LITTLE CYPRESS CREEK STUDY: A WATERSHED RESTORATION CASE STUDY

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Abstract—The Little Cypress Creek watershed, which is the home of the Louisiana Purchase Historic State Park and Natural Area, is one of the only remaining examples of a headwater swamp ecosystem left in Arkansas. An increase in water elevations and a change in species composition were noticed in the park in late 1970. A study of the upper watershed of Little Cypress Creek was conducted to identify potential factors causing these changes. Water elevations, vegetative composition, and physical modifications were recorded and compared to historical information. A conceptual model of the watershed was developed summarizing current understanding and hypotheses. Although natural variability in rainfall explains some of the changes observed, roads, beaver dams, clearing, levee construction, and irrigation tail water inputs contribute to hydrologic changes in the study area. The vegetation changes observed in the study area are likely due to multiple stressors rather than any single factor.

INTRODUCTION

The Louisiana Purchase Historic State Park and Natural Area (Park) is located in eastern Arkansas at the intersection of Monroe, Lee, and Phillips Counties (fig. 1). The 37-ac Park contains a granite monument commemorating the 1803 purchase of the Louisiana Territory from France and marks the point from which all land surveys of the Louisiana Territory were referenced. The Park is not only historically significant, but it also is ecologically significant in that it preserves one of the remaining examples of a headwater swamp ecosystem left in the State.

Arkansas Department of Parks and Tourism (Parks & Tourism) and Arkansas Natural Heritage Commission (Natural Heritage) personnel noticed that water levels were increasing in the Park in the late 1970s and early 1980s. Between an 18-to 24-in. increase in surface water elevations was reported. In the early 1980s, Parks & Tourism and Natural Heritage personnel observed that a large number of overcup oaks (*Quercus lyrata* Walt.) on the slopes adjacent to the deep swamp were dying; and species such as button bush (*Cephalanthus occidentalis* L.) and smart weed (*Polygonum hydropiperoides* Michx.) were becoming more dominant.

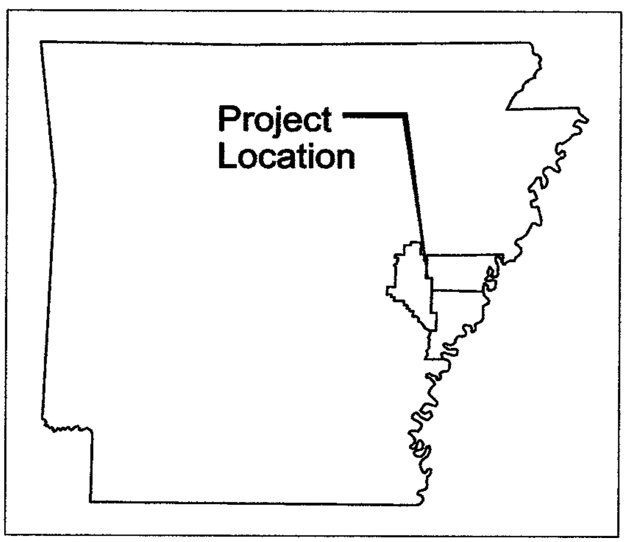

Figure 1—The Little Cypress Creek study area is located in eastern Arkansas at the intersection of Monroe, Lee, and Phillips Counties.

The ability to sustain this unique headwater swamp ecosystem and its rich heritage and values is an important goal for Parks & Tourism and Natural Heritage. Achieving this goal requires the cooperation of over 150 landowners within the Little Cypress Creek watershed. In 1998, Parks & Tourism and Natural Heritage initiated a study of the upper watershed of Little Cypress Creek as the first step in the process to achieve this goal. The objectives of this study were: (1) to identify the factors that most likely have or are contributing to changes in the upper watershed; and, (2) to build community and stakeholder interest and ownership in the restoration and long-term protection or sustainability of the swamp.

The results of phase one of the Little Cypress Creek watershed study are presented in this paper. The results of the initial historical and current data analyses and the community response to and involvement in the project are shown. A hydrologic or water-balance model and model analyses are being completed as phase 2, and the development of a conceptual plan for restoration will be completed as phase 3.

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PROJECT APPROACH AND METHODS

Community Involvement

The ultimate goal of this project is to develop a community-based restoration and protection plan that will be implemented by landowners and other stakeholders within the watershed. Community interest and involvement in the study is a critical component in the overall success of this project. Figure 2 shows the approach used to initiate and foster community involvement in the project. The approach consists of three interrelated and iterative steps: (1) community and stakeholder outreach; (2) education and community participation; and (3) transfer of project ownership to stakeholders. Steps one and two were initiated in this project.

Watershed Data and Analyses

The upper watershed of Little Cypress Creek was identified as the limits of the study (fig. 3) to make best use of project funding. As additional funding potentially becomes available, data collection efforts will be expanded to the lower parts of the watershed.

Available data and information describing historical and current conditions in the study area were obtained from a number of sources and through field surveys. These data and information were compared to current data to identify potential changes or factors within the study area that might have impacted water levels and plant communities.

