).

Soils formed in the alluvial fan/terrace complex of the Calhoun and Gilbert Lake DV include Oakville fine sandy loam; Worthen, Tice, Littleton, Hurst, Radford, Wakeland, and Blyton silt loams; and Beaucoup, Quiver, and Darwin silty clay loams (Fig. 4). Worthen, Tice, and Littleton soils formed under native prairie and mixed forest-grass communities (Fehrenbacher and Downey 1966). Beaucoup soils are haplaquolls that formed under bottomland forest and marsh grass vegetation in seasonally saturated areas. Wakeland, Quiver, and Blyton soils typically were formed under bottomland forest sites in floodplains and adjacent terraces. Darwin soils formed on natural levees under bottomland forest vegetation

A "delta-type" alluvial fan and point-bar floodplain terrace (referred to as the Calhoun Point-Bar Terrace) is present along the south side of the current Swan Lake. This point-bar terrace has marked ridges and swales caused by various channel movements and associated deposition of coarse grain sand on ridges and silty clays in swales. This terrace also separates the lower elevations of the more recent and active

morphology created a labyrinth of channels, natural levees, point bar ridges and swales, and bottomland lakes in the lower Illinois River Valley including the complex of Swan, Stump, Fuller, and Gilbert lakes in the confluence region.

The lower Illinois River Valley is entrenched in the flanking uplands contained in the Western Forest-Prairie and the Grand Prairie Divisions (Schwegman 1973). The Western Forest-Prairie is underlain by Pennsylvanian and Mississippian limestone, sandstone, and shale (Willman and Frye 1970, Willman et al. 1975). Numerous rock outcrops occur along streams and limestone bluffs border many areas of the Illinois Valley from the confluence area upstream about 60 miles. Entrenchment of the river has exposed Devonian, Silurian, and Ordovician strata that form these steep bluffs. The steep valley walls of the uplands and bluffs are separated from the adjacent Illinois River alluvial bottom by the meander belts of the Mississippi River in the Calhoun Point area and the Illinois River in the Swan and Gilbert Lake areas. Soils on this terrace are mostly Tice silt loams on higher ridges and Beaucoup silty clay loams in the bottoms of swales. Small, often unmapped, outcrops of Oakville fine sandy loams are present on some point bar ridges.

The floodplains on Calhoun and Gilbert Lake DV formed through vertical accretion, or in-filling, of lateral lakes within lacustrine and backwater environments (Rubey 1952). Geomorphic stratigraphy and topographic evidence suggest the Illinois River changed primary channels 4-5 times during the Holocene period and formed heterogeneous alluvial surfaces that include natural levees, abandoned channels (including Swan and Gilbert lakes), point bar ridges and swales, and active floodplain meander belt surfaces (Figs 3, 5). The location of the Illinois River has remained mostly stable in the last 2,500 years. Floodplain areas are classified as Types B and C (Hajic 2000a). Type B floodplains are composed mostly of natural levee deposits, whereas Type C floodplains are alluvial deposits. Most Type B soils are poorly drained Beaucoup and Tice silty clay loams deposited in the last 3,000 years. Most Type C soils are poorly drained Beaucoup silty clay loams and consist of up to 12 m of unoxidized silt loam to silty clay loam fluviolacustrine deposits that filled in former river channels and bottomland lakes. The uppermost part of these sedimentary deposit sequences consists of overbank sheet flood deposits that overlie upward fine sand and coarse silts deposited by secondary "slower" flood channels (Fig. 6). Locally, these secondary flood channels overlie a buried truncated soil formed in the Type C floodplains. Most Type C deposits date between 3,000 and 9,700 BP (Hajic 2000b).

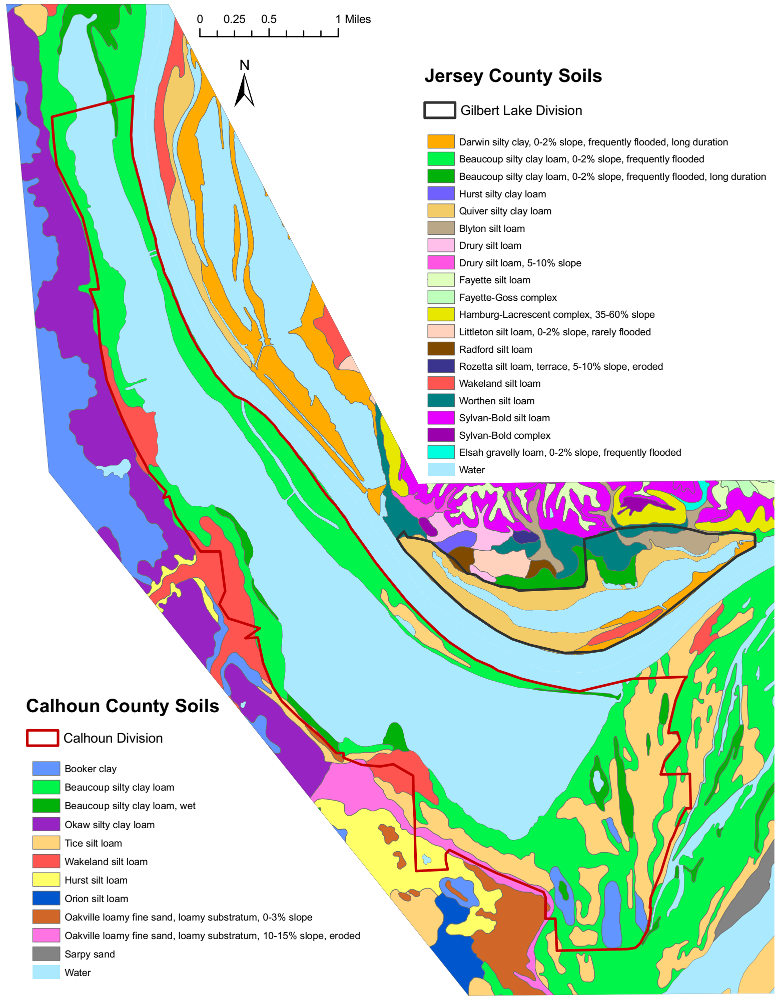

Figure 4. Soils in Jersey and Calhoun counties, Illinois on Calhoun and Gilbert Lake Divisions of Two Rivers National Wildlife Refuge (Data provided by Illinois Natural Resources Conservation Service, http://datagateway.nrcs.usda.gov)).

Elevations on Calhoun and Gilbert Lake DV historically ranged from 410- 412 feet amsl in the lowest depressions of Swan Lake to about 435 feet amsl on the Deer Plain Terrace (Appendix A). Dynamic deposition and scouring actions of flood waters and erosion from uplands in the confluence region have changed elevations throughout the area over time and continue to do so (Fig. 7). The first baseline elevations for the area were mapped in the late 1800s (five-foot contour intervals) by the Mississippi River Commission. In 1904 Woermann (Woermann 1902-1904) mapped one-foot contour intervals for the confluence region. In 1936, the USACE prepared "flowage survey" maps that mapped the region in five-foot intervals. The 1936 maps also included many spot elevations recorded at tenths of a foot and identified tree lines, lake boundaries, and other vegetation features. Collectively, these three historic maps provide information on topographic contour lines and water depths in the region prior to large changes in local land use, topography, and hydrology of the Illinois and Mississippi Rivers and identify the historic topography of the floodplain natural levees, bottomland lakes, river sloughs, point bars, and terraces. They also provide insight into the locations and elevations where Illinois River flows entered and exited Swan and Gilbert lakes during flooding and drying periods. In both bottomland lakes, the lowest elevation entry, and exit, point was at the downstream "bottom-end" of the lakes. This topog-

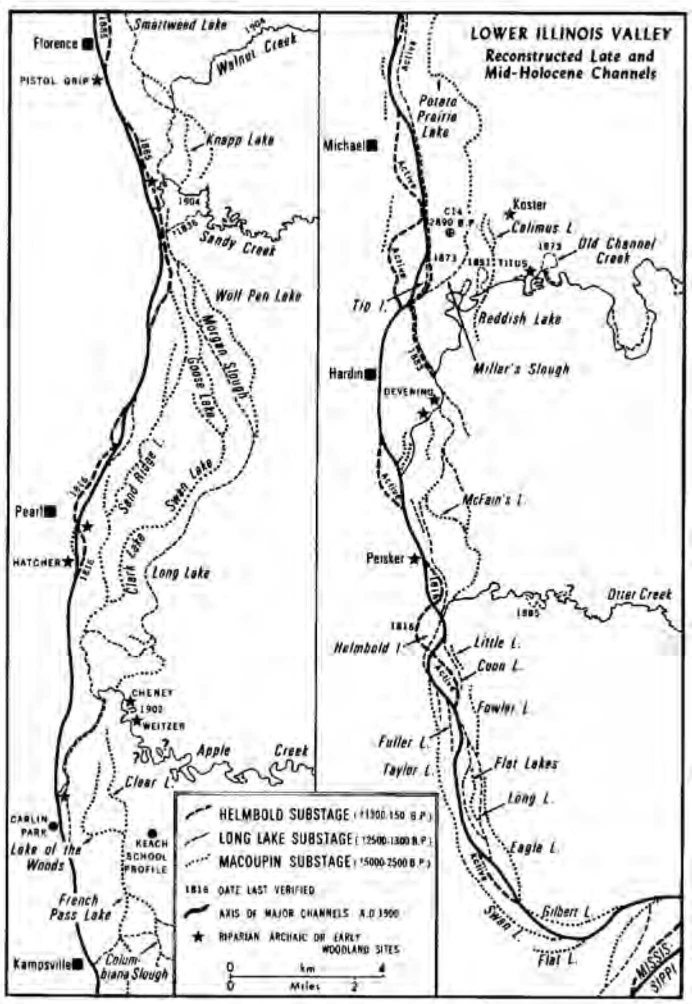

Figure 5. Historic channel changes of the Illinois River (from Butzer 1977)

raphy indicates that the most regular and frequent entry of flood water into these lakes was from slower "backwater" flooding. At less frequent intervals, very high water levels in the Illinois River flowed into the lakes at the upstream ends and created "headwater" flows that moved in greater velocity across the lakes and exited at the lower elevation downstream ends.

CLIMATE AND HYDROLOGY

The climate of the Illinois-Mississippi River confluence area is characterized by cold winters and hot, humid summers. The average winter temperature is 31 degrees F, and the average monthly minimum temperature in winter is 21 degrees F (Table 1). Shallow waters in wetlands in the region typically are frozen from late November through mid March; the first hard frosts and freezes usually occur in early to mid October (Table 2). Growing seasons average about 200 days annually (Table 3). The average summer temperature is 75 degrees F, with the maximum summer daily temperature being 87 degrees F.

Total annual precipitation in the confluence region is slightly over 35 inches (Table 1). Precipitation generally is low in winter. On average nearly 22 inches (62% of annual total) of rain falls from April through September. Summer storms are relatively common and daily rain totals of > 3-4 inches occur occasionally. Average snowfall is 21 inches and on average, about 28 days of winter will have at least 1 inch of snow on the ground. Snow melt and increasing rain in early spring create local runoff into floodplain habitats. In addition to regular seasonal patterns of regional precipitation, the Illinois River Valley also has longer term patterns in annual precipitation and runoff that suggest peaks and lows that alternate on about a 20-year recurring interval (Fig. 8).

Annual and long-term hydrology of river, wetland, and floodplain habitats in the confluence region are influenced by local rainfall and runoff and by discharge of the Illinois and Mississippi rivers (Demissie 1998, Demissie et al. 1999). Because the watersheds of the Illinois and Mississippi rivers above the confluence area are large, seasonal and annual fluctuations in river, and therefore floodplain wetland, levels are greatly influenced by precipitation events throughout the Upper Midwest of the U.S. Generally, Illinois River levels are highly correlated, both seasonally and annually, with regional precipitation events in the upper watershed (Fig. 8). High discharges down the Mississippi River act as a hydraulic dam that slows drainage and backs water up the lower Illinois River.

Water levels and seasonal discharge in the Illinois River have been significantly altered from historical condition (Demissie 1998, Demissie et al. 1999, Theiling 1996). The Illinois-Michigan Canal was completed in 1848 and connected some water flow from Lake Michigan into the headwaters of the Illinois River. By 1871, sewage disposal into the Chicago River was reversed away from Lake Michigan and into the Illinois-Michigan Canal, but periodic floods still allowed sewage to enter Lake Michigan at times. From 1894 to 1900, large volumes of water were diverted into the Illinois River and in 1900 the Chicago Sanitary and Ship Canal was constructed and diverted Lake Michigan water down the Illinois River. Later, major locks and dams were constructed on both the Illinois and Mississippi rivers.

The best pre-alteration river data that represent historic dynamics of river, and thus overflow and flooding/drainage patterns of floodplain wetlands in the Calhoun and Gilbert Lake DV area, are from the Grafton, Illinois gauge prior to 1900; the least altered flows occurred from 1879 to 1893. The Grafton gauge is located about 5 miles south of the water-control structure at the lower end of Swan Lake on Calhoun DV. Based on water level readings at the staff gauge located on the water-control structure at Swan Lake, the Grafton gauge reading typically is within 0.1 feet of the river level at Swan Lake throughout most of the year. Deviations of up to 0.3-0.5 feet can occur if large volumes of water enter the Illinois River in the immediate upstream area and cause a headwater "wall" of water to flow past Swan Lake into the Mississippi River. Despite these minor deviations, analyzing the Grafton gauge data provides the longest-term representative information on both seasonal and long-term dynamics of flooding and drying of floodplain wetlands in the confluence area.

The historic hydrograph of the Illinois River at Grafton indicates a strong seasonal pattern of increasing flow from January through April followed by gradually declining levels until September or early October (Fig. 9). Water levels then rose from October through winter and the following spring. This general seasonal pattern historically was relatively consistent among years with variation in timing and duration of peaks and lows in spring/summer and fall/winter depending on precipitation and runoff in the Illinois River watershed in any given year.

Long-term precipitation and river level data in the Illinois River Valley indicate relatively regular alternating wet and dry periods on about a 20-year periodicity (Fig. 8,10). During a dry period from 1883 to 1892, the Grafton gauge was > 410 feet amsl on

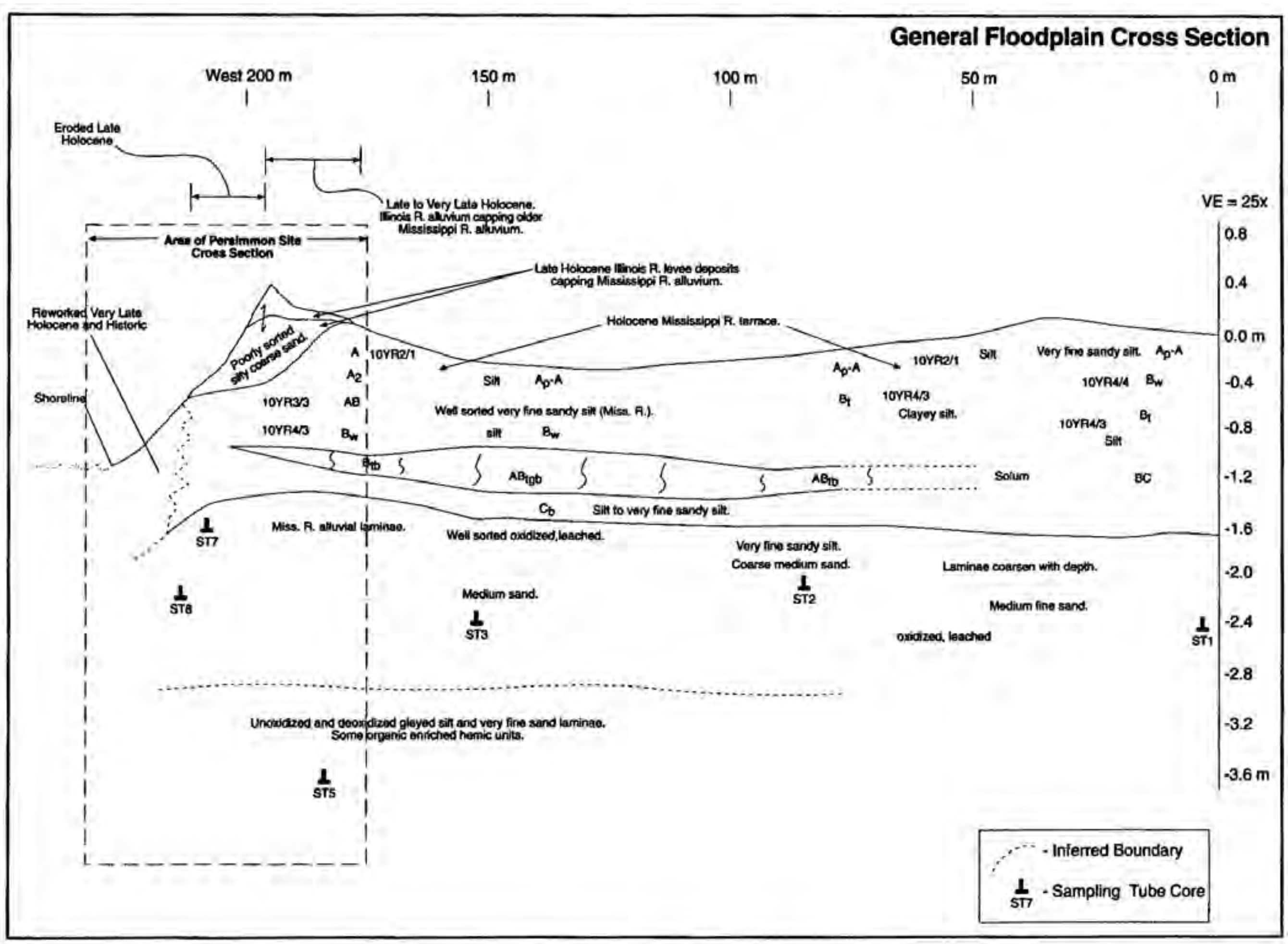

Figure 6. Stratigraphy of topographic cross-sections in Swan Lake, Calhoun Division, Two Rivers National Wildlife Refuge (from Butzer 1977).

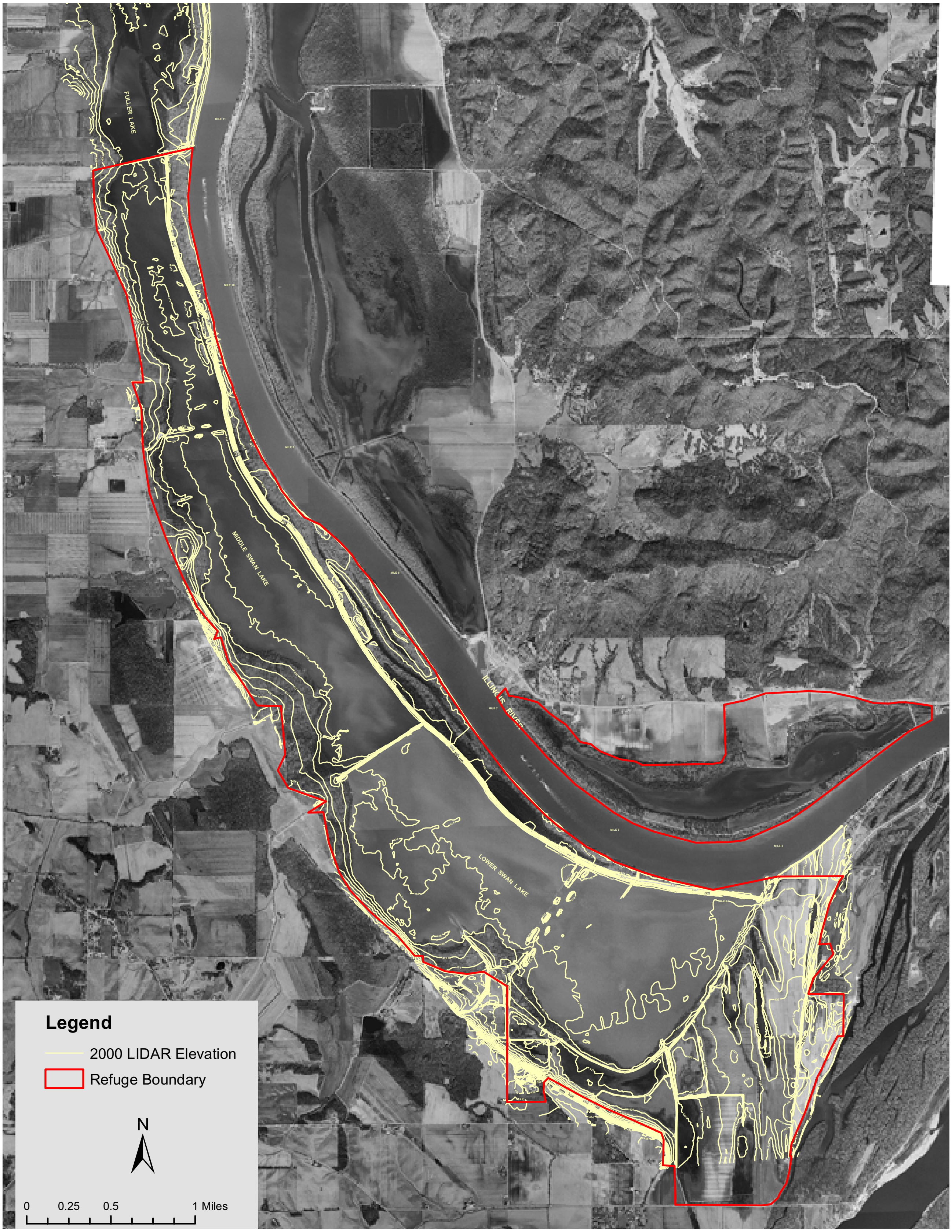

Figure 7. Elevations (two-foot contours) of Calhoun Division, Two Rivers National Wildlife refuge. Data are from 2000 LIDAR topographic surveys conducted by the U. S. Army Corps of Engineers.

Table 1. Average temperature and precipitation on patterns at Jerseyville, Illinois 1951-80 (from Lilly 1989).

Month	Temperature						Precipitation				
				2 Years in 10 will have --				2 Years in 10 will have --			
	Average daily maximum	Average daily minimum	Average	Maximum temperature higher than --	Minimum temperature lower than --	Average number of growing degree days*	Average	Less than --	More than --	Average number of days with 0.10 inch or more	Average snowfall
	°F	°F	°F	°F	°F	Units	In	In	In	In	In
January	37.3	17.8	27.6	40.8	11.7	4	1.58	0.42	2.37	4	5.6
February	42.8	22.4	32.6	46.8	17.8	7	1.79	0.59	2.59	4	4.4
March	53.3	31.0	42.1	58.2	28.7	54	3.17	1.25	4.45	6	5.0
April	67.2	42.9	55.1	69.2	40.9	216	3.91	1.51	5.53	7	0.5
May	76.4	52.1	64.3	78.9	49.2	456	3.72	1.52	5.20	7	0.0
June	85.0	61.2	73.1	86.4	59.0	702	3.84	1.23	5.60	6	0.0
July	88.8	64.7	76.8	91.5	64.0	836	3.62	1.34	5.16	6	0.0
August	86.9	62.5	74.7	88.1	62.1	775	3.51	1.11	5.14	5	0.0
September	81.2	54.7	67.9	84.6	53.8	546	3.30	0.95	4.90	5	0.0
October	69.8	43.6	56.7	72.2	42.4	257	2.58	0.64	3.90	5	0.0
November	54.1	32.9	43.5	57.7	32.1	58	2.48	0.87	3.56	5	1.8
December	42.2	23.9	33.0	45.7	19.9	8	1.99	0.40	3.07	4	3.7
Yearly:											
Average	65.4	42.5	54								
Total						3,919	35.49			64	21

* A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minimum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal crops in the area (50 degrees F).

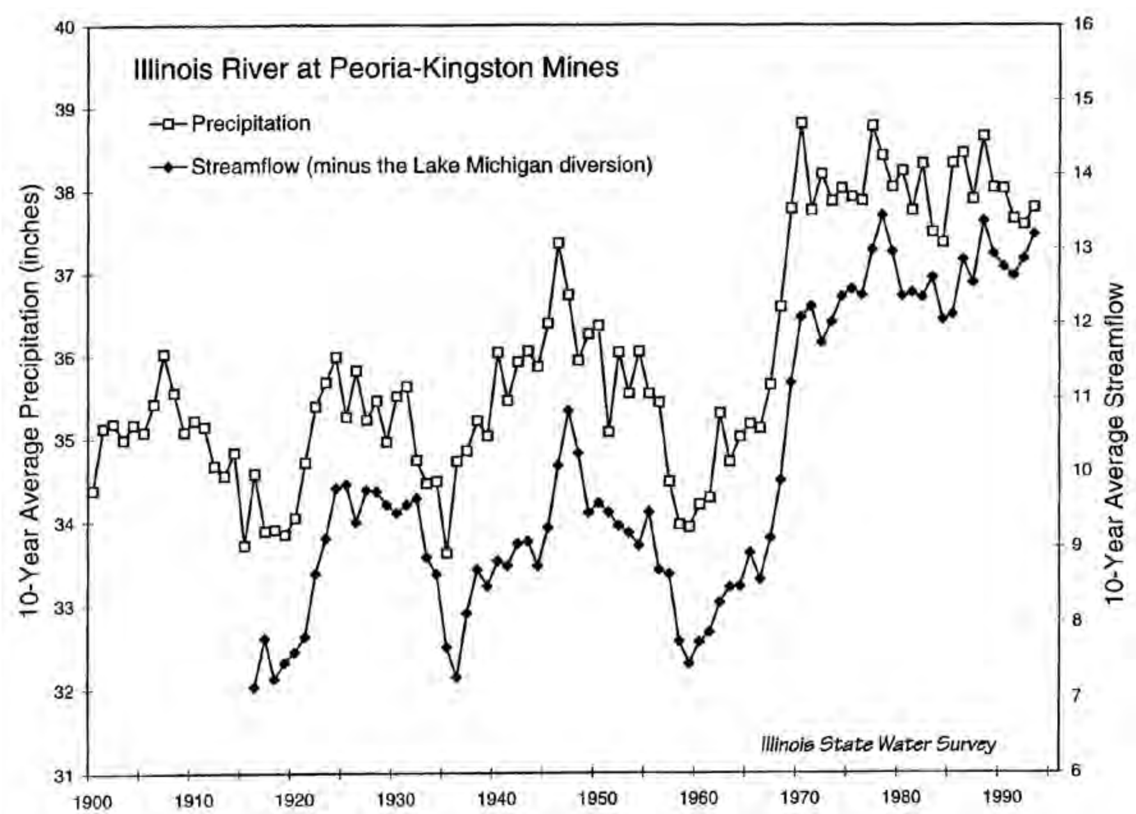

Figure 8. Long-term relationships between precipitation and Illinois River stage level at Peoria, Illinois (from Demissee 1998).

Table 2. Average freeze dates in spring and fall at Jerseyville, Illinois 1951-80 (from Lilly 1989).

	Temperature		
Probability	24° F or lower	28° F or lower	32° F or lower
Last freezing temperature in spring:			
1 Year in 10 later than	Mar. 8	Mar. 22	Mar. 30
2 Years in 10 later than	Mar. 18	Mar. 29	Apr. 7
5 Years in 10 later than	Mar. 26	Apr. 7	Apr. 14
First freezing temperature in fall:			
1 Year in 10 earlier than	Oct. 19	Oct. 10	Oct. 3
2 Years in 10 earlier than	Oct. 30	Oct. 22	Oct. 11
5 Years in 10 earlier than	Nov. 7	Oct. 29	Oct. 19

Table 3. Average growing season period at Jerseyville, Illinois 1951-80 (from Liley 1989).

	Daily minimum temperature during growing season		
Probability	Higher than 24° F	Higher than 28° F	Higher than 32° F
	Days	Days	Days
9 Years in 10	194	175	156
8 Years in 10	202	182	162
5 Years in 10	218	196	174
2 Years in 10	234	209	186
1 Year in 10	243	216	192

average 122.4 ± 44.3 days during the growing season (April - September) (Table 4). The lowest elevation in the Swan Lake depression in the early 1900s was about 410 feet, so this historic low Illinois River level suggests the Swan Lake depression would have been dry, or nearly so, when the river level was < 410 feet. During this drier period, Swan Lake was dry on average 60.6 days (range of 0-122 days) annually; at least some complete drying occurred every summer during this period except in 1885. At higher elevations where the natural drainage occurred from Swan Lake across a low natural levee (ca. 412 feet) and began to flood bottomland forest (> 414 feet) and bottomland prairie (> 417 feet), the hydrograph of the Illinois River floodplain included much longer, and pulsed, drying and flooding periods from spring through fall (Table 4). Extended drawdowns (> 84 days), when river levels were < 412 feet, occurred one year in 1884, two consecutive years in 1886-1887, and for three consecutive years from 1889-1891. In contrast, shorter drawdowns (< 50 days) never occurred more than one consecutive year.

During wet periods prior to 1883 and from 1894 to 1899 (when larger volumes of water were diverted into the headwaters of the Illinois River), the Grafton gauge was > 410, 412, 414, and 417 feet on average 169.0, 158.3, 143.3, and 88.3 days respectively (Table 4). At least some annual summer drying occurred when river levels were < 410- 412 feet in 4 of the 9 years of this period of record, and extended drying of areas > 417 feet occurred each year. Generally, flooding and drying pulses were less common in wet years in all elevations except the highest 417 foot level, because high water levels in the Illinois and Mississippi Rivers were prolonged (Table 4). During wet periods, drawdowns < 412 feet never occurred more than 71 consecutive days and during the very wet period of 1895-1899 drawdowns never occurred and Swan Lake apparently had at least some water throughout summer for 5 consecutive years.

In summary, the hydrology of floodplains in the confluence area historically was dynamic both seasonally and annually and was characterized by a strong seasonal pattern of higher river levels and flooding of bottomland lakes and habitats during spring and gradual drainage and drying in summer and early fall. This pattern was especially pronounced during regularly recurring "dry" periods and with more prolonged flooding during "wet" periods.

The influence of groundwater seepage and flow in the hydrology of confluence floodplain wetlands is relatively unknown. Likely, the position of the Calhoun and Gilbert Lake DV habitats next to higher elevation uplands, terraces, and alluvial fans created gradients of groundwater flow into the lower elevation floodplains in some seasons and years. Groundwater "well" data for the region are sparse and usually monitor deeper aquifer conditions > 50 feet below the surface (Illinois State Water Survey, Center for Groundwater Science, http://www.sws.uiuc.edu/gws/gwinfo.asp). These well data suggest some seasonal and annual fluctuation and may reflect some correlation with shallower groundwater levels, but this is not confirmed.

DISTRIBUTION AND ECOLOGICAL PROCESSES OF PRESETTLEMENT HABITATS

The lower Illinois River Valley is characterized by diverse habitats distributed across elevation and hydrological gradients of the floodplain (Fig. 11). Major natural communities/habitat types that historically were present include: 1) the main Illinois River channel and islands; 2) backwater sloughs and chutes; 3) natural levee "riverfront" forests; 4) floodplain lakes; 5) shrub/scrub (S/S) perimeters of bottomland lakes, sloughs, and chutes; 6) floodplain forest; 7) wet meadow bottomland prairie, 8) mesic prairie, and 9) upland forests (Zawacki and Hausfater 1969, Sparks 1993, 1995a, Nelson et al. 1998).

The main Illinois River channel and backwater sloughs and chutes contained open water with little or no plant communities other than phytoplankton and algae. During low-water periods in late summer, some chutes and sloughs became disconnected from main channel flows and held stagnant water that supported some macrophytes. Generally, permanent flowing waters and dynamic scouring and deposition of sediments limited establishment of rooted plants in these habitats (Appendix B). A wide diversity of fish were present in the Illinois River and its chutes and these habitats also supported many amphibians and reptiles, a few aquatic mammals, and some waterbirds (Appendices C-F).

