THE PLANNING LEVEL PLANT COMMUNITY AND WETLAND IDENTIFICATION OF HARRISON BAYOU WITHIN THE BOUNDS OF LONGHORN ARMY AMMUNITION PLANT, TX.

by

BOYD D. TRACY, B.S.F.

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APPROVED:

Dr. Hans M. Williams, Thesis Director

Dr. Victor Whitehead, Committee Member

Dr. James VanKley, Committee Member

David L. Jeffrey
Associate Vice President for
Graduate Studies and Research

ABSTRACT

Harrison Bayou is a unique remnant of the bottomland hardwood plant communities that once existed in the pre-settlement Lake Caddo region. This project focuses on Harrison Bayou within the confines of Longhorn Army Ammunition Plant (LHAAP) at Karnack, Texas. The project objectives were to identify and delineate major plant communities of Harrison Bayou and to identify which of these communities meet the requirements of a wetland according to the procedures outlined in the 1987 U.S. Corps of Engineers Wetland Delineation manual. Satellite imagery, aerial photos, and area maps have been utilized to create a Geographic Information System (GIS) database. Classification routines were performed on this database which identified and tentatively delineated the major vegetative communities within the study area. This delineation was used as the basis for sampling of the area. This sampling resulted in the identification of eleven community types in Harrison Bayou, six of which (51.25% of the total area) were identified as "wetland community types". The results of the plant community and wetland identification were entered into the GIS database and made

available to assist the LHAAP administration in managing this unique and precious natural resource of the East Texas region.

ACKNOWLEDGMENTS

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To my family, who have encouraged me in all my endeavors, I offer my sincere gratitude. Finally, to Jacqueline, who's endless support and understanding helped me through it all, I express my deepest gratitude and appreciation.

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INTRODUCTION

The bottomlands and streams of East Texas were once covered with a rich and diverse forest. However, many of these forests were removed as settlers encroached into the area. In presettlement times, there was an estimated 64,750 km^2 of bottomland hardwood and mixed riparian vegetation in Texas. By 1980, this area was reduced to 24,170 km^2 (Frye, 1987).

Prior to settlement, bottomland hardwood diversity was at its peak, with all stages of plant succession present. Trees of all ages, kinds, and sizes were present. Occasional floods imported nutrients from the uplands. There was a rich mosaic of wetland ecosystems present (Lay, 1987).

Harrison Bayou, a tributary of Caddo Lake on the Texas-Louisiana border, is an area that has been minimally impacted by man as compared to the rest of East Texas. When loggers first moved into the area around Caddo Lake, there were many areas that they were unable to cut over due to the inaccessibility of these areas and the primitive logging equipment of the time (Walker, 1983). By the time technology had advanced to the point where these areas were accessible, much of the area comprising Harrison Bayou had been incorporated into

Department of Defense (DoD) holdings and placed off-limits. Over time, those other areas that were initially inaccessible were cut over, until Harrison Bayou was one of the only areas that had not been cut.

In the years since its incorporation into what is now the Longhorn Army Ammunition Plant (LHAAP), the upland areas surrounding the bayou have been cut over several times. The bayou itself, however, has remained relatively untouched. As a remnant of some of the lands the first white explorers found, it serves as an example of what was present in East Texas prior to the European invasion.

The untouched areas of Harrison Bayou remain on DoD land. The DoD has recognized the value of the bayou, and has designated it as a "special management area." Nonetheless, future defense need could require the expansion of the munitions plant on LHAAP. Should this occur, the expansion could be planned in a manner that minimizes the impacts on the bayou. DoD land managers will require as much information as possible about Harrison Bayou to do so.

This project, which is being funded by the DoD through the Texas Regional Institute for Environmental Studies (TRIES), proposes to augment the current natural resource inventory of Harrison Bayou with a vegetative community characterization and wetland identification of Harrison Bayou. This characterization will include the delineation of the areas within the bayou that meet the requirements to be classified as a jurisdictional wetland.

LITERATURE REVIEW

Wetland Definition

Defining any ecological system is a difficult process, but several essentially similar definitions of wetlands do exist. Wetland definitions usually contain three components (Mitsch and Gosselink, 1993):

1. Wetlands are distinguished by the presence of water, either at the surface or within the root zone.
2. Wetlands often have unique soil conditions that differ from adjacent uplands.
3. Wetlands support vegetation adapted to the wet conditions (hydrophytes) and, conversely, are characterized by an absence of flooding-intolerant vegetation.

Although the U. S. Corps of Engineers (CoE) definition focuses on vegetation, the 1987 delineation manual does recognize that wetlands have three general diagnostic characteristics: hydrophytic vegetation, soils classified as hydric or possessing reducing conditions, and permanent or periodic inundation or saturation during the growing season. The current legal definition of wetlands, according to the 1987 Corps Manual, is: "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (Environmental Laboratory, 1987).

Wetlands occur over a wide range of landscape positions. Mitsch and Gosselink (1993) grouped wetlands into two major categories: coastal and inland. Coastal wetlands are those influcnced by the rise and fall of the tides of the ocean. Inland wetlands, those that are not influenced by the ocean tides, compose about 95% of the total wetlands in the lower 48 states of the U. S. (Frayer et al., 1983). Novitzki (1982) put forth a system for inland wetland classification that emphasizes hydrological processes. The system uses landscape position, depressions and slopes (including river, lake, and stream banks), and sources of water (groundwater or surface water) to describe inland wetlands.

Wetland Delineation

Delineation is the process of demarking a boundary. As it relates to wetlands within the United States, delineation is the process of determining where a legally defined wetland begins and ends, and therefore where the jurisdiction of the CoE begins and ends as outlined by section 404 of the Clean Water Act (CWA). In any area deemed as under the jurisdiction of the CoE, permits must be granted prior to any dredging, filling, or alteration of the wetland. It is important, therefore, to know exactly what lands are and what lands are not under the jurisdiction of the CoE.

The 1987 CoE wetland delineation manual was developed to provide guidelines and methods for determining whether an area is a wetland for the purposes of Section 404 of the Clean Water Act (Environmental Laboratory, 1987). The procedure examines the environmental characteristics of a potential wetland under the three parameters of hydrology , soils, and vegetation . To be considered a jurisdictional wetland, an area must possess indication of wetland conditions for all three parameters. Each of these parameters will be examined by this review in the following sections.

Wetland Hydrology

The hydrology of an area is the combination of all the factors that affect or are a result of the movement of water across the landscape. It exerts a controlling influence over all the processes and functions of wetlands. Nutrient input, output, and availability are dependent upon hydrology. Soil moisture, which is a component of hydrology, regulates the properties of aeration, redox potential, pH, mineral dissolution and organic matter accumulation (Haering et al., 1992). In addition, flood waters may deposit sediment and nutrients. Vegetation type and productivity are responsive to the specific hydrologic conditions of their environment (Gosselink and Turner, 1978).

One of the primary factors of the hydrology of an area is the hydroperiod. Hydroperiod is the seasonal pattern of a wetland's water level that defines the rise and fall of the its surface and subsurface water. The hydroperiod is the result of the balance between inflow and outflow of water, but also is influenced by physical features of the terrain and by proximity to other bodies of water (Mitsch and Gosselink, 1993).

Hydroperiod can affect potential primary productivity. Mitsch and Ewel (1979) found that productivity of baldcypress (*Taxodium distichum* (L.) L. C. Rich.) trees was greater under conditions of water level fluctuation than it was under conditions that were either continually flooded or continually drained. Also, it has been shown that much of the variation of productivity in cypress wetlands in Florida could be explained by variation in nutrient inflow (Brown, 1981). Productivity is lowest where the only nutrient inflow is from precipitation and is the highest where nutrients are brought in by flowing water. However, some researchers caution that it is a bad idea to ascribe a direct linkage between hydrologic variables and wetland productivity. Richardson (1979) states that it is not possible to make a definitive statement about the influence of water levels on primary productivity because the responses of individual species to water fluctuations vary. In response to this it should be noted that, although the responses of individual species to water level fluctuations vary, the responses of ecosystems may be more consistent (Mitsch and Gosselink, 1993).

Hydrology affects species composition and diversity. The action of the water and sediment deposition create differences across the landscape, which open up ecological niches (Gosselink and Turner, 1978). In fact, water level fluctuations have been likened to forest fires in their effect of eliminating one growth form of vegetation in favor of another (Keddy, 1992).

While it is true that hydrologic conditions affect most of the components of a wetland, it is also true that several of those components affect the hydrologic conditions of that wetland. For instance, wetland vegetation affects hydrologic conditions by binding sediments to reduce erosion, by trapping sediment, by interrupting water flows, and by building peat deposits (Gosselink, 1984). Animals can also affect hydrologic conditions. For example, it is well known that beavers (*Castor canadensis*) can create or destroy wetland habitats. They build dams which back up water, creating flooded areas where none was before (Naiman et al., 1991).

One component of wetlands most affected by hydrology is dead organic matter (OM). When decomposition and export are less than accumulation, organic matter builds up. This can occur as a result of either increased primary productivity or decreased organic matter export (Mitsch and Gosselink, 1993). Hydrology is the primary means of OM export. A high rate of export can be expected from wetlands that are open to the flow-through of water, such as riparian wetlands. The effect of hydrology on the actual decomposition of organic matter is unclear. There are conflicting results on this issue. Brinson et al. (1981) found that increased frequency or duration of saturation will not necessarily increase decomposition rates, but they did suggest that alternating wet and dry conditions are more optimum for litter decomposition than are constant anaerobic conditions.

Nutrient availability is affected almost exclusively by the hydrologic conditions. Input (in the form of precipitation, flooding, tides, and ground or surface water) and output (outflow of waters) of nutrients are controlled by water flow. Also, the availability of nutrients to vegetation in the wetland is effected by hydrology. Nitrogen is easily lost to the atmosphere, for instance, when a soil is waterlogged (Mitsch and Gosselink, 1993).

Wetland hydrology has a number of specific effects on vegetation and soils. Long periods of saturation may cause anaerobic soil conditions, limiting the number of species that can thrive. However, flood waters are an important source of nutrients and the differential deposition of sediments by flood waters can enhance spatial heterogeneity of the plant community. Both of these factors encourage species richness (Gosselink and Turner, 1978).

The rate of water flow through a wetland influences its vegetative productivity. Stagnant and/or slow flows yield lower net productivity than does fast flowing water due to the slower rate of oxygen and nutrient exchange (Brinson et al., 1981).

Many of the hydrologic factors that occur in a wetland make themselves evident in the form of visible indicators. These indicators are utilized in the wetland delineation process as clues to the presence of wetland conditions in the recent past (Environmental Laboratories, 1987). The indicators thus used include the presence of surface water, saturated soils, or a water table only a few centimeters below the soil surface. Also, water marks, drift lines, sediment deposits, waterstained leaves, crayfish castles, and drainage patterns can indicate wetland conditions that have been present in the recent past. In addition, clues other than those found at the site itself can indicate wetland hydrology. These can include past aerial photos or gage data, local soil survey information, or even individuals who are knowledgeable about the site.

Hydric Soils

Wetland soils are generally characterized by prolonged periods of saturation and the accumulation of organic matter (Faulkner and

Richardson, 1989). These soils can be further differentiated by the amount of accumulated organic matter they contain Some wetland soils are dominated by organic materials, while others that contain elevated levels of organic matter may still be dominated by mineral components and are therefore classified as mineral soils (Soil Survey Staff, 1990).