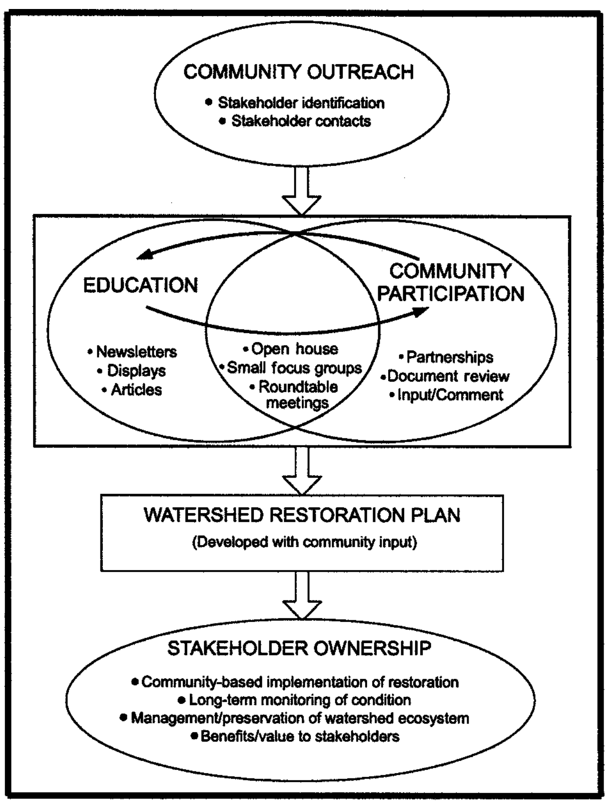

Figure 2—A three-stepped approach is being used to initiate and foster community involvement in the project.

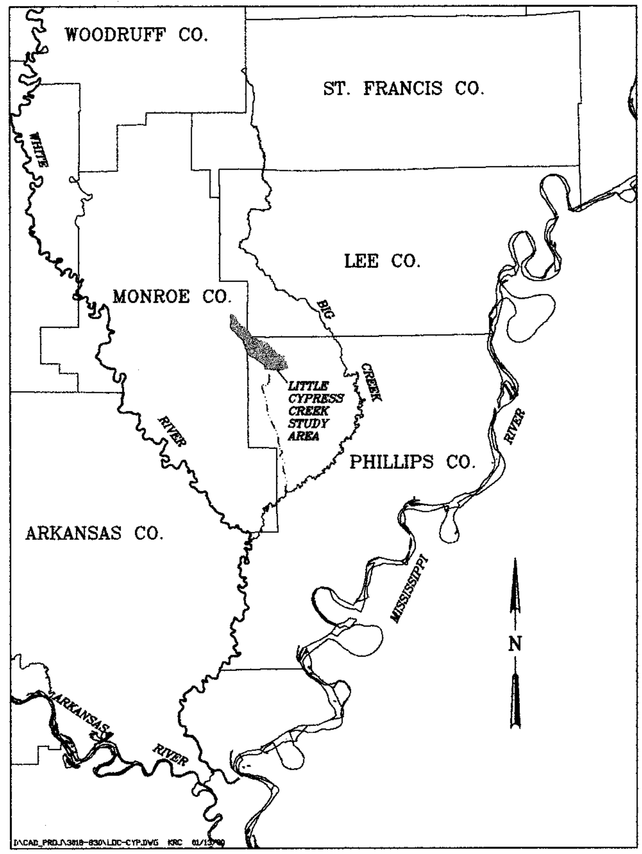

Figure 3—The Little Cypress Creek study area is located within the drainage basin of Big Creek within the White River watershed. The upper drainage area of Little Cypress Creek was the limits of phase 1 study area.

Drainage basin delineation—A preliminary delineation of the study area basin was made based on 1971 USGS topographic quadrangle maps (Monroe, Pine City, and Marvell, ARK 7.5 minute series maps). Field surveys were completed in April 1999 to confirm the preliminary drainage area delineation. Due to the flatness of the area, the drainage basin delineation will be refined as additional information on drainage patterns in the study area are collected.

Aerial photographs—Historical and current aerial photographs were used to identify changes in land use, drainage patterns, hydrologic modifications, and vegetation within and adjacent to the study area. Several sources for historical aerial photographs were investigated including the U.S. Department of Agriculture (USDA) Farm Service Agency (FSA) for Monroe and Phillips Counties, Arkansas State Highway and Transportation Department, and the USDA FSA Aerial Photography Field Office. The oldest aerial photographs of the site were found at the USDA FSA county offices. Black and white aerial photographs were obtained for Phillips County for the period covering 1969 through 1972. Black and white photos dated 1982 were obtained for Monroe County. No aerial photos were found for Monroe County before 1982. No aerial photographs were needed for Lee County because it was covered in the other photographs.

The USDA FSA Aerial Photograph Field Office obtained a set of color infrared photographs of the study area dated 1992. The watershed was flown in May 1999 to obtain current aerial photographs of the study area. Color infrared aerial photographs were produced.

Hydrometeorological data—Historical and recent precipitation and temperature data were available from the National Weather Service monitoring stations at Brinkley, Clarendon, and Marianna, AR. Monthly rainfall and temperature data for these stations were downloaded from CLIMATEDATAÔ (Hydrosphere 1998) for the period of record covering January 1948 through December 1998. Data for January 1999 through December 1999 were obtained from the climatological reports issued by the National Climatic Data Center. Daily rainfall and temperature data for the study period, i.e., February 1999 through August 1999, were obtained from the local observers. Based on the relative location to the study area, data from Clarendon and Marianna were averaged to develop mean annual and monthly precipitation totals for the study area. Data from Brinkley were only used to fill in missing data from the other two stations.