Table 4. Number of days the Illinois River exceeded 410, 412, 414, and 417 feet amsl from April-September 1880-1899 during dry and wet years[a].

Year	>410	<412	>414	>417
1880	129	112	95	27
1881	145	126	121	93
1882	153	127	127	115
1883	149	138	125	70
1884	119	99	71	40
1885	183	132	100	44
1886	86	74	68	61
1887	61	39	20	0
1888	151	124	118	86
1889	101	34	4	2
1890	115	74	42	11
1891	107	56	47	27
1892	152	123	122	87
1894	179	145	112	89
1895	183	183	136	11
1896	183	183	183	80
1897	183	183	150	149
1898	183	183	183	107
1899	183	183	183	124
Mean days				
Dry year	122.4	89.3	71.7	42.8
Wet year	169.0	158.3	143.3	88.3
Mean pulses				
Dry year	1.3	1.7	1.7	1.3
Wet year	1.0	1.1	1.3	1.5
Mean days/pulse				
Dry year	94.1	52.6	42.2	32.9
Wet year	169.0	143.9	110.2	58.9

[a] Dry precipitation years, based on below long-term precipitation during April-September, were 1883-1892 and wet precipitation years were 1880-1882 and 1894-1899. (Increased diversions of water from the Chicago Ship Canal occurred after 1894).

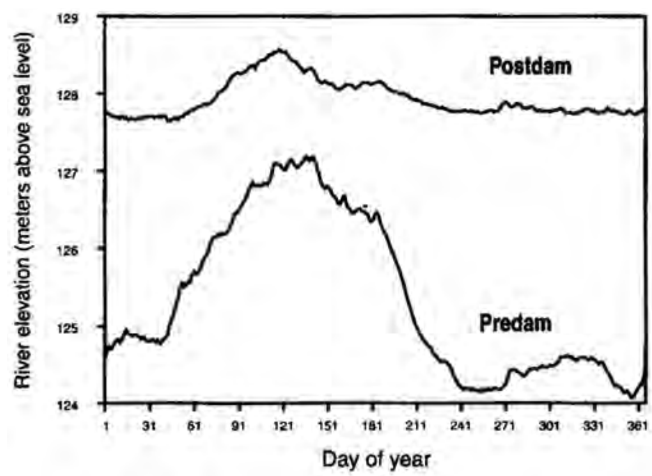

Figure 9. Season pattern of Illinois River flow at Grafton, Illinois (from Theiling 1996).

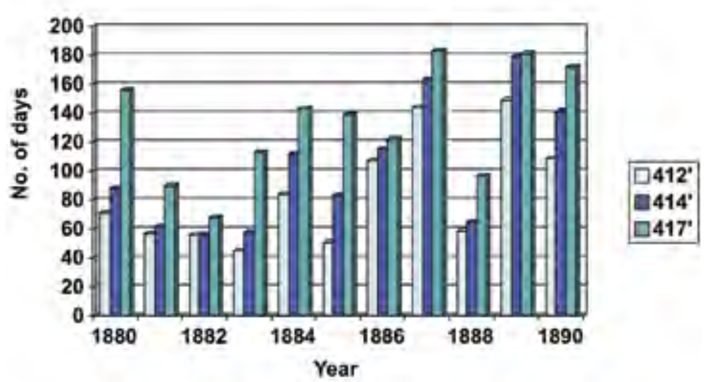

Figure 10. Number of days the Illinois River exceeded 410, 412, 414, and 417 feet amsl at Grafton, Illinois, 1880-1899 (Data analyzed from information provided by the St. Louis District, U. S. Army Corps of Engineers).

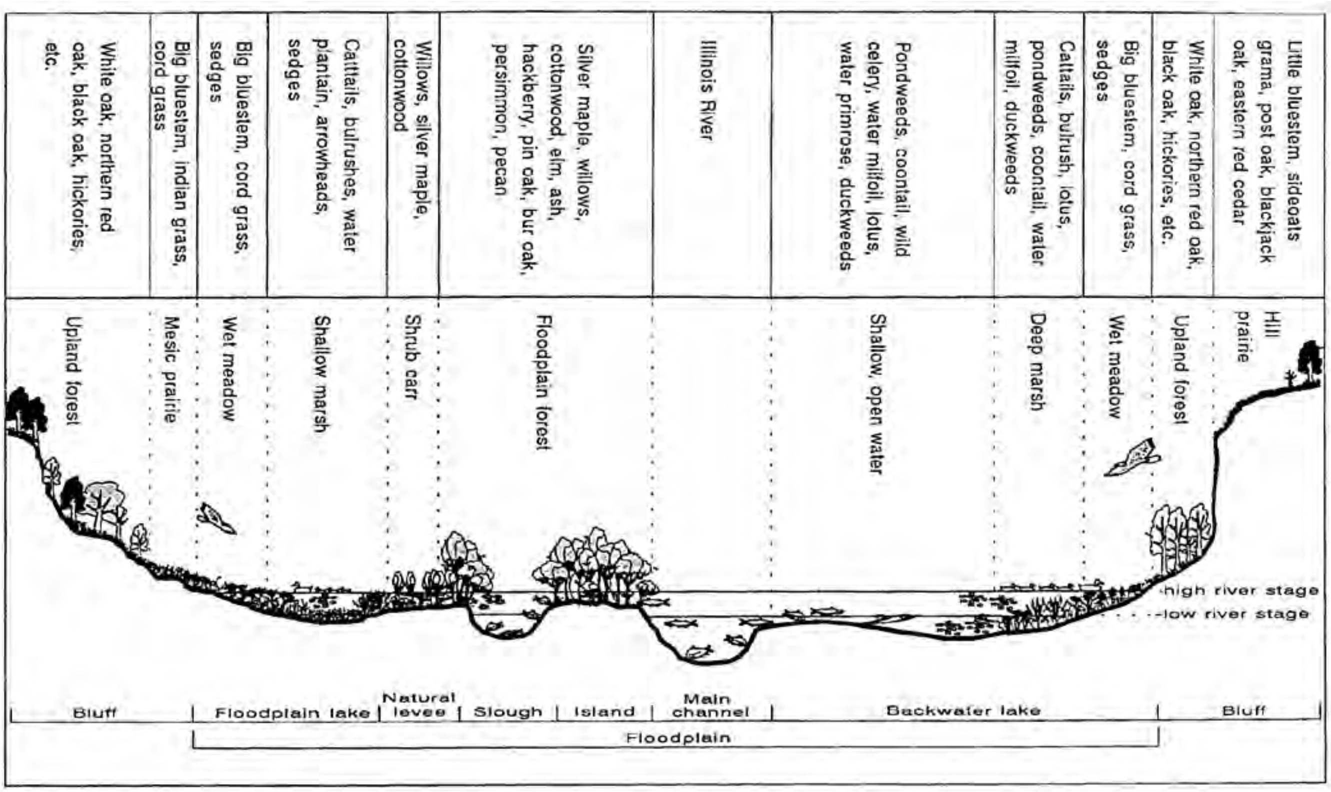

Figure 11. Cross-section of habitat types in the lower Illinois River Valley (from Sparks 1993).

Islands in the Illinois River channel contained vegetation communities that varied depending on size and configuration (Turner 1936). Most islands historically were 1-3 feet below adjoining floodplain elevations and frequently were overtopped during high flow events. During floods, some islands were severely scoured or destroyed. Small islands typically were irregularly oval shaped, rounded at the upper end and tapered toward the downstream end. The upper end of an island is the oldest and wears away while the lower end builds up. Pioneering vegetation on new deposits is mostly herbaceous plants, willow sprouts and seedlings of cottonwood (Fig. 12). Farther up the lower end of islands, swamp privet and willows dominate vegetation with maple and cottonwood also present. Interior and upper parts of islands contained maple, cottonwood, elm, and sycamore trees. Larger islands contained subdominant species such as pecan, pin oak, honey locust, hackberry, ash, hawthorn, river birch, and persimmon. Many amphibians, reptiles, and birds used islands seasonally, often for more secure nesting sites during dry summer months (Appendices C-F).

Natural levees deposited along the margins of the Illinois River channel typically were covered with bottomland "riverfront" forests and shared many common forest species with larger islands, especially willow, silver maple, cottonwood, pin oak, persimmon, and pecan (Hall and Ingall 1911, Nelson and Sparks 1998). Sediments were regularly deposited on natural levees and often caused forest species composition to change over time as sites became higher in elevation and less frequently overtopped by flood waters. Early deposition "new" natural levees contained mainly early successional forest species such as willow, cottonwood, and sycamore while older higher natural levees contained many higher zone, less water tolerant, species such as pin and bur oak, pecan, hackberry, and elm (Appendix B). Natural levee forests were used by many mammal and bird species as travel corridors and foraging sites (Appendices C-F). Arthropod numbers were high in these forests during spring and summer and they also contained soft and hard mast that were consumed by many bird and mammal species (e.g., Heitmeyer et al. 2005). The higher elevations of natural levees also provided refuge to many ground-dwelling species during flood events.

Bottomland lakes were distributed in braided abandoned channel areas of Illinois River floodplains (Bellrose et al. 1983). They included the historic Swan, Flat, and Gilbert lakes on Calhoun and

Gilbert Lake DV. Age and size of these bottomland lakes determined depth and composition of vegetation communities. Newer and deeper lakes often had larger areas of nearly permanent water with abundant aquatic vascular plants including floating leaved and submergent species such as pondweeds, coontail, *Elodea*, American lotus, and duckweeds (Bellrose et al. 1979). Edges of deeper areas typically dried for short periods during summer and contained seasonal emergent and herbaceous vegetation (Low and Bellrose 1944). Emergent vegetation included arrowhead, cattail, rushes, lizard tail, and sedges. Herbaceous vegetation was dominated by smartweeds, millet, panic grass, sedges, spikerush, beggarticks, and many other annual and perennial "moist-soil" species (Appendix B). The distribution of emergent and herbaceous communities in floodplains depended on length and frequency of summer drying both seasonally and among years (see previous hydrology section). In drier periods, these herbaceous communities apparently covered wide bands along the edges of bottomland lakes for several years, while in wetter periods they may have been confined to narrower bands along edges of deeper open waters.

Bottomland lakes supported high diversity and seasonally dynamic populations of many fish and wildlife species (Appendices C-F). Historically, fish moved into bottomland lakes when they are connected with the Illinois River for foraging and spawning and some species and individuals remained in deeper areas overwinter. Most fish moved back into the Illinois River channel when bottomland lakes dried, or after they spawned or fattened during higher flood periods (Sparks 1995a and references within). Bottomland lakes also supported high density and diversity of amphibian and reptile species and many species such as turtles moved in and out of these areas similar to fish. Aquatic mammals regularly used bottomland lakes and more terrestrial species traveled in and out of lower elevation areas for foraging, breeding, and cover during dry periods. Waterbird diversity in bottomland lakes is high, and extremely high densities of waterfowl, rails, shorebirds, and wading birds use these habitats for foraging as waters rose and receded during flooding and drying periods.

A S/S woody vegetation "zone" typically was present along the edges of bottomland lakes and sloughs (Yeager 1949). This S/S zone usually was narrow and represented the transition area from more frequently and prolonged flooding bottomland lake herbaceous and emergent habitats to higher drier bottomland forest habitats. S/S habitats typically were flooded a few inches to 2-3 feet for extended periods each year except in extremely dry years. S/S habitats usually are dominated by buttonbush, swamp privet, and willow (Appendix B). Fish and herptiles regularly moved into S/S habitats for breeding and foraging during higher water periods in spring (Appendices C,D). Some mammals and many birds also used S/S habitats for nesting, cover, and foraging resources (Appendices E,F).

Bottomland forests historically covered large areas of Illinois River floodplains from the borders of bottomland lakes and S/S zones and edges of river and chute channels to higher, drier parts of the floodplain (Turner 1936, Green 1947, Yeager 1949, Nelson et al. 1998). These forests often were shallowly inundated during times of higher flows and flooding of the Illinois River in late winter and spring, but became dry during summer and fall. Dominant species included silver maple, elm, pin oak, pecan, and hackberry with lesser amounts of river birch, persimmon, cottonwood, and honey locust (Appendix B). Early successional sites also included sycamore, willow, and swamp privet. Wetter areas of this forest had under stories and ground-

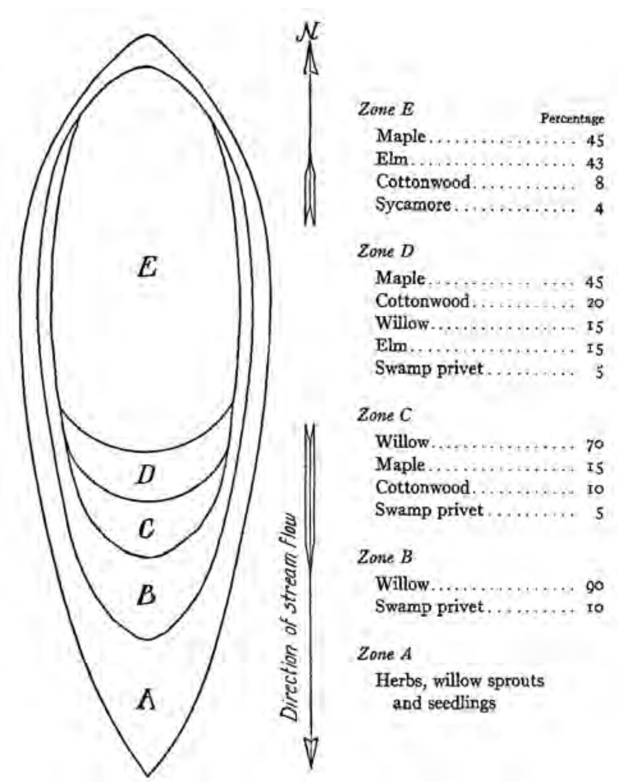

Figure 12. Typical distribution of vegetation on islands in the lower Illinois River (from Turner 1936).

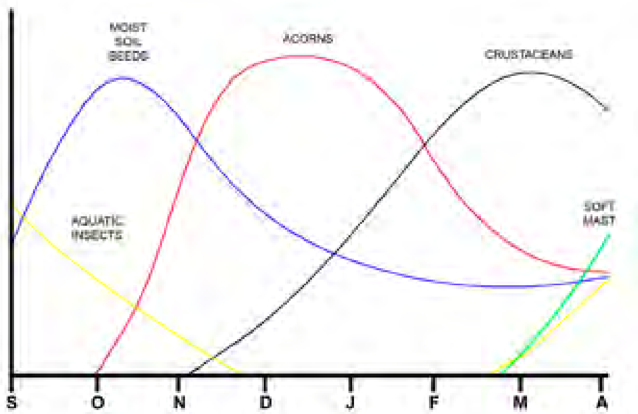

Figure 13. Seasonal dynamics of major food types in bottomland floodplains such as the lower Illinois River (Modified from Heitmeyer et al 2005).

cover dominated by many herbaceous and shrub species (Appendix B) and drier, better drained sites contained many moist-soil herbaceous plants such as smartweed, rice cutgrass, poison ivy, phloxes, beggarticks, and sedges. Vines including Virginia creeper and winter grape were common in these forests. Higher elevations of bottomland forests merged with bottomland prairie habitats and the transition "zone" that separated these two habitat types apparently was determined by where fires could travel into wetter, low elevation areas. These transitional areas often had a mix of bottomland trees and grasses and were savannas. Undoubtedly, fires ranged farther into bottomland areas during dry periods and conversely were restricted to more upland areas during wetter periods. Consequently, the distribution of savannas and the transition area of forest to prairie was dynamic over time.

Bottomland forests supported a rich diversity of animal species (Appendices C-F). During times of shallow flooding, fish moved into these forests for short periods for spawning and foraging. Many amphibians and reptiles also moved in and out of these areas as waters rose and fell. Many diverse food types were present in bottomland forests throughout the year (Fig. 13) and were used seasonally by many mammals and birds. Also, many species nest and roost in these habitats, and when historic floodplain forests were distributed in corridors along the length of the Illinois River they provided important travel and migration routes for many species.

Wet meadow or bottomland prairie was distributed in wide bands throughout the Illinois River floodplain between the lower floodplain forest and higher elevation uplands (Turner 1934, 1936, Nelson et al. 1998). Bottomland prairie areas were dominated by prairie cordgrass, big bluestem, blue joint, sedges, switch grass, water smartweed, and spikerushes (Appendix B). Many other species also were present in these prairies depending on how frequently the sites flooded and for how long. Characteristic species included vervain, marsh elder, sumpweed, false indigo, asters, swamp milkweed, and many others. The distribution of bottomland prairie was determined by the dynamic "line" of where floodwaters occasionally ranged toward the upland edges of floodplains vs. the "line" where fires originating in the uplands moved into wetter lowlands. Historically, wet prairie vegetation also was partly maintained by seasonal herbivory (elk, bison, and deer) that browsed invading woody shrubs and trees. These large herbivores and smaller rodents cycled grass vegetation and nutrients. Bottomland prairie supported many animal species, many of which used the areas during the short, sporadic inundation periods of spring and early summer (Appendices C-F).

Along the higher elevations of floodplain terraces, bottomland prairie often transitioned into narrow zones of more upland-type mesic prairie and then into hillside-talus slope forests along bluffs (e.g., Nelson 2005). Mesic prairie was dominated by big and little bluestem, Indian grass, sedges, and some switchgrass while upland forests contained white, northern red, and black oaks; hickories; elm; and box elder (Appendix B). Floodplain terrace forests contained species common to both floodplains and uplands such as elm, pecan, sycamore, hackberry, ash and honey locust. Vines and shrubs were common in these upland forests as were a variety of herbs.

The precise distribution of vegetation communities in the Two Rivers NWR area prior to significant European settlement in the mid 1800s is not known. Nonetheless, several sources of historical botanical data and accounts of early explorers, settlers, and naturalists suggest general patterns of distribution and can be used to predict early habitat composition and distribution. Perhaps the best historical information is from General Land Office (GLO) surveys completed in the early 1800s in what is now the floodplains of Pools 25 and 26 of the Mississippi River (GLO 1815-1842). Small numbers of European settlers were present in this area prior to the GLO surveys, but these early settlers relied mostly on small field "subsistence" agriculture and fish and wildlife resources. Consequently, the GLO maps and surveyor's field notes provide the best source of historical data.

GLO maps do not describe composition of forests nor do they delineate small areas of trees or herbaceous wetlands within bottomland prairie settings (Hutchinson 1988). GLO surveys probably mapped savannas as forest, but this is unclear because some small savanna areas may have contained larger (> 50%) amounts of bottomland prairie or other grasses. Also, GLO notes suggest travel through, and precise documentation of, vegetation in low, wet, floodplain elevations was difficult and somewhat cursory. Notes in these areas often refer to lands simply as "water", "wet", or "flooded."

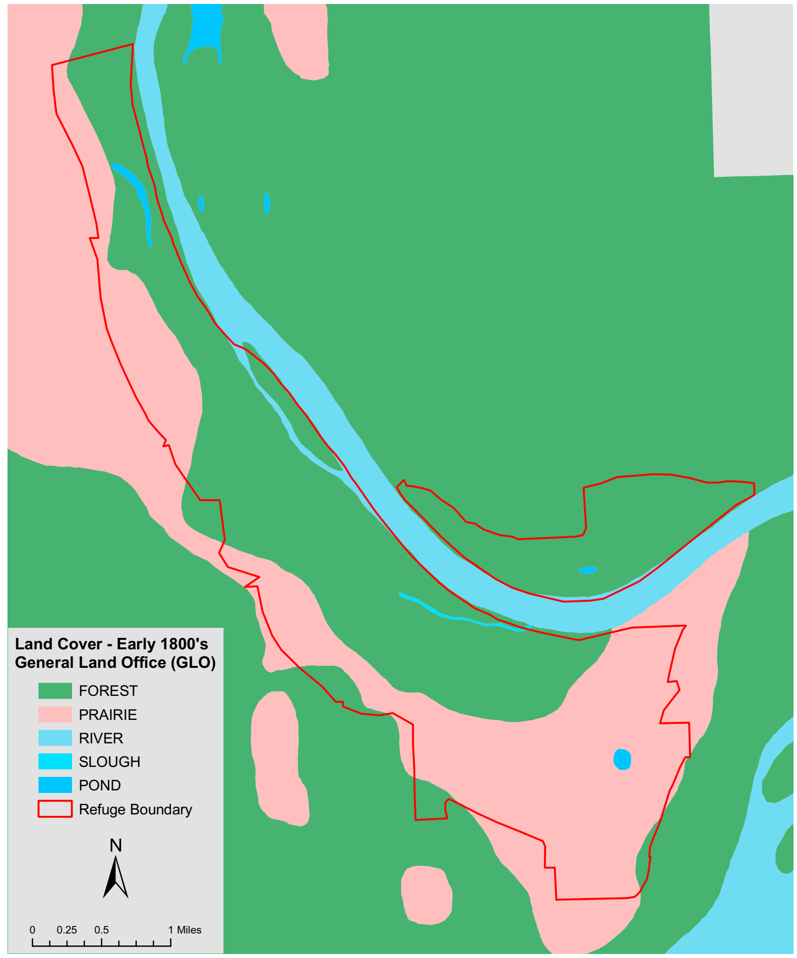

Figure 14. General Land Office land cover types in the Illinois-Mississippi River confluence area taken from surveys conducted in the early 1800s. Data provided by U. S. Geological Survey, Upper Midwest Environmental Data Sciences Center, LaCrosse, Wisconsin.

The few published descriptions and notes of native vegetation in the Illinois-Mississippi River confluence area in the late 1800s and early 1900s (e.g., GLO 1815-1842, Beck 1823, Featherstonhaugh 1844, Andres, Lyter and Company 1872, Hall and Ingall 1911, Forbes and Richardson 1919, Hamilton 1919) suggest Presettlement habitat composition was distributed along elevation and flooding gradients similar to communities documented in GLO notes and less altered contemporary settings. We believe this premise is correct, and with interpretation from historic GLO maps and notes for the area, is a basis for understanding the distribution and amount of habitats present in the confluence area. To predict distribution and area, we prepared a vegetation community matrix model (Table 5) and distribution map (Fig. 14) of habitats present in different geomorphological, soil, topography, and flood frequency settings.

Open water areas were present in deeper elevations of bottomland lakes including Swan, Flat, and Gilbert Lakes on Calhoun and Gilbert Lake DV and nearby sloughs on Fuller and Stump Lake and Calhoun Point WMAs. Open water sites were < 412 feet elevation and apparently supported dense aquatic vegetation communities. Edges of bottomland lakes had herbaceous and emergent vegetation communities between 412 to 414 feet; specific elevations of these habitats likely moved up and down elevation/flooding gradients over longer-term wet and dry precipitation and flooding periods. A relatively narrow band of S/S appears to have been adjacent to herbaceous communities on the edges of bottomland lake borders from about 413.5 to 414.5 feet elevation. Bottomland forest apparently was present on natural levees(419-421 feet) and in floodplain areas 414-419 feet elevation. Some bottomland forest and S/S also probably occurred in higher elevations along swales in the Calhoun Point-Bar Terrace in the Yorkinut, Little Swan, and Duck Pond sloughs. Likely, a transition zone of savanna developed at the upper extent of this elevation band on older floodplain terrace deposits and this in turn changed to bottomland prairie in the 417 to 422 foot elevation band. Bottomland prairie appears to have been confined to areas < 422 feet based on height and frequency of flooding information obtained from the Grafton river gauge and GLO notes. An area of floodplain terrace "beach ridge" is present at about 420-422 on the west side of the Calhoun DV and represents the point of transition from bottomland prairie to mesic prairie and forest types.

Collectively, the floodplain areas in the confluence region and along the Mississippi River reaches of current Pools 25 and 26 contained about 56% bottomland forest and 41% prairie, most of which appears to have been bottomland prairie (Yin and Nelson 1996, Nelson et al. 1998). This composition appears similar to that on the historic Calhoun and Gilbert Lake DV lands, with the exception of slightly more prairie on Calhoun DV and less on Gilbert Lake DV. GLO surveyor field notes conflict to some extent with the habitat distribution predicted above for the area immediately east of the current Gilbert Lake shore. GLO notes delineate this area as forest, however, other historic information and similar settings in the confluence area suggest it may have had a higher grassland or even bottomland prairie composition (Kullen 1994, Balek et al. 2001). GLO surveyor notes suggest historic forests in this area were generally "open" in character and consequently, it seems possible that this area was a savanna.

RESOURCES USED BY ANIMAL POPULATIONS

The diversity and heterogeneous distribution of habitats and seasonal dynamics of flooding and drying created an abundance of resources that supported high diversity and abundance of animal populations in the lower Illinois River Valley. While the region supported many resident species, the seasonal dynamics of habitat availability, especially foods, attracted many species seasonally depending on the resources present and the annual cycle needs of species. For example, nearly ½ of all birds using the area are present only during spring and fall migration. Each habitat type provided unique seasonal resources of food, cover, breeding sites, refugia, hibernacula, and travel corridors that attracted certain species during specific annual cycle events.

The natural hydrograph and flooding regimes of Illinois River floodplains historically was characterized by strong seasonal peaks of flooding in spring and early summer followed by gradual declining water levels through late summer (Theiling 1996, Theiling et al. 1996, Sparks et al. 1998). Fish and wildlife species using the area likewise are highly adapted to these seasonal dynamics and time annual events to coincide with specific resource

Table 5. Hydrogeomorphic (HGM) matrix of historic distribution of major vegetation communities/habitat types in the Illinois-Mississippi River confluence area near Calhoun and Gilbert Lake Divisions, Two Rivers National Wildlife Refuge in relationship to elevation, geomorphic surface, and soil type. Relationships were determined from land cover maps prepared by the Illinois Natural History Survey from General Land Office survey notes, taken in the early 1800s, the Mississippi River Commission in 1890, early soil maps for Jersey and Calhoun counties in Illinois, geomorphology maps prepared by Hajic (2000a,b), and various naturalist/botanical accounts and publications from the late 1800s and early 1900s.

Habitat type	Elevation	Primary Soil types	Geomorphic Surface
Open water	410-412	Beaucoup and Quiver silt loam	Abandoned channel
Seasonal herbaceous/ emergent wetland	412-414	Beaucoup silty clay loam; Quiver silt loam	Abandoned channel, Type B floodplain, point-bar swales
Shrub/scrub	413-415	Beaucoup silty clay loam; Blyton silt loam	Abandoned channel, Type B,C floodplain, point-bar swale
Bottomland forest	414-421[1]	Beaucoup silty clay loam; Wakeland, Quiver, and Blyton silt loam	Type B,C floodplain, natural levees
Bottomland prairie	417-422[2]	Tice, Worthen, and Littleton silt loam	Type B,C floodplain, point-bar ridges
Savanna	417-422	Beaucoup silty clay Loam; Worthen, Littleton, and Tice silt loam	Type B,C floodplain, beach and point-bar ridges
Mesic prairie	422-435	Tice, Worthen, Littleton silt loams; Oakville sandy loam	Floodplain terrace and beach ridge
Upland forest	> 435	Okaw silt loam	Loess hill, bluffs, terrace ridges

[1]Bottomland forest appears to have ranged 414-419 feet amsl in the Swan Lake floodplain area and 417- 421 feet amsl in the Gilbert Lake floodplain area.

[2]Bottomland prairie appears to have ranged 417-422 feet amsl in the Swan Lake floodplain area and 419-422 feet amsl in the Gilbert Lake floodplain area.

availability (Fig. 15). Beginning in fall, river and water levels in floodplain lakes begins to rise. This rise inundated herbaceous vegetation that germinated on mud flats as lakes and shorelines dried during summer. This shallowly flooded moist-soil habitat provided optimum foraging depths for migrant waterbirds as they consumed seeds, tubers, rootlets, and aquatic invertebrates. Gradually rising water also allowed fish to move back into deeper bottomland lake areas where they fattened on aquatic insects, zooplankton, and algae present in flooded herbaceous vegetation. Some fish spent the winter in deeper pools. Many species of fish prefer to overwinter in off-channel floodplain sites because water temperatures are higher and free from currents that require fish to expend energy in swimming to maintain position at a time when food supplies and metabolism are low (Sparks et al. 1998). Temperatures in the main channel of the river can be as low as 32 degrees F and prolonged exposure to cold water is lethal to some fish such as juvenile drum (Bodensteiner et al. 1990).

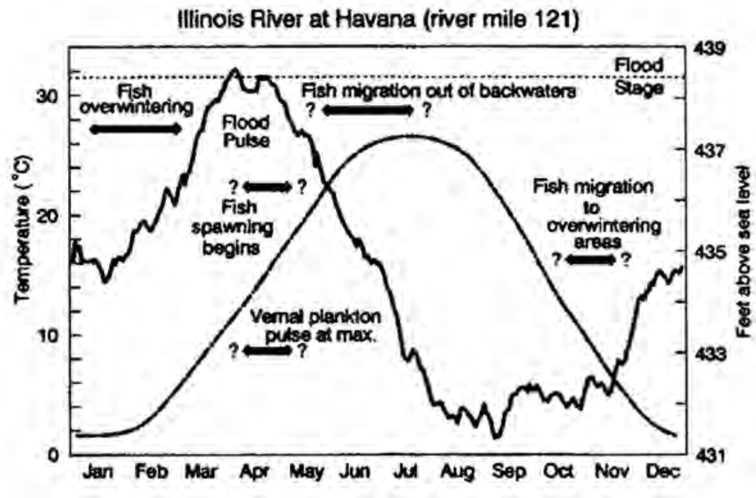

Figure 15. Annual cycle events of key fish and wildlife species related to seasonal dynamics of flooding and vegetation distribution in the lower Illinois River Valley (from Sparks 1995a).

As water levels rise in late winter and spring, most floodplain habitats gradually became inundated for at least some short periods and provide newly flooded foods and habitats used by migrant waterfowl, shorebirds, and neotropical migrant passerines (Bellrose et al. 1979, Havera 1999, Knutson et al. 1996). Newly flooded forests, in particular, provide critical crustacean and residual seed foods for migrant ducks such as mallards as they complete prebasic molt, replace energy used in northward migration to that point, and store nutrient reserves that will be used in eventual reproduction (Heitmeyer 2001, 2006). These forests also provide nest cavities, pre-breeding foods, and brood habitat for wood ducks and hooded mergansers. They also provide breeding habitats for colonial nesting wading birds and many passerine birds. Further, these shallowly flooded forests provide food to many amphibians and reptiles, fish, and mammals as they prepare to breed either locally or at some distant breeding/spawning location (e.g., Heitmeyer et al. 2005). Short duration flooding of bottomland prairie habitats similarly provides pre-breeding foods to many birds and some mammals and when flooded for longer duration provides nesting sites for species such as king, sora, and Virginia rail; marsh wrens; several species of sparrows; and massasauga rattlesnakes.

Water levels in floodplain habitats historically declined during summer and declining pools of water concentrated aquatic prey used by newly hatched wading birds, turtles, mustelids and otters, and some fish (Heitmeyer et al. 2005). Fish eventually moved out of these backwaters as they dried and the bottoms of bottomland lakes became exposed mudflats (Sparks 1995a). These mudflats were excellent foraging sites for shorebirds, swallows, and raccoons and also facilitated germination of moist-soil herbaceous vegetation that covered bottomland lake margins. Drying of floodplains consolidated sediments and reduced turbidity of waters, which encouraged establishment of submersed aquatic plants in standing water and enhanced germination of emergent and herbaceous plants on mudflats. Seasonal drying also released and recycled nutrients from sediments that helped maintain the high productivity of these habitats.