According to Soil Taxonomy, wet soils are classified in the aquic moisture regime. An aquic moisture regime is defined by the Soil Survey Staff (1990) as one in which the whole soil becomes saturated long enough for dissolved oxygen to become depleted to the surface and for reducing conditions to occur. Wetland soils are of two types: mineral soils, classified at the suborder level by the letters "aqu", and organic soils, classified as Histosols (Soil Survey Staff, 1990).

Mineral soils develop certain diagnostic characteristics when saturated for extended periods of time. In particular, saturated soils can become gleyed, which is a development of a gray or blue-gray color due to the chemical reduction of iron ($Fe^{+++} \rightarrow Fe^{++}$). Also, soils which are alternately wet and dry can develop mottles. Mottles are pockets of oxidized iron or manganese in an otherwise reduced soil matrix. They are either orange/reddish-brown, in the case of iron, or reddish-brown/black, in that of manganese (Mitsch and Gosselink, 1993).

Oxygen diffuses much more slowly through water than it does through air. The absence of air-filled pores and the lack of soil continuity to the surface in saturated soils causes oxygen to move an estimated 10,000 times slower in them than it does through well drained soils (Gambrell and Patrick, 1978). When microbial processes consume oxygen faster than it is supplied, the soil becomes anaerobic. It has been shown that when oxygen-containing soil is saturated, microbial and chemical oxidation consumes the remaining soil oxygen within a few hours to a few days (Faulkner and Richardson, 1989).

Depletion of oxygen is not uniform throughout the soil profile. Parker et al. (1985) conducted a study that related redox potential and oxygen distribution in soils to wetness and depth of profile. They found that O_2 concentration and redox potential decreased with increasing wetness and depth from surface. Unless the water over the surface of the soil has been stagnant for some time, its O_2 concentration will be higher than that of the soil below it due to photosynthesis of algae, low density of respiring organisms, and mixing of water (Gilmour and Gale, 1988; Howeler and Bouldin, 1971). This creates a thin layer of oxidized soil on the surface above more reduced layers of soil.

Redox potential (oxidation-reduction potential) is a measure of the tendency of a soil to oxidize or reduce substances (Faulkner and Richardson, 1989), and is often used to quantify the degree of electrochemical reduction of wetland soils. Oxidation occurs when a chemical loses an electron or hydrogen atom. Reduction is just the opposite, when a chemical gains an electron or hydrogen atom (Mitsch and Gosselink, 1993). Redox potential is measured in units of milivolts (mv).

Organic matter is one of the most reduced of substances in the soil, so it acts as a source of electrons and is oxidized whenever a terminal electron acceptor is present in the soil. This oxidization uses the electron acceptors in a predictable, sequential order. Table 1 lists several common soil elements and their redox potential. A particular acceptor is used until it has been exhausted, at which time an acceptor of lower redox potential is utilized. It should be noted that the redox potentials are not precise thresholds, however. Temperature and pH are important factors in the rate of transformation (Mitsch and Gosselink, 1993).

Table 1. Oxidized and reduced forms and approximate redox potentials of several common elements found in wetland soils.

Element	Oxidized Form	Reduced Form	Approx. Redox Potential (mv)
Oxygen	O_2	H_2O	400 to 600
Nitrogen	NO_3	N_2O, N_2, NH_4^+	250
Manganese	Mn^{+4}	Mn^{++}	225
Iron	Fe^{+++}	Fe^{++}	120
Sulfur	SO_4^{--}	S^{--}	-75 to -150
Carbon	CO_2	CH_4	-250 to -350

from Mitsch and Gosselink, 1993.

Anaerobic conditions occur when the free oxygen in the soil has been reduced and other electron acceptors begin to be reduced. In anaerobic conditions, decomposing bacteria must use these other electron acceptors. However, the energy yield is lower when these elements are used as compared to when oxygen is used. For example, 1.6 times more NO_3- is required than O_2 to produce the same amount of energy (Reddy et al., 1986).

The decreased energy yield in anaerobic respiration results in a decreased population of microbes and, therefore, a decreased rate of organic matter decomposition in wetlands (Neue, 1985). A study found that a soil anaerobically incubated for 128 days produced roughly half the CO_2 that aerobically incubated soils did (Reddy and Patrick, 1975). It also found that, contrary to the findings of other studies, alternating periods of aerobic and anaerobic conditions did not result in significantly greater organic matter decomposition than did aerobic conditions only. The decreased organic matter decomposition allows deep organic layers (peat) to accumulate in many wetland soils.

Lowered soil redox potential in a saturated soil is accompanied by changes in soil pH: the pH of most alkaline soils is lowered while the pH of most acid soils tends to rise. Both types of soils will end up with a pH of near 7 (Mitsch and Gosselink, 1993). This pH change is attributed to the build-up of CO_2 in alkaline soils and to the reduction of Fe-oxyhydroxides in acid soils (Faulkner and Richardson, 1989).

The previous chemical processes can be interpreted in the field in the form of field indicators of hydric soils. These indicators are clues that suggest a site possesses hydric soils, and, therefore, wetland conditions (Environmental Laboratories, 1987). These field indicators include the presence of mottles and the presence of a gleyed matrix, which indicate reducing conditions, direct indication of reducing conditions using αα-diphedryl, and the presence of a histic epipedon, which indicates reduced organic matter decomposition. Also, a soil may be listed on a national, state, or local hydric soil lists or may posses an aquic moisture regime.

Hydric Vegetation

There are many different types of plants that can be found in wetlands. Some of these plants grow only in wetlands, while others grow in wetlands and uplands both. Those species of plants that are found in wetlands a majority of the time can be used as one of the indicators of wetland conditions when a wetland identification or delineation is necessary.

Wetland plant species are defined as those species which have demonstrated an ability (presumably because of morphological and/or physiological adaptations and/or reproductive strategies) to achieve maturity and reproduce in an environment where all or portions of the soil within the root zone becomes periodically or continuously saturated or inundated during the growing season (Reed, 1988).

The U.S. Fish and Wildlife Service has developed a list of plants that grow in the nation's wetlands (Reed, 1988). This list is subdivided into regionai iists, each specific to an area of the country. Each plant is listed by scientific name and common name, if known, along with the plant's wetland indicator status. The wetland indicator status represents a plant's frequency of occurrence in wetlands. There are five major indicator categories:

1. obligate wetland (OBL) - greater than 99% occurrence in wetlands
2. facultative wetland (FACW) - 66-99% occurrence in wetlands
3. facultative (FAC) - 33-66% occurrence in wetlands
4. facultative upland (FACU) - 1-33% occurrence in wetlands
5. obligate upland (UPL) - less than 1% occurrence in wetlands.

In addition to these four categories, each category is often further split by breaking the range of the category into thirds and labeling them as "+", "-", and neutral, with "+" having a higher percentage of occurrence than neutral, which has a higher percentage of occurrence than "-". The obligate wetland, facultative wetland, and facultative plants are the best indicators of a wetland, while the facultative upland and obligate upland plants are the least useful as indicators of wetlands and are typically indicators of upland conditions (Tiner, 1988).

Plants that can survive wetland conditions do so because they have developed adaptations that make them more tolerant to these conditions. There are several different types, including structural, hormonal, physiological, and reproductive adaptations.

Structural adaptations include the development of aerenchyma (air spaces) in roots and stems, which allow diffusion of oxygen from the aerial portions of the plant. These aerenchyma develop either by the separation of cells during maturation or by cell breakdown (Mitsch and Gosselink, 1993). Flood-tolerant species respond to inundation by increased aerenchyma development (Burdick and Mendelssohn, 1990). Also, plants may develop adventitious roots, which form just above the submerged tissue (Jackson, 1985). Another response to inundation, found primarily in herbaceous species, is rapid stem elongation, which functions to increase the aerial portion of the plant (Mitsch and Gosselink, 1993).

Hydrophytes also have hormonal changes when subjected to flooding. The primary hormone affected is ethylene. Ethylene production is stimulated by flooded conditions, and it in turn stimulates physical responses in the plant (Mitsch and Gosselink, 1993). One response is the stimulation of cellulase activity and the subsequent disintegration of cell walls, which forms aerenchyma (Kawase, 1979). Ethylene may also be responsible for the production of adventitious roots (Mitsch and Gosselink, 1993).

Plants have also developed physiological adaptations to survive in flooded conditions. Oxidized rhizospheres are an effective adaptation in most flood-tolerant species that may offset the toxicity of soluble reduced ions, such as manganese, found in flooded soils. Flood-tolerant plants use various means to transport oxygen to their roots, which can no longer draw oxygen from the soil. This oxygen comes into contact with the reduced ions in the soil surrounding the roots and oxidizes them. The oxidized ions, no longer soluble, precipitate out of solution into the rhizosphere, which effectively detoxifies them (Armstrong, 1975).

Nutrient uptake is among the first of the processes affected by a flooded condition. In general, flood-intolerant species lose the ability to control nutrient absorption, whereas flood-tolerant species maintain normal nutrient absorption. This may be due to the flood-tolerant species' ability to maintain near-normal metabolism in flooded conditions (Mendelssohn and Burdick, 1988).

Another physiological adaptation to flooded (as well as arid) conditions is the C_4 biochemical pathway of photosynthesis. This method of photosynthesis utilizes CO_2 more efficiently than its counterpart, the C_3 method. This is especially important in saline wetlands that, due to the high salt content of the water, have water availability to plants similar to arid regions. Since CO_2 absorption requires open stomata, and open stomata allow water to escape the plant leaves, those plants that can use CO_2 more efficiently, and therefore reduce the time the stomata need to be open, have a distinct advantage (Mitsch and Gosselink, 1993).

Most flood-tolerant species have developed reproductive adaptations to "work around" the flooded period of the year. These include delayed or accelerated flowering to produce seed during non-flooded periods, the production of buoyant seeds, aerial flowers in emergent and submersed aquatic plants, and vivipary, which is the germination of seeds while still attached to the parent (Mitsch and Gosselink, 1993).

Southeastern Riparian Ecosystem

The southeastern alluvial river swamp ecosystem is a special type of wetland that exists along the course of rivers and streams that occur in the southeastern United States. Mitsch and Gosselink (1993) describe these areas as being dominated by a diversity of trees that are adapted to the wide variety of environmental conditions on the floodplain.

The most important local environmental condition in this type of system is the hydroperiod, which determines the "moisture gradient", which varies in time and space across the floodplain (Mitsch and Gosselink, 1993).

Eastern Texas is part of the Eastern Deciduous Forest Formation of North America (Braun, 1950). Although once a wide ranging and major component of the East Texas portion of this formation, bottomland hardwood forests have been seriously depleted by incursions and logging of man. Bottomland hardwoods and mixed riparian vegetation decreased by 63% in Texas from presettlement times to 1980 (Frye, 1987). Cypress swamps were the most severely modified bottomland hardwoods because of the high value of cypress wood. Most of the bottomlands were altered by logging by the early 1900s (Bray, 1906).

According to Wilkinson et al. (1987), of the 73 plant species considered to be of special concern in eastern Texas, 48 are found in bottomland hardwoods or associated wetlands.

OBJECTIVES

The purpose of this project was to identify and classify the major plant communities of Harrison Bayou within the confines of LHAAP, and to identify which of these communities are wetlands.