Runoff data—There are relatively few gauging stations within the immediate vicinity of the study area. The closest station is a discontinued station on Big Creek at Poplar Grove (USGS station 07077950) located southeast of the Little Cypress Creek study area. Data were available from this station for the period from 1970 through 1993. These data were supplemented with data from the L'Anguille River at Palestine (USGS station 07047950) to develop a historical record. This station was the closest station in the immediate vicinity that had similar land use. A comparison of annual runoff values from the L'Anguille River station with the Big Creek at Poplar Grove station for the overlapping period justified the use of the L'Anguille River data. The flow data were expressed as runoff in inches per year. The annual totals for the historical period and the mean monthly totals were obtained.

Government Land Office record review—Government Land Office survey records, housed at the Arkansas Geologic Commission office, document early land surveys throughout Arkansas. Records dating back to the original establishment of the Baseline and the 5th Principle Meridian, i.e., the location of the granite monument were reviewed. Information on the historical composition of vegetation in the watershed was obtained. Other vegetation accounts specifically relating to the watershed are practically nonexistent.

Arkansas Department of Heritage—Historical records maintained at the Arkansas Department of Heritage's Arkansas History Commission and Natural Heritage Commission offices also were reviewed to obtain available information on Little Cypress Creek upper watershed and the Louisiana Purchase Historic State Park. The available records spanned a time frame over the past 100 years.

Arkansas Department of Parks and Tourism—A review of files and records at Parks & Tourism's Planning and Development office was completed to obtain additional information on the historical condition or on activities and changes that have been documented for the Park. Information in these files covered a 30-year time frame from mid-1960 to mid-1990.

Water surface elevation measurements—No historical water-surface elevations were available or are known from the study area. To document current conditions within the study area, water-surface elevation data were collected at five locations within the study area (fig. 4). Three types of recording devices were used to measure water-surface elevations within the watershed: continuous stage recorders, staff gauges, and crest gauges.

Continuous stage recorders—Stevens™ stage recorders were placed at three locations within the Little Cypress Creek study area (fig. 4) to record water level data on a continuous basis during the study. One recorder (recorder 7) was placed adjacent to the granite monument to record water levels within the Park. A second recorder was placed on the upstream side of the road at the Cotton Trailer Road (recorder 3). This road is located in the approximate middle of the study area. The third recorder (recorder 9) was placed in the lower portion of the study area on the downstream side of Rogers Road. The monument and Cotton Trailer Road recorders were installed in the watershed in February 1999. The third recorder at Rogers Road was installed in June 1999 after a review of water-surface elevation data indicated that a recorder was needed in the lower part of the study area.

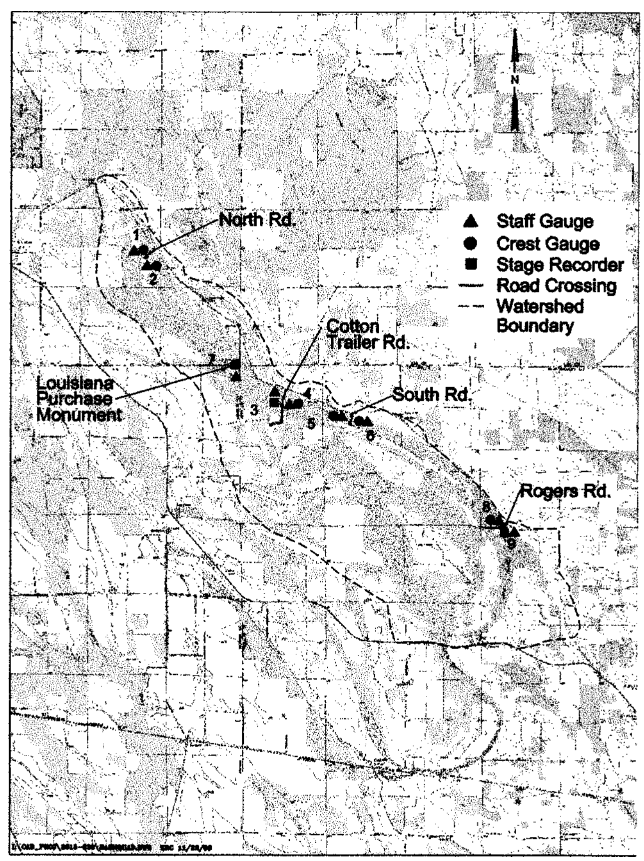

Figure 4—Locations of road crossings and water-surface elevation recorders in the study area.

The stage recorders were set to record changes in water-surface elevations over a 16-day period. Charts were replaced every 2 weeks from February 4, 1999, through August 9, 1999. Electronic data loggers were initially placed on the recorders at the monument and at the Cotton Trailer Road. Continuous water-elevation data were captured with the data loggers for a period of approximately 1 to 2 months, and the data were cross-referenced to the chart data to verify the operation of the recorders.

Staff gauges—A total of nine staff gauges were installed at five locations throughout the study area (fig. 4) to obtain instantaneous water-surface elevations. Only one staff gauge (staff gauge 7) was placed in the Park near the granite monument. Staff gauges were placed on the upstream and downstream sides of the North Road (staff gauges 1 and 2, respectively), the Cotton Trailer Road (staff gauges 3 and 4, respectively), the South Road (staff gauges 5 and 6, respectively), and Rogers Road (gauges 8 and 9, respectively). Staff gauges were surveyed at the beginning and end of the study. Staff-gauge readings were taken on a biweekly basis from February 4, 1999, to August 9, 1999.

Crest gauges—A total of six crest gauges were installed at three locations throughout the study area (fig. 4) to obtain the maximum surface-water elevation at designated locations within a 2-week period. Readings were taken on a biweekly basis from February 4, 1999, through August 9, 1999. Crest gauges were surveyed at the beginning and end of the study period.