Ice Jam Illinois River January 1968
Flood of '93
Gilbert Lake mallards 1966

CHANGES TO THE ILLINOIS-MISSISSIPPI RIVER CONFLUENCE ECOSYSTEM

REGIONAL LANDSCAPE CHANGES

Settlement and Early Landscape Changes. – Apparently some humans were present in the Lower Illinois River Valley as early as 10,000 years BP based on archaeological findings in the area (e.g., Farnsworth 1976). Many Indian burial mounds occur throughout the confluence region and artifacts indicate several succeeding cultures used the area until the early 1800s (Kullen 1994, Titus et al. 1995, 1996, Balek et al. 2001). In the late 1600s, the Illinois people (Illiniwek) occupied much of Calhoun and Jersey counties, but warfare with the Iroquois tribe and disease greatly reduced their numbers by the late 1700s (Carpenter 1967). The Peoria, a subgroup of the Illinois people, remained in the Illinois Valley until about 1773, and small remnant groups were present in the confluence area when the first European settlers arrived in the early 1800s. The Illinois ceded their territory to the U. S. Government through treaties in 1803 and 1818-19. The confluence region was used briefly by the Sauk and Mesquakie people until a cession treaty in 1832 cleared claims of the U. S. Government to the entire region.

With the decline of the Illinois people in the confluence region in the 1700s, few native people actually lived in the area, although some evidence suggests larger numbers of people migrated into and out of the area for hunting and gathering of foods (Titus et al. 1995, 1996, Balek et al. 2001). Artifacts from small campsites suggest most Indian activity in the pre-European settlement period was hunting of local fish and wildlife and gathering of fruits, nuts, berries, and tubers. Some agrarian activity was present, but likely was restricted to small patches of maize and other small grains. Descriptions of landscapes from early explorers including Marquette, Joliet, de Finiels, Allen, and Brackenridge describe the area as vast complexes of prairie, floodplain forest, and interspersed backwater lakes and sloughs with little influence of native people (Nelson et al. 1998, White 2000). GLO surveys conducted in the early 1800s also indicated few settlements or land clearing.

Early European settlers in the confluence area were restricted to higher uplands and bluffs that did not flood. Because much of the confluence area was low elevation and confined between the Mississippi and Illinois rivers (Calhoun County), overland travel and trade routes were restricted and European settlement was slow to occur. Major transportation routes were the rivers. Calhoun County still has the distinction of being the only county in Illinois (and one of the few nationwide) that did (does) not have a railroad present. The first bridge across the Mississippi River into Calhoun County was built in 1931. Calhoun County was part of the Military Tract established by the U. S. Congress in 1812, which gave land parcels to those that served in the War of 1812 (Vogel 1929, Carlson 1951). Many lands in Calhoun County initially given to soldiers were subsequently purchased by speculators and few individuals actually settled on the original land grants. The earliest European settlement occurred just north of Deer Plain and French trappers established a post near this location. This settlement subsequently was abandoned after a large flood in 1815. After development of steamboat transportation during the 1820s, settlers from the northeast U. S. and Western Europe began to locate in the area, and current communities still reflect past immigration of German and Irish peoples. The most intense occupation of the region occurred between 1840 and 1860, and the towns of Brussels and Batchtown enlarged. Despite gradual settlement, only about 1/4 of the original military lands of Calhoun County were in private ownership by the 1850s.

European settlement of Jersey County east of the Illinois River was more rapid and extensive than in Calhoun County partly because the area had natural overland road routes unimpeded by flood events in addition to river transportation (Hamilton 1919). By the 1830s, several roads were present along the east bank of the Illinois River and in 1833 a ferry was built across the Mississippi River at the mouth of the Illinois River to St. Charles County, Missouri. By 1836 another ferry was built across the Illinois River at the current Brussels Ferry location. The Chicago and Alton Railroad was built between Alton and Brighton in 1854 and the Wabash Railroad was built to Grafton in the mid-1880s

Much of the landscape of Calhoun and Jersey counties was difficult to farm because of relatively steep upland hills, bluffs, and flood-prone bottomlands. Early clearing was restricted to small fields and pastures and GLO survey maps prepared from 1817 to 1832 do not show many cultural features of settlements, farm fields, roads, or other clearings. Later in the mid 1800s, the timber industry expanded markedly in the area and most of the upland forest became "cut-over" by the early 1900s (Nelson et al. 1994, Williams 1980). Some bottomland forest also was cut, especially higher ridges along natural levees of the Illinois River, for cordwood to fuel steamboats. GLO surveyor notes from 1842 noted "cut-off" timber in about 50% of the line descriptions that ended at the river bank. Calhoun County ranked nationally among the highest in cordwood sales in 1840 (Williams 1980). Other wood was cut for boating and barrel staves, machinery parts, and construction and furniture lumber. Orchards became established on the loess upland hills of Calhoun County in the mid 1800s and by 1870, apple production was a major part of agricultural commerce.

Conversion of native prairie and upland forests to agricultural production increased greatly in the late 1800s in the confluence area. Maps of the region prepared in 1890 (Fig. 16) indicate that considerable parts of the higher elevations of bottomland and mesic prairie had been converted to grain production, especially wheat and corn. At this time, many stock and dairy farms were established. Floodplain forests also were exploited for some agricultural production at this time, but GLO maps from the 1840s do not indicate much change from earlier distribution, probably because these areas remained highly flood prone and were quickly revegetated when they were not regularly tilled.

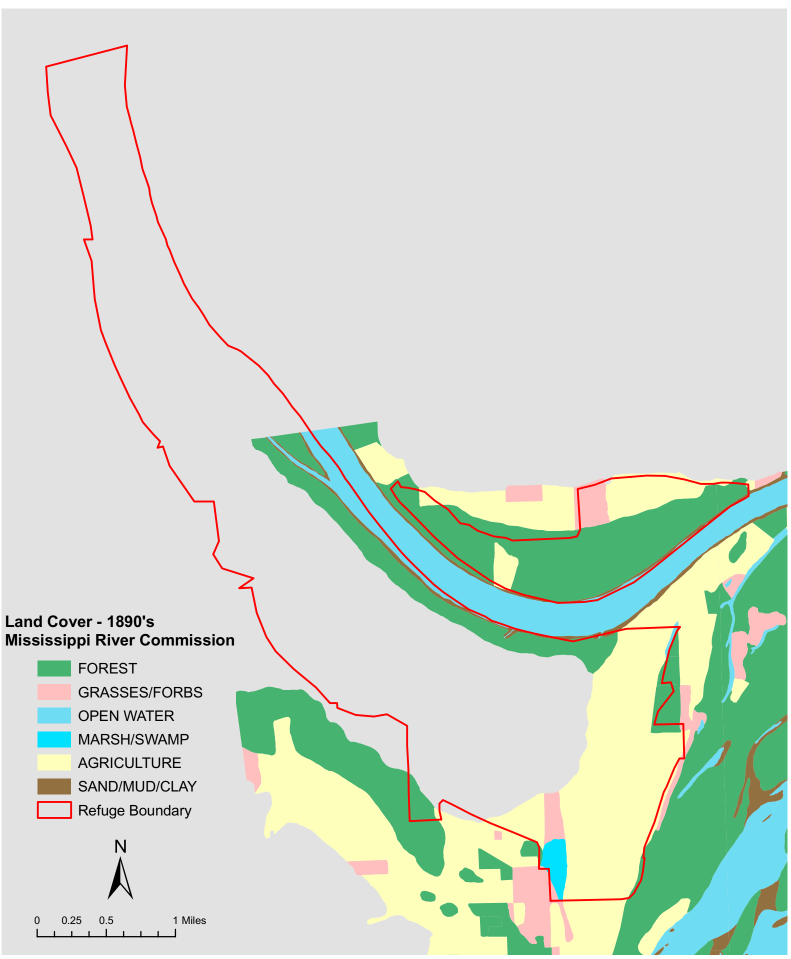

Figure 16. Land cover types mapped in the 1890s in the Illinois-Mississippi River confluence area by the Mississippi River Commission. Data provided by the U. S. Geological Survey, Upper Midwest Environmental Sciences Center, LaCrosse, Wisconsin.

Hydrological and Later Landscape Changes. – The flow regime in the Illinois River has been altered greatly from Presettlement times because of numerous attempts to control and manage water levels for river navigation, diversions of water into the river from the previously mentioned Chicago Sanitary and Ship Canal, and changes in watershed and floodplain land use (Theiling 1996, Theiling et al. 1996, Demissie et al. 1999). In the late 1880s, upland drainage for agriculture accelerated and increased the rate of delivery of seasonal runoff into the Illinois River as water entered the river and its floodplains more rapidly from many tributaries and ditches. The rate of rise of spring floods increased nearly 22% during this time (Kofoid 1903), but the rate of flood recession did not change because floodplains remained relatively intact and the downstream slope of the river and its floodplain was low (only 2 cm/km). Spring flooding on the Illinois River also coincided with spring floods in the upper Mississippi River watershed and high water in the Mississippi River at the confluence acted as a hydraulic dam that slowed drainage from, or backed water up into, the Illinois River. Apparently, increased upland drainage prior to 1900 did not affect biota of the floodplain of the Illinois River (Sparks et al. 1998), however, subsequent changes in uplands and in the river did, especially changes in mean low water levels and timing, depth, and duration of flows and floods.

The first efforts to control water levels in the Illinois River began in the late 1800s when four low-head dams were constructed to provide a 7-foot navigation channel in the lower river reaches. The first such dam was constructed in 1871 at Henry, Illinois; the other three were at Copperas Creek (RM 137.4) completed in 1877, at LaGrange (RM 79.5) in 1888, and at Kampsville (RM 31) in 1893. These low-head dams provided adequate navigation during low water periods for some time, but they quickly became outdated and were unable to support modern navigation that required a greater depth for boats and barges. In 1927, Congress authorized construction of a 9-foot navigation channel in the Illinois River and in the 1930s, seven locks and dams were completed on the Illinois, Mississippi, and Des Plaines rivers to create the Illinois Waterway that provided a minimum of 9-foot navigation channel from Lake Michigan to the Mississippi River.

The lower 80 miles of the Illinois River are controlled by Lock and Dam 26 (now Mel Price Locks and Dam) on the Mississippi River near Alton. Upstream, the locks and dams at LaGrange (RM 80) and Peoria (RM 157.7) are controlled by wicket dams that are lowered to the river bottom during periods of high flow (Sparks et al. 1998). Consequently, for most high flow periods, the locks and dams in the lower 230 miles of the Illinois River do not have significant impacts on river and floodplain water levels. Conversely, the locks and dams retain higher water levels, with reduced fluctuations in level, during low flow periods to maintain the 9-foot navigation depth. The areas immediately above the locks and dams, including the lower part of the Illinois River near Calhoun and Gilbert Lake DV, effectively have become "lakes" with relatively stabilized water levels during low flow periods and with fluctuating high flow flood events.

As previously mentioned, another major factor that significantly influenced water levels in the Illinois River and its floodplains in the early 1900s was diversion of water from Lake Michigan into the Illinois River. The Chicago Sanitary and Ship Canal was completed in 1900 primarily for the purpose of diverting diluted sewage from Lake Michigan to the Illinois River following concern that a typhoid and cholera epidemic could occur from sewage-contaminated drinking water in Chicago (Vonnahme 1996). The annual water diversion from Lake Michigan to the Illinois River varied from 3,000 to 10,000 cubic feet per second (cfs) from 1900 to 1939. After 1939, diversions were limited to an average of 3,200 cfs by the Supreme Court; 1,750 cfs was allocated for dilution and the remaining 1,700 cfs for domestic water supply. During high periods of water diversion from Lake Michigan, water levels in the Illinois River, especially in upper stretches, increased during summer and deepened and expanded bottomland lakes and other depressions in the floodplain. For example, diverted water increased surface water area in what is now the Alton pool 137% from the late 1880s to the early 1900s (Bellrose et al. 1983). This expanded water area also stimulated formation of drainage and levee districts in the Illinois River Valley. By 1920, over 35 districts were extant in the Illinois River Valley and covered over 200,000 acres of floodplain (Mills et al. 1966, Bellrose et al. 1983). Levee developments impinged the Illinois River floodplain and had the ultimate effects of increasing flood stages and prolonging flooding in floodplain wetlands and bottomland lakes (Thompson 1989).

Collectively, the hydrological changes in the Illinois River from the late 1800s to the mid 1900s caused Illinois River levels in the confluence region to have higher, more stabilized, levels throughout the year, especially during summer and early fall (Fig. 17). During high flow periods, water levels were raised 2-4 feet from historic levels; during low flow periods water levels increased on average by 8-9 feet. Also, short duration water-level fluctuations during the growing season increased following construction of the lock and dam system (Fig. 18). Further, even in higher elevations of floodplains that were not completely inundated, the soil moisture content became higher throughout much of the year.

After Lock and Dam 26 was completed in 1938, water levels immediately rose and permanently inundated low elevations of the floodplain and caused extensive mortality of bottomland forests that had not been cut when the lock and dam was constructed

(Green 1947, Yeager 1949). Water management of the Alton Pool above Lock and Dam 26 has sought to maintain at least a 419.5 foot level during summer, which is 7-8 feet higher than historic summer levels. These summer levels generally have been maintained since the "new" Mel Price Locks and Dam were built about 2 miles downstream from the old Lock and Dam 26 in 1989. The surface water area of the combined Swan/Fuller Lake area increased from 462 acres in 1903 to 2,873 acres in 1969 and Gilbert Lake increased from 96 acres in 1903 to 232 acres in 1969 (Bellrose et al. 1983). Historic bottomland forest mostly occupied 414-421 feet levels of the Calhoun and Gilbert Lake DV. Consequently, the minimal 419.5 water level after construction of Lock and Dam 26 permanently inundated most of these forests and forest cover was reduced from a pre-dam distribution of about 60% to a post-dam distribution of 35% by 1975 (Nelson et al. 1998). Remnant prairie area also was greatly reduced at this time; corresponding reciprocal increases occurred in open water, emergent and herbaceous marsh, and S/S habitats (Fig. 19, Nelson et al. 1994). In the Calhoun Point WMA southeast of Swan Lake on Calhoun DV, nearly all bottomland trees died within six years of closure of Lock and Dam 26 (Fig. 19b, Green 1947, Yeager 1949). At slightly higher elevations, where the effects of a perched water table were still evident, timber mortality ranged from 50-100% for all species except more water tolerant species such as ash, river birch, and cottonwood. Silver maple began to rapidly recolonize the exposed mud flat areas where dead timber occurred and it quickly became the dominant tree species in these areas.

In 1993 flooding of the Illinois and Mississippi river floodplains in the confluence region occurred for an unusually long time, extending into the summer growing season, when water levels are normally low (Kunkel 1994). The 1993 flood began in April, but multiple peaks continued through summer and the rivers did not drop below flood stage at Grafton until 30 September. This large 1993 flood had a recurrence interval of

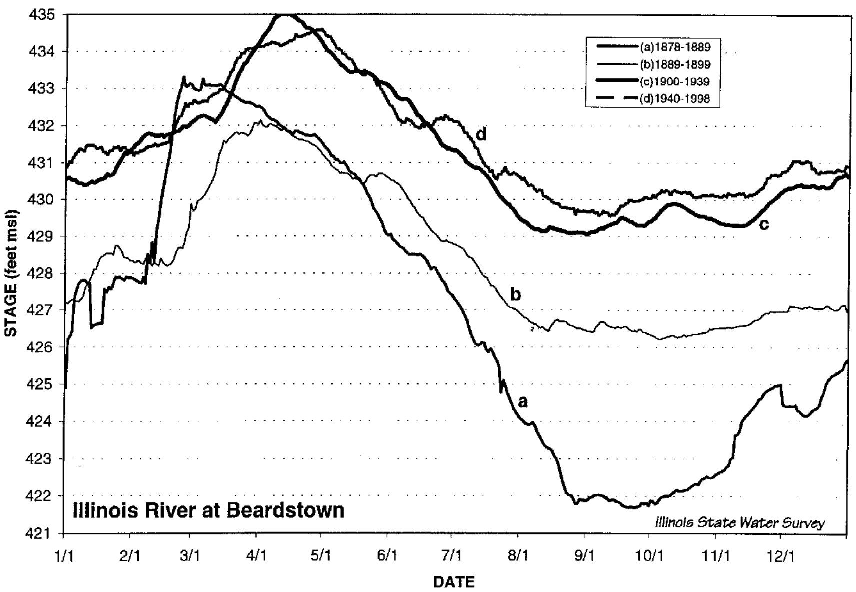

Figure 17. Long-term hydrological changes in Illinois River flow at Beardstown, Illinois (from Demissee 1992 et al.).

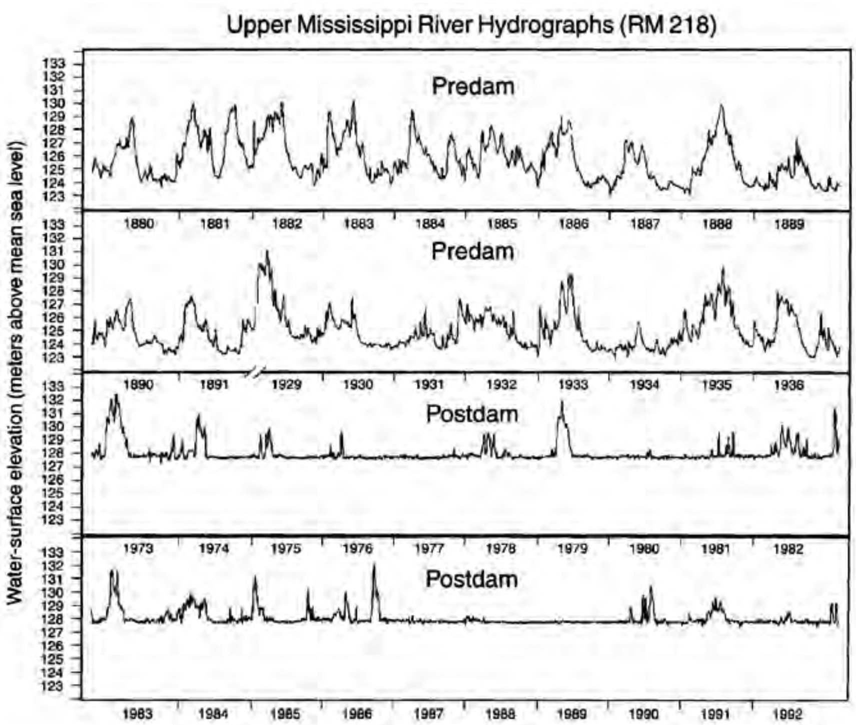

Figure 18. Yearly dynamics of river flow in the Illinois River at Grafton, Illinois pre- and post-construction of the Melvin Price Lock and Dam (from Theiling 1996).

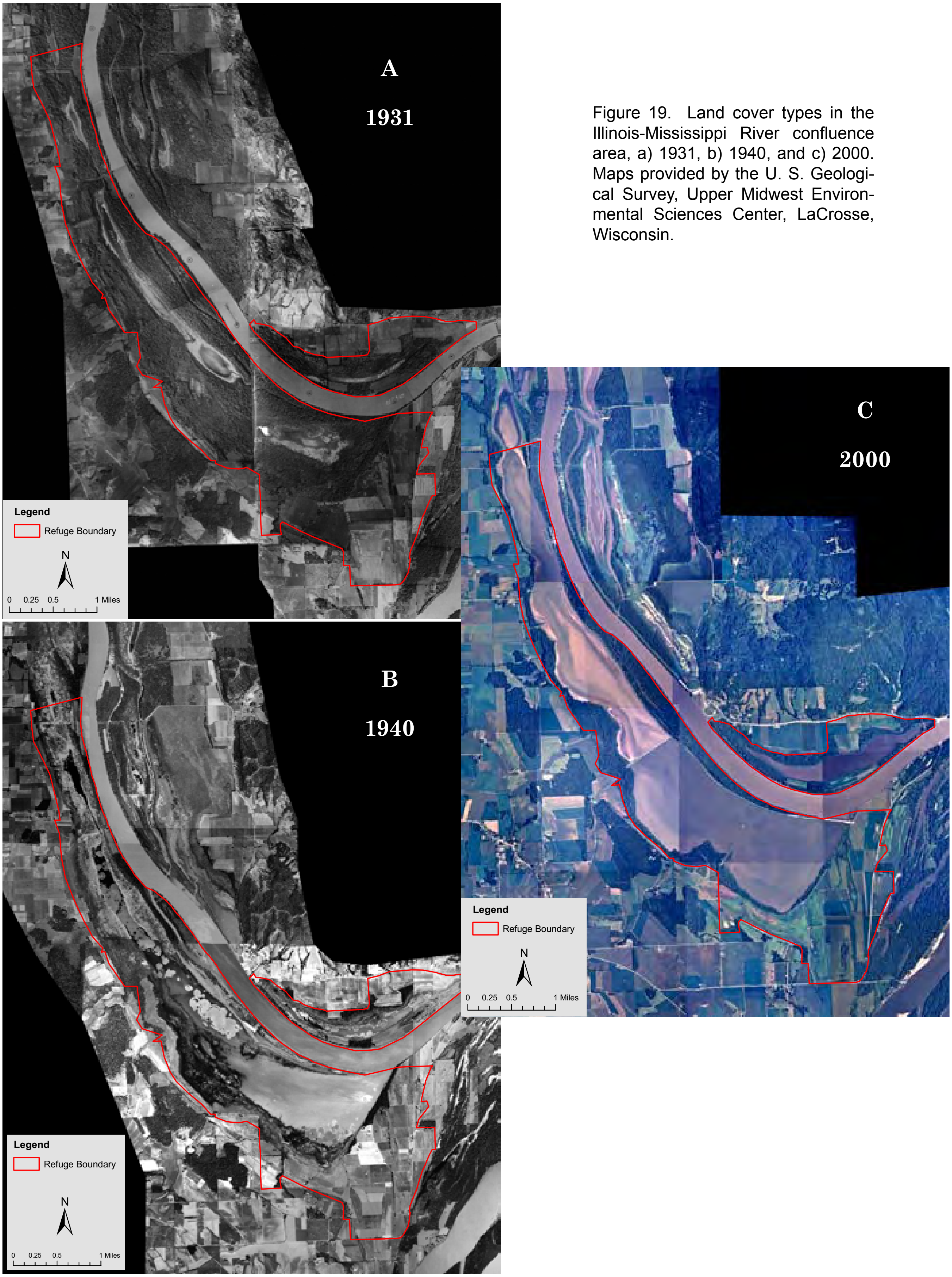

Figure 19. Land cover types in the Illinois-Mississippi River confluence area, a) 1931, b) 1940, and c) 2000. Maps provided by the U. S. Geological Survey, Upper Midwest Environmental Sciences Center, LaCrosse, Wisconsin.

greater than 100 years. Most remnant areas of bottomland forest in the confluence region were inundated throughout the growing season in 1993 and mortality of trees was high; almost all flooded dogwood, redbud, elm, hackberry, pin oak, and hickory were killed (Yin and Nelson 1996, USFWS 1994-1998, unpublished annual narratives). Even more water tolerant species such as cottonwood, sycamore, pecan, and willow suffered extensive mortality. Remnant bottomland forests today contain mostly silver maple, willow, cottonwood, and ash; scattered pin oak, pecan, hackberrry, and elm remain on the highest natural levee and terrace locations.

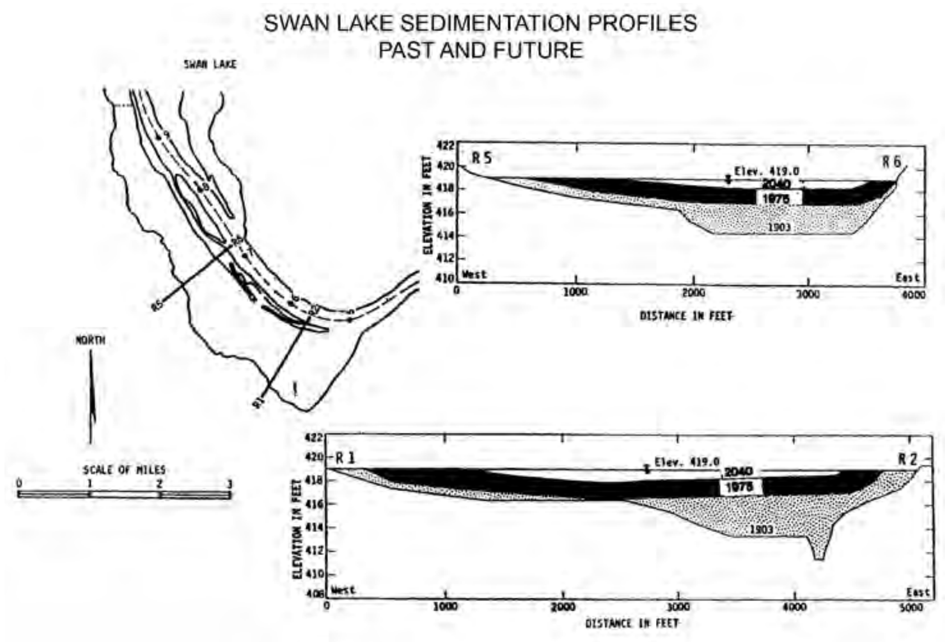

Figure 20. Sedimentation contours in Swan Lake, Calhoun Division, Two Rivers National Wildlife Refuge (from U. S. Army Corps of Engineers 1993).

Sedimentation and Water Quality Changes. – Suspended sediment levels, and ultimately sedimentation rates (deposits of silts and sands/year) in the Illinois River and its floodplains increased following clearing of uplands for agriculture, construction of drainage and levee districts, increased diversion of water into the river, and slower flows and impounded conditions following construction of locks and dams (Lee and Stall 1976, 1977, Bellrose et al. 1979, 1983, Bhowmik and Demissie 1986). In general, it was estimated that about 62% of silts came from valley slopes of tributary rivers and the parent valley and about 38% originated from upland, mostly agricultural field, areas (Lee and Stall 1976). Sediments tended to "fall-out" or be deposited at higher rates in bottomland lakes (Lee 1984, Demissie et al. 1992). Consequently, deeper bottomland lake depressions silted in first and gradually filled and became shallower (Fig. 20). From 1903 to 1978, sedimentation rates in Swan Lake averaged about 0.33 inches/year (Fig. 21). This sedimentation reduced the lake water storage capacity over 2,000 acre-feet (42.2%) during this period. Prior to impoundment from Lock and Dam 26, sediment rates were about 0.2 inches/year and average water depth was 54 inches in Swan Lake (Table 6). From 1940 to 1990 sediment rates increased to about 0.5 inches/year and average water depth decreased to about 40 inches. Recent analyses of sedimentation rates using radiometric dating of 137Cs profiles also suggests increased sedimentation in Swan Lake after Lock and Dam 26 was built (Cahill and Steele 1986). Sediment rates following completion of the HREP projects are estimated to be reduced by 60% (USACE 1989). Reduced sediment inflow from the Illinois River after completion of the HREP projects are predicted to change

Table 6. Estimated sedimentation rate and water depth changes in Swan Lake, Two Rivers National Wildlife Refuge related to completion of Lock and Dam 26 (from U.S. Army Corps of Engineers 1993).

Period	Average water depth (inches)[1]	Average sedimentation rate (inches/yr)
Pre-Lock and Dam 26 (1900-1940)	54	0.20
Past Post-Lock and Dam 26 (1940 - 1990)	40	0.50
Future Post-Lock and Dam 26 (1990-2040)	17	0.33

[1] Water depth relative to a reference water surface elevation of 419.5 feet.

sediment input into Swan Lake to a 50% river and 50% hillside contribution.

Recent analyses suggested the annual sediment load deposited in Swan Lake from the 23,000 acre watershed west of the lake in Calhoun County (Fig. 22) in the 1980s and 1990s was about 117,000 tons. Most of these sediments originate from erosion and runoff of agricultural lands in this watershed and travel into Swan Lake through three main tributaries. About 170 landowners control this watershed and agricultural cropping patterns vary among years and fields as price support and commodity prices vary.

Coincident with altered water flows and sedimentation, the water quality of the Illinois River and floodplain wetlands and lakes also changed. Generally, high sediment loads in the river and in floodwaters caused high turbidity of water (Cahill and Steele 1986, Demissie et al. 1992). High turbidity and reduced water clarity reduced aquatic plant beds in floodplain wetlands and caused more open water conditions where winds were less dampened by vegetation. Prolonged flooding, high wind fetch, and wave action from boat traffic also keep sediments suspended for longer periods and exacerbates turbidity levels in floodplain lakes, which deters establishment of vegetation and improved water clarity.

Increased diversion of water into the Illinois River from Lake Michigan in the early 1900s increased urban pollution sources and by 1923 much of the river was almost devoid of free oxygen. Pollution abatement during the last two decades has improved oxygen levels in the river, but some bottomland lakes continue to have low oxygen levels because resuspended sediments and unconsolidated lake bottoms tend to remove oxygen from the water (Butts 1974:12). Some amelioration of oxygen occurs when high wind fetches stir waters.

Sediments in bottomland lakes of the Illinois River Valley contain many inorganic elements including relatively high levels of Pb, Zn, As, Al, Cr, P, other phosphates and organic carbon (Cahill and Steele 1986). The origin of these elements is diverse and includes sources from urban, industrial, and agricultural areas. Especially high levels of Pb, Zn, and P_2O_5 were associated with die-offs of fingernail clams in some areas of

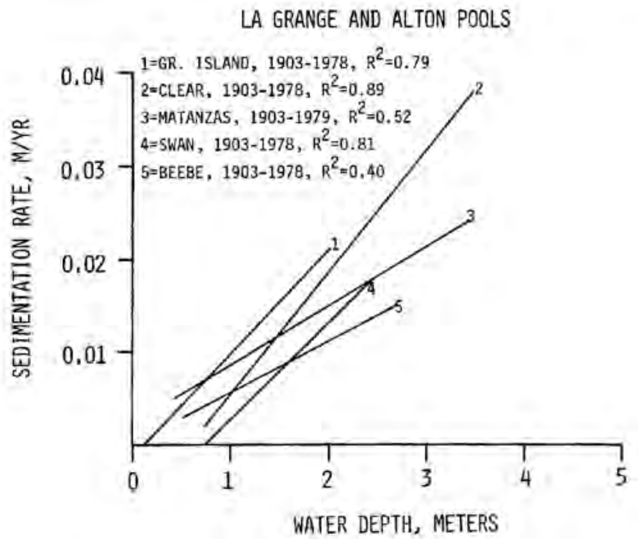

Figure 21. Sedimentation rates in Swan Lake, Calhoun Division, Two Rivers National Wildlife Refuge (from Bellrose et al. 1983).

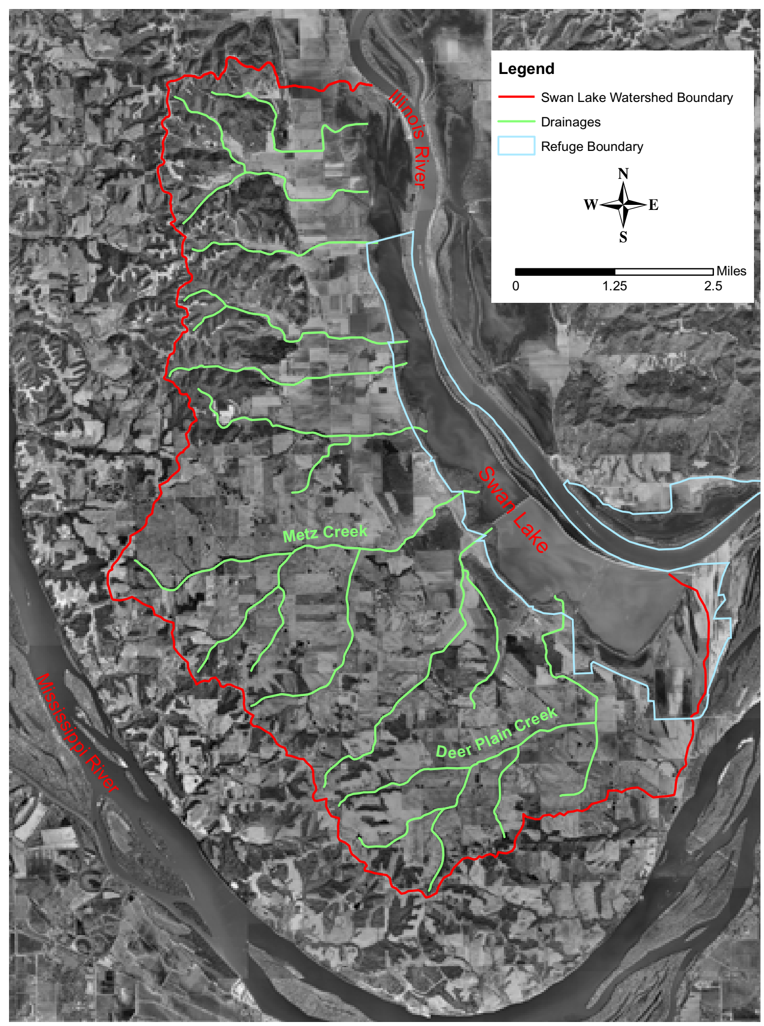

Figure 22. Upland watershed draining into Swan Lake, including primary tributaries.

the Illinois River in the early 1950s; levels of these elements in sediments has since declined.