Individual objectives included:

1. Using satellite imagery, aerial photos, and area maps, create a Geographical Information System (GIS) database to be used to delineate the major vegetative communities of Harrison Bayou within the confines of Longhorn Army Ammunition Plant.
2. Identify and classify each of the vegetative communities.
3. Using the 1987 Corps of Engineers Wetland Delineation Manual wetland delineation procedure, identify the wetland plant communities (Environmental Laboratory, 1987).

METHODS

Location Of Study Area

LHAAP lies on the shore of Lake Caddo, in the north-eastern corner of Texas (Figures 1 and 2). It is just east of Karnack, Texas, and about 15 miles northeast of Marshall, Texas. Harrison Bayou occupies approximately 5 km^2 within the bounds of LHAAP, in the eastern half of the plant (Figure 3).

Study Establishment

As the area to be studied lies within the confines of LHAAP, it was necessary to obtain permission from the facility administration to be allowed to work in Harrison Bayou. Once this permission was obtained and access to the base established, the study commenced as described below.

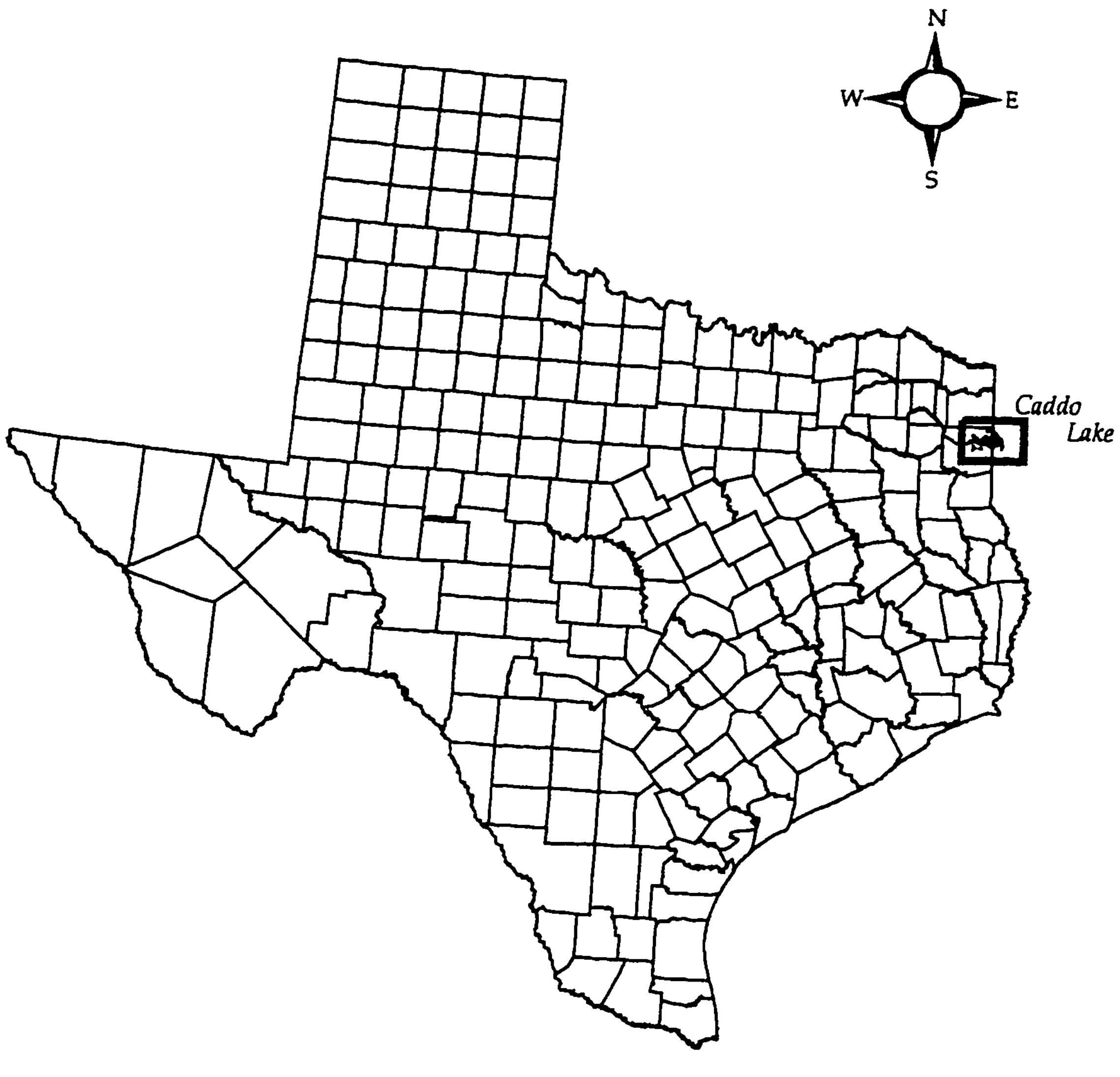


Figure 1. The location of Caddo Lake.

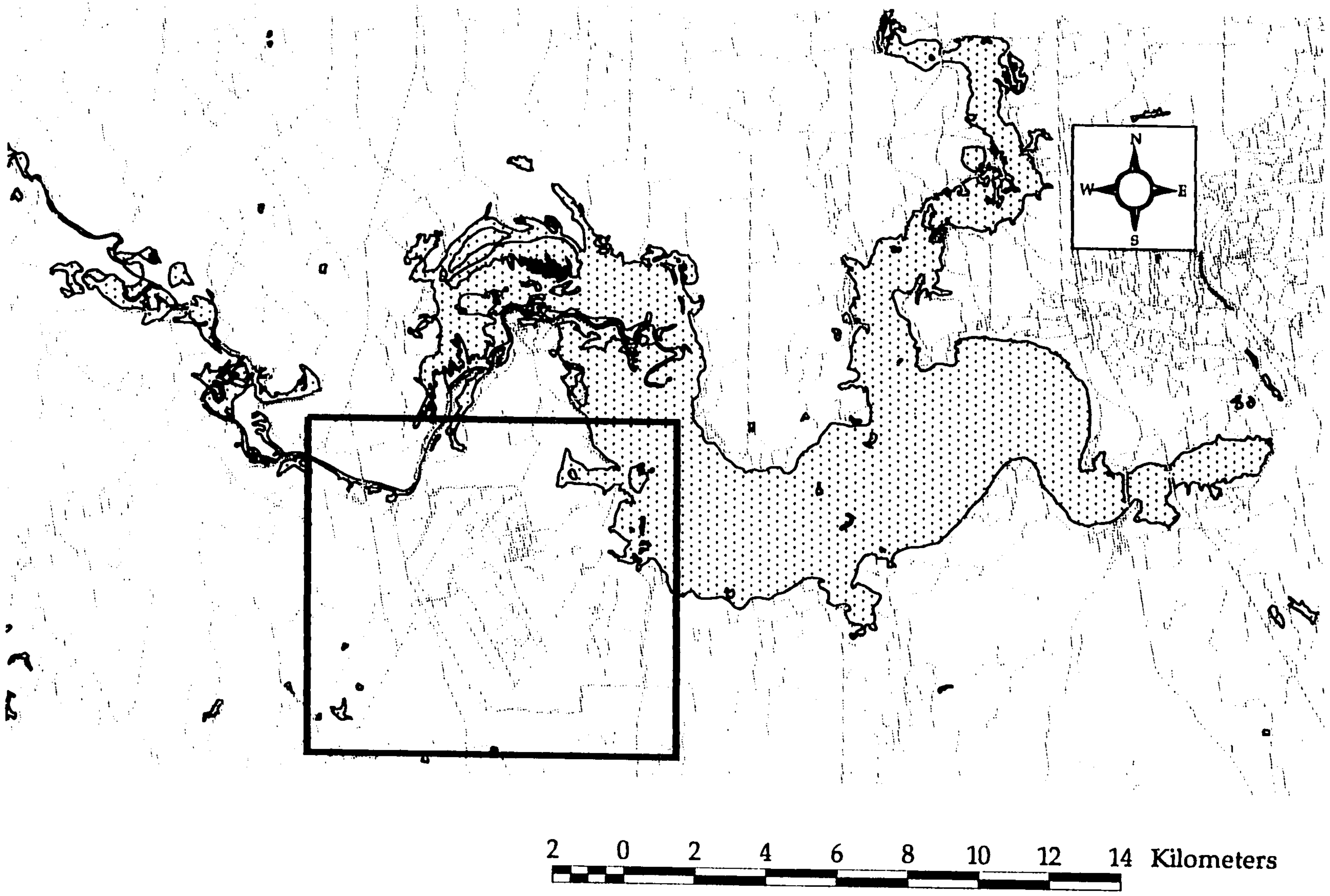


Figure 2. The location of Longhorn Army Ammunition Plant.

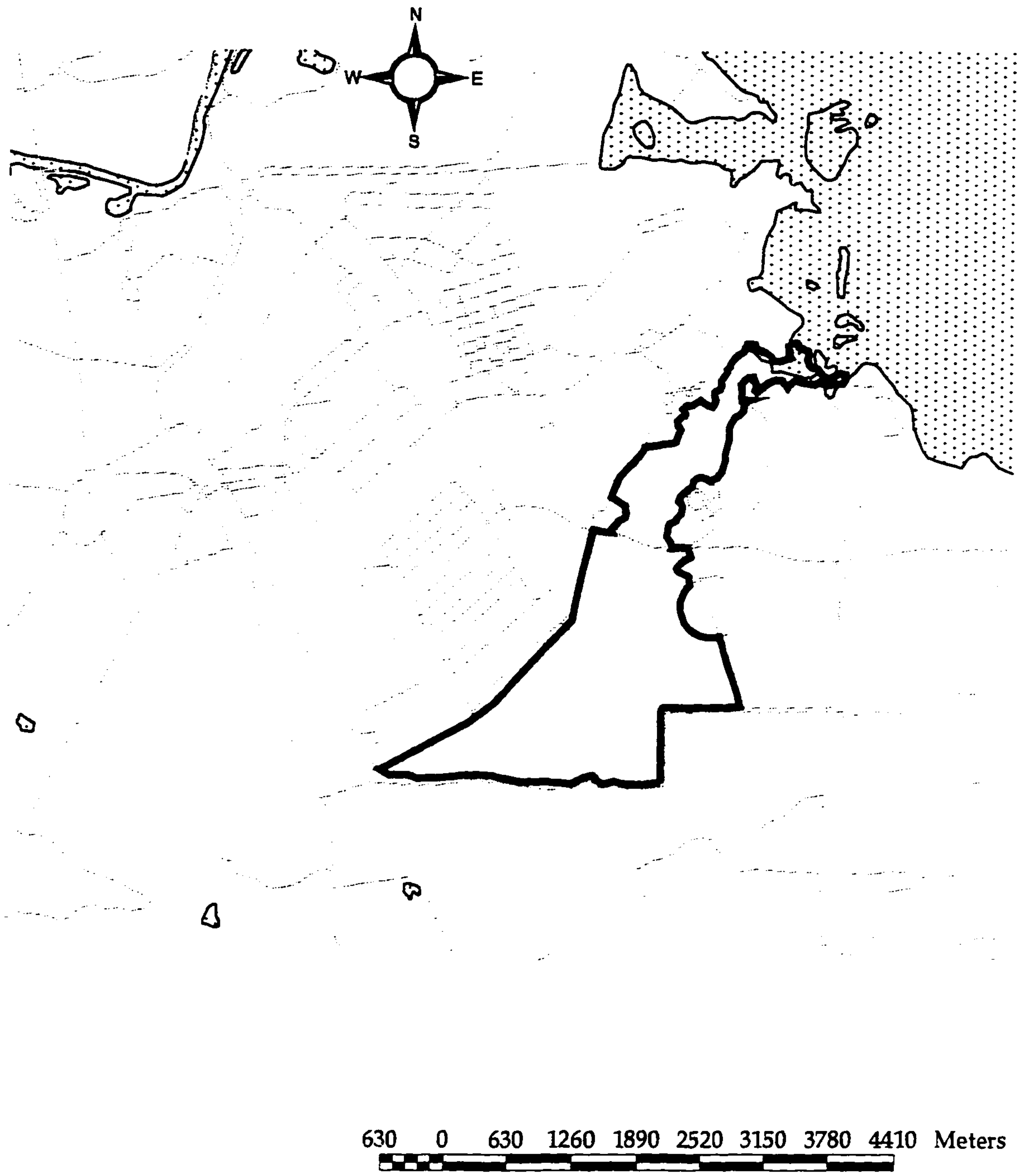


Figure 3. The location of the Harrison Bayou study area on Longhorn Army Ammunition Plant.