Spot elevations—No historical survey data documenting land-surface elevations within the headwater swamp or elevation of the granite monument were found. The elevations of the recorders and gauges, top of the granite monument in the Park, and the ordinary high-water mark on the granite marker were surveyed. Road profiles were shot for the North Road, Cotton Trailer Road, South Road, and Rogers Road to determine the elevation of the lowest point along each road. Where culverts were present under the road, the elevation was obtained for the invert of each culvert.

Surface water withdrawals and irrigation—The Arkansas Soil and Water Conservation Commission was contacted to identify whether any registered riparian or nonriparian water users were located within the study area. Registered users are persons that withdraw greater than or equal to 1 ac ft of water per year from a stream or other waterbody within the State. The USDA Natural Resources Conservation Service County offices in Monroe and Phillips Counties were contacted to identify any water withdrawals within the study area.

Groundwater withdrawals—The U.S. Geologic Survey (USGS) was contacted to obtain a list of irrigation or other wells within the watershed. Although there are several irrigation wells in the study area (USGS 1968, 1984), no information on the amount of groundwater withdrawn from the study area was available from the USGS.

Vegetation surveys—Vegetation surveys were completed in the Little Cypress Creek study area on March 30, April 13, and May 13, 1999, to make observations of existing vegetation. These surveys also were completed to identify potential reference areas within the watershed for restoration. Dominant species, community types, and condition of vegetation were observed and recorded.

RESULTS

Aerial Photograph Review

Land use changes—Approximately 65 percent of the approximately 7,680-ac study area, i.e., approximately 12 mi^2, is currently in agricultural crop production with the remaining 45 percent in forests. Historically, hardwood forests were extensive within the watershed. The majority of land clearing in the study area occurred prior to 1969. Land clearing has been minimal in the Little Cypress Creek study area since that time. A total of 440 ac were cleared in the lower half of the study area, i.e., below the Park, between 1969 and 1982. No additional land clearing of significance was identified between 1982 and 1999. Overall, < 10 percent of the land within the study area had been converted from forest to agricultural land use between 1969 and 1999.

Drainage—The comparison of historical and current aerial photographs did not reveal any obvious changes in drainage patterns within the study area from 1969 to the present. However, discussions with landowners indicated that large changes in drainage patterns have occurred within the watershed, including an increase in pumped drainage and rerouting of flows within the watershed. Detailed mapping of drainage patterns was not conducted as part of this phase of the project but general patterns were recorded. Fields on the far-west side of the study area generally pump water into ditches that ultimately drain to the lower part of the study area. Most of the fields close to or adjacent to Little Cypress Creek either pump or discharge directly into the creek. Several ditches along the west and east sides of the study area carry water directly into Little Cypress Creek.

Levees—Levees have been constructed throughout the watershed to eliminate inundation of adjacent farmland or to hold water during the winter for hunting leases. Landowners in the study area indicate that since the early 1950s, a significant number of acres that historically provided storage of water within the system have been cleared and leveed. Approximately 320 ac were cleared and leveed between 1979 and 1982. Without additional historical and current information, the reduction in storage capacity within the study area could not be adequately quantified, but it is estimated that approximately one-third of the historical storage capacity of the study area has been lost.

Irrigation—Based on conversations with landowners, there has been an increase in the acres of irrigated lands within the study area since the early 1980s due to the conversion from soybeans to rice production. Within the study area, groundwater is continuously pumped onto the fields to eliminate stagnation of water and increased incidence of pests. Consequently, irrigation tail water is continuously discharged into Little Cypress Creek from April through September. Rapid discharges of large volumes of water into Little Cypress Creek also occur at the end of the rice-growing season in preparation for harvest. The volume of water entering the system from irrigated fields was not quantified as part of this phase of the study.

Roads—The historical aerial photographs showed that a number of road crossings existed within the study area prior to 1969. Figure 4 shows the locations of three major crossings south of the Park, i.e., Cotton Trailer Road, South Road, and Rogers Road, and one north of the Park, i.e., North Road, that were present in the study area in 1969 and that currently exist. No new road crossings were constructed in the watershed since 1969. The roadbed of Cotton Trailer Road was elevated some time in the 1990s to its present height.

Hydrometeorological Data

Precipitation—Annual precipitation totals in the study area range from 35.3 to 71.5 in. over the approximately 42-year period of record (table 1), and the long-term mean annual precipitation total is 51.1 in. A comparison of rainfall data for the study period, i.e., 1999, to historical data indicates that total precipitation for 1999 was approximately 4 in. less than the long-term average. The highest total annual rainfall of 71.5 in. was observed in 1979 and was approximately 20 in. greater than the mean annual total rainfall. Observations of an approximate 18-to 24-in. increase in water elevations in the Park made by Parks & Tourism and Natural Heritage personnel in the late 1970s are consistent with this data.

Average monthly precipitation totals for the study area (fig. 5) for the period of record range from approximately 3.0 to 5.3 in. The greatest amounts of precipitation typically fall during the months of November through May. The driest months are June through October. During the study period, conditions were much drier than the average during the fall of 1998. With the exception of February 1999, conditions during the study period were wetter in the winter and spring than long-term monthly mean values.