Benthic Invertebrates, Fish, and Wildlife Populations.–Changes in hydrology, water clarity and quality, vegetation communities, and seasonal dynamics and availability of resources caused many changes in the biota of the Illinois River and its floodplain habitats since the late 1800s. Prior to major changes in the river ecosystem, a wide diversity and abundance of many benthic invertebrates were present. Changes in water clarity and quality gradually reduced "clean-water" animals and shifted communities to those species that could tolerate turbidity and higher contaminant levels. For example, much of the Illinois River and its bottomland lakes now is characterized by populations of "pollution" worms of the family Tubificidae (Richardson 1921, Mills et al. 1966). Fingernail clams occurred in large numbers in the Illinois River and some of its bottomland lakes until the mid-1950s (Paloumpis and Starrett 1960) but their numbers now are drastically reduced. Snails of the genera *Campeloma* and *Pleurocera* also were abundant in the early 1900s, but now are found in abundance in only a few locations. Likewise midge larvae and burrowing mayfly nymphs (*Hexagenia limbata)* now are sparse in the Illinois River system. These species are unable to withstand stagnant water conditions with low oxygen levels.

Native fish populations in the Illinois River and its backwaters also have declined markedly since the early 1900s, when the river supported a large commercial fishery. Declines have been especially marked for native sunfish, catfish, buffalo-fishes, bass, and other small species such as shiners. Interestingly, populations of many species apparently increased in the Illinois River following increased flows and flooding of the early 1900s when diversions of water from Lake Michigan entered the river. However, since 1907 commercial fish yields gradually have been declining (Fig. 23). Undoubtedly, gains in water area available to fish brought about by the diversion of Lake Michigan water began to be offset by drainage and filling of bottomland floodplain lakes in the early 1900s, and along with larger inputs of pollutants, reduced food supplies to fish. Between 1912 and 1917 pollution completely eliminated fish above Utica, Illinois. Populations of turtles, mussels, and amphibians and reptiles apparently were greatly reduced also (Mills et al. 1966).

A major change in the fish fauna of the Illinois River system occurred when common carp were introduced in the 1880s. Carp quickly became a dominant species and in 1908 during the peak of commercial fish take, common carp made up nearly 2/3 of the total catch. Over time common carp populations also declined and began to incur a knothead condition indicative of increased pollution. In the last two decades the fish fauna of the river has been dramatically altered by the increasing populations of bighead, silver, and grass carp (Koel et al 2000).

Waterfowl populations, especially diving ducks also have declined greatly in the Illinois River Valley. The gradual disappearance of aquatic vegetation, fingernail clams and other benthic fauna, and other foods has greatly reduced numbers of lesser scaup (Fig. 24), ring-necked duck, canvasback, redhead, and ruddy duck. Populations of dabbling ducks in the Illinois River Valley have not declined at the same rate as diving ducks, but nonetheless, decreases in bottomland lake vegetation and area have negatively influenced pintails, mallards, wigeon, gadwall, teal, and shovelers (Bellrose et al. 1979, Havera 1999).

Changes in composition and distribution of floodplain habitats also have affected many other animal species including mammals and birds (e.g., Sparks et al. 1998). Less is known about population changes of less-studied amphibians, reptiles, and terrestrial insects. Many neotropical migrant passerine species rely heavily on bottomland forest corridors

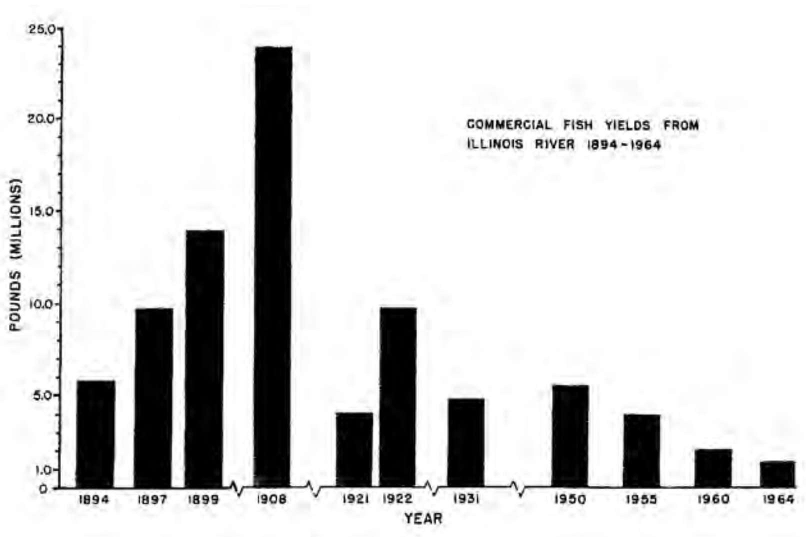

Figure 23. Long-term declines in fish abundance in the lower Illinois River (from Mills et al. 1966).

for food and refuge during fall and spring migration. Mortality and changes in distribution of these forests negatively influences resource abundance and causes declines in avian species richness and abundance (e.g., Knutson and Klaas 1997). Some bird species may have initially increased after greater flooding and expansion of floodplain lakes in the lower Illinois River Valley after locks and dams were built, but their populations now have declined as resources gradually disappeared. For example, prothonotary warblers nest in cavities in dead bottomland trees and forage in S/S and edges of flooded forests. Following closure of Lock and Dam 26, large areas of bottomland forest began dying and undoubtedly created more cavities and S/S habitats. Over time, however, dead trees and snags decayed and fell and S/S and forest edge habitats converted to open water areas. Similarly, increased shallow flooding of floodplains may have initially increased food supplies of fish, amphibians, reptiles, etc. for wading birds, cormorants, and gulls but subsequently declines in these food sources apparently have caused reduced numbers of at least some species such as nesting great blue herons, American egrets, and black-crowned night herons (Mills et al. 1966).

DEVELOPMENT AND MANAGEMENT OF CALHOUN AND GILBERT LAKE DIVISIONS

Acquisition and Early Management Authority. – Calhoun "Refuge", which contained lands now in Calhoun and Gilbert Lake DV was established in 1942 from lands originally purchased by the USACE for construction of the Mississippi River 9-foot navigation channel (Green 1949). The Calhoun refuge lands originally were administered by the Upper Mississippi River NWR, headquartered in Winona, Minnesota. Other refuge lands along the Mississippi River at Batchtown, Keithsburg, Louisa, and Flannigan Island also were administered by Upper Mississippi River NWR. Because of the distance from the Winona headquarters, these lands, including Calhoun were separated from Upper Mississippi NWR in 1958 and became the Mark Twain NWR. Mark Twain NWR was administered from Quincy, Illinois and had three district offices in Annada, Missouri; Brussels, Illinois; and Wapello, Iowa. The Brussels office managed NWR lands along the Mississippi and Illinois rivers near the confluence of the Illinois and Mississippi rivers and included Batchtown, Calhoun, Gilbert Lake, and Portage Island DV. In 2000, the Brussels District was renamed Two Rivers NWR.

The history and sequence of land transfers and cooperative agreements have intertwined the USFWS and USACE in management and development of Calhoun and Gilbert Lake DV lands. The USACE transferred management authority of Calhoun and Gilbert Lake DV lands to the USFWS through a sequence of agreements between the U.S Departments of Interior and Army beginning in the 1940s. A "General Plan (GP)" was executed for transfer of management authority including some lands being transferred to the state of Illinois (e.g.,Fuller Lake WMA). The GP provided a unified system of administration over USACE lands and clarified rights and responsibilities with lands being made available "... for the conservation, maintenance, and management of wildlife, resources thereof, and its habitat thereon, in connection with the national migratory bird management program... subject to numerous conditions and reservations." The Department of Army reserved rights to change water surface elevations, to dredge

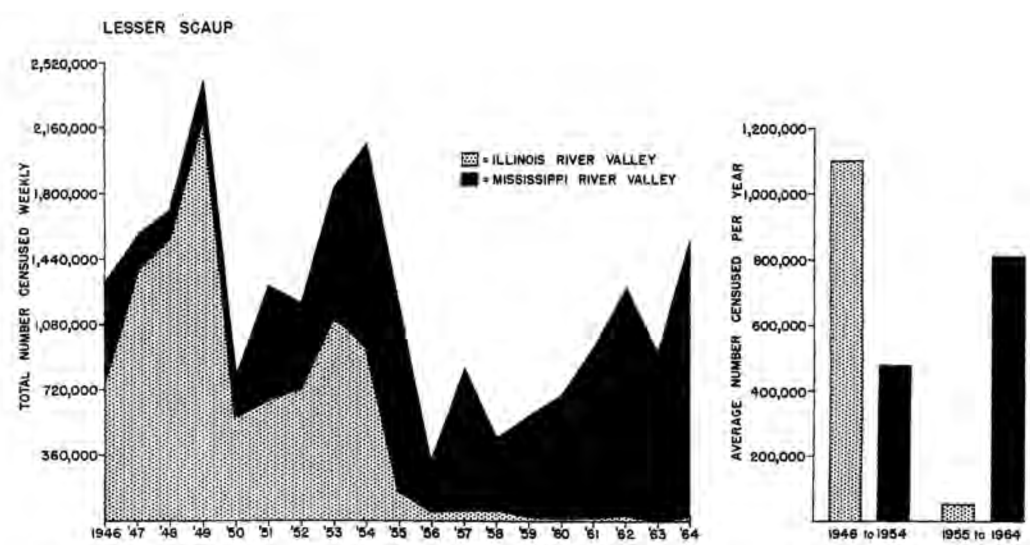

Figure 24. Long-term declines in lesser scaup numbers counted in the lower Illinois River valley during fall and winter (from Mills et al. 1966).

and dispose of spoil, to dispose lands for commercial and industrial sites, and to issue leases for accommodating public uses of land. Further the NWR could not interfere with navigation.

In 1958, amendments were passed to the earlier Coordination Acts and further changes occurred in the 1961 GP and the 1963 Coordination Agreements. These new agreements and amendments provided important restrictions for public uses and phased out leases for agriculture and recreational purposes. The agreements specified that mutual agreement and consent of both agencies were needed before construction of rights-of-way for roads, telephone lines, and power lines. They also provided authority to the USFWS to regulate public access. In 1966, Congress passed the National Wildlife Refuge System Administration Act to consolidate authorities for areas administered by the U. S. Department of Interior for conservation of fish and wildlife. This Act did not clarify how GP lands were incorporated into the NWR system. In 1976, the Refuge System Act was amended and identified that GP lands, including Mark Twain NWR, were subject to all laws and policies of the NWR system including compatibility, to the extent of the authority granted to the USFWS in cooperative agreements.

More recent revisions to the cooperative agreement have refined the structure of interagency procedures that affect management operations on GP lands within the Mark Twain NWR complex. The agreement states that all USACE activities, including natural resource-based activities, on GP lands "will be coordinated with the USFWS for input and review of impacts of proposed actions on wildlife management use of the project." This change is significant because forest management authority for GP lands was retained by the USACE in previous agreements. The newest version of the cooperative agreement in 2001 states that refuge CCP goals and objectives will provide guidance to the USACE for forest management (USFWS 2004:278). The agreement also establishes annual interagency coordination meetings, simplified agency reporting requirements, and dispute resolution procedures. In general, the USFWS and USACE enjoy a very cooperative and productive relationship on the management of GP lands.

In 1967, the USFWS purchased in fee-title 796 acres of cropland adjacent to the GP lands on the Calhoun DV. Another 55 acres were purchased in 1979 for construction of an office and maintenance facilities. Finally, 33 acres of flowage easements were purchased by the USFWS to facilitate the Swan Lake HREP in 1995 and 1996. Currently, the Calhoun DV contains 4,836 acres and Gilbert Lake DV contains 736 acres.

Development and Management of Calhoun Division. – The first management on Calhoun DV apparently occurred in 1942, when the U. S. War Department and the U. S. Department of the Interior reached agreement to transfer management authorities on most lands in the Swan Lake area to the USFWS as "red" lands that subsequently were closed to hunting and trespass (Green 1949). Most of Swan Lake was previously owned by the Deer Plain Hunting Club and it became a waterfowl sanctuary at this time. A small 255-acre area on the southwest border of Swan Lake, also previously owned by the Deer Plain Club was designated as "blue" lands and subsequently leased to Mr. Bob Meyers for agricultural production and hunting. In 1948, this blue land (the Meyers lease) was transferred to the USFWS and became a waterfowl sanctuary where no hunting was allowed. The Swan Lake "sanctuary" quickly became effective after hunting was discontinued and peak waterfowl numbers on Swan Lake were estimated at over 500,000 in fall 1943 and near 1 million ducks in fall 1944 (Adams 1946). In 1942, Swan Lake had extensive beds of aquatic vegetation including smartweeds, pondweed, coontail, and duckweeds (Fig. 19b, Adams 1946). Extended high water and Illinois River floods in 1943 reduced the area of this vegetation substantially and by 1944, the only remnant vegetation was American lotus beds in the northeast corner of the lake. Also, by 1944, over 60% of the bottomland forest trees in lower elevations had been cut, burned, or killed by extended high water levels following closure of Lock-and-Dam 26.

A reconnaissance of the Swan Lake and Gilbert Lake areas was conducted in 1946 to evaluate ecological conditions on these lands and make recommendations for subsequent development and management (Adams 1946). The "Adams" report and the first annual narratives for the Calhoun DV (Table 7) noted rapid siltation in Swan Lake and reduction of aquatic vegetation. Disturbance from hunting on the Meyers lease also was noted as were beaver problems. The Adams report recommended: 1) construction of a levee along the Illinois River on the east side of Swan Lake and a water-control structure in the southeast corner of the lake, 2) incorporation of the Meyers lease into refuge administration and sanctuary, 3) beaver trapping to reduce impounded water area in summer, 4) expansion of refuge land acquisition, and

Table 7. Summary of management activities and observations on Calhoun Division, Two Rivers National Wildlife Refuge 1946-2006 (from unpublished U.S. Fish and Wildlife Two Rivers National Wildlife Refuge annual narratives).

1946-47
Swan Lake is silting badly and should be protected by dikes if it is to be maintained as a waterfowl area.

1967
Toppmeyer and LaMarsh properties were acquired.

1968
796 acres of land were purchased. Most is cropland, but two ponds and two semi-marshes also were added -- Yorkinut, Duck Pocket, CA10a, CA13a.

Constructed ¾-mile ditch and low dike in AU-26-11 and AU-26-12 to permit flooding of these fields. Installed tube as emergency spillway.

Pump station constructed on south shore of Swan Lake to permit flooding and removal of water from AU-26-11, 12, 13, and 14.

1969
AU-26-12: Dike widened and raised, berm established on the pool side, second missile tube spillway installed.
Begin draglining ditch from Bittern Hole (CA-13a) through CA-13 to Schoolhouse Lake ditch to allow moist soil cropping in Bittern Hole.

1970
Ditching completed for moist soil units near Swan Lake. Four stop log structures installed in ditches for water control.

1971
New 8000 gpm pump, gearhead, and excess property Caterpillar engine were installed at pump station.

1975
Dike construction and isolation of the feeder ditch to complete new MSU's[a] 5 and 6t.

Low level dikes constructed at the upper edge of existing MSU's 1 and 2.

Low-level dike constructed parallel to the old feeder ditch as far as the Schoolhouse Lake stoplog structure.

Ditch extended eastward from the Schoolhouse Lake structure a distance of 750 feet so MSU 6 could be flooded via Crissafulli pump.

An 18-inch pipe with slide gate was placed under the service road near the Schoolhouse Lake structure to flood MSU 5 directly from the feeder ditch.

Stoplog structures placed in the MSU dikes for water level control and drainage.

A 50-foot dike and 18" CMP and slide gate constructed north of Water Unit 4.

A depression where the Illinois River floods Yorkinut and Unit 4 was blocked off to hold floodwaters in bottomland timber during wood duck nesting and brooding season.

Stoplog structure placed on culvert under County Road 1 near headquarters to hold water in a proposed MSU.

1976
Tubes to equalize water pressure between MSU 1 and Swan Lake during floods were replaced with a 75-foot spillway.

A natural depression where floods inundate a wooded area north of Water Unit #4 was blocked by a dike and slide gate to create a small greentree reservoir. The gate was opened in April during river rise and closed as water receded.

(Table 7, cont'd.)

1977
A quarter mile of ditch was constructed to carry water from the main feeder ditch to MSU 3 over a more direct route.

1980
Construction began on a refuge office and maintenance area.

1981
The Illinois River flooded the refuge most of the months of May, June, and July.

Silver maple and sycamore trees (750 total) were planted near the new buildings.

Big bluestem/indiangrass mix, prairie switch grass and prairie forb mixture planted around new headquarters site.

1982
Planted black walnut, red oak, autumn olive, pin oak, crab apple, and white pine on south side of new building site.

1983
Plans made to plant pin oaks in MSU 3 to start a hardwood timber plot.

1984
Spring floods persisted into late summer. When waters receded, they left a layer of silt that filled in water control ditches.

1985
Several tons of silt were removed from the ditch leading to the Swan Lake pump station.

Small masses of sago pondweed were observed on Swan Lake for the first time since its apparent disappearance around 1969-1970.

1986
Reforestation efforts continued with the planting of about 1500 seedlings of 16 different species. After the flood receded, weeds were soon as high as the trees with no way to control them.

1987
The dike between Swan Lake and MSU 1 was raised. Silt was removed from the pump station ditch.

1990
Flooding impacted Swan Lake vegetation. Sago pondweed is now almost entirely absent.

1991
Approximately 5000 feet of dike was built, creating MSU 7.

Parts of agricultural units CA-3 (9 acres) and CA-10 (18.6 acres) were retired from farming to be seeded to native grasses.

1992
MSU 2 and MSU 6/Goose Pasture were partially leveled to gain more useable acreage. The separating levee was removed, creating one larger unit designated as "new" MSU 2.

1993
Worst flooding on record. For the fourth consecutive year, spring flooding inundated most of Calhoun Division. Heavy rains continued through the summer and the flood water continued to rise, finally peaking in late July and early August.

1994
Flood recovery efforts began with extensive road repair and silt removal efforts.

(Table 7, cont'd.)

1995
Continued flood recovery efforts with removal of silt from moist soil units.

Two small islands constructed in MSU 4 with some of the silt to be seeded with native grasses.

The flood-damaged pipe and stoplog structure between CA-10 and MSU 2 were removed. New pipe placed between CA-10 and Swan Lake to allow drainage from CA-10 when MSU 2 is flooded.

1996
Swan Lake HREP – dredging and construction of the Fuller Lake riverside levee.

1997
Swan Lake HREP – items completed include seven miles of dredging, construction of Swan Lake riverside levee, island building.

Planted 33 acres of retired agricultural fields to trees.

1998
Swan Lake HREP – began construction of Fuller Lake and Middle Swan pump sites, and Fuller, Middle and Lower Swan stoplog structures.

Replaced culverts and screw gates at the Swan Lake pump station. Installed taller WCS at Schoolhouse Lake for better water management.

1999
Swan Lake HREP – Fuller Lake portion completed.

Replaced water control structures at Office and Duck Club MSU's. Installed new stoplog, culvert and screwgate at Calhoun MSU. All are at a lower elevation to facilitate more complete drawdowns. Extensive ditch clean-out.

2000
Replaced the Calhoun pumping station pump.

First attempt to draw down Middle and Lower Swan Lake. Multiple engine and gearhead problems plus heavy rains resulted in less-than-complete drawdown. About 300 acres of exposed mud in Middle Swan was seeded with Japanese millet in August and kept about one foot lower than the Illinois River using a Crissafulli pump.

2001
Began construction of the Swan Lake HREP pump station in Lower Swan.

Dewatered Middle Swan with pumping beginning in July.

Converted 75 acres of cropland to forest habitat by planting native hardwood saplings (RPM) near Pohlman Slough. Part of Calhoun HREP.

2002
Lower Swan pump station completed – 48,000 gpm capacity.

Both Lower and Middle Swan dewatered, with pumping beginning in July. Floating excavator used to dig ditches to allow disconnected pools of water to move to pumps.

Rip-rap wave break (3000') built partway across Lower Swan, just upstream of barrier islands to lessen wave action and island erosion.

Installed new culvert with stop-log structure for managing water levels in County Road MSU.

Installed new culvert with stop-log structure in Little Swan MSU.

(Table 7, cont'd.)

2003
Partially dewatered Middle Swan down to 418' msl.

2004
Dewatered Middle Swan down to 417.5' msl.

Created MSU 8, a new 30-acre unit by installing stop-log structure on a culvert going into Lower Swan.

Converted 70 acres of cropland to grassland habitat in Calhoun DV. Planted mixtures of warm and cool season grasses.

Repaired old dike and installed new 24" diameter culvert with stop-log structure in wooded area below Yorkinut unit.

2005
Dewatered Middle Swan down to 416.5' msl.

Raised and extended west end of Swan Lake interior cross dike to force high water over dike instead of around it.

Added new pipe with screw gate in NE corner of Upper Calhoun to improve water management capability.

2006
Initiated 2-yr. drawdown of Lower Swan in early June but encountered serious pump problems. Eventually lowered water to 417.0' msl. Pump sent off for repairs.

Installed 3 new 2500 gpm ground water wells in Calhoun wetland complex. Discontinued use of old Calhoun pump station.

Raised and extended west end of dike between Middle Swan and Fuller Lake to force high water over dike instead of around it.

[a] MSU = moist-soil impoundment unit.

5) development of public access routes and a patrolman's quarters.

Wetland development and management on Calhoun DV was limited until the late 1960s when the above mentioned 796 acres of land were purchased on the south and west sides of Swan Lake (much of the Calhoun Point-Bar Terrace and parts of the Deer Plain Terrace). Many of these lands subsequently were developed as wetland impoundments through construction of small levees, ditches, pumps and wells, and water-control structures (Table 7). By 1981, Calhoun DV had constructed 7 moist-soil units totaling 198 acres (Fig. 25) .Other areas on Calhoun DV were maintained for agricultural production; harvested crop fields in lower elevations occasionally were flooded in fall and winter by pumping water from Swan Lake. Attempts were made to reforest some higher elevation areas with mast producing oaks and pecan. Prairie grasses were planted in small areas in higher elevations. Siltation of ditches and Swan Lake continued to be a recurring problem that required periodic dredging and silt removal.

In the early 1980s, a cross-dike was built to separate Swan Lake into two compartments; the southern Swan Lake managed by USFWS and the northern Upper Swan Lake (Fuller Lake WMA) managed by the IDNR. A cooperative agreement was signed between the USFWS and the IDNR to pump and gravity flow water from Swan Lake into Fuller Lake WMA in fall. Additionally, a water-control structure with a 36 inch diameter pipe was installed between the two areas to allow water to drain from Fuller Lake WMA into Swan Lake (bottom invert elevation of 418') during summer to stimulate moist-soil plant production in Fuller Lake WMA. The management intent was, and has continued to be, to drain Fuller Lake WMA each year.

By 1992 several additional moist-soil impoundments were constructed on Calhoun DV (Table 7). Small areas of agricultural fields were retired and planted to native grasses. Attempts to reforest some areas that bordered Swan Lake with pin oak and pecan continued, but most trees died from extended flooding during growing seasons. In 1993, the prolonged large flood on the Mississippi and Illinois River inundated most of the refuge and caused extensive damage to levees, roads, ditches, and water-control structures. Repairs to flood damage occurred in 1994 and 1995 and included removal of silt, replacement of structures and roads, and rehabilitation and reshaping levees.

The first construction on the Swan Lake HREP project began in 1995. Over the next 7 years, HREP construction projects included three phases. Phase I constructed a riverside levee along Fuller Lake. Phase II installed three pump stations for Fuller Lake WMA and Middle and Lower Swan compartments, and stoplog water-control structures for Middle and Lower Swan. Phase III constructed and raised the riverside levee along the Illinois River, subdivided Swan Lake into the ca. 1,000 acre Middle Swan and the 1,300 acre Lower Swan Lake compartments. Two island groups were built to reduce wind fetch. One island group is in Lower Swan and one is in Middle Swan. Some areas in Middle and Lower Swan were dredged for deep-water fish habitat and for boat ramps and lanes.

A 20-foot stoplog water-control structure was built in Middle Swan and another 20-foot structure was built in the southeast corner of Lower Swan Lake to allow management of water flow into and out of these areas depending on water level in the Illinois River. These structures provided passage routes for fish moving between the Illinois River and Swan Lake. In 2000, a 30,000 gallons/minute pump was constructed in Middle Swan to assist in draining Middle and Lower Swan during summer. In 2002, a second 48,000 gpm pump was installed in Lower Swan. A water-control structure (36" pipe with screw-gate) was installed in the cross dike between Lower and Middle Swan to assist water movement between these compartments.

Since the HREP project has been completed, Middle Swan has been nearly completely drained in 2001, 2002, and 2005 and partly drawn down in 2000, 2003 and 2004. The 2000 drawdown achieved

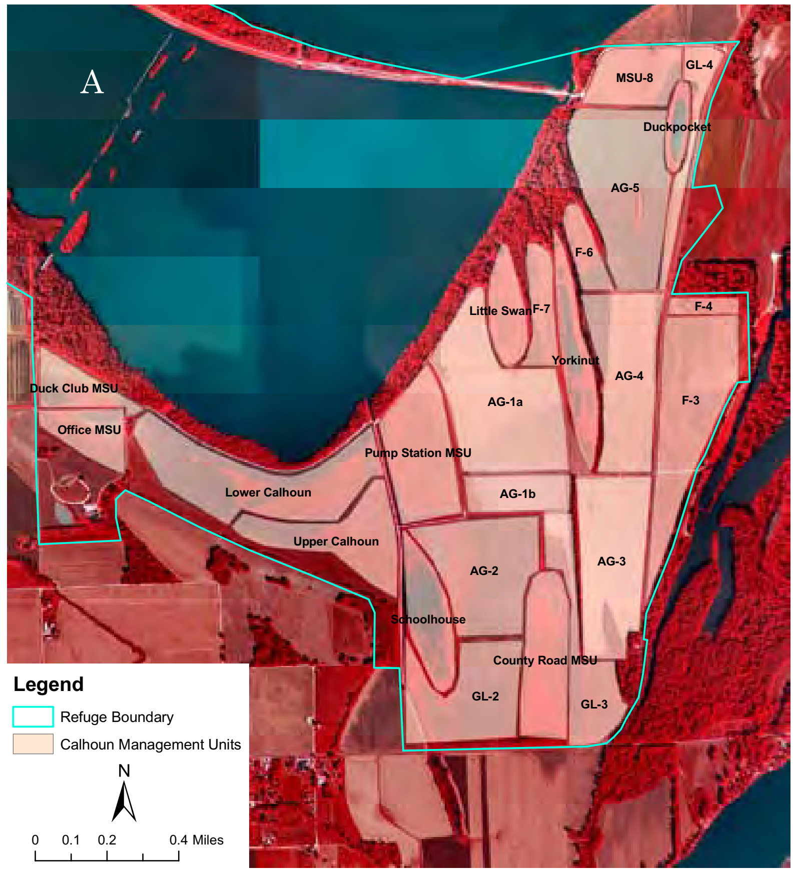

Figure 25. Wetland impoundments and management compartments on a) the Calhoun Point-Bar terrace on Calhoun and b) within Gilbert Lake Divisions, Two Rivers National Wildlife Refuge.

only about a 50% drainage because of pump problems, but the drawdowns in 2002 and 2005 achieved nearly 90% drainage in August. Periodic pumping in Middle Swan maintained a dewatered condition until late September in both years when pumping stopped and water levels gradually rose through winter and spring. In 2002, the first attempt to partly drain Lower Swan Lake exposed areas that had been continuously submerged since Lock and Dam 26 was completed in 1938. Pumping began on 8 July, 2002 and continued until 20 August when water levels reached a 414.4 foot elevation and about 90% of Lower Swan was dry. By 2002, the dredged areas made in Lower Swan in 1995 had mostly silted in from sediments suspended in the lake water. The time elapsed between dredging and this first draw down exacerbated siltation of dredge areas and created silt “dams” in some low areas that prevented complete drainage of Lower Swan. On 12 November, 2002 the stoplog structure on Lower Swan was opened two inches and allowed water from the Illinois River to flow into Lower Swan. By mid-November water levels reached 418 feet and by the end of December, 2002 they exceeded 419 feet. In 2006, pumping began to dewater Lower Swan, but engine and pump problems constrained drainage to about 50%. Additionally, further siltation in dredged areas prohibited water from draining from some lower elevation areas in the lake bottom.

A Phase IV of the Swan Lake HREP plan proposed several treatments in private agricultural lands that drained into the west side of Swan Lake (Fig. 22). Soil conservation practices proposed for private lands included conservation crop rotation, conservation tillage, seeding field edges and borders to grass and trees, grassed waterways, terraces, sediment control basins, concrete and block chutes, and grade stabilization structures. These practices were designed to reduce hillside erosion and sediment input to the lake by 30% and overall lake sedimentation by 17%. These calculations were derived by the Natural Resources Conservation Service from standard formulas rather than on-the-ground measurements. To date only a few of these practices have been installed on private lands and reductions in sediment inputs to Swan Lake appear minimal (USFWS Two Rivers NWR, unpublished annual narratives). Landowner acceptance of the soil conservation practices has been low because financial incentives were not adequate to offset lost revenue from agricultural production; benefits of agricultural retirement were not demonstrated, and some practices desired by landowners; such as cost-sharing of farm ponds, were not offered.

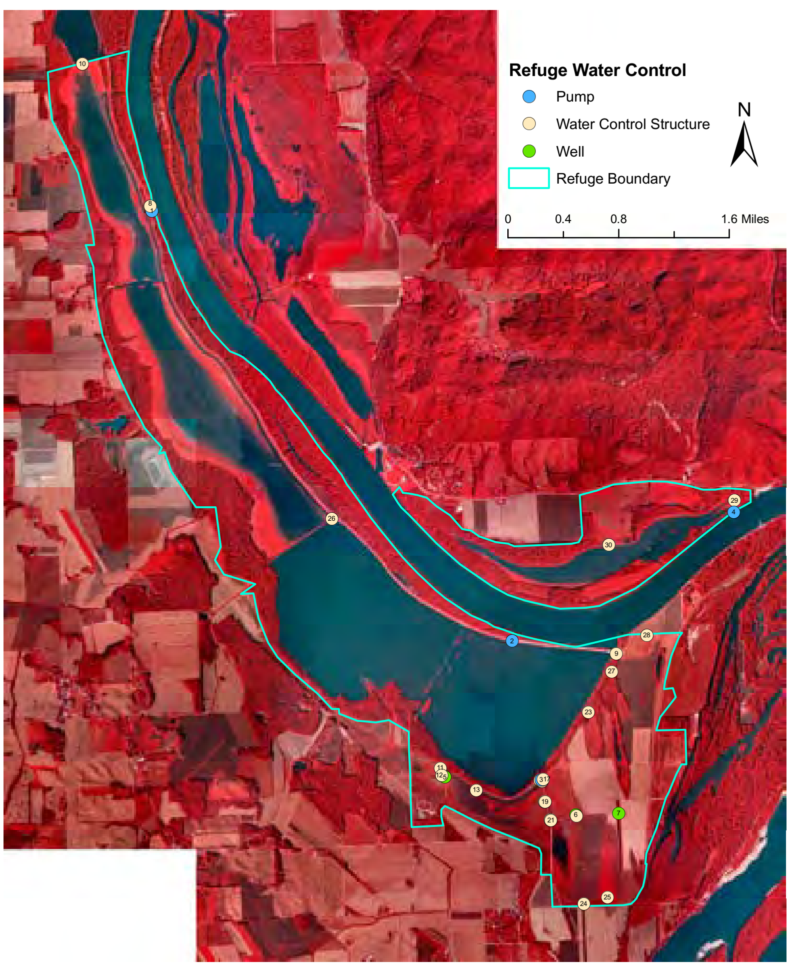

Figure 26. Location of water-control structures and pumps on Calhoun and Gilbert Lake Divisions, Two Rivers National Wildlife Refuge.