Definition Of Area To Be Sampled

For the purposes of this study, the area that is to be examined had to be precisely defined. To make the identification of the study area as simple as possible, man-made features have been used wherever possible to define the bounds of the study area (Figure 4).

The southwest corner of the study area coincides with the intersection of Haystack Road and 2607 Plant Road. The southern bound follows the LHAAP fence along 2607 Plant Road for approximately 2500 meters. From here, the western bound begins at the intersection of the south fence and Avenue P.

The bound follows Avenue P for approximately 1000 meters until the road intersects with a railroad track of the Louisiana and Arkansas line. The western bound continues along this track from Avenue P for approximately 2000 meters to where the track intersects with Avenue O. Directly north of this intersection lies a waste storage site. The eastern edge of this cleared area continues the western bounds of the study area. North of this area a dirt road continues the boundary in a north north-eastern direction for approximately 1000 meters to a chemical production facility. The eastern fence of this facility continues the western bounds of the study area. Near a dirt road that exits this facility

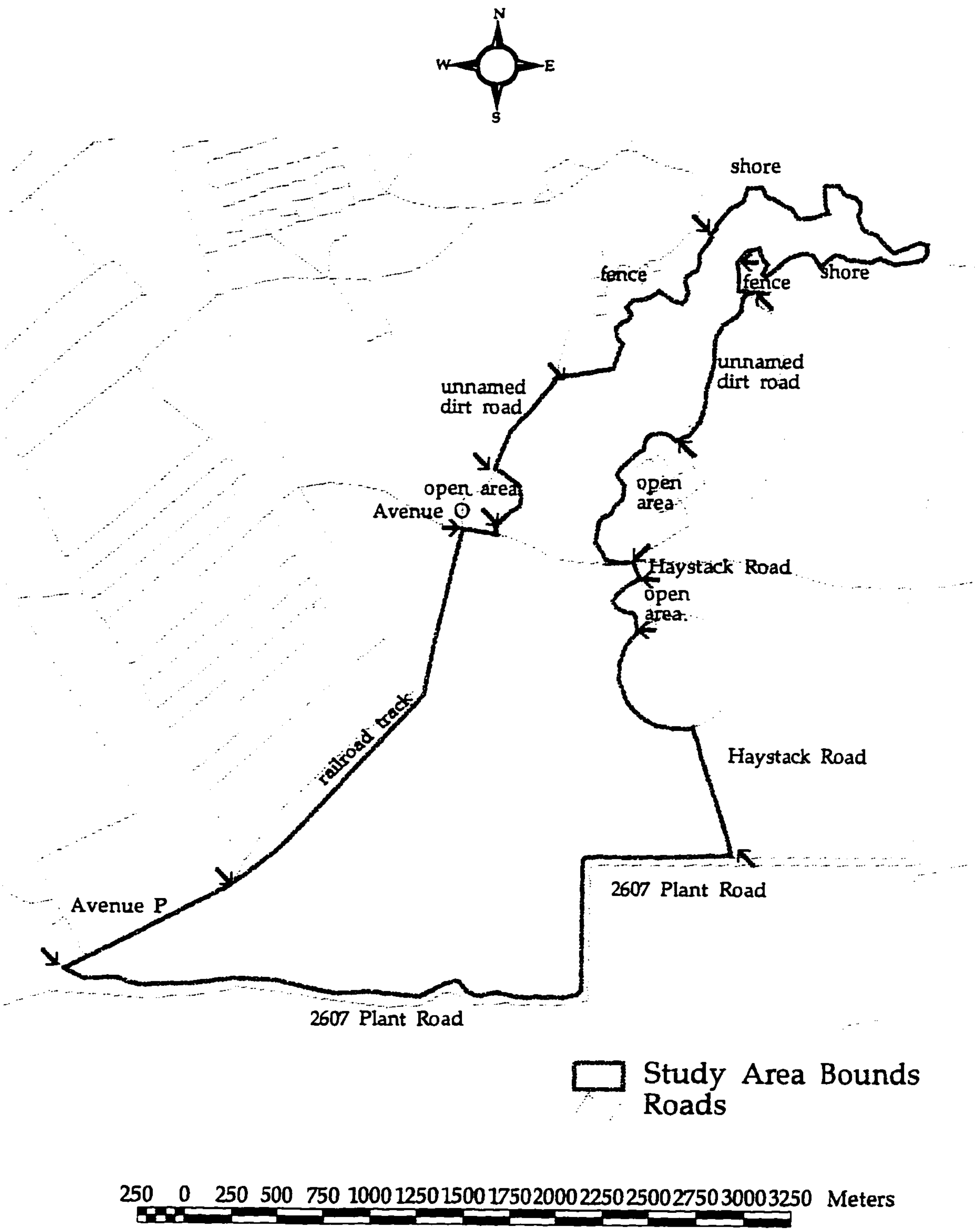


Figure 4. The boundaries of the Harrison Bayou study area at Longhorn Army Ammunition Plant. The text labels describe the feature defining the bounds between the adjacent arrows.

to the north-east is the shore of Harrison Bayou.

The bounds of the study area follow this shore to the mouth of the bayou, which for logistical reasons cannot be precisely defined on the ground. The boundary crosses the mouth of the bayou in an eastern direction for approximately 1000 meters, at which point a fence-line running north-south approaches the shore.

The bounds follow this fence south for 250 meters, then east for 100 meters to an unnamed dirt road. The bounds continue along this dirt road in a southerly direction for approximately 800 meters. Here, the bounds follow the perimeter of a cleared area along the road on the west of the burning grounds, then along the road that exits the burning grounds, and travels to Avenue O. At this intersection, the bounds follow Haystack Road briefly, then along the western edge of a cleared area for 200 meters, then back on the road to the signal test area. Here, the bounds follow the western half of the test area in a half circle, then back along Haystack Road to where it intersects with 2607 Plant Road.

Minimum Plant Community Area

The restrictions imposed by time, cost, and practical feasibility prohibit the identification and delineation of every single plant community in Harrison Bayou. There must be a stated minimum area which a group of plants must dominate for that group to be considered a community. For the purposes of this study, the target minimum area of delineation will be set at one hectare. Since the minimum resolution of the satellite imagery to be used is a pixel 30 meters on a side (900 meters^2), this area will approximate ten screen pixels. Any plant communities of less than this minimum area was not considered as an independent community.

GIS Database Development

A GIS database was developed to approximate the location of the plant community bounds, to aid in navigation through the area, and to produce a graphic representation of the final community delineation. The database was created using a UNIX computer platform and various software packages, including *ArcInfo*®, *ArcView*®, and *Imagine*®.

Initial identification and delineation of the communities of Harrison Bayou were done by combining the output of the *Imagine*® pixel classification routine and an ocular community delineation done on stereoscopic photographs of the study area, digitized soils, and digitized topography data.

The computer classification was performed on satellite imagery obtained from EROS Data Center, Sioux Falls, South Dakota.

Classification routines are computer programs that compare each pixel to every other pixel in the image. Pixels are then grouped together according to their similarity to one another. The output of such a routine is an image in which the pixels which have been grouped together are indicated. These groupings of pixels were assumed to represent a rough estimate of the plant communities. The classification routine output was compared with the topography and soils of the study area to create a final estimate of plant community locations on which to base the sampling.

Sampling Procedure

Two objectives were to be concurrently met by the field sampling procedure. First, the vegetative component was to be described for each community. Second, each community was to be assessed for the three wetland indicators established by the 1987 CoE Wetland Delineation Manual (Environmental Laboratory, 1987).

Sample Point Placement

Sample points were initially placed on a computer-generated map of the plant communities. Four points were placed in each community classification. The intent of the placement was to provide sufficient sampling of each community type with a minimum of sample points.

However, after sampling the communities of Harrison Bayou, many changes were made to the initial community bounds. The majority of these changes consisted of the merging of adjacent communities that had originally been considered separate. This resulted in some community classifications being sampled with more than the originally intended 4 points, and, in two instances, resulted in a community being sampled with less than four points. A total of 106 sample points were placed in the study area.

Once placed on the digital map of the plant communities, distance and direction to each point was calculated relative to a known feature on the landscape. With this information, the researchers were able to locate the approximate physical representation of each sample point using compass and pacing.

Plant Community Characterization

It was determined that the vegetation sampling procedure recommended by the 1987 CoE Wetland Delineation Manual would provide sufficient data to describe the vegetative community present at each sample point, so no sampling other than that described below for the wetland determination was performed.

Sampling For Hydric Soil Conditions

Each point was sampled for hydric soil conditions in accordance with the 1987 CoE Wetland Delineation Manual (Environmental

Laboratory, 1987). This procedure involved digging a half-meter deep pit. Using a ped cut from the wall of the pit, the soil profile was characterized. This involved breaking the profile into horizons and determining the texture (by feel) and color (by Munsell® Soil Color Chart) of each horizon. Also, any redoximorphic features, such as mottling, gleying, concretions, or a sulfidic odor, were noted and their color, size, and distribution recorded.

Sampling For Hydrologic Indicators

The area surrounding each point was examined for signs of hydrologic indicators. This involved recording the depth of the surface water, if present, the depth to the water table if it appeared in the soil pit, and the presence or lack of soil saturation. Other indicators, such as crayfish castles, watermarks, waterstained leaves, and silt deposits, were also noted as necessary.

Sampling For Hydric Vegetation

The vegetative community at each sample point was broken into four strata: tree, sapling and shrub, woody vine, and herbaceous. The dominant species of each stratum was identified using the following procedure and the wetland indicator status of these species determined. This indicator status was used to determine if the point possessed a prevalence of hydrophytic vegetation.

The tree stratum was sampled using a 8.9 meter radius circular plot (250 m^2). Within this plot, the basal area (BA) of all woody vegetation greater than 12.5 cm (5 inches) diameter at breast height (dbh) (1.4 meters from the ground) was measured. All plants were identified to species and ranked in descending order by BA. The dominant species were then identified using the 50 / 20 rule.

The 50 / 20 rule states that, when ranked in descending order by some measure of dominance, the dominant species are those whose cumulative total of this measure immediately exceeds 50% of the total of this measure for all species present, plus any additional species comprising 20% or more of the total dominance measure (Federal Interagency Committee for Wetland Delineation, 1989).