Runoff—The delineation for the upper Little Cypress Creek drainage area was based on historical topographic maps

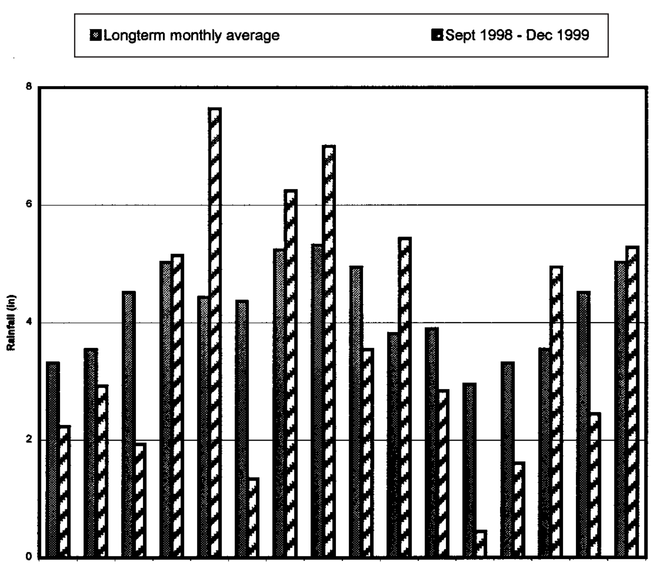

Figure 5—Comparison of monthly rainfall totals during the study period with long-term monthly average rainfall.

and a ground reconnaissance. Due to the flatness of the area and the many anthropogenic modifications for drainage, the basin boundaries are difficult to define and probably have changed over the years. Runoff averaged 18.3 in. per year or approximately 36 percent of precipitation. On a monthly basis, runoff varied from 0.46 in. or 12 percent of precipitation in July to 2.54 in. or 58 percent of precipitation in February.

Groundwater

Although irrigation wells exist within the study area (USGS 1968, 1984), there is no published groundwater level data to characterize groundwater levels within the Little Cypress Creek watershed or to confirm whether groundwater discharges to the Little Cypress Creek wetland ecosystem. Papers describing the geomorphology of the Little Cypress Creek drainage area and the HGM classification of wetlands in Arkansas (Klimas 1999, Saucier 1996) indicate that there is the potential for groundwater discharge into Little Cypress Creek. Based on groundwater data (USGS 1998) collected from a well located less than one-fourth of a mile south of the study area (local well 1S01E20DDB1), the water table may be as close as 10 to 20 ft below ground surface at ground surface elevations of 185 ft.

Hydrographs from wells located throughout the region show a general decrease in groundwater levels, since the mid-1950s (USGS 1998). Landowners with irrigation wells within the study area indicated that groundwater within the study area has not exhibited this trend. These observations are consistent with groundwater elevation data collected from a local well several miles south of the study area in Phillips County (local well 02S01E28CCB1). Data collected since 1955 from this well show that groundwater levels have varied over the 40-year period of record but have not been decreasing.

Water-Surface Elevations

Time series plots of water-surface elevations at the monument and at Cotton Trailer Road indicate that water-surface elevations within the wetland ecosystem follow seasonal rainfall patterns, increasing during the winter and early spring, then dropping during late summer and early fall. Early in the season, water levels in the swamp also rise in response to individual storm events (fig. 6). The corresponding rise in surface-water elevations with large storm events occurs mostly before leaf out and disappears during the latter part of the growing season when evapotranspiration is at its highest. The measured increase in water-surface elevations is greater than total precipitation inputs into the basin, indicating that runoff is an important hydrologic input into the system.

During the study period, maximum water-surface elevations in the Park were approximately 10 in. lower than the high-water mark on the granite marker. The high water levels observed in the late 1970s and 1990s were not observed during this study. Staff gage readings taken on the upstream and downstream sides of four major roads show that surface-water elevations on the upstream sides of the roads typically were higher than the downstream sides.

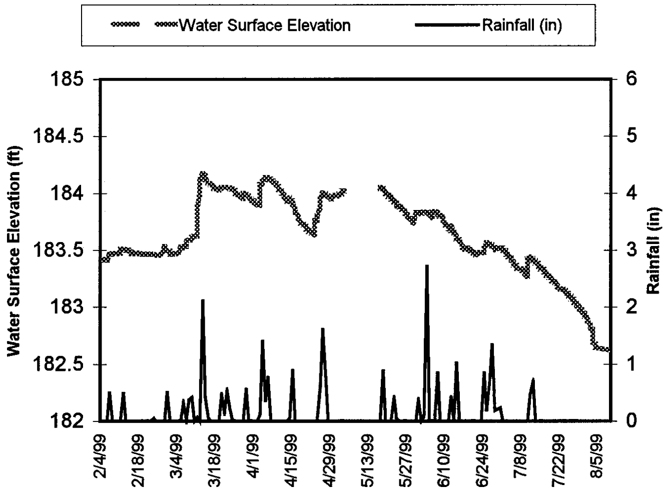

Figure 6—Continuous stage recorded within the Park (recorder 7), and daily rainfall from January 1999 through August 1999.

Surface-water profiles of the study area for the months of March, June, and July 1999 provide a graphical depiction of surface-water elevations relative to location in the watershed and the roads (figs. 7, 8, 9). Water-surface elevations drop over the season and typically are higher on the upstream side than the downstream side of the road. The profile from July shows an increase in surface-water elevations between the South Road and Rogers Road during a period when the water levels are dropping in other parts of the ecosystem. Landowners indicate that at times, water flows backwards, i.e., upstream, over the South Road.

Vegetation Assessment

The original survey notes of the Louisiana Purchase Monument area provide strong evidence that the basic vegetation and landscape features immediately surrounding the granite monument probably have changed little since 1815. The survey notes do not adequately distinguish between certain critical species. However, the records clearly denote that areas presently occupied by tupelo swamp were occupied by swamp in 1815. From the historical accounts, it appears that the area surrounding the granite monument ranged from being flooded to dry during the summer months. No historical information was found describing the vegetation in other areas of the Park or within the study area.