Management of moist-soil impoundments on the Calhoun DV has varied among units and years depending on infrastructure capability and management objectives (Table 7). Flooding of moist-soil units formerly occurred by pumping water from Swan Lake through a pump site on the south side of the lake. Generally, rotational drainage schedules have been employed to alternate timing and duration of flooding among units and to control undesirable woody and perennial herbaceous vegetation. In 2005, three groundwater wells were installed, and water delivery ditches and routes were constructed to allow more independence in water management of most units (Fig. 26). These wells have essentially eliminated the need to rely on pumping from Swan Lake and the existing pump site on the lake has been abandoned. The Yorkinut, Little Swan, Schoolhouse, and Duck Pond units (Fig. 25) are all historic "swales" in the Calhoun Point- bar Terrace along the southern border of Swan Lake and historically had earlier and deeper flooding than other units. This flooding regime encouraged establishment of woody vegetation along the edges of these swales and management has periodically controlled or removed this woody vegetation to maintain more open herbaceous vegetation at least in the lower elevation centers of these swales.

Bottomland forest on Calhoun DV declined markedly following closure of Lock and Dam 26 and by 1944 only about 300 acres of live forest remained in the Swan Lake area (Green 1944). Gradually, the only bottomland forest that survived was on the natural levee that separated Swan Lake and the Illinois River and at higher elevations (> 419 feet) along the southern and western borders of the lake. This forest extended upland to agricultural fields on the Calhoun Point-Bar Terrace south of Swan Lake and to uplands on the west side of the lake. Much of the bottomland forest < 420 feet died during the prolonged flooding of 1993 except for the more water tolerant willow, cottonwood, buttonbush, and locust. Scattered patches of pecan and pin oak survived along the south and northwest part of the lake. After the 1993 flood, a few small agricultural fields were reforested between 1994 and 1997.

Development and Management of Gilbert Lake Division. – The original Gilbert Lake lands acquired by the USACE contained 528 acres including the ca. 250 acre Gilbert Lake. Later acquisitions enlarged this area to about 736 acres. This property was designated as "red" lands and Gilbert Lake was closed to public waterfowl hunting in 1942. Farm fields adjoined the north side of Gilbert Lake and other areas included a narrow strip of bottomland forest on the old natural levee between the Illinois River and the south side of Gilbert Lake and scattered idle lands. Early descriptions of Gilbert Lake indicate considerable siltation in the lake in the early 1940s (Adams 1946, Green 1949) and dense stands of moist-soil herbaceous vegetation in summer when lake levels were low. Some aquatic plants were present when lake levels were high throughout summer.

Little active management of Gilbert Lake DV lands occurred until the early 1960s (Table 8). Up until 1964, water levels in Gilbert Lake fluctuated with Illinois River levels and no levees or water control structures were present. The bottom elevation of Gilbert Lake in the early 1940s was about 417 feet and water entered and drained from the lake through a slough cut in the natural levee on the southeast side of the lake. Because Gilbert Lake was about 5 feet higher elevation than Swan Lake, it became at least partly dry in most summers and was almost completely dry in about 3 of every 5 years (Fig. 10, Table 4). In 1964, 2.5 miles of low levee were constructed between Gilbert Lake and the Illinois River and a two-way pump station of 8,000 gpm capacity was completed. A 24-foot wide ditch was dug 2,350 feet from the pump station into the Gilbert Lake with a bottom elevation of 417 feet. This ditch was constructed because siltation had gradually filled much of the Gilbert Lake bottom and reduced the potential to drain low elevation interior areas of the lake (Hall 1966). In 1965 this ditch was extended 900 feet farther into the lake to allow drawdowns at a 417 level for most of the lake bottom. Since 1965, at least partial drawdowns in Gilbert Lake have been attempted in most years when the Illinois River had low levels in summer; nearly complete drawdowns were achieved in 1971, 1977, 1983, 1989, 2000, 2003, and 2005. These drawdowns have attempted to emulate natural patterns of summer drawdown in Gilbert Lake and to encourage moist-soil plant germination and foods for migrant waterfowl and other water- and shorebirds.

Many changes have occurred in the Gilbert Lake water management infrastructure since the first developments in the mid 1960s (Table 8). At various times spillways, levees, and water-control structures and pumps were built or replaced. In 1971, a silt basin was constructed on the north side of the lake to reduce sediment inputs from adjacent agricultural fields. Later, a second silt basin was constructed and in 2003 both silt traps were rehabilitated by reshaping and dredging the areas to provide emergency spillways and to create about 10 acres of shallow wetland. Increased silt and regular drawdowns caused willow and other woody vegetation to encroach into the historic lake bottom and at various times attempts were made to control or remove woody vegetation using mechanical treatment and water management that held water high during summer.

In 1993, the entire Gilbert Lake DV was covered with flood water throughout summer and many levees and water-control structures were damaged. Starting in 1994, large spillways were built into the south-side levee and the pump station was relocated. Also flood debris, silt, and woody vegetation were

Table 8. Summary of management activities on Gilbert Lake Division, Two Rivers National Wildlife Refuge 1940s-2005 (from unpublished U.S. Fish and Wildlife Two Rivers National Wildlife Refuge annual narratives).

1940's-'60s
Cleared brush and trees, enlarging fields.

1960
The 1.5 mile road leading through the woods to the lake was improved with a dozer.

1963
250 pin oak seedlings set out in the higher part of the timbered area. Survival believed to be about 50% due to drought.

1964
Construction completed on 2.5 miles of road and embankment between lake and river. Two-way 8000 gpm pump station completed. Excavated 2350 feet of ditch from the river to the lake for water flow.

1965
Ditch extended 925 feet further into the lake bed to permit rapid and controlled draw down.

Lake drawn down to 416.77 msl in August, the lowest level yet achieved. Surface water reduced to less than 60 acres.

1966
Three riprapped spillways constructed in the service road.

Ditch bulldozed through treeline bordering the lake at the borrow pit at the east end of field AU-26-18 to permit flooding of the borrow pit and the buckwheat grown there.

1970
A 50-inch pipe with stoplog structure installed in the dike.

1971
De-silting basins constructed in AU-26-16 and 19 with about 1 mile of dike. Drainage controlled through pipes set at various levels in the embankments.

Gilbert Lake was drawn down to less than 15 acres.

1972
Excavated ditches in PM-1 and PM-3 to tie de-silting basins into their watersheds. Old ditches were closed and incorporated into the fields.

1976
The most steeply sloping areas of PM-1 were planted to brome, orchard grass, timothy, alfalfa, and oats for erosion control.

About 15 acres of former farm units AU-26-16 and PM-3 were converted to cover crop units.

1977
Gilbert Lake dried out to the point where a tractor/mower could cut willow/cottonwood on the lake border.

1978
Drawdown could not be completed due to siltation of the ditch.

1981
Two attempts to drain Gilbert Lake to clean out the ditch failed due to flooding.

Sowed a permanent pasture crop on the archeological site to stop erosion.

1982
The Duncan Farm Site was listed in the National Register of Historic Places.

Gilbert Lake was flooded during 7 months of the year.

(Table 8, cont'd.)

1983
Explosives expert opened up 1000' of ditch leading from lake to water control structure. Another 3000' were dug out with dragline. Several acres of brush in the lake were cleared.

1984
The Illinois River kept most of this division under water from March until August. No water management was possible. Silt was scraped off and rock was tailgate spread on the 3 miles of road between the lake and the river.

1985
When river levels reach about 418 feet or higher, the lake becomes almost entirely inundated with water. Persistent flooding, pump failure, and beaver activity prevented the early draining of Gilbert Lake as planned.

1986
Gilbert Lake was flooded most of the year.

1987
Water was held on Gilbert Lake with no pumping in or out during 1987.

1988
An attempt to hold water on Gilbert Lake during 1988 was made, but a leaking water control structure and no floods, left only the deepest portions of the lake with water.

1989
Low river levels permitted Gilbert Lake to slowly withdraw over the spring and summer leaving several acres of mudflats exposed. The water control structure on the lower end of the lake is non-functional.

Surveys "rediscovered" *Boltonia decurrens* on Gilbert Lake DV.

1990
Native grasses planted atop a Native American burial mound to discourage illegal artifact hunting.

1992
An additional 22 acres of the Duncan Farm archeological site were retired from farming and seeded to native grasses and forbs.

1993
The Great Flood of 1993 kept most of the refuge underwater for eight months.

1994
The 3-mile service road was reconstructed to original 1963 specifications, with changes including two large spillways, and relocation of the pump structure to a site right next to the river to reduce sediment problems.

1995
Contract began for 1-mile of dredging in Gilbert Lake. The mudcat equipped with cutter head knives was not sufficient and only a quarter of the job was completed.

1997
Planted 17 acres on PM-3 and AU-26-18 to prairie grasses.

2001
Construction completed on new 14,000 gpm pump for water input into Gilbert Lake.
Also installed new 48" culvert with 6' stop-log structure at lower end of lake. Dilapidated 2-way pump station removed.

2003
Rehabilitated the sediment trap dikes. East dike -- removed old water control structures, built new overflow spillway. West dike – removed overflow tubes, constructed new spillway, installed culvert with screw gate.

(Table 8, cont'd.)

2004
Converted 28 acres of cropland to forest habitat by planting native hardwood saplings (RPM) in crop field between Gilbert Lake and IL. River.

2005
Converted 17 ac. crop field on west end of Gilbert Lake to cool season grasses to be managed through annual haying.

removed from ditches. In 1995, an attempt was made to dredge silt from about one-mile of the middle of Gilbert Lake, but only about 1000 feet of dredging was achieved. In 2002, a 14,000 gpm pump was installed to reflood the lake while gravity flow and a new 60 foot stoplog structure allowed dewatering of the lake. Currently, the stoplog structure is opened usually in early summer when Illinois River levels stabilize to minimum summer levels (about 419 feet) and the lake begins a gradual drawdown. By mid-October the stoplog structure is closed and water is pumped back into the lake at a rate of about 0.2 feet/week during fall and winter.

Farm fields on the north side of Gilbert Lake DV historically have been managed to provide green browse, cover crops, and agricultural grains for upland wildlife and wintering Canada geese. Certain of these fields have been retired from cropping, especially fields close to the Duncan Farm archeological site that includes native American burial mounds. This area has been revegetated with native grasses. Also, the northeast part of Gilbert Lake DV contains a small remnant population of decurrent false aster (*Boltonia decurrens*). *Boltonia* was found and mapped on several parts of Gilbert Lake DV in 1943 (Green 1949) but subsequently declined until 1989 when it was "rediscovered" in the current location. Since that time, regular disturbance of the site with mowing and burning has occurred to encourage its expansion (USFWS unpublished annual narratives from Two Rivers NWR, USFWS 1990, Schwegman 1995).

In the early 1940s, most BLH on Gilbert Lake had been cleared or died from higher water levels following closure of Lock and Dam 26 (Fig. 19b). Remnant patches of forest remained on the higher elevation natural levee between Gilbert Lake and the Illinois River and in scattered patches along higher grounds adjacent to the north and west parts of the lake. These remnant forest patches have expanded over time and some abandoned farm fields have become partly reforested. Active reforestation of higher elevations on Gilbert Lake DV began as early as 1963 when pin oak seedlings were planted in a few areas. Summer drought and later floods killed most of these trees. The flood of 1993 killed most pin oak, pecan, hackberry and elm in lower elevations, but some pecan and pin oak survived in higher elevations. In 2004, an abandoned farm field on the south side of Gilbert Lake was reforested by planting container-grown pin oak, swamp white oak, and pecan trees on small berms interspersed with a redtop grass cover crop to reduce competition from weeds and other shrubs and trees. Current forest areas are not managed for cutting or species selection.

RESTORATION AND MANAGEMENT OPTIONS

The area near the confluence of the Illinois and Mississippi rivers, including the current Calhoun and Gilbert Lake DV, historically contained a diverse and productive floodplain ecosystem with high ecological functions and values. This confluence area was created by dynamic fluvial processes that shaped landscapes and floodplains through sequential scouring and deposition actions. These processes created heterogeneous landforms, soils, and hydrology that supported a mosaic of vegetation communities and seasonal resources that were used by many fish and wildlife species. Many changes have occurred in this remarkable ecosystem, most notably the seasonal and long-term flooding dynamics of the two rivers have been highly altered by diversions of water into the Illinois River, construction of locks and dams, and changes in regional land use and corresponding sediment and water runoffs. The Illinois-Mississippi River confluence area is in a strategic ecological location that "funnels" nutrients, energy flow, and animal populations along these river corridors. It also is in close proximity to large and increasing human populations. Because of its unique geographical position and ecological importance, it is important to restore and manage this area to sustain and provide critical natural resources and ecological functions including floodwater storage, nutrient cycling and filtration, carbon sequestration, fish and wildlife habitat, education, and recreational opportunities (e.g., Sparks 1995b, USACE 2000, USFWS 2004).

This study is an attempt to evaluate restoration and management options to improve natural ecosystem processes, functions, and values rather than to manage for specific plant/animal guilds or species. Based on information gathered in this study, future management of the Calhoun and Gilbert Lake DV should seek to: 1) restore more natural seasonal and annual hydrological regimes in Swan and Gilbert lakes, 2) maintain floodplain community structure and health in relationship to topographic and geomorphic landscape position, 3) restore floodplain habitats that have been highly destroyed or degraded, and 4) serve as a "core" of critical floodplain resources that can complement and encourage ecosystem restoration and management on adjacent and regional floodplain lands.

Key summary data and observations obtained in this study indicate:

1. The current locations of the Mississippi and Illinois rivers and their floodplains reflect channel and flow changes associated with Quaternary glacial events. Most notably, the retreat of the Wisconsin glacier and its major glacial outwash moved the Mississippi River west to its present channel from its previous path down the current Illinois River floodplain and caused extensive deposition in the confluence area, backed water up the Illinois Valley, and created wide floodplain valleys partly filled with sands, gravels, and silts.

2. The current Illinois River occupies a much wider former channel of the ancient Mississippi River and its discharge and river slope are low. These hydrological attributes formed a braided channel geomorphology and a labyrinth pattern of channels, natural levees, point bar ridges and swales, and bottomland lakes including the complex of Swan, Stump, and Gilbert lakes in the confluence area.

3. Soils formed in the confluence region include fine sandy loams on point bar and beach ridge surfaces, silt loams on terraces and alluvial fans, and silty clays in floodplains and point-bar swales.

4. The location of the Illinois River has remained relatively stable in the last 2,500 years. Floodplain surfaces include Type B natural levee deposits deposited in the last 3,000 years and Type C alluvial deposits formed 3,000 to 9,700 years BP that are overlain by up to 40 feet of silt and silty clay loam veneer.

5. Elevations in Calhoun and Gilbert Lake DV in the late 1800s ranged from 410- 412 feet in the bottom of Swan Lake to over 430 feet on the Deer Plain Terrace.

6. The climate of the confluence region is characterized by cold winters and hot humid summers. Growing seasons average about 200 days annually. Total precipitation is slightly over 35 inches and nearly 2/3 occurs from April through September.

7. The hydrology of the Illinois River and its floodplains in the confluence region are influenced primarily by seasonal discharge of the Illinois and Mississippi rivers that follows seasonal changes in regional precipitation and snow melt runoff in the upper part of the Mississippi River watershed. High discharge down the Mississippi River in spring and early summer act as a hydraulic dam that slows drainage from the Illinois River and backs water into confluence floodplains.

8. Using long term data from the Grafton gauge, the historic, relatively unaltered, hydrograph of the Illinois River indicated a strong seasonal pattern of increasing flow and water levels from January through April followed by gradually declining levels until late September or early October when fall and winter rains began to raise water levels again.

9. Long-term precipitation and river level data indicate relatively regular alternating wet and dry periods on about a 20-year periodicity.

10. The low natural levee points where Illinois River water historically flowed into and out of Swan and Gilbert lakes was about 412 and 417 feet, respectively. In the late 1800s, prior to major changes in flows in the Illinois River, extended drying (> 3 months) of Swan Lake < 412 feet occurred in about 7 of every 10 years in dry periods and during wetter periods it dried at this level in slightly less than 5 of every 10 years. During dry periods Gilbert Lake was nearly completely dried for > 3 months every year and even in wet periods it dried during summer nearly 80% of these years.

11. The Lower Illinois River Valley historically contained 9 major habitat types distributed across elevational and hydrological gradients. They included: 1) the main Illinois River channel and islands, 2) backwater sloughs and chutes, 3) natural levee "riverfront" forests, 4) floodplain lakes, 5) S/S, 6) floodplain bottomland forest, 7) bottomland "wet" prairie, 8) mesic prairie, and 9) upland forest.

12. Many diverse resources were provided in these habitats and they were used seasonally by a wide diversity of animals. For example, the annual flooding and drying regimes in most floodplain habitats provided winter and spring water connectivity and access for spawning and overwintering fish; concentrated prey during summer drawdowns for breeding wading birds, turtles, migrant shorebirds, and mammals; and germination of moist-soil herbaceous plants during dry periods of summer that became shallowly reflooded in fall and provided seeds and invertebrates for fall migrant waterfowl.

13. Several sources of historical information, especially GLO maps and notes, indicate that presettlement vegetation distribution followed elevation contours that reflect timing, depth, and duration of flooding and geomorphic surface. Open water in Swan Lake was present < 412 feet elevation. The edges of Swan Lake had seasonal herbaceous vegetation 412-414 feet as did drained mudflat areas of Gilbert Lake. A narrow band of S/S occurred around the upper edges of bottomland lakes and BLH was present on natural levees and floodplain areas 414-419 feet in the Swan Lake area and up to 420 feet at Gilbert Lake. A transition zone of savanna developed at the upper edges of bottomland forest and graded into bottomland prairie in the 417-422 foot elevation band. This bottomland prairie apparently transitioned into mesic prairie at about 422 feet. Talus upland forest was present on higher elevations of terraces, loess upland hills, and bluffs.

14. The floodplain in the confluence region and along the Mississippi River in the current Pool 25 and 26 area contained about 56% bottomland forest and 41% prairie in the late 1800s.

15. Native people occupied the confluence region as early as 10,000 BP, but evidence suggests they primarily migrated into and out of the Calhoun/ Gilbert Lake area for hunting and gathering of food and did not alter native vegetation much except for small areas immediately around camp sites.

16. Early European settlers in the region were restricted to higher uplands and bluffs that did not flood and occupation and changes to regional landscapes was minimal until the mid 1800s.

17. Initial harvest of most bottomland forests in the region occurred in the late 1800s through about 1910, although some more extensive cutting occurred on natural levees along the Illinois River in the mid 1800s for cordwood to fuel steamboats.

18. Early records indicate bottomland forest contained a diverse mix of species including pin oak, pecan, hackberry, elm, and silver maple; forest area was reduced by over 80% by the mid 1970s.

19. Water levels and flow in the Illinois River began to be altered from historical condition as early as the late 1800s when large volumes of water were diverted into the Illinois River from the Chicago River and Lake Michigan through the Chicago Sanitary and Ship Canal. These diversions increased the rate of spring flood rise in the Illinois River by 22%. Since 1939 diversions have been limited to 3,200 cfs.

20. By 1920, over 35 drainage and levee districts were formed in the Illinois River Valley and covered over 200,000 acres of floodplains; none were in the Calhoun/Gilbert Lake area, however, upstream developments increased flood stages and prolonged flooding in the area at that time.

21. Lock and Dam 26 was completed near Alton in 1938 and waters in the lower Illinois River near Calhoun/Gilbert Lake rose immediately and permanently inundated low elevations and caused extensive mortality of bottomland forests. Water management of Pool 26 (including the lower Illinois River Valley) currently attempts to maintain a 419.5 minimum summer pool level, which is 8-9 feet higher than historic summer levels.

22. Surface water area of the combined Swan/Fuller Lake area increased from 462 acres in 1903 to 2,873 acres in 1969 and Gilbert Lake increased from 96 to 232 acres over the same time period.

23. Because the historic bottomland forest occupied 414-421 levels near Swan Lake and Gilbert Lake, the new minimum summer water levels in the Alton Pool reduced forest cover from about 60% of the region pre-dam to < 35% by 1975. Remnant bottomland prairie also was greatly reduced during this time from rising water and clearing for agriculture. Tree species that survived were mainly at higher elevations and species composition has shifted to more water tolerant species such as cottonwood, willow, river birch, and silver maple.

24. The large flood in 1993 inundated the confluence region from April through September and caused mortality of most bottomland forest < 420 feet. Remnant trees today are mostly on higher natural levees and terraces and are dominated by cottonwood, silver maple, and ash.

25. Sediment levels and sedimentation rates increased in the Illinois River and its floodplains following clearing of surrounding uplands in the watershed for agriculture, construction of levee and drainage districts, increased diversion of water into the river, and slower impounded flows after locks and dams were built.

26. Historically, the source of sediments in the Illinois River and its floodplain were estimated to have been derived at about 62% from valley slopes and tributary rivers and 38% from local upland erosion, mostly from agricultural fields. Following construction of the Swan Lake HREP levees and water-control structures along the Illinois River, the relative importance of sediment inputs was estimated to shift to 50% river and 50% hillside contributions.

27. From 1903 to 1978, sedimentation rates in Swan Lake averaged about 0.33 inches/year and reduced water storage capacity by about 42% over this time. Further, natural topographic contours in Swan and Gilbert lakes have been moderated or eliminated as low depressions filled with sediments and flattened the bottom contour.

28. Oxygen levels in floodplain lakes and the Illinois River are low at times as sediments become unconsolidated and suspended and sediments also contain many inorganic elements at relatively high levels.

30. Changes in hydrology, water clarity and quality, vegetation communities, and seasonal dynamics and availability of resources has caused many changes to biota of the Illinois River and habitats in the Calhoun/Gilbert Lake region.

31. Benthic invertebrates of bottomland lakes now are dominated by Tubificide worms. Fingernail clams mostly are eliminated from bottomland lakes as are certain snails, midge larvae, and burrowing mayfly nymphs.

32. Native fish populations in the Illinois River and its backwaters including Swan and Gilbert lakes have declined markedly and current fish populations are dominated by Asian carp and longnose gar.

33. Waterfowl populations, especially diving ducks such as lesser scaup, have declined in the confluence region as aquatic vegetation, benthic invertebrates such as fingernail clams, and other foods have been reduced.

34. Calhoun and Gilbert Lake DV are administered and managed under a revised agreement between the USFWS and USACE that supports opportunities for restoration and ecosystem management.

35. Wetland management on Calhoun DV was mostly restricted to development and annual manipulation of 8 moist-soil impoundments until the 1990s when the Swan Lake HREP project built levees and water-control structures/pumps to separate Swan Lake into two lower compartments and close the inlet/outlet area between Swan Lake and the Illinois River in the southeast corner.

36. Since the HREP project was completed, Middle Swan Lake was nearly completely drawn down in 2001, 2002, and 2005 and partly drawn down in 2000, 2003, and 2004. In 2002 Lower Swan Lake was drawn down with about 90% drainage. A second drawdown of Lower Swan was attempted in 2006 but only ca. 50% drainage occurred because of pump problems.

37. Gilbert Lake is at a higher elevation than Swan Lake and water levels naturally declined during summer. In the early 1960s a low levee was constructed between Gilbert Lake and the Illinois River and a pump station was installed to reflood the lake following drawdowns. Since 1965, nearly complete drainage of Gilbert Lake during summer occurred in 1971, 1977, 1983, 1989, 2000, 2003, and 2005.

GENERAL RECOMMENDATIONS FOR MANAGEMENT AND RESTORATION OBJECTIVES

Given the above observations and data, the following general management and restoration objectives are recommended for Calhoun and Gilbert Lake DV:

1. *Emulate a more "natural" seasonally- and annually-dynamic water regime in bottomland lake and floodplain areas.*

The floodplain ecosystem of the Lower Illinois River Valley developed under, and is adapted to, a strongly seasonal flooding regime (e.g., Sparks 1995a). In general, the system is dominated by late winter and spring flooding and summer drying. Superimposed on this strongly seasonal pattern are long-term dynamics in winter and spring precipitation that cause a 8-10 year pattern of regular peaks and lows in extent and duration of flooding during a year. Annual variation in precipitation and regional runoff in the Illinois River Valley, the Mississippi River watershed, and locally in the confluence area created this dynamic pattern.

Most bottomland lakes in the Illinois River Valley became connected to the Illinois River during spring in most years depending on their age and geomorphic formation, elevation of natural levees and connecting sloughs, and siltation and filling of their bottoms. The "pulse" of this flooding, however, was seasonal and bottomland lakes rarely were flooded an entire year. During wetter periods in the long-term precipitation cycle these lakes were flooded and connected to the Illinois River for most of the summer with a short drying period in late summer, but in dry periods these lakes completely dried for 2-4 months in summer. Following construction of Lock and Dam 26, these natural flooding and drying patterns were eliminated for Swan and Gilbert lakes, large floodplain areas became permanently inundated, bottomland forests were killed, aquatic vegetation declined, and nutrients became bound in bottom sediments.

Future management of Swan and Gilbert lakes and other associated lower elevation floodplain habitats must seek to restore at least some more regular pulses of drainage of these sites during summer and early fall (see rationale in Junk et al. 1989, Bayley 1991, Poff et al. 1997, Sparks et al. 1998, Galat et al. 1998). Restoration of natural pulsed hydrology will help restore the primary ecological process that sustained this diverse ecosystem and will help restore natural vegetation communities and seasonal resources that supported diverse animal populations. Historic river gauge data from the Illinois River in the late 1800s, prior to significant diversion of water from the Chicago Sanitary and Ship Canal and then later inundation from the locks and dams, suggests that at least partial drawdowns occurred in most years, and complete drainage occurred in about half of the years during dry periods and that at least partial drawdowns occurred in more than half of the years even in wet periods.

2. *Control and reduce sedimentation rates into bottomland lakes and restore at least some natural topography in floodplains that have become highly silted in.*

Sedimentation has been a major factor reducing the ecological integrity and annual productivity of bottomland lakes in the Illinois River Valley (Bellrose et al. 1983, Demissie et al. 1992). Many factors have increased sediment loads in the Illinois River and deposition in backwater lakes and floodplains. Most sediments originate from bank erosion of the river, erosion of bluffs along the floodplain, and sheet and rill erosion from agricultural lands in and adjacent to floodplains. Historically, some erosion and sedimentation naturally occurred in the Illinois River Valley during large precipitation and flood events, but flood waters spread over wide floodplains and interconnected sloughs, chutes, and bottomland lakes. Consequently, sedimentation rates were relatively low and in fact helped import nutrients and sustained productivity of these systems. As drainage and levee districts reduced floodplain area and channeled waters into narrow corridors, sediments became more concentrated and when waters slowed in unleveed bottomland lakes and extensive sedimentation occurred. Further, as locks and dams were constructed, waters slowed near the dams and sediments were deposited at greater rates.

Because sedimentation fills deeper waters at a faster rate than in shallow water, bottomland lakes essentially became "silt" basins. The formation of bottomland lakes in the Illinois River Valley reflects their history of being relict channels of the Mississippi and Illinois rivers and associated deposition and scouring actions. Consequently, the bottom topography of bottomland lakes was heterogeneous with a diversity of elevations present from deeper relict scour channels to higher remnant point bars. This diversity of elevations provided dynamic hydrology and soil texture surfaces and supported a diversity of vegetation communities. As sediments gradually filled these lakes, they have become: 1) uniform, platter-shaped, basins that have a low volume-to-surface area ratio; 2) smaller as sediment fans and "deltas" have encroached shorelines and entry points of upland tributaries; and 3) more open water habitats with reduced aquatic macrophytes in lower elevations and increased encroachment of pioneer woody species such as willow along sediment edges. Extended inundation of these lakes because of higher water levels above Lock and Dam 26 has increased turbidity of waters in these lakes as bottoms are stirred by wind and wave action without protection from aquatic and emergent vegetation and because of actions of carp and other bottom-dwelling fishes. Increased turbidity and reduced vegetation also reduces detrital biomass and thus benthic invertebrates.

Sediment deposition in Swan and Gilbert lakes must be controlled and reduced to sustain their productivity and lifespan (e.g., Korschgen 1990, USACE 1993). Further, restoration of at least some topographic diversity in these lake bottoms is desirable to help restore elevation gradients, diversity of plant communities, and deeper water habitats for fish and other aquatic animal species. Controlling sediments is needed in both the Illinois River and in local tributaries and drainages into Swan and Gilbert lakes. Control of sediments is most effective when it addresses the source of sediments in higher elevations of the watershed, both local and basin-wide. Generally, this means that actions must be taken to reduce erosion from upland agricultural fields and their drainages (NRCS 1998). In the absence of control of upland sources of sediments, management must seek further downstream control measures including silt basins or drainage deflections such as levees, berms, or alternate sediment flow and deposition channels or depressions. Construction of silt basins or deflection levees should be built in upland watersheds and drainages as far away from Swan and Gilbert lakes as possible. Building silt levees or basins within the historic floodplain areas of Swan and Gilbert lakes is not desirable because of the difficulty and expense of construction activities in these areas and because levees/berms potentially could cause undesirable physical and biological attributes to these lakes and compromise restoration efforts identified in this report. These degradations include: 1) further compartmentalizing and reducing bottomland lake and forest habitats, 2) reducing floodplain connectivity and further altering and restricting water and nutrient flows, and 3) long-term maintenance of levees, regular silt dredging or removal.

3. *Restore and maintain the diversity, composition, distribution, and regeneration of floodplain and terrace vegetation communities in relationship to topographic and geomorphic landscape position and current Illinois River water management.*

The distribution of vegetation communities in the lower Illinois River Valley was, and is, determined by geomorphic surface, elevation, hydrological regime, and periodic natural disturbances such as fire, flood, drought, wind storms, etc. Perhaps the most dominant of these factors is the seasonal flooding regime that caused geographic variation in degree and duration of surface inundation and soil saturation. The significant alterations in hydrology of the lower Illinois River because of lock and dam construction have changed locations and elevations in the floodplain where certain vegetation communities can be supported and maintained. Nonetheless, certain structural developments, such as the levee and water-control structures along the Illinois River side of Swan Lake offer the opportunity to restore more natural patterns of flooding and drying in at least some parts of the floodplains. Higher elevation sites retain more natural hydrological regimes and are capable of being restored to historic vegetation communities and some floodplain forest types. Generally, restoring the diversity and more natural distribution patterns of habitats in this region is important for sustaining plant and animal communities and providing other functions and values such as nutrient and energy flow, carbon sequestration, water filtration, sediment reduction, and groundwater recharge.