The sapling and shrub stratum was assessed using a 5.6 meter (100 m^2) radius plot nested within the tree plot. All non-vine woody vegetation less than 12.5 cm dbh was identified to species and tallied by species. The number of individuals of each species was used as the measure of dominance for this stratum. The 50 / 20 rule was then used to identify the dominant species.

The woody vine stratum was assessed using the same 100 m^2 plot used to assess the sapling and shrub stratum. Each woody vine was identified and tallied by species. The number of individuals of each species was used as the measure of dominance. The 50 / 20 rule was then used to identify the dominant species.

The herbaceous stratum was assessed using 1 m^2 plots. These plots were established within the 250 m^2 plot area using 1 m^2 frames placed at random throughout the plot. The number of frame samples performed was determined using a modified species-area curve: for each frame sample, the number of species found in that frame that had not yet been found in any frame at that sample point was recorded. When this number was zero for two consecutive frames, herbaceous sampling was concluded for that point.

Each herbaceous plant within the frame was identified to species and the percent aerial cover of each species within the frame estimated by eye. The species were then ranked in descending order by average percent aerial cover over all frame tosses. The dominant species were identified by the application of the 50 / 20 rule to this measure.

Once the dominant species of all strata were identified, the wetland indicator status was determined for these species. The wetland indicator status was taken from the "National List of Plant Species that Occur in Wetlands: South Plains: Region 6" (Reed, 1988). If more than 50% of the dominant vegetation of all four strata taken together were classified as FAC or wetter (including FAC +), the site was considered to posses wetland vegetation.

If, at any time during the sampling procedure, a plant was encountered that could not be identified in the field, a sample was collected. Unknown plants were recorded using a unique identifier until proper identification could be made, but the sampling procedure otherwise proceeded as usual. In the few cases where a positive identification could not be made, the plant was keyed as far as possible and labeled with an "unknown" prefix. For example, a grass that could not be identified due to a lack of seedheads would be recorded as "unknown Poacea." The unknowns with dominant status at a sample point were not taken into consideration when wetland determinations were made.

Wetland Community Determination

Each sample point was labeled as possessing or not possessing wetland soils, wetland hydrology, and wetland vegetation. Data for each parameter were used to adjust the original estimates of plant community locations. Plant community bounds were merged, split, or deleted as necessary to group similar areas together.

The sample points were used to determine the wetland status of each community classification. If all the sample points within a community class possessed wetland characteristics of hydrology, soils, and vegetation, that community was labeled as a wetland community.

RESULTS

Plant Community Characterization

The data were used to generate a series of eleven community classifications, plus the Beaver Pond classification (Table 2). Each classification is a grouping of one or more communities with similar enough soils (Table 3, Figure 5), hydrologic characteristics, and dominant vegetation (Table 4) to be considered as a unit.

Cherrybark Oak (CBO)

This community lies in the center of Harrison Bayou near the southern bounds of LHAAP. It is a broad, flat area with several 0.5 to 1 meter deep channels coursing through it. There are periodic depressional areas with saturation and inundation present, but on the whole, there is little standing water. Most trees possessed watermarks up to 300 cm high, and there were obvious drainage patterns throughout the community. This community does posses wetland hydrology.

The dominant vegetation in this community include cherrybark oak (*Quercus pagoda* Raf.), American elm (*Ulmus americana* L.), water hickory (*Carya aquatica* (Michx. F.) Nutt.), water locust (*Gleditsia aquatica*

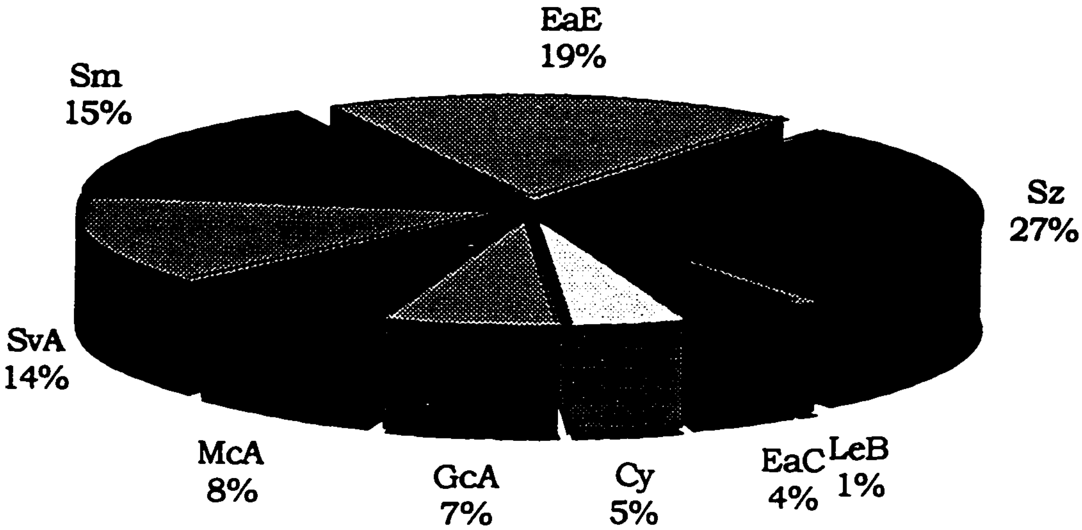
Table 2. Summary of the plant community classifications of Harrison Bayou.

Community Class	Number of Communities	Total Area of Class (m^2)	Percent of Study Area Represented by Class
CBO	1	237087	4.45
LLP	8	740751	13.91
OCP	2	445963	8.37
OLO	1	508462	9.55
OO	1	937432	17.60
SBE	1	76212	1.43
SLO	4	523669	9.83
UHW	2	273493	5.14
UPH	6	894452	16.80
WO	2	87759	1.65
BP	3	129351	2.43
WWOxLLP	1	470485	8.83
Total	32	5325116	99.99

Table 3. Summary of the soils found in the Harrison Bayou study area on Longhorn Army Ammunition Plant.

Map Symbol	Map Unit Name	Area within Harrison Bayou (m^2)	Area within Harrison Bayou %	Community Classes with this Soil	Hydric Characteristics from Hydric Soils List*	Observed Hydric Characteristics
Cy	Cypress clay loam, submerged	246012	4.62%	3	1 and 2	gleyed, low chroma aquic moisture regime sulfidic odor
EaC	Eastwood very fine sandy loam, 1 to 5 percent slopes	238204	4.47%	5	none	none
EaE	Eastwood very fine sandy loam, 5 to 20 percent slopes	997032	18.73%	6	none	none
GcA	Guyton - Cart complex, 0 to 1 percent slopes	353329	6.64%	8	1	concretions
LeB	Latex fine sandy loam, 1 to 3 percent slopes	38108	0.72%	2	none	none
McA	Metcalf - Cart complex, 0 to 2 percent slopes	410821	7.72%	9	none	none
Sm	Sardis-Mathison complex, frequently flooded	801137	15.05%	2	2	gleyed, low chroma concretions
SvA	Scottsville very fine sandly loam, 0 to 2 percent slopes	738014	13.86%	11	none	none
Sz	Socagee silty clay loam, frequently flooded	1501333	28.20%	2	1	gleyed, low chroma
Total		5323990	100.01%			

*From the Harrison County Hydric Soils List:
1- a frequently occurring water table less than 1.5 feet from the surface for a significant period (usually 14 consecutive days or more) during the growing season if permeability is less than 6.0 in/hr in any layers within 20 inches.
2- soils that are frequently flooded for long or very long duration during the growing season.



Cy - Cypress clay loam, submerged
EaC - Eastwood very fine sandy loam, 1 to 5 percent slopes
EaE - Eastwood very fine sandy loam, 5 to 20 percent slopes
GcA - Guyton - Cart complex, 0 to 1 percent slopes
LeB - Latex fine sandy loam, 1 to 3 percent slopes
McA - Metcalf - Cart complex, 0 to 2 percent slopes
Sm - Sardis-Mathison complex, frequently flooded
SvA - Scottsville very fine sandly loam, 0 to 2 percent slopes
Sz - Socagee silty clay loam, frequently flooded

Figure 5. Relative abundance of the soils found in the Harrison Bayou study area.

Table 4. List of all species, and their wetland indicator category assigned by Reed (1988), found in dominant status at least once in Harrison Bayou.

species name	indicator	species name	indicator
Acer barbatum	NI[‡]	*Panicum anceps*	FAC+
Acer rubrum	FAC	*Parthenocissus quinquefolia*	FAC
Ampelopsis arborea	FAC	*Pinus palustris*	FAC-
Arundinaria gigantea	FACW	*Pinus taeda*	FAC-
Asimina triloba	FAC-	*Planera aquatica*	OBL
Berchemia scandens	FAC+	*Polygonum pensylvanicum*	FACW-
Bignonia capreolata	FAC	*Quercus alba*	FACU+
Boehmeria cylindrica	FACW	*Quercus falcata*	FACU
Brunnichia ovata	NI	*Quercus laurifolia*	FACW
Celtis verticellata	NI	*Quercus lyrata*	OBL
Calicarpa americana	FACU	*Quercus marilandica*	NI
Carex sp.	OBL	*Quercus nigra*	FAC+
Carpinus caroliniana	FAC	*Quercus pagoda*	FAC+
Carya aquatica	OBL	*Quercus phellos*	FACW
Carya lieodermis	NI	*Quercus stellata*	NA*
Carya texana	NI	*Quercus virginiana*	FACU-
Carya tomentosa	NI	*Rubus hispida*	NI
Celtis laevigata	FAC	*Rubus trivialis*	FAC
Cephalanthus occidentalis	OBL	*Saururus cernuus*	OBL
Cercis canadensis	NI	*Smilax bona-nox*	FAC
Chasmanthium laxum	FAC	*Smilax glauca*	NI
Chasmanthium sessiliflorum	FAC	*Smilax lanceolata*	NI
Cornus florida	FACU	*Smilax rotundifolia*	FAC
Cretaegus marshallii	FAC	*Sphagnum sp.*	NI
Elephantopis carolinianus	FAC	*Styrax americana*	FACW
Forestiera acuminata	OBL	*Taxodium distichum*	OBL
Fraxinus pennsylvanicum	FACW-	*Toxicodendron radicans*	FAC
Gelsemium sempervirens	FAC	*Trachelospermum difforme*	FACW
Hibiscus militaris	NI	*Ulmus alata*	FACU
Hibiscus moscheutos	OBL	*Ulmus americana*	FAC
Ilex coreacea	FACW	*unknown Cyperacea*	NI
Ilex glabra	FACW	*unknown Poacea*	NI
Ilex verticellata	OBL	*unknown Poacea*	NI
Ilex vomitoria	FAC	*unknown Poacea*	NI
Leersia oryzoides	OBL	*Viola primulifolia*	FAC
Liquidambar styraciflua	FAC	*Vitis aestivalis*	FAC
Lonicera japonica	FAC	*Vitis mustangensis*	NI
Maclura pomifera	NI	*Vitis rotundifolia*	FAC-
Nyssa sylvatica	FAC		

[‡]Species indicated by "NI" were not present in the "National List of Plant Species that Occur in Wetlands: South Plains Region 6". These species were omitted in calculations for wetland vegetation.

*Species indicated by "NA" were present in the list, but no indicator could be agreed upon by the authors.

Marshall), common greenbriar (*Smilax rotundifolia* L.), poison ivy (*Toxicodendron radicans* (L.) Kuntze), lizard's tail (*Saururus cernuus* L.), and slender spikegrass (*Chasmanthium laxum* (L.) H. Yates) (Table 5). This community classification does posses hydric vegetation.