The upper watershed of Little Cypress Creek contains a diversity of upland and wetland plant communities. The central core of the wetland ecosystem supports the deepest water levels, i.e., 2 to 5 ft deep, and is dominated by water tupelo (*Nyssa aquatica* L.), although, in some cases, bald cypress (*Taxodium distichum* L.) also occurs. Historically, bald cypress was codominant in the deep swamps. With the exception of a few depressions within the deep swamp, timber harvest activities have removed most of the bald cypress from this community.

The shallowly flooded areas on the west side of the Park were dominated by overcup oak, red maple [*Acer rubrum* L. var. *rubrum* (BB) and *A. rubrum* L. var. *drummonii* (H. & A.) Sarg.], sweet gum (*Liquidambar styraciflua* L.), and button bush. Several dead snags of overcup oak are present within this community, and those that are alive exhibit morphological features indicative of stress. Tree branches are short, thickened, and knarled, and many exhibit epicormic branching. Almost all of the dead trees appear to be overcup oak and approximately the same age. The 1999 field surveys also identified that many overcup oaks near the entrance of the Park appear to be infected with a canker rot fungus. A large percentage of the oaks in this part of the Park and along the road leading into the Park are heavily infested with insect galls.

Beaver Impacts

Beaver dams exist throughout the watershed. Large beaver dams were recorded at the North Road, at the Cotton Trailer Road, in the vicinity of the South Road, and at the outlet end of the study area where Little Cypress Creek crosses Arkansas State Highway 49. Other beaver dams likely exist within the study area. Most of the beaver activity appears to take place in the more shallowly flooded areas and where there has been disturbance. The beaver-impacted area upstream of the North Road appears to have been in existence for approximately 30 years based on the size and appearance of the black willow (*Salix nigra* Marsh.) trees. Some of these areas also appear to have been cut over repeatedly by beaver. Beaver activity has resulted in a degradation of bottomland hardwood forests and loss of overstory and resulted in increased scrub/shrub communities dominated by black willow and buttonbush.

Timber Harvest

Historical and recent timber-harvesting activities have occurred throughout the study area. In drier portions of the swamp such as the area adjacent to the Park on the east, there is ample evidence of former timber-harvest activities in the form of stumps and downed logs. An open area within the swamp just upstream of the South Road has been impacted by timber harvest of bald cypress. No pole-sized timber or seedlings have become reestablished in this area.

DISCUSSION

Over the past decade there has been a shift away from the management and protection of natural resources on a site-by-site basis to the management and protection of natural resources on an ecosystem basis, i.e., watershed, landscape, or regional scale (Sparks 1995). The assessment, management, and protection of resources is being conducted on spatial scales ranging from millions of acres, such as in the Chesapeake Bay and the Florida Everglades, to hundreds of acres in individual drainage basins and watersheds. Current programs and regulatory mandates, e.g., unified watershed assessments, total maximum daily load studies, etc., are evidence that policy and decisionmakers, natural resource managers, scientists, regulators, and the public recognize that the sustainability of natural resources is dependent on the management of these resources at larger scales.

The attempt to manage resources and water within the Little Cypress Creek study area on an individual-by-individual farm basis has failed. As landowners have cleared, drained,

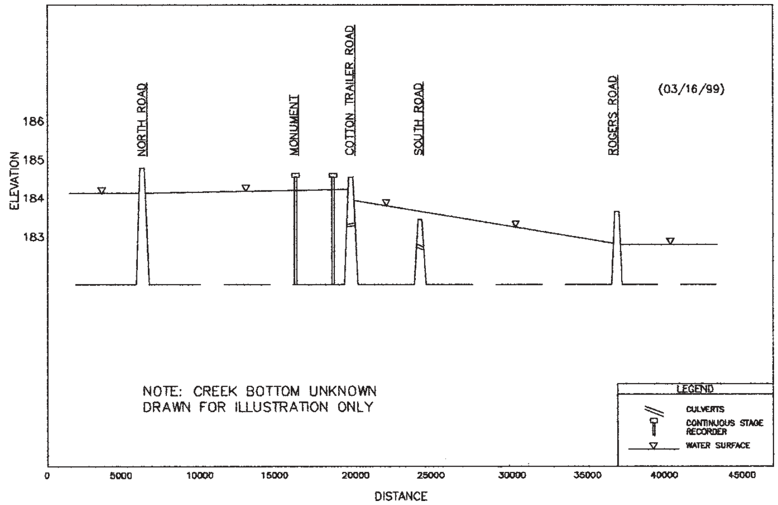

Figure 7—Water-surface profile in the Little Cypress Creek upper watershed study area on March 16, 1999.