Restoration on Calhoun and Gilbert Lake DV should attempt to restore at least some functional patches of all 9 habitat types that historically occurred in the confluence region. The size and configuration of habitat patches influence how they can sustain themselves and provide resources (e.g., Noss and Cooperrider 1994, Forman 1995). Some habitat types in the confluence area, such as S/S, seasonal herbaceous wetlands, and open water now occur in larger areas and patch sizes than historically occurred, whereas others, such as bottomland forest and bottomland prairie, now are present only in small fragmented patches. Restoration priority should be given to those habitats that have declined the most. Generally, habitat patches are most functional if they: 1) are in natural distribution patterns, 2) larger, 3) in close proximity to other similar patches, and 4) have larger interior area to exterior edge ratios (i.e., square or round is better than linear) (e.g., Shrader-Frechett and McCoy 1993, Noss and Cooperrider 1994). Further some habitat types, such as grasslands, need to be of some minimum size to support breeding populations of some animal species groups. For example, small isolated prairie patches < 40 acres may not be able to support breeding populations of some grassland birds (Helzer and Jelinski 1999). Also, many breeding forest birds require larger patches of bottomland forest to support viable populations (e.g., Mueller et al. 2000).

Despite some limitations, small patches can provide very important ecological functions and values such as providing critical resources to migrant or seasonally present birds, fish, and herptiles (see discussion in Shafer 1995). Further, most animals using floodplain and bottomland forest ecosystems do not necessarily require large individual forest or prairie patches, but they do depend on extensive areas of these habitats within a region and along river corridors to meet annual cycle needs (Heitmeyer et al. 2005). One of the objectives of NWR's is to provide "core" habitats and resources that can complement existing and restored habitats in such corridors and seems an important goal and contribution of Calhoun and Gilbert Lake DV (USFWS 2004).

Higher elevations > 420 feet on Calhoun and Gilbert Lake DV that have been cleared for agriculture have retained soils, topography, and some natural hydrology (e.g., local precipitation percolation and runoff on terraces and uplands) and offer opportunities for restoring a complex of bottomland forest, savanna, and bottomland prairie habitats. In contrast, elevations below 420 feet vary in their ability to restore floodplain communities of bottomland forest, wet prairie, S/S, seasonal herbaceous wetland, and aquatic plant-dominated bottomland lakes because of higher water levels managed in Mel Price Locks and Dam. If water control capabilities and management strategies outlined in following sections of this report for Swan and Gilbert lakes can be implemented to restore more natural patterns of seasonal and long-term flooding and drying patterns, then restoration of these habitats in some areas seems possible and desirable. For example, regular seasonal drainage of Swan Lake in summer should allow early successional forest and S/S edges to move back into the bottom of the now open water part of Swan Lake. Further, some expansion of bottomland forest to about 419 feet elevation might occur. The sustainability of bottomland forest will depend, however, on regular repeated summer drawdowns and absence of prolonged flooding. Encroachment of early successional forest into the edges of Swan and Gilbert lakes may reduce areas of seasonal herbaceous and open water habitats, however, it will restore a habitat component that has been almost totally eliminated in the area and provides critical resources for many animal species. Also, less water tolerant forest species probably can be restored on some higher elevation terrace sites, that may not have supported much forest historically, but with changed hydrological conditions now are capable of supporting forest species.

4. *Provide natural patterns of resource availability and abundance including nutrient cycling; seasonal energy flow; and key food, cover, reproductive, and refuge resources for endemic animal species.*

Annual primary and secondary productivity and biomass in the lower Illinois River floodplain and associated terraces historically were very high because of the diversity of plant and animal species and seasonal pulses of nutrients and floodwaters. Productivity was dynamic among seasons and years due to dynamics of flooding and other disturbances (drought, fires, wind). High primary productivity was possible because of the inherent, and regularly recharged, fertility of the alluvial-derived floodplain surfaces and soils. High secondary productivity was the by-product of heterogeneous vegetation communities, flow of nutrients and waters across terraces and floodplains, and large annual inputs of detrital matter from woody vegetation. Maintaining more natural patterns of hydrology (#1 above), reducing the overwhelming dampening effect of excessive sedimentation (#2 above), and restoring natural vegetation communities (#3 above) is critical to maintaining rich seasonal pulses of resources in this floodplain system and the many potential foods and niches for fish and wildlife species.

Food webs in floodplain systems are complex and most animals rely on multiple food sources during the year, or they are present only during seasons when specific resources are present (e.g., Sparks et al. 1998, Heitmeyer et al. 2005). Consequently, the most common endemic animal species in the confluence region are omnivorous and mobile. Seasonal connected water flow between the Illinois River and its floodplain, and across the floodplain itself, enables many mobile species such as fish, amphibians, and reptiles to move throughout the system during flood periods and aids disbursement of nutrients in various habitats. Connectivity of habitat patches further aids distribution of nutrients and animals including neotropical and wetland birds, small mammals, amphibians, and reptiles. Consequently, maintaining or restoring seasonal connectivity of water flow and habitats types on Calhoun and Gilbert Lake DV is critical for sustaining traditions of use of seasonal animal visitors; providing resources to meet annual needs of migrants and residents; and reducing disturbance, predation, and other mortality agents. The key to achieving these ecological goals, however, is seasonal, not permanent connectivity. When high water levels connect the Illinois River with its former floodplain permanently, or for many consecutive years, the productivity and ecological integrity of the entire system is compromised, native habitat type and distribution is altered, exotic animal species such as Asian carp replace endemic species, and nutrient cycles and food webs are disrupted.

The historic diversity of vegetation communities in the confluence region assured that many food types were present and abundant in all seasons (Fig. 13). Changes in distribution and relative amounts of some habitats (e.g., marked declines in bottomland prairie and bottomland forest) have altered amount and availability of some foods and other resources (e.g., prairie nesting sites for songbirds and reptiles). Where declines in critical resources are identified, attempts should be made to either restore that component of the system or replace the resource with another similar type. For example, where hard mast from pin oaks and pecans now is reduced, this high energy food used by many animals in fall and winter can partly be replaced by production of moist-soil vegetation in wetland impoundments or in edges of bottomland lakes and certain agricultural crops with high energy composition.

SPECIFIC RECOMMENDATIONS FOR MANAGEMENT AND RESTORATION OF CALHOUN AND GILBERT LAKE DIVISIONS

Swan Lake. – Prior to significant alteration of the hydrology of the Illinois River, the Swan Lake area contained mostly bottomland hardwood forest that surrounded the relatively small remnant Swan and Flat bottomland lakes. The lakes represented deeper depressions in a relict channel of the Illinois River and were connected by a narrow chute when waters were > 412- 414 feet. Edges of these lakes contained S/S and when drawn down these lakes supported dense stands of emergent herbaceous vegetation. Long-term precipitation and river gauge data indicate the Swan Lake area historically was partly flooded each year from rises in the Illinois River in late winter and spring, and also was at least partly drained in late summer and fall. During dry periods of long-term precipitation cycles the bottom of Swan Lake was nearly completely drained for about 60 days in most years. Extended drainage for over 3 months occurred in 6 of 10 years during dry periods, but never for more than 2-3 years consecutively. Even in wet periods, water in Swan Lake dropped below 412 feet for over two months in about ½ of the years. Collectively, the hydrograph of this region included annual drawdowns with alternating periods of more extended (> 84 days) vs. shorter duration (< 60 days) drainage in summer.

More complete mimicry of late 1880s condition would require a dramatic change in management of water levels in Swan Lake along with extensive dredging to restore natural topographic variation. The presence of Mel Price Locks and Dam and the 6-8 feet of silt deposition in the deepest depressions of Swan Lake does not make this possible. However, the levee and water-control structure on the Illinois River side of Swan Lake does offer potential to emulate at least some natural patterns of seasonal and annual drying in summer. This large levee is artificial, however, in an unusual way it replicates creation of a natural levee through sediment deposition. The water-control structures in the levee also replicate low points on the downstream ends of natural levees where rising river water "backed" into bottomland lakes and then drained out when river levels fell. The effectiveness of managing water regimes in Swan Lake to emulate natural hydrological patterns and restore at least some diversity and distribution of natural vegetation communities will depend on the capability that managers have to drain the area during summer. The cross-levees in Swan Lake have subdivided it into 3 compartments (Fuller Lake, Middle Swan, Lower Swan) and while this compartmentalization inhibits water flow among areas, it also provides some opportunity to vary annual water management to accommodate multiple species needs. We recommend:

1. Maintain existing levees and water-control structures on the Illinois River side of Swan Lake and upgrade pumping facilities to efficiently drain the area to at least 10-20% water coverage in summer when draw downs are scheduled.

2. Attempt to at least partly drain edges of Swan Lake during late summer and early fall in all dry years and in over half of wet years. Because it will be difficult to predict weather patterns and wet or dry periods, we suggest closing the water-control structures in Middle and Lower Swan in most years (at least 8 of 10 summers) to allow at least some natural drying of lake margins. In alternating 2-3 year patterns, attempt to more completely drain Middle and Lower Swan compartments for > 60 days during summer and early fall (Fig. 27). For example, in Year 1 attempt to completely drain Middle Swan and close structures to allow summer drying of edges of Lower Swan. In Year 2, attempt to completely drain both Middle and Lower Swan during summer for > 60 days. In Year 3, attempt to completely drain Lower

Swan for a second consecutive year and close the structure on Middle Swan to allow natural drying of lake margins in summer. In Year 4 allow water to flow into Lower Swan except for a short one month closure during late summer while completely draining Middle Swan. The pattern of alternating more extended flooding or drying of these two compartments does not need to be exactly replicated as stated in the above example so long as some more regular pattern of drying occurs. Further, managers should have the flexibility to change water management if extended summer drying, or conversely flooding, occurs.

3. If a complete drawdown can be achieved for Lower Swan in summer in the near future, it may be desirable to keep the water-control structure between Lower Swan and the Illinois River closed that winter and hold water levels low with intent of attempting a second relatively complete drawdown the subsequent summer. This extended draw down over two years might "kick-start" a more rapid consolidation of bottom sediments and subsequent revegetation of the lake.

4. Because draining Swan Lake currently requires closing the water-control structures into the Illinois River and pumping remaining water in Swan Lake into the Illinois River during late summer, fish remaining in the lake at the time of drawdown will be trapped and can only exit the lake through pumps. While some periodic mortality of "drainage-year" fish trapped in the drawn down lake will occur, the long-term benefits of improved vegetation, invertebrate, and substrate conditions in Swan Lake ultimately will positively affect fish populations that use the lake because greater foraging and cover resources will improve fish survival and recruitment in subsequent years. In non-drawdown years and seasons when drainage is not occurring, water-control structures in Lower and Middle Swan should be open to provide fish passage. Ideally, some lowering of the Illinois River < 419.5 feet in late summer, when water-control structures could remain open, would help drain Swan Lake through gravity flow and allow fish to exit the lake as it dried. Discussions should continue about a way to accommodate at least short reductions in Illinois River levels in late summer through management of Mel Price Locks and Dam water levels to help restore and manage the Swan and Gilbert Lake ecosystems.

5. Continue summer drainage of Upper Swan on Fuller Lake WMA whenever possible. Fuller Lake WMA is at the higher upstream elevation of the historic Swan Lake channel and it naturally dried more often and for longer periods. This area most likely was dry in most summers except during extended flood events, and management should attempt to emulate this pattern.

6. As more regular drying of Swan Lake occurs during summer, the bottom sediments of the lake should become more consolidated and support larger areas of emergent herbaceous vegetation on lake margins, aquatic vegetation in deeper depressions, and encroachment of early successional tree and shrub species on edges. Some encroachment of woody vegetation is desirable to provide a wider vegetation buffer on the lake edges to trap sediments and provide forest resources to many animal species. While some encroachment of woody vegetation is beneficial, control of this encroachment will be needed if woody species become wide-spread in the lake bottom. The degree of control will depend on several, perhaps competing, objectives to provide larger areas of herbaceous moist-soil vegetation, some open water and aquatic vegetation, and public access. Acceptance of woody encroachment may vary among user groups, however, from a restoration objective, reforestation of edges of Swan Lake is important, especially if some hard mast oak and pecan ultimately can be reestablished on higher elevations.

7. If lake sediments consolidate and aquatic/herbaceous vegetation is reestablished, it may be possible to restore and maintain some natural topographic features within the silted-in lake bottom (e.g., Stratman and Barickman 2000). A combination of dredging meander scrolls, slough channels, and small depressions would help create more deep water habitats. Material dredged from excavations could be deposited in natural patterns along concave back slopes of dredge cuts, on higher natural ridges in

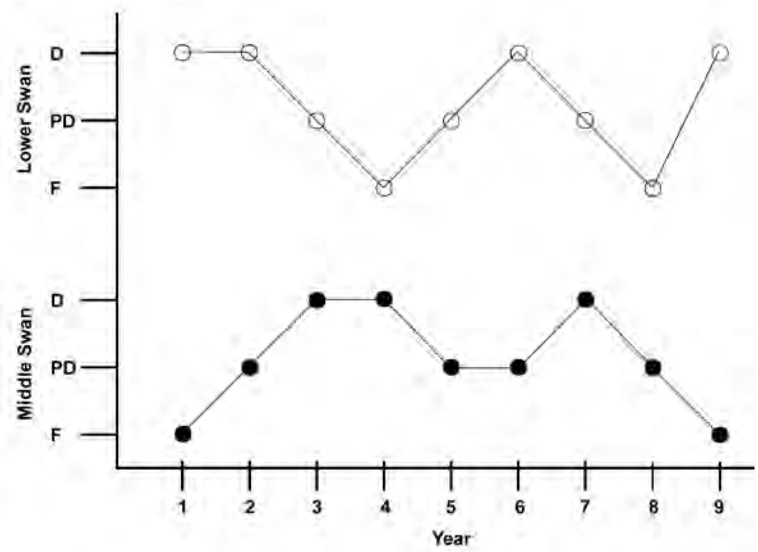

Figure 27. An example of a long-term water management schedule for Middle and Lower Swan Lake compartments on Two Rivers National Wildlife Refuge. F = Maintain the compartment near full pool throughout the year by at least partly opening the water-control structure (WCS) between the compartment and the Illinois River. Keeping the WCS open will allow water levels in the compartment to fluctuate seasonally with levels in the Illinois River. PD = Attempt to partly drain edges of the compartment during summer and early fall by closing the WSC and using natural evapotranspiration (ET) or supplemental pumping to create mudflat conditions on the edges of the compartment. Ideally, a partial drawdown would dry 25-50% of the compartment. D = Attempt to drain the compartment to < 20% surface water during summer and early fall. Drainage would be achieved by closing the WSC in early summer and with a combination of ET and pumping, water would be removed from the compartment. At least once in a 10-year period, the compartment would be drained (D) for two consecutive years to accelerate consolidation of bottom sediments and stimulate growth of herbaceous and aquatic vegetation. In these years, the WCS would remain closed from the first summer, through winter, and until the second fall when it would be reopened.

the lake bottom where BLH was present (as evidenced by remnant stumps now present), and in small "island-type" mounds with wide slopes. Initial dredging may be limited to higher elevation edges of Swan Lake. During extended drying periods, some dredging of lower elevations might be possible with floating-type dredge equipment. Dredging is costly, and likely can occur only during dry summers. A careful evaluation should be conducted to determine the most natural and cost-effective sites for initial excavations and methods to maintain these areas.

8. Long-term restoration and maintenance of the Swan Lake ecosystem will require control and reduction of sedimentation in the lake bottom. Sediment control is most economical and effective when it is closer to the source area, i.e., upland watersheds. Attempts to reduce sediment loads in the Illinois River is a large and complicated task and additional programs are needed to address erosion of uplands and agricultural lands throughout its watershed. Mostly, this will require landscape-level efforts to reduce sediment runoff from agricultural fields in the Illinois River watershed. In the immediate Swan Lake area the largest source of sediments is introduced into the lake via two small creek drainages on the west side of the lake (Fig. 22). The best long-term solution to reduce sediment loads in these two drainages is to implement soil and water conservation practices and encourage land use changes in upland sediment-source areas. If upland soil conservation practices can not be implemented, or are minimal, then some retention or diversion of sediments at lower parts of the drainage may be necessary. Generally, the most effective silt basins would occur farther upstream at higher elevations before they reach the deposition site of Swan Lake. Attempts should be made to locate silt management areas as far away from Swan Lake as possible. In the worst case scenario, some silt basin development adjacent to Swan Lake where these drainages enter the lake could occur. A "delta-type" fan of sediment has developed in this area and it seems possible that some excavation of depressions in this delta fan, and/or rerouting the drainage flow into other areas might be useful. As suggested earlier, any attempt at sediment reduction in Swan Lake should avoid construction of additional levees or further compartmentalization of the lake bottom.

9. Several NRCS, USFWS, IDNR programs may be available to help reduce erosion and sediment runoff from adjacent agricultural lands in the Swan Lake watershed. These include Conservation Reserve Program, Environmental Quality Improvement Program, and Conservation Security Programs of NRCS and the Partners For Fish and Wildlife Program of USFWS. If these programs could be prioritized for the Swan Lake watershed, more funds and effort could be directed here.

Gilbert Lake – Like Swan Lake, Gilbert Lake is a remnant channel of the historic Illinois River and in the late 1800s contained a narrow corridor of deeper open water surrounded by bottomland forest. Gilbert Lake sits at a slightly higher elevation than Swan Lake and the low elevation point in the natural levee along the Illinois River where water entered and exited the lake was at about 416-417 feet. Consequently, Gilbert Lake flooded slightly later than Swan Lake as the Illinois River rose, and conversely drained earlier and for more extended periods each summer. This drier condition caused Gilbert Lake to contain extensive areas of moist-soil herbaceous vegetation and wider bands of S/S around the lake than in Swan Lake. Also, because Gilbert Lake sits in a narrower floodplain between the Illinois River and the nearby bluffs to the north, the band of bottomland hardwood around the lake was somewhat narrow. GLO maps indicate the area immediately north of Gilbert Lake in the Duncan Farm cultural site was forest. However, the soils and elevations, the occurrence of grass and herbaceous species such as decurrent false aster, and artifacts obtained in the Duncan Farm area suggest that some prairie may have been present there, perhaps a narrow band between 418 and 420 feet. GLO surveys often mapped savanna as forest, and this area may have been a savanna.

A riverside levee was constructed along Gilbert Lake in the mid 1960s and subsequent installation of pumps and water-control structures have allowed managers to drain the lake in summer. Silt basins also were built on the north side of the lake to reduce sediment inputs into Gilbert Lake. The discovery of decurrent false aster has affected management of fields on the north side of the lake. We recommend the following actions to help restore and manage the Gilbert Lake area:

1. Attempt to at least partly drain Gilbert Lake each summer and completely drain the lake for at least 3 months in about 3 of every 5 years to encourage establishment and production of a more diverse moist-soil plant community, consolidate bottom sediments, and improve water quality for establishment of aquatic macrophytes during flooded periods.

2. Control woody species encroachment into the lake bottom with the intent of sustaining a S/S community around its edges.

3. Maintain silt basins on the north side of Gilbert Lake and develop wetlands behind silt berms by restoring natural topographic depressions and sloughs and managing water with water-control structures to create seasonally flooded herbaceous wetland impoundments. Periodic disturbance will be required to maintain herbaceous and S/S vegetation in these sites

4. If more regular and extended drawdowns consolidate the bottom of Gilbert Lake, then some restoration of topographic variation in the edges of the lake may be possible by dredging and creation of sloughs, swales, and other depressions. Spoil from excavations can be deposited in natural patterns along the outside bends of meander scrolls and small islands (see recommendations for Swan Lake).
5. Reforest the natural levee along the Illinois River and in elevations > 419.5 feet with a diverse mix of bottomland tree species including pin oak and pecan. This reforestation should occur in all parts of Gilbert Lake DV except the lake basin and its immediate edges and in the silt basin wetlands. A mixed mesic prairie/savanna community could be restored in the Duncan Farm alluvial fan area.

Calhoun Point-Bar Terrace – The Calhoun Point-Bar Terrace is a complex of ridge and swale geomorphic surfaces formed by Holocene channel dynamics of the Mississippi and Illinois rivers. The north side of this terrace contains a higher elevation (419-422 feet) natural levee deposit formed along the south side of Swan Lake. The south side of the terrace slopes down into the recently active meander belt of the Mississippi River at Calhoun Point WMA. Historically the Calhoun Point-Bar Terrace was predominantly bottomland prairie on higher point-bar ridges, herbaceous and emergent wetland vegetation in swales bordered by S/S and bottomland forest, and contiguous bands of bottomland forest on the natural levee along Swan Lake and in the Calhoun Point WMA area. The higher elevation of this terrace and the presence of prairie vegetation caused this area to be among the first sites cleared and farmed in the confluence area. Few remnants of historic prairie vegetation exist. The terrace sits above the higher water level created by historic Lock and Dam 26 and surface inundation has not been greatly altered except by developments to create moist-soil impoundments (the Calhoun wetland complex). Opportunities for restoration and management include:

1. Restore prairie or a mixed prairie-savanna community on higher elevation ridges throughout this point-bar area. Long-term maintenance of prairie vegetation will require periodic disturbance, preferably fire. The CCP for Two Rivers NWR identifies possible elimination of agricultural farming in fields/units A3, A4, and A5 if they are not used by large numbers of wintering waterfowl. Each of these units could be restored to bottomland prairie and savanna.

2. Manage moist-soil impoundments for a mix of annual and perennial vegetation and encourage wet prairie species in at least some of these units. Impoundments will need to be actively managed to prevent encroachment of woody and invasive species and should be mechanically disturbed about once every 3-4 years. Current water-control infrastructure seems adequate to manage these units, although several units have levees that are not aligned with topographic contours. Each unit should be evaluated to determine if, and where, exterior and interior cross levees are needed, or could be eliminated, to achieve diversity of topography and desirable vegetation communities.

3. Manage swales in this area (Yorkinut, Schoolhouse, Duck Pond, Little Swan) as herbaceous emergent wetlands with a border of S/S or bottomland forest around them. Early successional trees and shrubs such as willow, buttonbush, and cottonwood will try to encroach into the bottoms of these swales and will need to be removed periodically.

4. Restore bottomland hardwood forest on the higher elevation natural levee on the southeast side of Swan Lake and in the transition zone where the terrace slopes down into Calhoun Point WMA. Some active planting of hard mast species such as pecan and oaks may be needed to start the reforestation. Planting trees on berms should be evaluated, but probably is not necessary or desirable because of the potential to disrupt sheetflow of water across these sites during flood events.

5 Maintain some agricultural fields that have traditional high use by wintering waterfowl. Use rotational crop production in moist-soil impoundments as a disturbance mechanism and to provide high carbohydrate foods for wintering waterfowl and upland wildlife (Fredrickson and Taylor 1982).

Deer Plain Terrace – Prior to European settlement the higher elevations of most of the Deer Plain Terrace and adjacent uplands were upland-type forest. Lower elevations on the southern most part of the Deer Plain Terrace were grassland. Bottomland prairie probably was present in low elevations that periodically flooded and within landscape depressions and mesic drier-type prairie occurred at higher sites. GLO maps (Fig. 14) indicate the historic distribution of these communities and offers some guidance for restoration of communities today. Although the Calhoun DV contains little of the Deer Plain Terrace surface, restoration of natural communities on, and adjacent to, refuge lands would be desirable. Opportunities include:

1. Most higher elevation upland areas can be reforested to upland forest species if desired. Reforestation of most agricultural lands above 440’ seems possible depending on land ownership objectives.

2. Higher elevations of the Deer Plain Terrace can be reforested to a mix of upland and more bottomland species. The lower elevations of this terrace historically were prairie; restoring these sites will require regular vegetation disturbance, and where these areas now have been developed for moist-soil impoundments, wetter regimes may be more suitable for bottomland prairie species instead of the historic mesic grassland.

MONITORING AND EVALUATION

The ultimate success of restoring parts of the historic Illinois River floodplain communities and their ecological functions and values will depend on how well infrastructure and management strategies can emulate more natural water regimes in Swan and Gilbert lakes and the adjacent natural levees and floodplains. Many of the HREP project features constructed in the last several years are beneficial to managing water levels in the altered Illinois River (lock-and dam) ecosystem, but uncertainty exists about the most effective spatial and temporal pattern of emulating more natural drainage of Swan and Gilbert Lakes. Future management using the recommendations and options identified in this report can be done in an adaptive management framework where predictions (i.e. improved lake bottom consolidation and increased aquatic vegetation) about specific management actions (i.e. regular summer drainage) are made and then select abiotic and biotic features (e.g., sediments, vegetation, invertebrates, etc.) are monitored to determine ecosystem responses and to suggest future changes or strategies in the management actions taken. In most cases, the most important features that need monitoring are the primary abiotic attributes of this ecosystem that ultimately will sustain communities and their productivity such as seasonal and long-term flooding and drying dynamics, subsurface water inputs and changes, sediment and contaminant loads and depositional rates, consolidation of lake bottoms, and nutrient cycling. The most important biotic feature that must be monitored, at least in the short term, is aquatic macrophyte distribution and abundance in bottomland lakes. Without changes in water regimes, sedimentation, and restoration of aquatic and herbaceous wetland vegetation in Swan and Gilbert lakes, response of primary and secondary consumers and larger vertebrates will be limited at best.

FLOODING AND DRYING REGIMES IN SWAN AND GILBERT LAKES

If water management in Swan and Gilbert lakes can regularly draw down water levels in summer then the extent of surface and subsurface dewatering must be monitored for rates, efficiency, timing, and extent of drainage. Monitoring surface water drainage must be accompanied by recording information on pump capabilities, efficiencies, and man and financial costs. These variables should be related to climatic conditions, Illinois River levels, and Alton Pool water management that occur during drawdown times.

As water is drained from these lakes, topographic information will be needed to determine how and if water drains from various parts of the lake bottom and where natural, or mechanically changed, topography has occurred. If some natural topography can be recreated in lake bottoms after drying in successive years, water dynamics in restored depressions and deposits must be determined. Techniques to create and maintain deeper depressions in the lake bottoms should be evaluated to determine effect and efficiency.

SEDIMENT LOADING AND RATES OF DEPOSITION

A major long-term challenge to maintain and restore Swan Lake, and to a lesser degree Gilbert Lake, is to reduce sediment inputs into these bottomland lakes. As previously stated, the most desirable strategies to reduce sediment inputs would address upland watershed "sources" of sediments rather than physical developments adjacent to, or in, lake bottoms. However, to date, attempts to control soil erosion from upland watersheds have not been successful. Renewed emphasis on controlling soil erosion from uplands adjacent to Swan Lake is needed and a regular monitoring program should be implemented to determine rates of sedimentation, source of sediments, and contaminant levels in sediments. If upland or upstream conservation measures such as silt basins, agricultural land management, and vegetation buffers are implemented, their effects both in the immediate area, and downstream in Swan Lake must be evaluated.

REVEGETATION OF SWAN AND GILBERT LAKES

If water regimes in Swan and Gilbert lakes can be restored to more regular extended drawdown patterns during most summers, and if sedimentation rates also can be reduced in these areas, then lake bottoms should become more consolidated, water clarity should be improved, and nutrients bound in sediments should be released and become available to both plants and animals. We predict that aquatic and herbaceous (moist-soil) macrophytes, phytoplankton, and algae all should increase in these areas. Another result of more regular drying will be encroachment of early successional tree species into lake bottoms. The distribution, composition, and abundance of vegetation in Swan and Gilbert Lakes should be monitored annually. In an adaptive management context, if revegetation of Swan and Gilbert lakes does not occur, then changes to water management and/or possible planting or reintroduction of desirable species may be needed. In contrast, if excessive encroachment of woody species such as willow, cottonwood, and buttonbush occurs then some control by physical, chemical, and hydrological methods may be needed and the efficiency of control methods should be monitored. If more vegetation is restored to Swan and Gilbert lakes, zooplankton, fish, amphibian and reptile, and some waterbird populations should increase. Monitoring populations of these animals is important.

RESTORATION OF PRAIRIE AND BOTTOMLAND FOREST

To some degree restoration of wet prairie and bottomland forest will require restoration of more natural water regimes and reduced sedimentation outlined above. However, several locations seem excellent sites to restore these communities on the higher elevation natural levee, Calhoun Point-Bar Terrace, and Deer Plain Terrace areas. If the locations chosen to restore these communities match the historic sites that had geomorphology, soils, elevation, and topography that supported these communities then restoration should have the highest probability of success. Ultimate success will require, however, that management provide appropriate seasonal water regimes, disturbance processes, and sources of vegetation stock. In all restoration sites, regular monitoring of survival, growth, distribution, and composition of restored prairie and bottomland forest species is needed.

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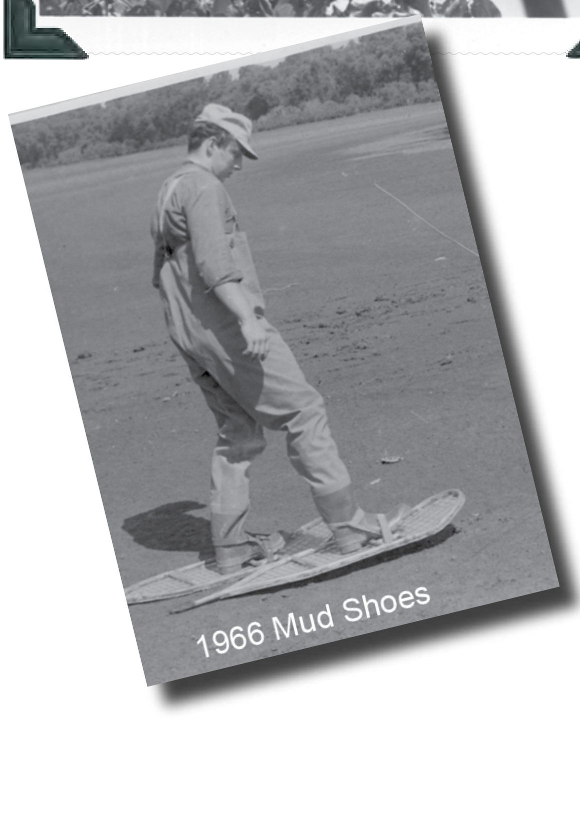
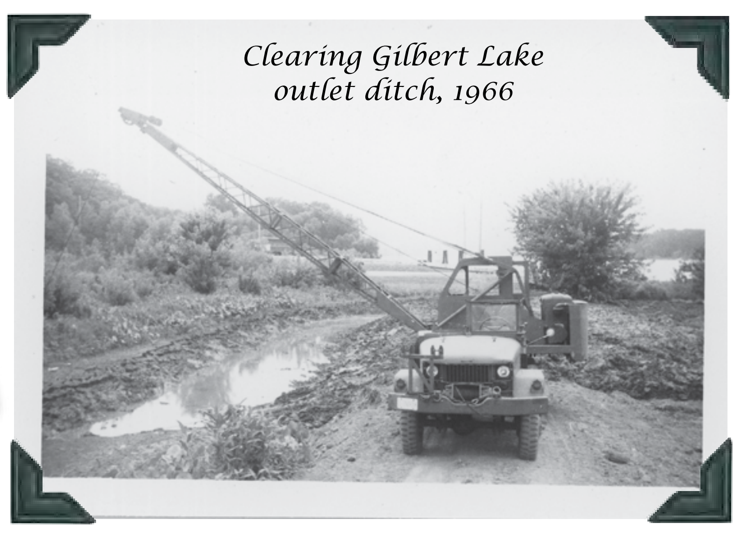
1959 Refuge Managers Davis and Mehrhoff inspect the milo crop on Calhoun Unit, at left.

Dynamiting water control ditch. . .

. . . has great results, 1966.



1966 Mud Shoes



Clearing Gilbert Lake outlet ditch, 1966

LITERATURE CITED

Adams, H. 1946. Calhoun County area, Illinois. Report prepared for U. S. Fish and Wildlife Service.