This community is located on soils mapped as Sm (Sardis-Mathiston complex, frequently flooded). Sampling found no saturation, some faint mottling at all sample points and gleyed conditions at half of the sample points. This community does posses hydric soils.

Loblolly Pine (LLP)

Communities of this classification lie mostly on the edges of the study area. They are present on the highest areas in the bayou, on broad, gently sloping terrain. These communities posses none of the hydrologic features found in wetlands.

The dominant vegetation in these communities include loblolly pine almost exclusively in the tree overstory, sweetgum (*Liquidambar styraciflua* L.), winged elm (*Ulmus alata* Michx.), poison-ivy, common greenbriar, Alabama supple-jack (*Berchemia scandens* (J. Hill) K. Koch), and Virginia creeper (*Parthenocissus quinquefolia* (L.) Planch.) (Table 6). This community class does posses hydric vegetation.

These communities are found on areas mapped as SvA (Scottsville very fine sandy loam, 0 to 2 percent slopes). The soil samples possessed no features typical of wetland areas, so this classification is not

Table 5. Average relative dominance for the dominant species in the cherrybark oak community (CBO).

Tree		Herbaceous		Woody Vine		Sapling and Shrub	
species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
Q. pagoda	29.8	*T. radicans*	22.4	*S. rotundifolia*	36.1	*U. americana*	29.3
C. aquatica	15.1	*S. cernuus*	20.8	*T. radicans*	32.9	*C. aquatica*	20.3
U. americana	13.3	*C. laxum*	16.7	*V. rotundifolia*	5.6	*G. aquatica*	10.7
Q. lyrata	9.9	*P. quinquefolia*	9.8	*B. capreolata*	5.6	*C. canadensis*	8.1
L. styraciflua	7.9	*Carex sp.*	5.0	*P. quinquefolia*	2.6	*C. carolinianus*	8.1
Q. phellos	6.4					*S. americana*	7.2
Q. nigra	5.6					*C. americana*	3.6

Table 6. Average relative dominance for the dominant species in the loblolly pine community (LLP).

Tree		Herbaceous		Woody Vine		Sapling and Shrub	
species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
P. taeda	90.8	*T. radicans*	45.2	*T. radicans*	20.8	*L. styraciflua*	26.3
		P. quinquefolia	12.7	*S. rotundifolia*	14.6	*U. alata*	18.0
		S. bona-nox	5.5	*B. scandens*	10.2	*U. americana*	4.5
		C. sessiliflorum	4.4	*V. rotundifolia*	7.8	*Q. laurifolia*	4.4
		S. rotundifolia	4.0	*P. quinquefolia*	6.9	*C. canadensis*	3.6
				A. arboreum	4.8	*A. arboreum*	3.5
				V. mustangensis	3.4	*P. taeda*	3.5
				M. scandens	2.6	*Q. nigra*	2.6
				S. glauca	2.5	*Q. lyrata*	1.6
				S. bona-nox	1.8		

considered to posses hydric soils.

Overcup - Laurel Oaks (OLO)

This community is a "first floodplain" of Harrison Bayou. It is a broad, flat expanse in the center of the bayou, through which the main channel (≥1 meter deep) and several minor ones (0.5 to 1 meter deep) wind. Most trees in this community have watermarks from flooding, and waterstained leaves and sometimes saturated soils are present anywhere there is a slight depression. This community does posses wetland hydrology.

The vegetation in this community is dominated by overcup oak and swamp laurel oak (*Quercus laurifolia* Michx.) in the overstory, with baldcypress (*Taxodium distichum* (L.) L. C. Rich.) existing almost exclusively in or on the banks of the channels. Also dominating this community are inkberry (*Ilex glabra* (L.) Gray), sweetgum, poison-ivy, saw greenbriar, common greenbriar, Alabama supple-jack, southern dewberry (*Rubus trivialis* Michx.), and slender spikegrass (Table 7). This site does posses hydric vegetation.

This community is located in areas mapped as Sm, GcA (Guyton-Cart complex, 0 to 1 percent slopes), and Sz (Socagee silty clay loam, frequently flooded). Sampling revealed gleyed conditions and some concretions. This site does posses hydric soils.

Table 7. Average relative dominance for the dominant species in the overcup - laurel oak community (OLO).

Tree		Herbaceous		Woody Vine		Sapling and Shrub	
species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
Q. laurifolia	38.4	*C. laxum*	23.9	*T. radicans*	34.1	*I. glabra*	39.2
Q. lyrata	15.2	*T. radicans*	9.8	*V. rotundifolia*	6.7	*L. styraciflua*	10.0
T. distichum	10.9	*R. trivialis*	5.7	*S. bona-nox*	6.4	*I. coreacia*	4.5
P. taeda	6.0	*unk. Cyperacea*	5.3	*B. scandens*	6.0	*Q. laurifolia*	4.2
C. aquatica	4.7	*C. sessiliflorum*	4.4	*T. difforme*	5.9	*I. verticellata*	3.9
C. verticellata	3.8	*V. rotundifolia*	2.6	*S. rotundifolia*	4.6	*C. americana*	3.0
Q. nigra	3.1	*H. militaris*	1.5	*A. arboreum*	1.9	*H. militaris*	1.7
L. styraciflua	2.6	*L. japonicum*	1.5				
Q. phellos	2.0	*unknown Poacea*	1.0				
F. pennsylvanica	1.8	*P. anceps*	1.0				
		Sphagnum sp.	0.7				

Overcup Oak - Baldcypress (OCP)

There are two widely separated communities in this classification. The larger is the community found at the mouth of Harrison Bayou, where it empties into Caddo Lake. The other lies adjacent to a large flooded area in the southeastern part of the study area. Both communities are prone to long periods of inundation. Those areas not inundated lie in between the channels and pools that criss-cross these communities, and are barely exposed. All the trees have watermarks, and only the newest fallen leaves are not waterstained. These signs are all indicators of wetland hydrology.

The vegetation of these communities is dominated by overcup oak and baldcypress in the overstory. There is a gradient as one moves towards the deeper water in the center of the mouth community and to the east of the southern community in which the overcup oak diminishes and the baldcypress is eventually alone in the overstory. In the shallower and less frequently flooded areas of these communities are found swamp privet (*Forestiera acuminata* (Michx.) Poir.), buttonbush (*Cephalanthus occidentalis* L.), and lizard-tail. On the least frequently flooded areas are found common greenbriar, American buckwheat vine (*Brunnichia ovata* Walt.), rice cutgrass (*Leersia oryzoides* (L.) Schwartz), and slender spikegrass. These communities do posses hydric vegetation (Table 8).

These communities are located on areas mapped as Sz in the more frequently exposed areas and Cy (cypress clay loam, submerged) in the areas flooded most of the year. These communities do posses hydric soils.

Overcup Oak (OO)

This community exists in the southern half of the study area, slightly higher on the landscape than the OLO community. These communities are very similar in most respects with the major difference being in the dominant vegetation. Like the OLO community, this community is a broad, flat, first terrace of Harrison Bayou. The main and several minor channels of Harrison Bayou wind throughout the community in such a manner that no a point within it is very far from one. This community possesses periodic depressions with saturation and waterstained leaves, watermarks in the trees, and drainage patterns from previous periods of flooding. This community does posses wetland hydrology.

The dominant vegetation in this community are similar to OLO, with the difference being that in this community the overcup oak is much more prevalent. In fact, it makes up by far the majority of the overstory. Baldcypress is found densely, but exclusively, in and along the banks of the water channels. Also found in the overstory are

Table 8. Average relative dominance for the dominant species in the overcup oak - baldcypress community (OCP).

Tree		Herbaceous		Woody Vine		Sapling and Shrub	
species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
Q. lyrata	66.5	*L. oryzoides*	19.4	*S. rotundifolia*	25.0	*F. acuminata*	23.8
T. distichum	19.9	*G. sempervirens*	6.4	*B. ovata*	25.0	*T. distichum*	21.2
U. americana	5.1	*B. ovata*	6.4	*A. arboreum*	10.1	*C. occidentalis*	14.6
		C. laxum	6.3	*V. rotundifolia*	7.8	*I. verticellata*	13.9
		S. cernuus	6.0			*L. styraciflua*	5.6
		I. verticellata	5.5			*I. glabra*	5.6
		B. cylindrica	5.4				
		H. moscheutos	3.9				

sweetgum and swamp laurel oak, with water oak (*Quercus nigra* L.) appearing on higher areas and on the edges of the community. Other species which dominate this community are inkberry, American hornbeam (*Carpinus carolinianus* Walter), American elm, poison-ivy, slender spikegrass, and Virginia creeper (Table 9). This community does posses hydric vegetation.

This community is located on an area mapped as Sz and GcA. Sampling revealed gleying conditions and some concretions present in the soil. This community does posses hydric soil conditions.

Sugarberry - Elm (SBE)

This community is found very low on the landscape adjacent to the flooded area in the southeastern portion of the study area. It is mostly inundated (0.5 to 1 meter with underwater channels of 1.5 meters and deeper) with many small islands scattered throughout. All trees have watermarks and waterstains prevail on all areas except for the tops of the islands. This community does posses wetland hydrology.

The overstory vegetation is dominated by sugarberry (*Celtis laevigata* Willd.) growing on the higher ground, American elm, and green ash (*Fraxinus pennsylvanica* Marshall). Also dominating this community are swamp laurel oak, Alabama supple-jack, sedges, and lizard-tail in the

Table 9. Average relative dominance for the dominant species in the overcup oak community (OO).

Tree		Herbaceous		Woody Vine		Sapling and Shrub	
species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
Q. lyrata	30.1	*T. radicans*	18.6	*T. radicans*	29.9	*I. glabra*	22.7
L. styraciflua	11.0	*C. laxum*	15.8	*S. glauca*	16.7	*C. carolinianus*	16.7
Q. laurifolia	9.6	*P. quinquefolia*	11.5	*P. quinquefolia*	15.4	*U. americana*	12.2
Q. nigra	8.7	*Sphagnum sp.*	8.2	*B. scandens*	15.4	*U. alata*	7.6
P. aquatica	6.9	*V. primulifolia*	2.6	*S. bona-nox*	8.3	*Q. lyrata*	6.3
M. pomifera	6.3					*M. pomifera*	4.5
N. sylvatica	5.1					*A. gigantea*	4.4
U. americana	4.5					*P. aquatica*	3.1
G. aquatica	3.4					*L. styraciflua*	3.1
						Q. lyrata	3.1

saturated and inundated areas (Table 10). This community does posses hydrophytic vegetation.

The area of this community is mapped as Sm, Cy, and Sz. Sampling of soils revealed saturation and gleying conditions. Soils in this community are hydric.

Swamp Laurel Oak (SLO)

These communities occupy the second terrace position of Harrison Bayou. These are small communities on gently to moderately sloping terrain. There are some depressional areas with waterstained leaves and shallow inundation. These are indicators of wetland hydrology.

The overstory vegetation is massively dominated by swamp laurel oak with some willow oak (*Quercus phellos* L.) and a small amount of overcup oak. The midstory is massively dominated by *inkberry (Ilex glabra* (L.) Gray), with some American and winged elms also dominating. Also found in dominant quantities are common greenbriar, Alabama supple-jack, and poison-ivy (Table 11). The vegetation of this community is hydric.