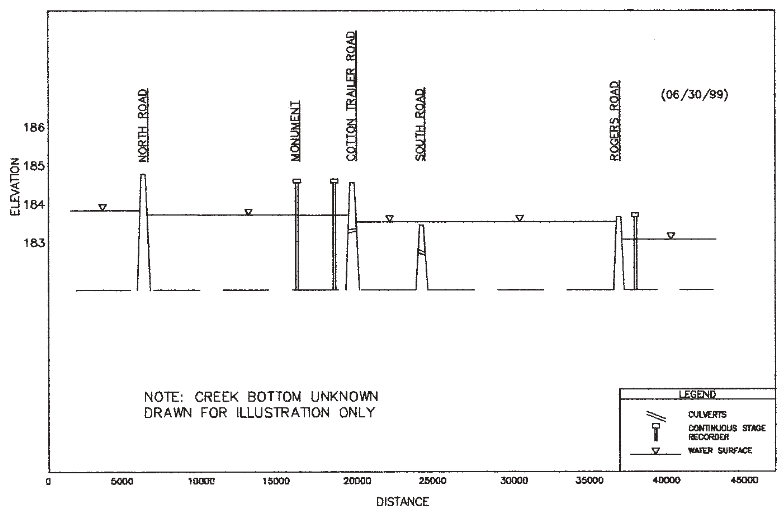

Figure 8—Water-surface profile in the Little Cypress Creek upper watershed study area on June 30, 1999.

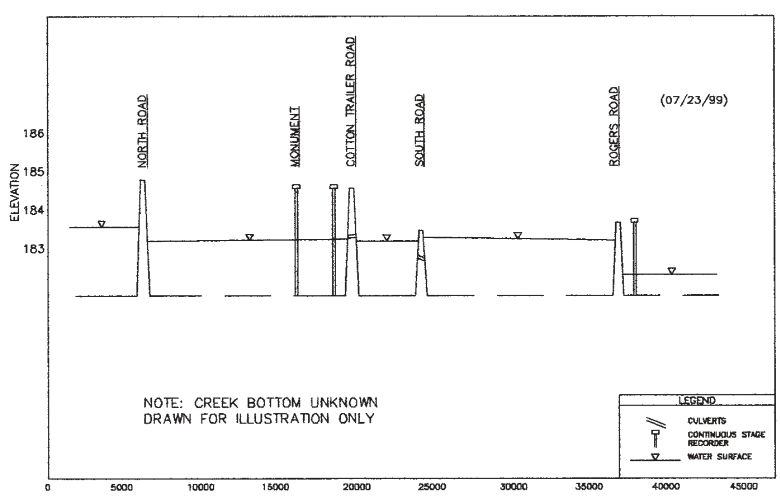

Figure 9—Water-surface profile in the Little Cypress Creek upper watershed study area on July 23, 1999.

or held water on one property, others have been flooded and lost timber on other parcels. Although small relative to other large-scale restoration and management efforts in the United States., a comprehensive watershed approach is needed to manage, restore, and sustain the values and condition of the Little Cypress Creek headwater swamp ecosystem.

Because little historical data is available to compare to current data and conditions, it is difficult to clearly identify and quantify the changes within the headwater swamp ecosystem. In the absence of historical data, the data collected in the phase 1 study were summarized in the context of a conceptual model (fig. 10). This conceptual model focuses on the changes in hydrology within the upper watershed, which can then be linked or correlated to other changes within the watershed, e.g., changes in plant community composition, changes in wildlife habitat and usage, etc. This conceptual model summarizes the hypotheses and assumptions that can be tested or evaluated and serves as a framework for identifying data gaps and future data needs or studies. The conceptual model will be modified and expanded over time as new information and data are gathered, the natural variability within the system is better quantified, and as changes or perturbations continue to occur within the system.

Changes in Storage

Alterations in the Little Cypress Creek upper watershed have had an influence on the historical hydrologic regime of the headwater swamp ecosystem. These changes can be expressed as a change in the water balance within the system. Although alterations within the watershed can either increase or decrease water stored within the swamp ecosystem, the direction of change in the Little Cypress Creek study area has been weighted more toward an increase in the amount of water stored within the Little Cypress Creek headwater swamp ecosystem (fig. 10).

Like most watersheds in the Mississippi Alluvial Plain of the Lower Mississippi Valley, bottomland and upland forests of the Little Cypress Creek watershed have been cleared for agricultural production. Approximately 65 percent of the Little Cypress Creek study area has been cleared of its original

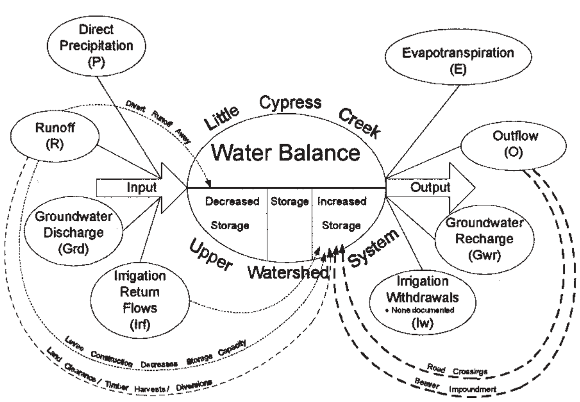

Figure 10—Conceptual model of potential factors affecting water storage within the Little Cypress Creek upper watershed study area.

forest cover and is in agricultural production. Clearing within the Little Cypress Creek study area likely has changed the amount and timing of runoff into the Little Cypress Creek headwater swamp. Continuous water-surface elevation data collected at the stage recorders indicate that changes in stage are greater than the total rainfall of any single storm event. The data suggest surface runoff during a storm event is an important input into the system.

Crop changes from soybeans to rice also have changed the hydrology of the Little Cypress Creek ecosystem. The timing of hydrological inputs has been altered, and inputs of water into the system are currently being extended into late summer and fall when natural precipitation and runoff inputs typically begin to decrease. Groundwater has now become a surface-water input into the system as it is pumped onto fields and discharged into the creek on a continuous basis from April through September.