Andreas, Lyter and Company. 1872. Atlas map of Jersey County, Illinois. Andreas, Lyter, and Company, Davenport, IA.

Balek, C. L., K. P. McGowen and G. R. Walz. 2001. Phase I archaeological and geomorphological reconnaissance of the 37-acre Gilbert Lake Project at Two Rivers National Wildlife Refuge, Jersey County, Illinois. Contract Report No. 301811N028 prepared for U. S. Fish and Wildlife Service, Fort Snelling, MN.

Bayley, P. B. 1991. The flood pulse advantage and the restoration of river-floodplain systems. Regulated Rivers: Research and Management 6:75-86.

Beck, L. C. 1823. A gazetteer of the states of Illinois and Missouri. Charles R. and G. Webster Printing, Albany, New York.

Bellrose, F. C., F. L. Paveglio, Jr. and D. W. Steffeck. 1979. Waterfowl populations and the changing environment of the Illinois River Valley. Illinois Natural History Survey Bulletin 32: 1-54.

Bellrose, F. C., S. P. Havera, F. L. Paveglio and D. W. Steffeck. 1983. The fate of lakes in the Illinois River Valley. Illinois Natural History Survey Biological Notes 119.

Bhowmik, N. G. and M. Demissie 1986. Sedimentation in the Illinois River Valley and backwater lakes. Journal of Hydrology 105:187-195.

Bodensteiner, L. R., R. J. Sheehan and W. M. Lewis. 1990. Differences in the physical environment of the Upper Mississippi River as factors in the overwinter survival of fish. Pages 109-117 *in* The restoration of stream fish habitat. Rivers and Streams Technical Committee, North Central Division of the American Fisheries Society.

Butts, T. A. 1974. Measurements of sediment oxygen demand characteristics of the Upper Illinois Waterway. Illinois State Water Survey Report of Investigations 79. 60pp.

Butzer, K. W. 1977. Geomorphology of the lower Illinois River Valley as a spatial-temporal context for the Koster Archaic site. Illinois State Museum Reports of Investigations No. 34. Springfield, IL.

Cahill, R. A. and J. D. Steele. 1986. Inorganic composition and sedimentation rates of backwater lakes associated with the Illinois River. Illinois State Geological Survey Environmental Notes 115.

Carlson, T. L. 1951. The Illinois military tract: a study of land occupation, utilization, and tenure. Illinois Studies in the Social Sciences No. 32., University of Illinois Press, Urbana, IL.

Carpenter, G. W. 1967. Calhoun is my kingdom: the sesquicentennial history of Calhoun County, Illinois. Dan Merkle Printing Co.

Demissie, M. 1996. Impact of the 1993 flood on sedimentation and sediment quality in backwater lakes of Illinois. Report prepared for the Illinois Environmental Protection Agency. Illinois State Water Survey, Champaign, IL. 204pp.

Demissie, M. 1998. Hydrology of the Illinois River. Illinois State Water Survey, Champaign, IL.

Demissie, M., L. Keefer and R. Xia. 1992. Erosion and sedimentation in the Illinois River Basin. ILENR/RE-WR-92/104.

Demissie, M., R. Xia and H. V. Knapp. 1999. Significance of water-level fluctuation management in the restoration of large rivers. *In* Proceedings of ASCE International Water Resources Engineering Conference, Seattle, WA.

Farnsworth, K. B. 1976. An archaeological survey of the lower Illinois River shoreline (miles 1-80). Northwestern University Archaeological Program, Kampsville, IL.

Featherstonhaugh, G. W. 1844. Excursion through the slave states. Harper and Brothers Publishing Co.

Fehrenbacher, J. B. and C. E. Downey. 1966. Soil survey, Jersey County, Illinois. U. S. Department of Agriculture, Soil Conservation Service. Urbana, IL.

Forbes, S. A. and R. E. Richardson. 1919. Some recent changes in Illinois River biology. Illinois State Natural History Survey Bulletin 13:139-156.

Forman, R. T. 1995. Land mosaics: the ecology of landscapes and regions. Cambridge University Press, New York.

Fredrickson, L. H. and T. S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. U.S. Department of the Interior, Fish and Wildlife Service Resource Publication 148. 29pp.

Galat, D. L., L. H. Fredrickson, D. D. Humburg, K. J. Bataille, J. R. Bodie, J. Dohrenwend, G. T. Gelwicks, J. E. Havel, D. L. Helmers, J. B. Hooker, J. R. Jones, M. F. Knowlton, J. Kubisiak, J. Mazourek, A.C. McColpin, R.B. Renken and R.D. Semlitsch. 1998. Flooding to restore connectivity of regulated, large-river wetlands. Bioscience 48: 721-733.

Galatowitsch, S. M. and T. V. McAdams. 1994. Distribution and requirements of plants on the Upper Mississippi River NWR. Literature Review, Iowa Cooperative Fish and Wildlife Research Unit, Ames, IA.

GLO. 1815, 1817, 1826, 1842. General land office survey, federal land surveyors field notes. Illinois State Archives. Vols. 254, 258, 328, 331, 464. Springfield, Illinois. Microfiche on file Lovejoy Library, Southern Illinois University, Edwardsville.

Green, W. E. 1947. Effect of water impoundment on tree mortality and growth. Journal of Forestry 45:118-120.

Green, W. E. 1949. Land examination report, Pool 26, Illinois side. Report prepared for U.S. Fish and Wildlife Service, Winona, MN.

Hajic, E. R. 2000a. Landform sediment assemblage (LSA) units in the Illinois River Valley and the Lower Des Plaines River Valley. Volume I. Technical Report No. 99-1255-16. Illinois State Museum, Springfield, IL.

Hajic, E. R. 2000b. Landform sediment assemblage (LSA) units in the Illinois River Valley and the Lower Des Plaines River Valley. Volume II. Technical Report No. 99-1255-16. Illinois State Museum, Springfield, IL.

Hall, R. D. and O. D. Ingall. 1911. Forest conditions in Illinois. Pages 175-253 *in* S.A. Forbes, ed. Bulletin of the Illinois State Laboratory of Natural History: Contributions to the natural history survey of Illinois Vol. 9.

Hall, R. D. 1966. Water elevation study, 1966, Mark Twain National Wildlife Refuge, Grafton, Illinois. Report prepared for U.S. Fish and Wildlife Service.

Hamilton, R. B. 1919. History of Jersey County, Illinois. Mainsail Publishing Company.

Havera, S. P. 1999. Waterfowl of Illinois: status and management. Illinois Natural History Survey Special Publication 21.

Heitmeyer, M. E. 2001. Waterfowl. Pages 209-223 *in* J.E. Dicks on, ed. Wildlife of southern forests. Hancock House Publishing Company, Blaine, WA.

Heitmeyer, M. E. 2006. The importance of winter floods to mallards in the Mississippi Alluvial Valley. Journal of Wildlife Management 70:101-110.

Heitmeyer, M. E., R. J. Cooper, J. E. Dickson and B. D. Leopold. 2005. Ecological relationships of warm-blooded vertebrates in bottomland hardwood ecosystems. Pages 281-306 *in* L. H. Fredrickson, S. L. King and R. D. Kaminski, eds. Ecology and management of bottomland hardwood systems: the state of our understanding. University of Missouri-Columbia, Gaylord Memorial Laboratory Special Publication No. 10. Puxico.

Heitmeyer, M. E. and L. H. Fredrickson. 2005. An evaluation of ecosystem restoration and management options for the Ouray National Wildlife Refuge, Utah. University of Missouri-Columbia, Gaylord Memorial Laboratory Special Publication No. 8. Puxico.

Heitmeyer, M. E., F. A. Nelson and L. H. Fredrickson. 2006. An evaluation of ecosystem restoration and management options for the Duck Creek/Mingo Basin area of southeast Missouri. University of Missouri-Columbia, Gaylord Memorial Laboratory Special Publication No. 12.

Helzer, C. J. and D. E. Jelinski. 1999. The relative importance of patch area and perimeter area to grassland breeding birds. Ecological Applications 9:1448-1458.

Hutchinson, M. 1988. A guide to understanding, interpreting, and using the public land survey field notes in Illinois. Natural Areas Journal 8: 245-255.

Junk, W. J., P. B. Bayley and R. E. Sparks. 1989. The flood pulse concept in river-floodplain systems. Canadian Special Publication in Fisheries and Aquatic Sciences 106:110-127.

Knutson, M. G., J. P. Hoover and E. E. Klaas. 1996. The importance of floodplain forests in the conservation and management of neotropical migratory birds in the midwest. Pages 168-188 *in* F. Thompson, III ed. Management of midwestern landscapes for the conservation of neotropical migratory birds. U. S. Forest Service General Technical Report NC-187.

Knutson, M. G. and E. E. Klaas. 1997. Declines in abundance and species richness of birds following a major flood on the Upper Mississippi River. Auk 114:367-380.

Koel, T. M., K. S. Irons and E. Ratcliff. 2000. Asian carp invasion of the Upper Mississippi River system. U. S. Geological Survey Upper Midwest

Environmental Sciences Center Project Status Report 2000-05.

Kofoid, C. A. 1903. Plankton studies: IV. The plankton of the Illinois River, 1894-1899, with introductory notes upon hydrology of the Illinois River and its basin. Part I. Quantitative investigations and general results. Illinois State Laboratory of Natural History Bulletin 6:95-629.

Korschgen, C. E. 1990. Feasibility study - impacts of turbidity on growth and production of submersed plants. U. S. Fish and Wildlife Service Report No. 90-07. 11pp.

Kullen, D. 1994. Phase I. Archaeological survey at selected areas in the Gilbert Lake Division of the Mark Twain National Wildlife Refuge, Jersey County, Illinois. Report prepared for U. S. Fish and Wildlife Service, Allied Archeology, Aurora, IL.

Kunkel, K. E. 1994. A Climatic perspective on the 1993 flooding rains in the Upper Mississippi River Basin. Water International 19:199-206.

Lee, M. T. 1984. Sedimentation in the backwater lakes and side channels along the Illinois Rivers, USA. Proceedings of the Second International Symposium of River Sedimentation, October 1983. Nanjing, China. Illinois State Water Survey Reprint 617.

Lee, M. T. and J. B. Stall. 1976. Sediment conditions in backwater lakes: along the Illinois River - Phase I. Illinois State Water Survey Contract Report 176A. Champaign, IL.

Lee, M. T. and J. B. Stall. 1977. Sediment conditions in backwater lakes: along the Illinois River - Phase I. Illinois State Water Survey Contract Report 176A. Champaign, IL.

Lilly, M. E. 1989. Soil survey of Calhoun County, Illinois. U.S. Department of Agriculture, Soil Conservation Service, Urbana, IL.

Low, J. B. and F. C. Bellrose, Jr. 1944. The seed and vegetative yield of waterfowl food plants in the Illinois River Valley. Journal of Wildlife Management 8:7-22.

Mills, H. B., W. C. Starrett and F. C. Bellrose. 1966. Man's effect of the fish and wildlife of the Illinois River. Illinois Natural History Survey Biological Notes 57. 24pp.

Mueller, A. J., C. R. Loesch and D. J. Twedt. 2000. Development of management objectives for breeding birds in the Mississippi Alluvial Valley. *In* R. Bonney, D. N. Pashley, R. Cooper, and L. Niles, eds. Strategies for bird conservation: The Partners in Flight planning process. Cornell Laboratory of Ornithology, New York.

Natural Resources Conservation Service. 1998. Swan Lake Watershed Area - a cooperative approach to upland erosion control on private property that provides sediment reduction benefits on federal property. Hardin, IL. 6pp.

Nelson, J. C., A. Redmond and R. E. Sparks. 1994. Impacts of settlement on floodplain vegetation at the confluence of the Illinois and Mississippi rivers. Transactions of the Illinois State Academy of Science 87:117-134.

Nelson, J. C. and R. E. Sparks. 1998. Forest compositional changes at the confluence of the Illinois and Mississippi Rivers. Transactions of the Illinois State Academy of Science 91:33-46.

Nelson, J. C., R. E. Sparks, L. DeHaan and L. Robinson. 1998. Presettlement and contemporary vegetation patterns along two navigational reaches of the Upper Mississippi River. Pages 51-60 *in* T. D. Sisk, ed. Perspectives on the land use history of North America: a context for understanding our changing environment. U. S. Geological Survey Biological Science Report USGS/BRD/BSR - 1998-0003.

Nelson, P. W. 2005. Terrestrial natural communities of Missouri, revised edition. Missouri Natural Areas Committee. Published by Missouri Department of Natural Resources, Jefferson City, MO.

Noss, R.F. and A. Y. Cooperrider. 1994. Saving natures legacy: protecting and restoring biodiversity. Island Press, Washington, D. C.

Paloumpis, A. A. and W. C. Starrett. 1960. An ecological study of benthic organisms in three Illinois River floodplain lakes. American Midland Naturalist 64:406-435.

Poff, N. L., J. D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks and J. C. Stromberg. 1997. The natural flow regime. Bioscience 47:769-784.

Richardson, R. E. 1921. The small bottom and shore fauna of the middle and lower Illinois River and its connecting lakes, Chillicothe to Grafton: its valuations; its sources of food supply; and its relation to the fishery. Illinois State Natural History Survey Bulletin 13: 363-522.

Rubey, W. W. 1952. Geology and mineral resources of the Hardin and Brussels Quadrangles (in Illinois). U.S. Geological Survey Professional Paper 218 in cooperation with Illinois State Geological Survey Division. Washington, D.C. 179pp.

Schwegman, J. E. 1973. The natural divisions of Illinois. Illinois Natural Preserves Commission, Rockford, IL.

Schwegman, J. E. 1995. A delicate balance: the decurrent false aster. Illinois Steward 3-5.

Shrader-Frechette, K. S. and E. D. McCoy. 1993. Method in ecology: strategies for conservation. Cambridge University Press, New York.

Shafer, C. L. 1995. Values and shortcomings of small reserves. Bioscience 45:80-88.

Simons, D. B., S. A. Schumm, M. A. Stevens, Y. H. Chen and P. F. Lagasse. 1975. Environmental inventory and assessment of navigation pools 24, 25, and 26. Upper Mississippi and Lower Illinois Rivers: a geomorphic study. Contract Report Y-75-3 for U.S. Army Corps of Engineers, St. Louis District.

Sparks, R. E. 1993. Making predictions that change the future forecasts and alternative visions for the Illinois River. Holly Korab, ed. Proceedings of the Third Biennial Governor's Conference on the Management of the Illinois River System. Peoria, IL.

Sparks, R. E. 1995a. Need for ecosystem management of large rivers and their floodplains. Bioscience 45: 168-182.

Sparks, R. E. 1995b. Maintaining and restoring the ecological integrity of the Mississippi River: importance of floodplains and floodpulses. Transactions of the North American Wildlife and Natural Resources Conference 60: 90-97.

Sparks, R. E., J. C. Nelson and Y. Yin. 1998. Naturalization of the flood regime in regulated rivers. Bioscience 48: 706-720.

Starrett, W. C. 1972. Man and the Illinois River. Pages 131-169 *in* R. T. Oglesby, C. A. Carlson and J.A. McCann, eds. River ecology and man. Academic Press, New York.

Stratman, D. and G. Barickman. 2000. Using micro and macrotopography in wetland restoration. U.S. Department of Agriculture, Natural Resources Conservation Service, Illinois Biology Technical Note 20.

Theiling, C. H. 1996. An ecological overview of the Upper Mississippi River System: implications for post-flood recovery and ecosystem management. Pages 3-28 *in* D. L. Galat and A. G. Frazier, eds. Overviews of river-floodplain ecology in the Upper Mississippi River Basin. Volume 3. Science for Floodplain Management into the 21st Century. U. S. Government Printing Office, Washington, DC.

Theiling, C. H., R. J. Maher and R. E. Sparks. 1996. Effects of variable annual hydrology on a river regulated for navigation: Pool 26, Upper Mississippi River system. Journal of Freshwater Ecology 11:101-114.

Thompson, J. 1989. Case studies in drainage and levee district formation and development on the floodplain of the lower Illinois River, 1890s to 1930s. Urbana (IL) Water Resources Center. Special Report No. 016.

Titus, S., W. G. Howe, W. Neal and J. D. Anderson. 1995. A Phase I archaeological survey for historic properties within the Swan Lake Habitat Rehabilitation Enhancement Project (HREP), Environmental Management Program (EMP), Pool 26, Illinois River, Calhoun County, Illinois. U.S. Army Corps of Engineers, St. Louis District Historic Properties Management Report No. 42..

Titus, S., W. Neal, J. Armstrong and G. Howe. 1996. Phase III data recovery at the Persimmon Site (11-C-152) Swan Lake Rehabilitation Enhancement Project (HREP), Environmental Management Program (EMP), Pool 26, Illinois River, Calhoun County, Illinois. Cultural Resources Management Report No. 268. American Resources Group, Ltd. Carbondale, IL.

Turner, L. M. 1934. Grassland in the floodplain of the Illinois Rivers. American Midland Naturalist 15:770-780.

Turner, L. M. 1936. Ecological studies in the Lower Illinois River Valley. Ph.D. Dissertation, University of Chicago, Chicago. Reprinted from The Botanical Gazette 97:689-727.

U. S. Army Corps of Engineers. 1993. Upper Mississippi River System Environmental Management Program, Definite Project Report Swan Lake Project Rehabilitation and Enhancement, Pool 26, Illinois River, Calhoun County, Illinois. St. Louis, MO

U. S. Fish and Wildlife Service. 1963-2006. Unpublished annual narratives and water management plans, Two Rivers National Wildlife Refuge, Brussels, IL.

U. S. Fish and Wildlife Service. 1990. Decurrent false aster recovery plan. U. S. Fish and Wildlife Service, Twin Cities, MN. 26pp.

U. S. Fish and Wildlife Service. 2004. Mark Twain National Wildlife Refuge Complex Comprehensive Conservation Plan and Environmental Assessment. U. S. Fish and Wildlife Service. 441pp.

Vogel, E. 1929. Calhoun County, Illinois: a study in geographic landscapes. M. S. thesis, University of Illinois, Urbana, IL.

Vonnahme, D. R. 1996. Navigation on the Illinois. Proceedings of the 1995 Governor's Conference on the management of the Illinois River system. Special Report No. 22, Water Resources Center. Institute for Environmental Studies, University of Illinois, Urbana-Champaign.

White, J. 2000. Early accounts of the ecology of the Big Rivers area. Volume 5 Illinois Critical Trends Assessment Program. Illinois Department of Natural Resources, Springfield, IL.

Willman, H. B. 1973. Geology along the Illinois Waterway - a basis for environmental planning. Illinois State Geological Survey Circular 478. 48pp.

Willman, H. B. and J. C. Frye. 1970. Pleistocene stratigraphy of Illinois. Illinois State Geological Survey Bulletin 94. 204pp.

Willman, H. B., E. Atherton, T. C. Buschbach, C. Collinson, J. C. Frye, M. E. Hopkins, J. A. Lineback and J. A. Simon. 1975. Handbook of Illinois stratigraphy. Illinois State Geological Survey Bulletin 95. 261pp.

Williams, M. 1980. Products of the forest: mapping the census of 1840. Journal Forest History, January issue.

Woermann, J. W. 1902-1904. Map of the secondary triangulation system of the Illinois and Des Plaines Rivers from Chicago, Illinois to the Illinois River. Corps of Engineers, Chicago Office, U.S. Army.

Yeager, L. E. 1949. Effect of permanent flooding in a river-bottom timber area. Illinois Natural History Survey Bulletin 25:35-65.

Yin, Y. and J. Nelson. 1996. Modifications of the Upper Mississippi River and the effects on floodplain forests. Pages 29-40 *in* D. L. Galat and A. G. Frazier, eds. Overview of river-floodplain ecology in the Upper Mississippi River Basin. Volume 3, J. A. Kelmelis Science for floodplain management into the 21st century. U. S. Government Printing Office, Washington, DC.

Zawacki, A. A. and G. Hausfater. 1969. Early vegetation of the Lower Illinois Valley. Illinois Valley Archaeological Program Research Papers, Vol. I. Illinois State Museum, Reports of Investigations No. 17. 65pp.

APPENDICES

PLACEHOLDER ONLY

PLEASE INSERT
APPENDIX A

MAP 11X17 FOLDED

HERE

Appendix B. Common plants on Two Rivers National Wildlife Refuge. Data modified from Galatowitsch and McAdams 1994.

Common Name	Scientific Name	Guild[a]
American bindweed	*Convolvulus arvensis*	V
American elm	*Ulmus americana*	SFT
American germander	*Teucrium canadense*	MF
Aquatic liverwort	*Riccia fluitans*	FA
Arrow arum	*Peltandra virginica (L.) schott & Endl.*	EP
Arrow-leaved violet	*Viola sagittata Ait.*	MF
Asiatic dayflower	*Commelina communis*	TAF
Awned cyperus	*Cyperus squarrosus*	SAG
Bald spikerush	*Eleocharis erythropoda Steud.*	MG
Barnyard grass	*Echinochloa crusgalli (L.) Beauv.*	SAG
Basswood	*Tilia americana*	BHT
Bead grass	*Paspalum fluitans (Elliott) Kunth.*	MG
Begg's sedge	*Carex bebbii Olney*	MG
Bellwort	*Uvularia grandiflora J.E. Smith*	SE
Bicknell's sedge	*Carex bicknellii Britt.*	MG
Biennial gaura	*Gaura biennis D.*	TAF
Big bluestem	*Andropogon gerardii Vitman*	FTSS
Bigleaf pondweed	*Potamogeton amplifolius Tuckerm.*	RSA
Bitternut hickory	*Cary cordiformis (Wang.) K. Koch*	BHT
Bittersweet	*Solanum dulcamara*	MF
Black cherry	*Prunus serotina Ehrh.*	BHT
Black locust	*Robinia pseudo-acacia*	BHT
Black mustard	*Brassica nigra*	TAF
Black nightshade	*Solanum nigrum*	TAF
Black raspberry	*Rubus occidentalis*	WS
Black walnut	*Juglans nigra*	BHT
Black willow	*Salix nigra Marsh.*	FTPT
Black-eyed susan	*Rudbeckia hirta*	MF
Blood polygala	*Polygala sanguiea*	TAF
Bloodroot	*Sanguinaria canadensls*	SE
Blue flag	*Iris virginica L. var. shrevei (Small) E. Anders.*	EP
Blue vervain	*Verbena hastata*	MF
Blue-joint	*Calamagrostis canadensis (Michx.) Nutt.*	MG
Blunt broom sedge	*Carex tribuloides Wahl.*	MG
Bluntleaf bedstraw	*Galium obtusum bigel.*	MF
Boneset	*Eupatorium perfoliatum*	MF
Bottlebrush sedge	*Carex hystericina Muhl.*	MG
Bottomland aster	*Aster ontarionis Wieg.*	FTSS
Box elder	*Acer negundo*	FTPT
Bristly greenbrier	*Smilax hispida Muhl.*	V
Broad-leaved arrowhead	*Sagittaria latifolia Willd.*	EP
Bulbet-bladder fern	*Cystopteris bulbifera (L.) Bernh.*	AWF
Bull thistle	*Cirsium vulgare (Savi) Tenore.*	TAF
Bur marigold	*Bidens laevis (L.) BSP.*	SAF
Burhead	*Echinodorus Corddifolius (L.) Griseb.*	EP
Burhead	*Sparganium americanum Nutt.*	EP
Bushy knotweed	*Polygonum ramosissimum Michx.*	SAF
Butternut	*Juglans cinerea*	BHT
Buttonbush	*Cephalanthus occidentalis*	FTSS

Appendix B. Common plants, cont'd.

Common Name	Scientific Name	Guild[a]
Buttonweed	*Spermacoce glabra Michx.*	MF
Canada goldenrod	*Solidago canadensis*	MF
Canada thistle	*Cirsium arvense (L.) Scop.*	MF
Canada tick-trefoil	*Desmodum canadense (L.) DC.*	MF
Cardinal flower	*Lobelia cardinalis*	AWF
Carpetweed	*Mollugo verticillata*	TAF
Catchfly grass	*Leersia lenticularis Michx.*	MG
Cattail sedge	*Carex typhina Michx.*	MG
Chickweed	*Cerastium vulgatum*	MF
Choke-cherry	*Prunus virginiana*	FIPT
Cinnamon fern	*Osmunda cinnamonea*	MF
Clammy ground cherry	*Physalis heterophylla Nees.*	AWF
Clasping dogbane	*Apocynum sibiricum Jacq.*	FTSS
Climbing milkweed	*Amphelamus albidus (Nutt.) Britton*	FTSS
Common blackberry	*Rubus allegheniensis Porter.*	WS
Common buckthorn	*Rhamnus cathartica*	WS
Common burreed	*Sparganium eurycarpum Engelm.*	EP
Common cattail	*Typha latifolia*	EP
Common chickweed	*Stellaria media (L.) Cyrillo*	TAF
Common cocklebur	*Xanthium strumarium*	TAF
Common plantain	*Plantago major*	MF
Common poison ivy	*Toxicodendron radicans ssp. Negundo (Greene) Gillis*	V
Common purslane	*Portulaca oleracea*	MF
Common ragweed	*Ambrosia artemisiifolia*	TAF
Coontail	*Ceratophyllum demersum*	USA
Cottonwood	*Populus deltoides Marsh.*	FTPT
Crab grass	*Digitaria sanguinalis (L.) Scop.*	MG
Creeping burhead	*Echinodorus berteroi (Sprengel) Fassett*	SAF
Crown vetch	*Coronilla varia*	
Curl+A70y dock	*Rumex crispus*	MF
Curly-leaved pondweed	*Potamogeton crispus*	RSA
Cursed crowfoot	*Ranunculus scleratus*	SAF
Daisy fleabane	*Erigeron annuus (L.) Pers.*	TAF
Dandelion	*Taraxacum officinale Weber.*	MF
Deer-tongue grass	*Panicum clandestinum*	TAG
Devil's beggarticks	*Bidens frondosa*	SAF
Dock	*Rumex salicifolius J. A. Weinm.*	MF
Duckweed	*Lemna sp.*	FA
Early meadow rue	*Thalictrum dioicum*	SE
Early wild rose	*Rosa blanda Ait.*	WS
Eastern serviceberry	*Amelanchier canadensis (L.) Medikus*	FTSS
Elderberry	*Sambucus canadensis*	WS
Evening primrose	*Oenothera biennis*	MF
Fall panic grass	*Panicum dichotomiflorum Michx.*	TAG
False buckwheat	*Polygonum scandens*	MF
Field mint	*Mentha arvensis*	MF
Flat-stem pondweed	*Potamogeton zosteriformis Fern.*	RSA
Flatstem spikerush	*Eleocharis compressa Sullivant*	MG
Fleabane	*Erigeron philadelphicus*	MF

Appendix B. Common plants, cont'd.

Common Name	Scientific Name	Guild[a]
Floating pondweed	*Potamogeton natans*	RSA
Floating primrose willow	*Lidwigia peploides (HBK) Raven*	MF
Flowering dogwood	*Cornus florida*	WS
Fog fruit	*Phyla lanceolata Michx. (Green)*	MF
Fox sedge	*Carex vulpinoidea Michx.*	MG
Foxtail sedge	*Carex alopecoidea tuckerm.*	MG
Garlic mustard	*Alliaria petiolata*	
Giant foxtail	*Setaria faberi Herrm.*	TAG
Gooseberry	*Ribes hirtellum Michx.*	WS
Grape fern	*Botrychium dissectum Sprengel var. obliquum Clute*	AWF
Grass-leaved arrowhead	*Sagittaria graminea Michx.*	EP
Gray's sedge	*Carex grayi Carey.*	WG
Great ragweed	*Ambrosia trifida*	TAF
Greater duckweed	*Spirodela polyrhiza (L.) Schleiden*	FA
Green ash	*Fraxinum pennsylvanica Marsh.*	FTPT
Green dragon	*Arisaema dracontium (L.) Schott.*	FTSS
Green foxtail	*Setaria viridis (L.) Beauv.*	TAG
Ground ivy	*Glechoma hederacea*	MF
Hackberry	*Celtis occidentalis*	SFT
Hart Wright's sedge	*Carex hyalinolepis Steud.*	MG
Hazelnut	*Corylus americana Walter.*	WS
Honey locust	*Gleditsia triancanthos*	SFT
Honeysuckle	*Lonicera x bella Zabel.*	WS
Horseweed	*Conyza canadensis (L.) Cronq.*	TAF
Illinois pondweed	*Potamogeton illinoensis Morong*	RSA
Indian grass	*Sorghastrum nutans (L.) Nash*	MG
Indian hemp	*Apocynum cannabinum*	FTSS
Joe-pye-weed	*Eupatorium maculatum*	MF
Joint rush	*Juncus nodosus*	MG
Lady's thumb	*Polygonum persicaria*	SAF
Leafy pondweed	*Potamogeton foliosus Raf.*	RSA
Leafy spurge	*Euphorbia esula*	
Lizard's tail	*Saururus cernuus*	SAF
Low cyperus	*Cyperus diandrus Torr.*	SAG
Marsh elder	*Iva annua*	TAF
Marsh spikerush	*Eleocharis palustris (L.) Roem. & Schultes*	MG
May apple	*Podophyllum peltatum*	SE
Meadow sedge	*Carex granularis Muhl. Ex Willd.*	MG
Milfoil	*Myriophyllum heterophyllum Michx.*	RSA
Missouri ironweed	*Vernonia missurica Rat:*	MF
Mist flower	*Eupatorium coelestinum*	AWF
Mockernut hickory	*Carya tomentosa Nutt.*	BHT
Moneywort	*Lysimachia nummularia*	AWF
Mud plantain	*Heterantheria limosa (Sw,) Willd.*	MF
Narrow-leaved cattail	*Typha augustifolia*	EP
Needle spikerush	*Eleocharis acicularis (L.) Roem. & Schultes*	MG
Nodding smartweed	*Polygonum lapathifolium*	SAF
Nutsedge	*Cyperus esculentus*	MG
Partridge pea	*Chamaecrista fasciculata Michx.*	TAF

Appendix B. Common plants, cont'd.

Common Name	Scientific Name	Guild[a]
Pecan	*Carya illinoensis (Wang.) K. Koch*	BHT
Persimmon	*Diospyros virginiana*	FIPT
Pin oak	*Quercus palustris Muench.*	BHT
Pinkweed	*Polygonum pensylvanicum*	SAF
Prairie cord grass	*Spartina pectinata Link.*	MG
Prairie milkweed	*Asclepias hirtella)Pennell) Woodson*	FTSS
Prairie three-awn	*Aristida oligantha Michx.*	FTSS
Quillwort	*Isoetes melanpoda Gay and Dur.*	RSA
Red maple	*Acer rubrum*	SFT
Red top	*Agrostis gigantea Roth.*	MG
Red-rooted sedge	*Cyperus erythrorhizos Muhl.*	SAG
Reed canary grass	*Phalaris arundinacea*	MG
Rice cutgrass	*Leersia oryzoides (L.) Sw.*	MG
River birch	*Betula nigra*	FTSS
River bulrush	*Scirpus fluviatilis Torr. & Gray*	EP
Riverbank grape	*Vitis riparia Michx.*	V
Rough-leaved dogwood	*Cornus drummondii Meyer*	FTSS
Sago pondweed	*Potamogeton pectinatus*	RSA
Sandbar willow	*Salix interior Rowlee*	FTPS
Sassafras	*Sassafras albidum (Nutt.) Nees.*	WS
Shagbark hickory	*Carya ovata (Mill.) K. Koch.*	BHT
Shellbark hickory	*Carya laciniosa (Michx.) Loud.*	BHT
Silver maple	*Acer saccharinum*	FTPT
Soft rush	*Juncus effusus*	MG
Spanish needles	*Bidens bipinnata*	FTSS
Spatter dock	*Nuphar advena Aiton*	FP
Spikerush	*Eleocharis ovata (Roth) R. & S.*	SAG
Spurge	*Euphorbia humistrata (Engelm.)*	MF
Square-stemmed spikerush	*Eleocharis quadrangulata (Michx.) Roem. & Schultes*	EP
Stick-tight	*Bidens cernua*	FTSS
Summer grape	*Vitis aestivalis var. argentinfolia*	V
Swamp barnyard grass	*Echinochloa walteri (Pursh) Heller*	SAG
Swamp buttercup	*Ranunculus hispidus Michx.*	MF
Swamp dock	*Rumex verticillatus*	MF
Swamp milkweed	*Asclepias incarnata*	FTSS
Swamp privet	*Forestiera acuminata (Michx.) Poiret.*	FTSS
Swamp white oak	*Quercus bicolor Willd.*	BHT
Sweet flag	*Acorus calamus*	EP
Switchgrass	*Panicum virgatum*	MG
Sycamore	*Platanus occidentalis*	SFT
Tall beggars tick	*Bidens vulgata Greene.*	SAF
Toothcup	*Ammania coccinea Rottb.*	SAF
Virginia creeper	*Parthenocissus quinquefolia (L.) Planch*	V
Virginiana wild rye	*Elymus virginicus*	MG
Water dock	*Rumex orbiculatus Gray*	MF
Water lily	*Nymphaea adorata Aiton*	FP
Water lotus	*Nelumbo lutea (Willd.) Pers.*	FP
Water meal	*Wolffia papulifera Thompson*	FA
Water pepper	*Polygonum hydropiper*	SAF

Appendix B. Common plants, cont'd.