The soils of these communities are mapped as EaE (Eastwood very fine sandy loam, 5 to 20 percent slopes), GcA, and Sz. Sampling revealed gleying and some concretions present in the soil. These communities do posses hydric soils.

Table 10. Average relative dominance for the dominant species in the sugarberry - elm community (SBE).

Tree		Herbaceous		Woody Vine		Sapling and Shrub	
species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
C. laevigata	44.3	*S. cernuus*	31.2	*B. scandens*	75.3	*Q. laurifolia*	59.5
U. americana	23.1	*P. pensylvanicum*	18.7			*U. americana*	13.4
F. pennsylvanica	12.3	*Carex sp.*	15.9				

Table 11. Average relative dominance for the dominant species in the swamp laurel oak community (SLO).

Tree		Herbaceous		Woody Vine		Sapling and Shrub	
species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
Q. laurifolia	39.9	*C. laxum*	26.7	*S. rotundifolia*	20.8	*I. glabra*	31.4
Q. phellos	14.5	*C. sessiliflorum*	13.2	*B. scandens*	8.5	*U. americana*	19.1
U. alata	9.1	*T. radicans*	5.4	*T. radicans*	6.0	*U. alata*	12.5
Q. lyrata	6.9	*V. rotundifolia*	4.6	*V. rotundifolia*	5.7	*A. triloba*	8.0
Q. pagoda	4.4	*P. quinquefolia*	4.0	*S. bona-nox*	2.1	*P. taeda*	3.1
Q. nigra	3.2	*Sphagnum sp.*	3.2			*A. pavia*	2.6
L. styraciflua	2.2	*unk. Poacea*	2.9			*F. pennsylvanica*	2.5
		Carex sp.	1.3				
		Carex sp.	1.3				

Upland Hardwoods (UHW)

These communities are generally flat to moderately sloping areas above the bayou. Their borders with the bayou are marked by an abrupt and sharp drop to the level of the OO community. These communities posses no hydrologic features typical to wetland communities. The vegetation of these communities is strongly dominated by sweetgum, but also includes blackjack oak (*Quercus marilandica* Muenchh.) and Florida maplc (*Acer barbatum* Michx.) in significant quantities. Also dominant in these communities are cat greenbriar (*Smilax glauca* Walt.), muscadine grape (*Vitis rotundifolia* Michx.), long-leaf spikegrass (*Chasmanthium sessiliflorum* (Poir.) H. Yates), and poison ivy (Table 12). These communities do not posses a prevalence of hydrophytic vegetation.

The soils of these communities are mapped as Sm and EaE. Sampling revealed no characteristics typical to hydric soils. These soils are not considered to be hydric.

Upland Pine Hardwood (UPH)

These communities are very similar to and share essentially the same position on the landscape as the LLP communities, but they have a much stronger hardwood component in the overstory. These communities posses no features indicative of wetland hydrology.

Table 12. Average relative dominance for the dominant species in the upland hardwood community (UHW).

Tree		Herbaceous		Woody Vine		Sapling and Shrub	
species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
L. styraciflua	28.1	*C. sessiliflorum*	23.6	*S. glauca*	18.0	*L. styraciflua*	17.7
Q. marilandica	10.9	*T. radicans*	13.7	*V. rotundifolia*	18.0	*A. barbatum*	12.4
Q. nigra	7.8	*Q. alba*	5.6	*T. radicans*	9.0	*Q. phellos*	7.1
Q. falcata	7.6	*U. alata*	3.9	*L. japonica*	8.6	*U. alata*	4.0
Q. stellata	7.6	*S. bona-nox*	2.6	*B. scandens*	5.9	*Q. marilandica*	3.4
Q. alba	7.3	*V. rotundifolia*	1.6	*R. trivialis*	4.0	*P. palustris*	3.1
P. taeda	6.8	*C. americana*	1.5	*S. bona-nox*	3.7	*C. americana*	2.8
		S. lanceolata	1.4	*S. lanceolata*	2.2	*C. florida*	2.3
		L. japonica	1.4			*Q. alba*	2.3
		S. glauca	1.0			*U. americana*	2.2
						A. rubrum	1.3

The overstory vegetation is strongly dominated by loblolly pine, but there are also found sweetgum, post oak (*Quercus stellata* Wang.), and blackjack oak in significant quantities. Other than these trees, the dominant vegetation includes farkleberry (*Vaccinium arboreum* Marshall), winged elm, muscadine grape, summer grape (*Vitis aestivalis* Michx.), poison ivy, long-leaf spikegrass, and Virginia creeper (Table 13). These communities do not posses hydrophytic vegetation.

These communities are found on areas mapped as McA, SvA, and EaE soils. Sampling of the soils revealed no characteristics typical of hydric soil conditions.

Water Oak (WO)

These communities are found on moderately to severely sloping areas on the transition from the lower OLO communities to the higher LLP type areas. These communities posses no indicators of wetland hydrology.

The vegetation is massively dominated by water oak, but includes some American elm in dominant status as well. Also found in dominance are American beauty-berry (*Calicarpa americana* L.), inkberry, common greenbriar, poison-ivy, muscadine grape, and longleaf spikegrass (Table 14). These communities do posses hydric vegetation.

The soils of these communities are mapped as EaE and GcA. Sampling of the soils revealed sparse concretions and some gleying in

Table 13. Average relative dominance for the dominant species in the upland pine - hardwood community (UPH).

Tree		Herbaceous		Woody Vine		Sapling and Shrub	
species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
P. taeda	45.3	*C. sessiliflorum*	14.9	*V. rotundifolia*	21.5	*Q. marilandica*	13.1
L. styraciflua	12.3	*P. quinquefolia*	14.5	*V. aestivalis*	11.1	*P. taeda*	7.2
N. sylvatica	6.0	*V. rotundifolia*	8.2	*T. radicans*	11.1	*V. arboreum*	5.9
Q. stellata	4.1	*T. radicans*	7.7	*S. bona-nox*	9.6	*U. alata*	5.2
Q. marilandica	4.1	*Q. marilandica*	3.3	*B. scandens*	5.9	*C. florida*	4.6
Q. falcata	3.3	*R. hispida*	2.2	*A. arborea*	4.2	*U. americana*	3.5
C. lieodermis	2.2	*Sphagnum sp.*	2.1	*S. glauca*	4.0	*A. rubrum*	3.5
Q. phellos	1.7	*unk. Poacea*	1.7	*P. quinquefolia*	3.8	*Q. phellos*	2.7
C. texana	1.1	*E. carolinianus*	1.6	*V. mustangensis*	3.7	*D. virginiana*	2.2
		unk. Cyperacea	1.4	*S. rotundifolia*	1.6	*L. styraciflua*	2.1
						C. texana	1.9
						O. virginiana	1.7
						F. americana	1.3
						C. marshallii	1.1
						C. canadensis	0.9

Table 14. Average relative dominance for the dominant species in the water oak community (WO).

Tree		Herbaceous		Woody Vine		Sapling and Shrub	
species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
Q. nigra	56.9	*C. sessiliflorum*	29.1	*S. rotundifolia*	50.5	*C. americana*	27.1
U. americana	17.4	*T. radicans*	20.8	*T. radicans*	14.3	*I. glabra*	13.3
		T. radicans	20.8	*V. rotundifolia*	13.8	*Q. phellos*	7.9
		P. quinquefolia	12.5			*A. rubrum*	6.9
		S. rotundifolia	3.9			*Q. laurifolia*	5.0
						C. canadensis	4.3
						L. styraciflua	4.3

areas adjacent to the OLO community. These communities do posses hydric soils.

Special Classifications

Willow Oak - Loblolly Pine Complex (WWOxLLP)

This area, in the southwest corner of the study area, is a complex mosaic of the LLP community type and a community type found only in this mosaic: the willow oak (WWO) type. The willow oak community type is almost identical to the water oak type, except for the replacement of willow oak for water oak as the dominant overstory vegetation (Table 15).

The terrain of this community is highly variable, with many small hills of varying size dominated by LLP communities and many gullies and steep slopes dominated by WWO communities. The scale of these features is such that they could not be mapped individually, so they were included together in this complex. There were some small depressional area with waterstained leaves. Also, the terrain was crossed periodically with small ephemeral streams. However, these were considered to be insufficient to indicate the existence of wetland hydrology.

The soils present on this complex are mapped as McA, GcA, EaC, and SvA. Sampling revealed occasional concretions. This complex does not possess hydric soils.

Table 15. Average relative dominance for the dominant species in the willow oak - loblolly pine complex community (WWOxLLP).

Tree		Herbaceous		Woody Vine		Sapling and Shrub	
species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
WO component							
Q. phellos	44.7	*Sphagnum sp.*	37.9	*S. glauca*	22.9	*Q. phellos*	34.2
Q. pagoda	22.7	*T. radicans*	17.2	*V. rotundifolia*	16.7	*I. vomitoria*	17.0
Q. marilandica	18.9	*C. sessiliflorum*	9.0	*T. radicans*	16.6	*Q. marilandica*	6.6
		C. laxum	7.5	*V. aestivalis*	5.9	*U. alata*	5.1
		V. aestivalis	7.1	*R. trivialis*	5.3	*P. taeda*	4.6
LLP component							
P. taeda	78.9	*T. radicans*	34.8	*V. rotundifolia*	30.7	*Q. marilandica*	14.8
C. tomentosa	9.1	*C. sessiliflorum*	13.3	*T. radicans*	25.3	*U. alata*	13.9
L. styraciflua	3.9	*V. rotundifolia*	3.7	*S. glauca*	19.6	*L. styraciflua*	10.0
		S. bona-nox	3.1	*S. bona-nox*	6.7	*P. taeda*	7.6
		Sphagnum sp.	2.7	*V. aestivalis*	5.0	*A. rubrum*	4.0
		C. marshallii	2.6			*Q. phellos*	1.6
						A. arborea	1.6

Beaver Pond (BP)

There are three areas in Harrison Bayou that are classified as BP. Two of these areas are near each other in the western half of the study area, and the other exists in the southeastern-most corner. These areas are all several hectares in size, and appear to have been permanently flooded for many years. These areas are considered as permanent aquatic communities, and so are not described in this study other than to identify their location and extent.

Wetland Plant Community Identification

Six of the plant community classifications are composed of communities that posses wetland features in all three indicator groups (Figure 6). These classifications are therefore considered to be composed of "wetland plant communities". The wetland plant community classifications are CBO, OLO, OCP, OO, SBE, and SLO, which cover 2,728,824 m^2 and represent 51.25% of the study area (Table 16). Tables 17 - 19 summarize by community class those that posses wetland hydrology (Table 17), those that posses wetland soils (Table 18), and those that posses wetland vegetation (Table 19).

These results show a very strong relationship between the presence of wetland soils and wetland hydrology. All the communities that were classified as possessing wetland soils were also classified as possessing wetland hydrology (Tables 15 and 16; Figures 7 and 8). Significantly fewer communities were classified as possessing either wetland soils or hydrology (51.23% of the study area) than possessing wetland vegetation (95.40%) (Figure 9), so these proved to be the limiting factors in deciding which would be considered as wetland communities.