Levee construction within the study area has largely been successful in keeping water off many parcels that historically were wet and supported bottomland hardwood forests. Levee construction, however, has effectively reduced the historical storage capacity, constricted drainage, and reduced total storage area within the watershed. Belt (1977) and Myers and White (1993) have documented that the constriction of the floodway has increased flood stage on the Mississippi River. Although the hydraulics of the Little Cypress Creek system are very different from the Mississippi River, the loss of storage capacity and constriction of drainage by levee construction can have the same effect. Without a concomitant reduction in hydrologic inputs, the amount of water stored within the remaining headwater swamp ecosystem and water levels will increase on a per-acre basis.

Road construction and the introduction of beaver have also contributed to the alteration of the natural hydrology of the system. The roads and the beaver dam at the North Road have compartmentalized the ecosystem and impeded natural flows within and discharge out of the system. In this low gradient, flat ecosystem where there is < 1 ft difference in elevation from the top of the watershed to the outlet end, water is easily impounded on the upstream sides of the roads increasing both the aerial extent of inundation and water depths within each compartment. The total acres inundated and depth of water within each compartment will depend on the amount, timing, and duration of the various hydrologic inputs into each of these compartments.

Above normal rainfall totals and increased runoff that occurred in the late 1970s and in the early 1990s are consistent with increased storage and increased surface-water elevations observed in the Park since the late 1970s. Based on these data alone, it would suggest that some of the increases in surface-water levels observed in the Park in the late 1970s through the early 1990s were due to natural variability in rainfall. Although no data are available to document whether water storage has increased in the Little Cypress Creek headwater swamp, it is indicated by this study that the cumulative effects of increased runoff, loss of storage capacity, constriction and impediments in the drainageway, and new hydrologic inputs should increase the amount of storage within the remaining headwater swamp ecosystem.

Vegetation Changes

Beaver impacts have become widespread throughout Arkansas since the reintroduction of this species in the State in the 1950s (Selander 1979). Beaver activities within the study area have led to a marked increase in sedimentation, loss of forest cover, and changes in vegetative composition. Some of these areas appear to have been affected by beaver for at least 30 years.

Changes in the duration, depth, and timing of flooding or inundation of bottomland hardwood systems are documented to have an effect on the survival of many bottomland hardwood trees (Theriot 1993, Whitlow and Harris 1979). Although it is reported that major changes in water level may cause mortality in water tupelo (Johnson and Beaufait 1965), no evidence of dead or stressed tupelo was observed within the Park or in the rest of the study area.

There is evidence of mortality in overcup oak near the entrance of the Louisiana Purchase Historic State Park. The oak mortality at the entrance to the Park appears, however, to represent an episodic event rather than a continuing occurrence at the site. Almost all of the dead trees appear to be overcup oak, and most appear to be of approximately the same age. In addition to mortality, many of the overcup oak trees that remain in this part of the Park are infected with what appears to be a canker rot fungus. Canker rot fungus has been reported to occur in bottomland hardwood forests in the South and to cause mortality in many wetland species (McCracken 1978), but overcup oak is not reported to be susceptible to canker rot (Morris 1965, Solomon 1990).

The reported flood tolerance of overcup oak varies from being very tolerant of deep flooding, i.e., flooding for more than 1 year (Theriot 1993, Whitlow and Harris 1979) to moderately tolerant; i.e., able to tolerate saturated or flooded soils for several months during the growing season but susceptible to high mortality if flooding persists or reoccurs several consecutive years (Hook 1984, McKnight and others 1981). A few reports indicate that high mortality in overcup oak is likely if flooding persists or reoccurs for a period greater than 3 years (Teskey and Hinckley 1978).

Historical precipitation data, however, show an approximate 10-year period of below average rainfall conditions from 1962 to 1972. The study suggests that dry conditions in the ecosystem from 1962 to 1972 could be as important a factor in stressing overcup oak as increased storage of water in the late 1970s. Periodic occurrences of oak decline have been reported in many areas of the southeast (Wargo and others 1983). The causes of oak decline are very complex and often are due to the interaction of multiple stressors (Leininger 1998, McCracken and others 1991, Wargo and others 1983). A combination of drought, flooding, changes in hydroperiods, and pest infestation could be important factors in the decline of overcup oak-dominated forest in the Park.

Community Involvement

Initial public participation in and response to this study has been positive. Many landowners cooperated with the study, and a partnership with the local high school was formed. Over 40 individual stakeholders have provided support to the project in the form of interest in the project, information, permission to enter property, permission to install scientific equipment on private property, and collection of data.

Involved landowners and stakeholders would like to see the Little Cypress Creek watershed restored to: (1) reduce flooding on their properties; (2) increase ability to farm marginal property; (3) restore lost bottomland hardwoods to increase income from hunting leases; and, (4) restore bottomland hardwood values for personal recreational opportunities. With a core group of landowners showing interest in the management and restoration of the Little Cypress Creek ecosystem, the initial steps in gaining community involvement in the project were considered successful. Like other community-based restoration programs that have been developed throughout the country to sustain natural resources (EPA 1997, French 1999), it is anticipated that it will take years to build a community-based alliance focused on the restoration of the Little Cypress Creek watershed.

The information collected in this first phase of the Little Cypress Creek watershed study has only begun to scratch the surface of the information needed to assess condition, determine restoration alternatives, and develop management plans for the watershed. Nevertheless, this study of the Little Cypress Creek upper watershed has lead to a number of important findings relative to the project goals and objectives; and community awareness of the issue has increased. A more organized or formal vehicle for stakeholder involvement has been established as a result of the study along with identification of those areas that are critical for continued investigation.

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