Common Name	Scientific Name	Guild[a]
Water primrose	*Ludwigia polycarpa Short & Peter*	MF
Water smartweed	*Polygonum punctatum Ell.*	MF
Water smartweed	*Polygonum aviculare*	TAF
Water starwort	*Callitriche heterophylla Pursh.*	RSA
Water weed	*Elodea nuttallii (Planch.) St. John*	RSA
Wedge grass	*Sphenopholis obtusata (Michx.) scribn.*	SAG
White snake root	*Eupatorium rugosum Houttuyn.*	AWF
Wild garlic	*Allium canadense*	MF
Wild geranium	*Geranium maculatum*	SE
Wild ginger	*Asarium canadense*	FTSS
Wild oats	*Chasmanthium latifolium (Michx.) Yates.*	WG
Wild water pepper	*Polygonum hydropiperoides Michx.*	MF
Wild yellow lily	*Lilium canadense*	MF
Wood anemone	*Anemone quinquefolia*	FTSS
Wood nettle	*Laportea canadensis (L.) Wedd.*	AWF
Wood-sorrel	*Oxalis stricta*	MF
Yellow foxtail	*Setaria glauca (L.) P. Beauv.*	TAG

[a]Aquatic guilds: EP = emergent perennials; RSA = rooted submersed aquatics; USA = unrooted submersed aquatics; FP = floating perennials; FA = floating annuals. Semi-aquatic and terrestrial herbaceous guilds: SE = spring ephemerals; AWF = autumnal woodland forbs; WG = woodland graminoids; V = vines; MF = meadow forbs; MG = meadow graminoids; SAF = Semi-aquatic annual forbs; SAG = semi-aquatic annual grasses; TAF = terrestrial annual forbs; TAG = terrestrial annual grasses. Wood plant guilds: FTPT = flood-tolerant pioneering trees; FIPT = flood-intolerant pioneering trees; SFT = softwood floodplain trees; BHT = bottomland hardwood trees; FTPS = flood-tolerant pioneering shrubs; FTSS = flood-tolerant stable shrubs; WS = woodland shrubs.

Appendix C. Amphibians and reptiles known or likely to occur on Two Rivers National Wildlife Refuge (from U. S. Fish and Wildlife Service 2004).

Common Name	Scientific Name
Frogs and Toads	
Frog	*Acris crepitans*
American Toad	*Bufo americanus*
Woodhouse Toad	*Bufo woodhousii*
Cope's Gray Treefrog	*Hyla chrysoscelis*
Gray Treefrog	*Hyla versicolor*
Spring Peeper	*Pseudacris crucifer*
Illinois Chorus Frog	*Pseudacris streckeri*
Western Chorus Frog	*Pseudacris triseriata*
Northern Crawfish Frog	*Rana areolata*
Bullfrog	*Rana catesbeiana*
Green Frog	*Rana clamitans*
Pickerel Frog	*Rana palustris*
Southern Leopard Frog	*Rana sphenocephala*
Wood Frog	*Rana sylvatica*
Salamanders	
Smallmouth Salamander	*Ambystoma texanum*
Eastern Tiger Salamander	*Ambystoma tigrinum*
Longtail Salamander	*Eurycea longicauda*
Four-toed Salamander	*Hemidactylium scutatum*
Mudpuppy	*Necturus maculosus*
Central Newt	*Notophthalmus viridescens*
Slimy Salamander	*Plethodon glutinosus*
Lesser Siren	*Siren intermedia*
Lizards	
Six-lined Racerunner	*Cnemidophorus sexlineatus*
Five-lined Skink	*Eumeces fasciatus*
Broadhead Skink	*Eumeces laticeps*
Slender Glass Lizard	*Ophisaurus attenuatus*
Ground Skink	*Scincella lateralis*
Fence Lizard	*Sceloporus undulatus*
Snakes	
Copperhead	*Agkistrodon contortrix*
Western Worm Snake	*Carphophis amoenus*
Kirtland's Snake	*Clonophis kirtlandi*
Blue Racer	*Coluber constrictor*
Ringneck Snake	*Diadophis punctatus*
Great Plains Rat Snake	*Elaphe guttata*
Black Rat Snake	*Elaphe obsoleta*
Fox Snake	*Elaphe vulpina*
Eastern Hognose Snake	*Heterodon platirhinos*
Prairie Kingsnake	*Lampropeltis calligaster*
Speckled Kingsnake	*Lampropeltis getula*
Milk Snake	*Lampropeltis triangulum*
Yellowbelly Water Snake	*Nerodia erythrogaster*
Diamondback Water Snake	*Nerodia rhombifer*

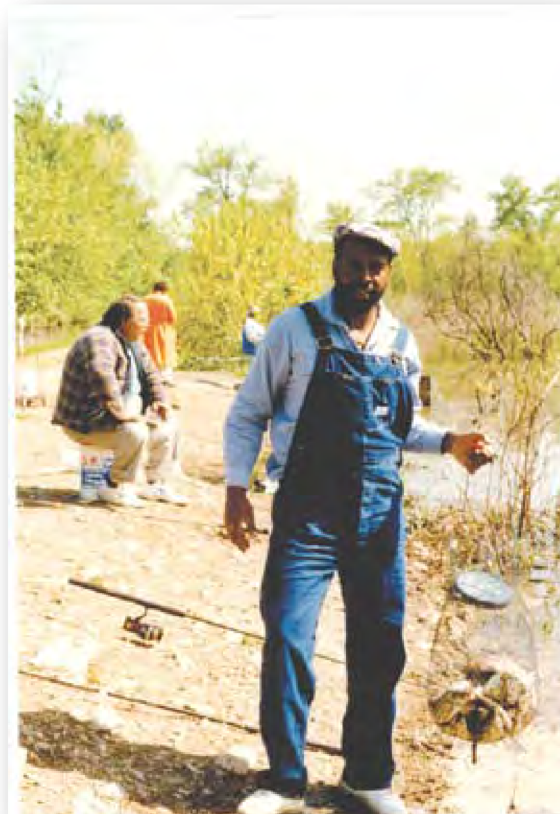
Common Name	Scientific Name
Northern Water Snake	*Nerodia sipedon*
Rough Green Snake	*Opheodrys aestivus*
Bullsnake	*Pituophis melanoleucus*
Graham's Crayfish Snake	*Regina grahamii*
Brown Snake	*Storeria dekayi*
Northern Red-bellied Snake	*Storeria occipitomaculata*
Western Ribbon Snake	*Thamnophis proximus*
Plains Garter Snake	*Thamnophis radix*
Eastern Garter Snake	*Thamnophis sirtalis*
Lined Snake	*Tropidoclonion lineatum*
Smooth Earth Snake	*Virginia valeriae*
Turtles	
Smooth Softshell Turtle	*Apalone mutica*
Spiny Softshell Turtle	*Apalone spinifera*
Snapping Turtle	*Chelydra serpentina*
Painted Turtle	*Chysemys picta*
Map Turtle	*Graptemys geographica*
False Map Turtle	*Graptemys pseudogeographica*
Mississippi Mud Turtle	*Kinosternum subrubrum*
Alligator Snapping Turtle	*Macroclemys temminckii*
River Cooter	*Pseudemys concinna*
Stinkpot	*Sternotherus odoratus*
Eastern Box Turtle	*Terrapene carolina*
Ornate Box Turtle	*Terrapene ornata*
Red-eared Slider	*Trachemys scripta*

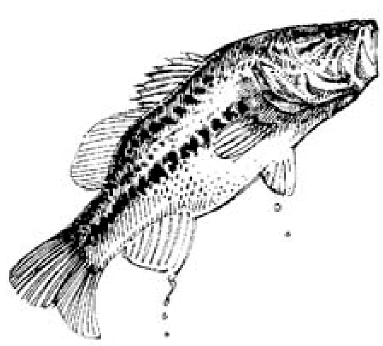
Appendix D. Fishes known or likely to occur on Two Rivers National Wildlife Refuge (from U. S. Fish and Wildlife Service 2004).

Common Name	Scientific Name
Bass Family	
White Bass	*Morone chrysops*
Yellow Bass	*Morone mississippiensis*
Bowfin Family	
Bowfin	*Amia calva*
Catfish Family	
Black Bullhead	*Ameiurus melas*
Yellow Bullhead	*Ameiurus natalis*
Brown Bullhead	*Ameiurus nebulosus*
Blue Catfish	*Ictalurus furcatus*
Channel Catfish	*Ictalurus punctatus*
Freckled Madtom	*Noturus nocturnus*
Tadpole Madtom	*Noturus gyrinus*
Stonecat	*Noturus flavus*
Flathead Catfish	*Pylodictis olivaris*
Drums	
Freshwater Drum	*Aplodinotus grunniens*
Eels	
American Eel	*Arguilla rostrata*
Gar	
Spotted Gar	*Lepisosteus oculatus*
Longnose Gar	*Lepisosteus osseus*
Shortnose Gar	*Lepisosteus platostomus*
Herring Family	
Skipjack Herring	*Alosa chrysochloris*
Gizzard Shad	*Dorosoma cepedianum*
Killifish Family	
Starhead Topminnow	*Fundulus dispar*
Blackstripe Topminnow	*Fundulus notatus*
Lampreys	
Chestnut Lamprey	*Ichthyomyzon castaneus*
Silver Lamprey	*Ichtyomyzon unicuspis*
Minnows	
Goldfish	*Carassius auratus*
Grass Carp	*Ctenopharyngodon idella*
Red Shiner	*Cyprinella lutrensis*
Common Carp	*Cyprinus carpio*
Western Silvery Minnow	*Hybognathus argyritis*
Mississippi Silvery Minnow	*Hybognathus nuchalis*
Plains Minnow	*Hybognathus placitus*
Bighead Carp	*Hypophthalmichthys nobilis*
Silver Carp	*Hypophthalmichthys molitrix*
Speckled Chub	*Macrhybopsis aestivalis*
Sicklefin Chub	*Macrhybopsis meeki*
Silver Chub	*Macrhybopsis storeriana*
Golden Shiner	*Notemigonus crysoleucas*
Emerald Shiner	*Notropis atherinoides*
River Shiner	*Notropis blennius*
Ghost Shiner	*Notropis buchanani*
Spottail Shiner	*Notropis hudsonius*
Silverband Shiner	*Notropis shumardi*
Pugnose Minnow	*Opsopoeodus emiliae*
Suckermouth Minnow	*Phenacobius mirabilis*
Southern Redbelly Dace	*Phoxinus erythrogaster*
Bluntnose Minnow	*Pimephales notatus*
Bullhead Minnow	*Pimephales vigilax*
Fathead Minnow	*Pimephales promelas*
Flathead Chub	*Platygobio gracilis*
Creek Chub	*Semotilus atromaculatus*
Mooneye Family	
Goldeye	*Hiodon alosoides*
Mooneye	*Hiodon tergisus*
Mosquitofish	
Western Mosquitofish	*Gambusia affinis*
Mudminnows	
Central Mudminnow	*Umbra limi*
Paddlefish	
Paddlefish	*Polyodon spathula*
Perch Family	
Mud Darter	*Etheostoma asprigene*
Bluntnose Darter	*Etheostoma chlorosomum*
Johnny Darter	*Etheostoma nigrum*
Yellow Perch	*Perca flavescens*
Logperch	*Percina caprodes*
Slenderhead Darter	*Percina phoxocephala*
River Darter	*Percina shumardi*
Sauger	*Stizostedion canadense*
Walleye	*Stizostedion vitreum*
Silversides	
Brook Silverside	*Labidesthes sicculus*

Appendix D. Fishes, cont'd.

Common Name	Scientific Name
Sturgeons	
Lake Sturgeon	*Acipenser fulvescens*
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*
Suckers	
Highfin Carpsucker	*Carpiodes velifer*
River Carpsucker	*Carpiodes carpio*
Quillback	*Carpiodes cyprinus*
White Sucker	*Catostomus commersoni*
Blue Sucker	*Cycleptus elongatus*
Smallmouth Buffalo	*Ictiobus bubalus*
Bigmouth Buffalo	*Ictiobus cyprinellus*
Black Buffalo	*Ictiobus niger*
Golden Redhorse	*Moxostoma erythrurum*
Shorthead Redhorse	*Moxostoma macrolepidotum*
Sunfish Family	
Rock Bass	*Ambliplites rupestris*
Green Sunfish	*Lepomis cyanellus*
Warmouth	*Lepomis gulosus*
Orange-spotted Sunfish	*Lepomis humilis*
Bluegill	*Lepomis macrochirus*
Smallmouth Bass	*Micropterus dolomieu*
Largemouth Bass	*Micropterus salmoides*
White Crappie	*Pomoxis annularis*
Black Crappie	*Pomoxis nigromaculatus*
Trout-perch	
Trout-perch	*Percopsis omiscomaycus*





Appendix E. Mammals known or likely to occur on Two Rivers National Wildlife Refuge (from U. S. Fish and Wildlife Service 2004).

Common Name	Scientific Name
Bats	
Big Brown Bat	*Eptesicus fuscus*
Silver-haired Bat	*Lasionycteris noctivagans*
Red Bat	*Lasiurus borealis*
Hoary Bat	*Lasiurus cinereus*
Gray Bat	*Myotis grisescens*
Little Brown Bat	*Myotis lucifugus*
Indiana Bat	*Myotis sodalis*
Eastern Pipistrel	*Pipistrellus subflavus*
Carnivores	
Coyote	*Canis latrans*
River Otter	*Lutra canadensis*
Bobcat	*Lynx rufus*
Striped Skunk	*Mephitis mephitis*
Long-tailed Weasel	*Mustela frenata*
Mink	*Mustela vison*
Raccoon	*Procyon lotor*
Badger	*Taxidea taxus*
Gray Fox	*Urocyon cineroargenteus*
Red Fox	*Vulpes fulva*
Hooved Animals	
White-tailed Deer	*Odocoileus virginianus*
Insectivores	
Short-tailed Shrew	*Blarina brevicauda*
Least Shrew	*Cryptotis parva*
Eastern Mole	*Scalopus aquaticus*

Common Name	Scientific Name
Marsupials	
Virginia Opossum	*Didelphis marsupialis*
Rabbits	
Eastern Cottontail	*Sylvilagus floridanus*
Rodents	
Beaver	*Castor canadensis*
Plains Pocket Gopher	*Geomys bursarius*
Southern Flying Squirrel	*Glaucomys volans*
Prairie Vole	*Microtus ochrogastor*
Pine Vole	*Microtus pinetorum*
Woodchuck	*Marmota monax*
House Mouse	*Mus musculus*
Muskrat	*Ondatra zibethicus*
White-footed Mouse	*Peromyscus leucopus*
Deer Mouse	*Peromyscus maniculatus*
Norway Rat	*Rattus norvegicus*
Western Harvest Mouse	*Reithrodontomy megalotis*
Eastern Fox Squirrel	*Sciurus niger*
Eastern Gray Squirrel	*Sciurus carolinensus*
Franklin's Ground Squirrel	*Spermophilis franklinii*
Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus*
Southern Bog Lemming	*Synaptomys cooperi*
Eastern Chipmunk	*Tamias striatus*
Meadow Jumping Mouse	*Zapus hudsonius*

Appendix F. Birds known or likely to occur on Two Rivers National Wildlife Refuge (from U. S. Fish and Wildlife Service 2004).

Common Name	Scientific Name
Grebes	*Podicipedidae*
Horned Grebe	*Podiceps auritus*
Pied-billed Grebe	*Podilymbus podiceps*
Cormorants	*Phalacrocoracidae*
Double-crested Cormorant	*Phalacrocorax auritus*
Pelicans	*Pelecanidae*
American White Pelican	*Pelecanus erythrothynchos*
Herons, Egrets, and Bitterns	*Ardeidae*
Least Bittern	*Ixobrychus exilis*
American Bittern	*Botaurus lentiginosus*
Black-crowned Night-Heron	*Nycticorax nycticorax*
Yellow-crowned Night-Heron	*Nycticorax violaceus*
Little Blue Heron	*Egretta caerulea*
Green Heron	*Butorides striatus*
Cattle Egret	*Bubulcus ibis*
Great Egret	*Casmerodius albus*
Snowy Egret	*Egretta thula*
Great Blue Heron	*Ardea herodias*
Swans, Geese, and Ducks	*Anatidae*
Tundra Swan	*Cygnus columbianus*
Greater White-fronted Goose	*Anser albifrons*
Snow Goose	*Chen caerulescens*
Canada Goose	*Branta canadensis*
Wood Duck	*Aix sponsa*
Mallard	*Anas platyrhynchos*
Duck, American Black	*Anas rubripes*
Gadwall	*Anas strepera*
Green-winged Teal	*Anas crecca*
American Wigeon	*Anas americana*
Northern Pintail	*Anas acuta*
Northern Shoveler	*Anas clypeata*
Blue-winged Teal	*Anas discors*
Ruddy Duck	*Oxyura jamaicensis*
Redhead	*Aythya americana*
Lesser Scaup	*Aythya affinis*
Greater Scaup	*Aythya marila*
Ring-necked Duck	*Aythya collaris*
Canvasback	*Aythya valisineria*
Bufflehead	*Bucephala albeola*
Common Goldeneye	*Bucephala clangula*
Long-tailed Duck	*Clangula hyemalis*
Common Merganser	*Mergus merganser*
Hooded Merganser	*Lophodytes cucullatus*

Common Name	Scientific Name
Vultures	*Cathartidae*
Turkey Vulture	*Cathartes aura*
Hawks, Kites and Eagles	*Accipitridae*
Bald Eagle	*Haliaeetus leucocephalus*
Golden Eagle	*Aquila chrysaetos*
Cooper's Hawk	*Accipiter cooperii*
Northern Goshawk	*Accipiter gentilis*
Sharp-shinned Hawk	*Accipiter striatus*
Broad-winged Hawk	*Buteo platypterus*
Red-shouldered Hawk	*Buteo lineatus*
Red-tailed Hawk	*Buteo Jamaicensis*
Rough-legged Hawk	*Buteo lagopus*
Northern Harrier	*Circus cyaneus*
Mississippi Kite	*Ictinia mississippiensis*
Osprey	*Panion haliaetus*
Falcons	*Falconidae*
Merlin	*Falco columbarius*
Peregrine Falcon	*Falco peregrinus*
American Kestrel	*Falco sparverius*
Pheasants, Grouse, and Quail	
Northern Bobwhite	*Colinus virginianus*
Wild Turkey	*Meleagris gallopavo*
Ring-necked Pheasant	*Phasianus colchicus*
Rails and Coots	*Rallidae*
King Rail	*Rallus elegans*
Virginia Rail	*Rallus limicola*
Sora	*Porzana carolina*
Yellow Rail	*Colurnicops noveboracensis*
Common Moorhen	*Gallinula chloropus*
American Coot	*Fulica americana*
Cranes	*Gruidae*
Sandhill Crane	*Grus canadensis*
Plovers	*Charadriidae*
Killdeer	*Charadrius vociferus*
Piping Plover	*Charadrius melodus*
Semipalmated Plover	*Gharadrius semipalmatus*
American Golden-Plover	*Pluvialis dominica*
Black-bellied Plover	*Pluvialis squatarola*
Avocets and Stilts	*Recurvirostridae*
American Avocet	*Recurvirostra americana*

Appendix F. Birds, cont'd.

Common Name	Scientific Name
Sandpipers and Allies	*Scolopacidae*
Willet	*Catoptophorus semipalatus*
Greater Yellowlegs	*Tinga melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Spotted Sandpiper	*Actitis macularia*
Solitary Sandpiper	*Tringa solitaria*
Red-necked Phalarope	*Phalaropus lobatus*
Wilson's Phalarope	*Phalaropus tricolor*
Sanderling	*Calidris alba*
Dunlin	*Calidris alpina*
Baird's Sandpiper	*Calidris bairdii*
White-rumped Sandpiper	*Calidris fuscicollis*
Stilt Sandpiper	*Calidris himantopus*
Western Sandpiper	*Calidris mauri*
Pectoral Sandpiper	*Calidris melanotos*
Least Sandpiper	*Calidris minutilla*
Semipalmated Sandpiper	*Calidris pusilla*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Short-billed Dowitcher	*Limnodromus griseus*
Common Snipe	*Gallinago gallinago*
American Woodcock	*Scolopax minor*
Upland Sandpiper	*Bartramia longicauda*
Buff-breasted Sandpiper	*Tryngites subruficollis*
Gulls and Terns	*Laridae*
Herring Gull	*Larus argentatus*
Ring-billed Gull	*Larus delawarensis*
Glaucous Gull	*Larus hyperboreus*
Bonaparte's Gull	*Larus philadelphia*
Franklin's Gull	*Larus pipixcan*
Thayer's Gull	*Larus thayeri*
Black Tern	*Chlidonias niger*
Caspian Tern	*Sterna caspia*
Common Tern	*Sterna hirundo*
Forster's Tern	*Sterna forsteri*
Doves	*Columbidae*
Mourning Dove	*Zenaida macroura*
Rock Dove	*Columba livia*
Cuckoos	*Cuculidae*
Yellow-billed Cuckoo	*Coccyzus americanus*
Black-billed Cuckoo	*Coccyzus erythropthalmus*
Owls	*Tytonidae/Strigidae*
Barn Owl	*Tyto alba*
Short-eared Owl	*Asio flammeus*
Long-eared Owl	*Asio otus*
Great Horned Owl	*Bubo virginianus*

Common Name	Scientific Name
Eastern Screech-Owl	*Otus asio*
Barred Owl	*Strix varia*
Nightjars	*Caprimulgidae*
Chuck-will's-widow	*Caprimulgus carolinensis*
Whip-poor-will	*Caprimulgus vociferus*
Common Nighthawk	*Chordeiles minor*
Swifts	*Apodidae*
Chimney Swift	*Chaetura vauxi*
Hummingbirds	*Trochilidae*
Ruby-throated Hummingbird	*Archilochus colubris*
Kingfishers	*Alcedinidae*
Belted Kingfisher	*Ceryle alcyon*
Woodpeckers	*Picidae*
Red-bellied Woodpecker	*Melanerpes carolinus*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Northern Flicker	*Colaptes auratus*
Yellow-bellied Sapsucker	*Sphyrapicus varius*
Downy Woodpecker	*Picoides pubescens*
Hairy Woodpecker	*Picoides villosus*
Pileated Woodpecker	*Dryocopus pileatus*
Tyrant Flycatchers	*Tyrannidae*
Eastern Kingbird	*Tyrannus tyrannus*
Great Crested Flycatcher	*Myiarchus crinitus*
Olive-sided Flycatcher	*Contopus borealis*
Eastern Wood-Pewee	*Contopus virens*
Eastern Phoebe	*Sayornis phoebe*
Alder Flycatcher	*Empidonax alnorum*
Yellow-bellied Flycatcher	*Empidonax flaviventris*
Least Flycatcher	*Empidonax minimus*
Willow Flycatcher	*Empidonax traillii*
Acadian Flycatcher	*Empidonax virescens*
Shrikes	*Laniidae*
Loggerhead Shrike	*Lanius ludovicianus*
Vireos	*Vireonidae*
Bell's Vireo	*Vireo bellii*
Yellow-throated Vireo	*Vireo flavifrons*
Warbling Vireo	*Vireo gilvus*
White-eyed Vireo	*Vireo griseus*
Red-eyed Vireo	*Vireo olivaceus*
Philadelphia Vireo	*Vireo philadelphicus*
Blue-headed Vireo	*Vireo solitarius*

Appendix F. Birds, cont'd.

Common Name	Scientific Name
Crows and Jays	*Corvidae*
American Crow	*Corvus brachyrhynchos*
Fish Crow	*Corvus ossifragus*
Blue Jay	*Cyanocitta cristata*
Larks	*Alaudidae*
Horned Lark	*Eremophila alpestris*
Swallows	*Hirundinidae*
Barn Swallow	*Hirundo rustica*
Cliff Swallow	*Hirundo pyrrhonota*
Bank Swallow	*Riparia riparia*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Tree Swallow	*Tachycineta bicolor*
Purple Martin	*Progne subis*
Chickadees and Titmice	*Paridae*
Black-capped Chickadee	*Parus atricapillus*
Carolina Chickadee	*Parus carolinensis*
Tufted Titmouse	*Parus bicolor*
Nuthatches	*Sittidae*
White-breasted Nuthatch	*Sitta carolinensis*
Red-breasted Nuthatch	*Sitta canadensis*
Creepers	*Certhiidae*
Brown Creeper	*Certhia americana*
Wrens	*Troglodytidae*
Marsh Wren	*Cistothrous palustris*
Sedge Wren	*Cistothorus platensis*
Bewick's Wren	*Thryomanes bewickii*
Carolina Wren	*Thryothorus ludovicianus*
House Wren	*Troglodytes aedon*
Winter Wren	*Troglodytes troglodytes*
Kinglets	*Regulidae*
Ruby-crowned Kinglet	*Regulus calendula*
Golden-crowned Kinglet	*Regulus satrapa*
Gnatcatchers	*Sylviidae*
Blue-gray Gnatcatcher	*Plioptila caerulea*
Thrushes and Allies	*Turdidae*
Veery	*Catharus fuscescens*
Hermit Thrush	*Catharus guttatus*
Gray-cheeked Thrush	*Catharus minimus*
Swainson's Thrush	*Catharus ustulatus*

Common Name	Scientific Name
Wood Thrush	*Hylocichla mustelina*
Eastern Bluebird	*Sialia sialis*
American Robin	*Turdus migratorius*
Mockingbirds and Thrashers	*Mimidae*
Gray Catbird	*Dumetella carolinensis*
Northern Mockingbird	*Mimus polyglottos*
Brown Thrasher	*Toxostoma rufum*
Starlings	*Sturnidae*
European Starling	*Strunus vulgaris*
Waxwings	*Bombycillidae*
Cedar Waxwing	*Bombycilla cedrorum*
Pipits	*Motacillidae*
American Pipit	*Anthus rubescens*
Wood Warblers	*Parulidae*
Black-throated Blue Warbler	*Dendroica caerulescens*
Bay-breasted Warbler	*Dendroica castanea*
Cerulean Warbler	*Dendroica cerulea*
Yellow-rumped Warbler	*Dendroica coronata*
Yellow-throated Warbler	*Dendroica dominica*
Blackburnian Warbler	*Dendroica fusca*
Magnolia Warbler	*Dendroica magnolia*
Palm Warbler	*Dendroica palmarum*
Chestnut-sided Warbler	*Dendroica pensylvanica*
Yellow Warbler	*Dendroica petechia*
Pine Warbler	*Dendroica pinus*
Blackpoll Warbler	*Dendroica striata*
Cape May Warbler	*Dendroica tigrina*
Black-throated Green Warbler	*Dendroica virens*
Worm-eating Warbler	*Helmitheros vermivorous*
Black-and-white Warbler	*Mniotilta varia*
Connecticut Warbler	*Oporornis agilis*
Kentucky Warbler	*Oporornis formosus*
Mourning Warbler	*Oporornis philadelphia*
Prothonotary Warbler	*Protonotaria citrea*
Orange-crowned Warbler	*Vermivora celata*
Golden-winged Warbler	*Vermivora chrysoptera*
Tennessee Warbler	*Vermivora peregrina*
Blue-winged Warbler	*Vermivora pius*
Nashville Warbler	*Vermivora ruficapilla*
Canada Warbler	*Wilsonia canadensis*
Hooded Warbler	*Wilsonia citrina*
Wilson's Warbler	*Wilsonia pusilla*
Common Yellowthroat	*Geothlypis trichas*

Appendix F. Birds, cont'd.

Common Name	Scientific Name
Yellow-breasted Chat	*Icteria virens*
Northern Parula	*Parula americana*
Ovenbird	*Seiurus aruocapillus*
Louisiana Waterthrush	*Seiurus motacilla*
Northern Waterthrush	*Seiurus noveboracensis*
American Redstart	*Setophaga ruticilla*
Tanagers	*Thraupidae*
Scarlet Tanager	*Piranga olivacea*
Summer Tanager	*Piranga rubra*
Cardinals and Allies	*Cardinalidae*
Northern Cardinal	*Cardinalis cardinalis*
Indigo Bunting	*Passerina cyanea*
Snow Bunting	*Plectrophenax nivalis*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Dickcissel	*Spiza americana*
Sparrows and Allies	*Emberizidae*
Henslow's Sparrow	*Ammodramus henslowii*
Le Conte's Sparrow	*Ammodramus leconteii*
Grasshopper Sparrow	*Ammodramus savannarum*
Lark Sparrow	*Chondestes grammacus*
Swamp Sparrow	*Melospiza georgiana*
Lincoln's Sparrow	*Melospiza lincolnii*
Song Sparrow	*Melospiza melodia*
American Tree Sparrow	*Spizella arborea*
Clay-colored Sparrow	*Spizella pallida*
Chipping Sparrow	*Spizella passerina*
Field Sparrow	*Spizella pusilla*
Fox Sparrow	*Passerella iliaca*
Savannah Sparrow	*Passerculus sandwichensis*
Eastern Towhee	*Pipilo erythrophtlalmus*
Vesper Sparrow	*Pooecetes gramineus*
White-throated Sparrow	*Zonotrichia albicollis*
White-crowned Sparrow	*Zonotrichia leucophrys*
Harris' Sparrow	*Zonotrichia querula*
Dark-eyed Junco	*Junco hyemalis*
Lapland Longspur	*Calcarius lapponicus*
Blackbirds and Allies	*Icteridae*
Bobolink	*Dolichonyx oryzivorus*
Eastern Meadowlark	*Sturnella magna*
Western Meadowlark	*Strunella neglecta*
Red-winged Blackbird	*Agelaius phoeniceus*
Rusty Blackbird	*Euphagus carolinus*
Brewer's Blackbird	*Euphagus cyanocephalus*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*

Common Name	Scientific Name
Brown-headed Cowbird	*Molothrus ater*
Common Grackle	*Quiscalus quiscula*
Baltimore Oriole	*Icterus galbula*
Orchard Oriole	*Icterus spurius*
Finches	*Fringillidae*
Pine Siskin	*Carduelis pinus*
American Goldfinch	*Carduelis tristis*
Purple Finch	*Carpodacus purpureus*
House Finch	*Carpodacus mexocanus*
Evening Grosbeak	*Coccothraustes verpertinus*
Old World Sparrows	*Passeridae*
House Sparrow	*Passer domesticus*
Eurasian Tree Sparrow	*Passer montanus*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