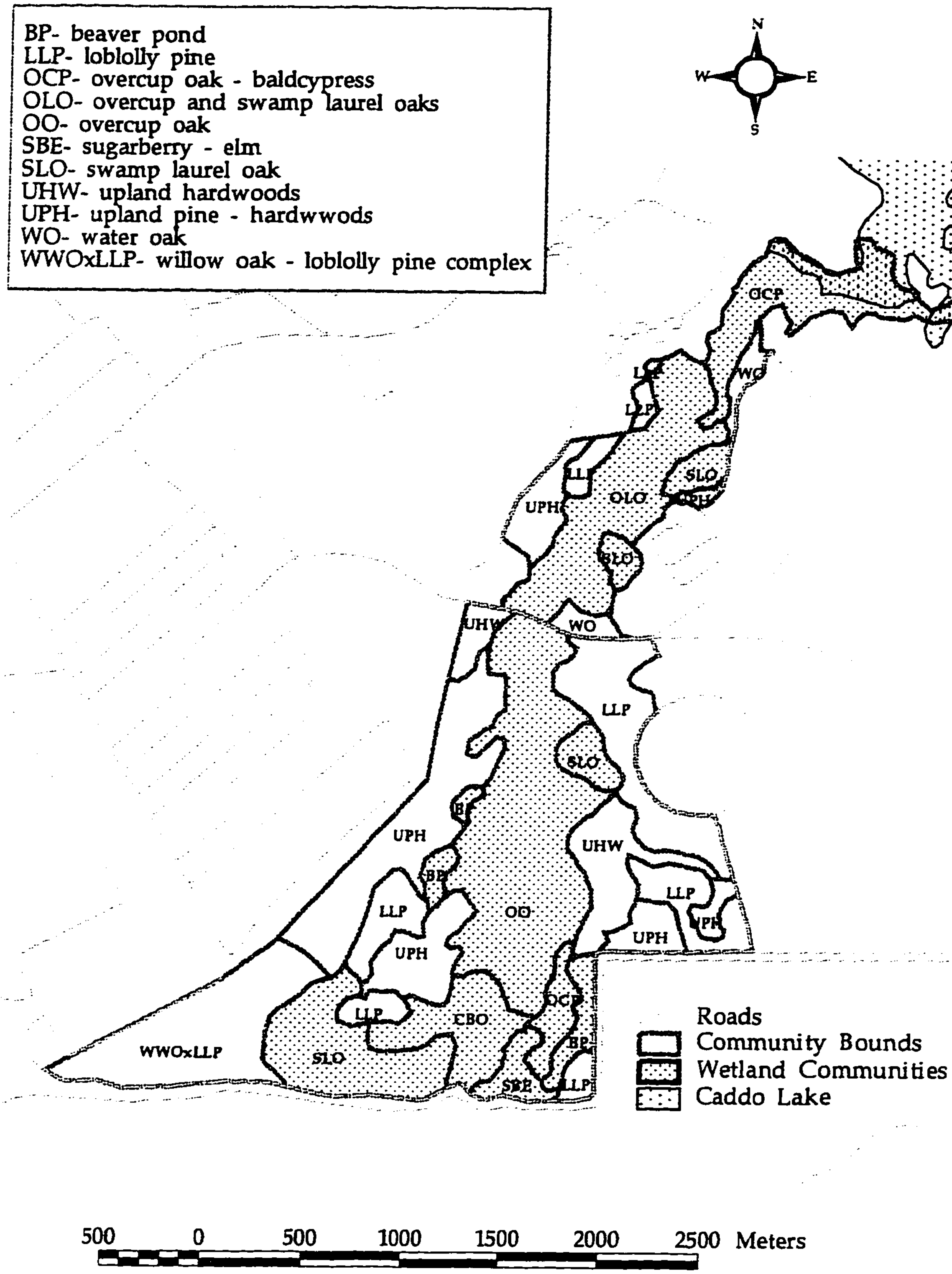


Figure 6. Communities of Harrison Bayou that are considered to be wetland communities.

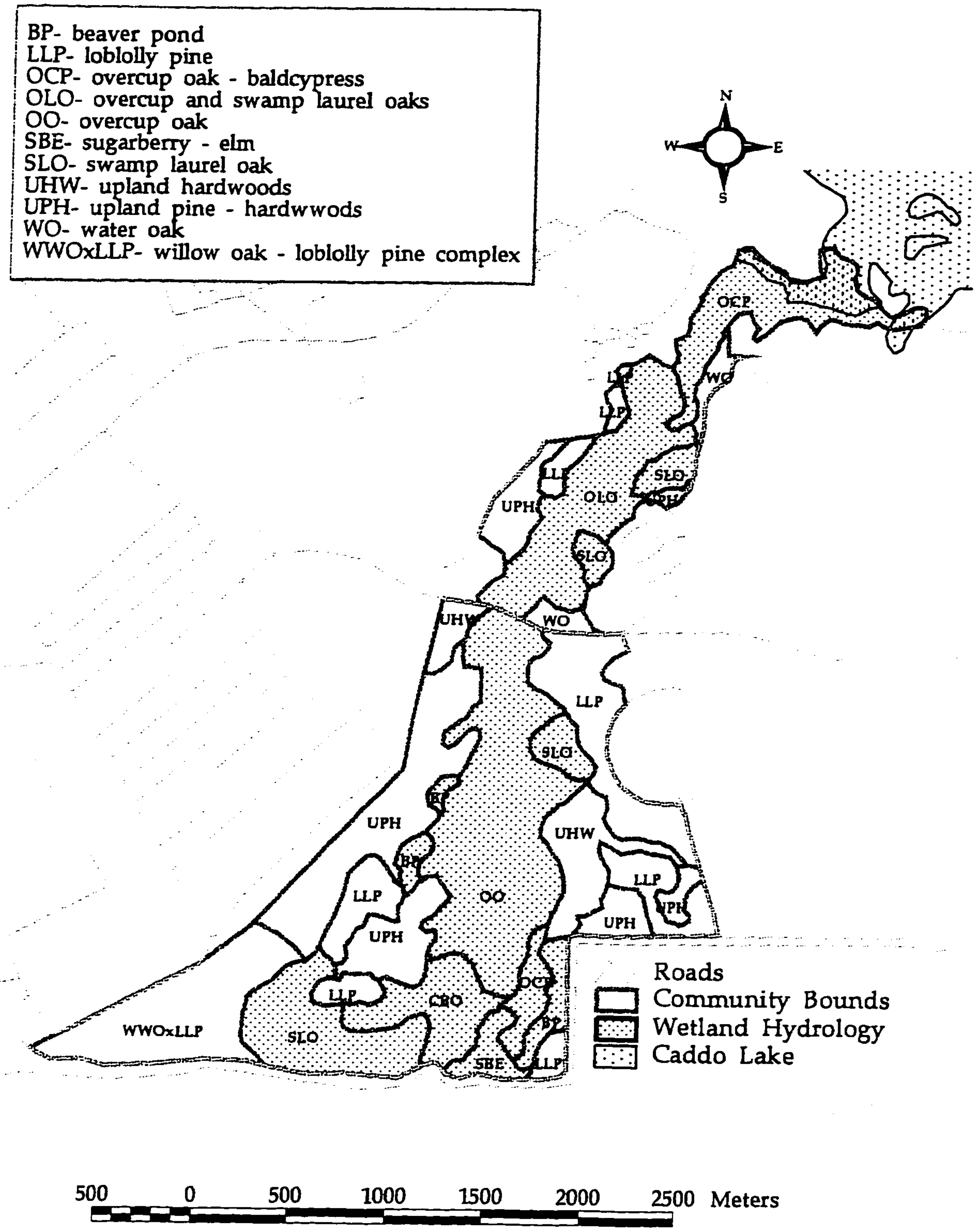


Figure 8. Communities of Harrison Bayou that posses wetland hydrology.

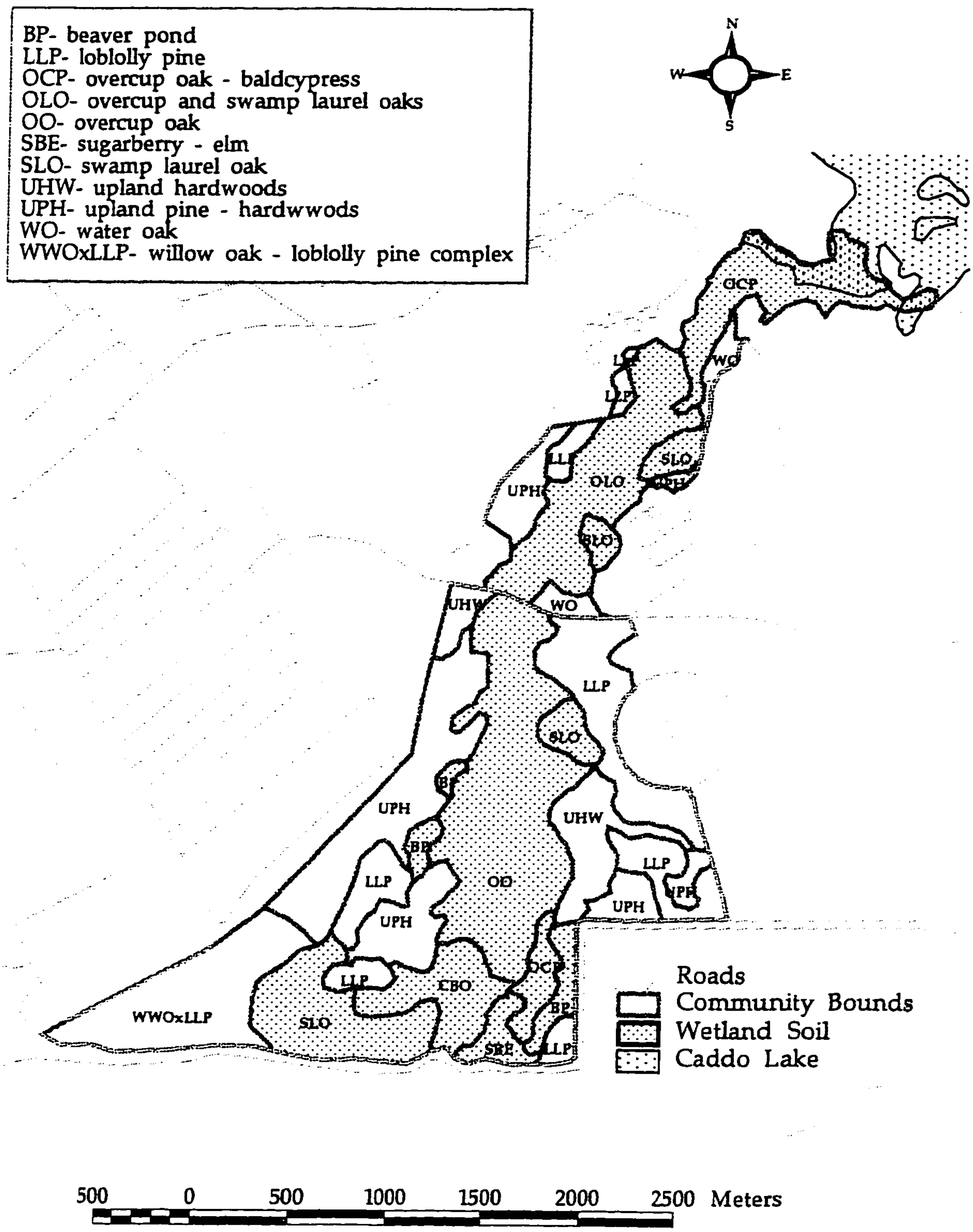


Figure 7. Communities of Harrison Bayou that posses wetland soils.

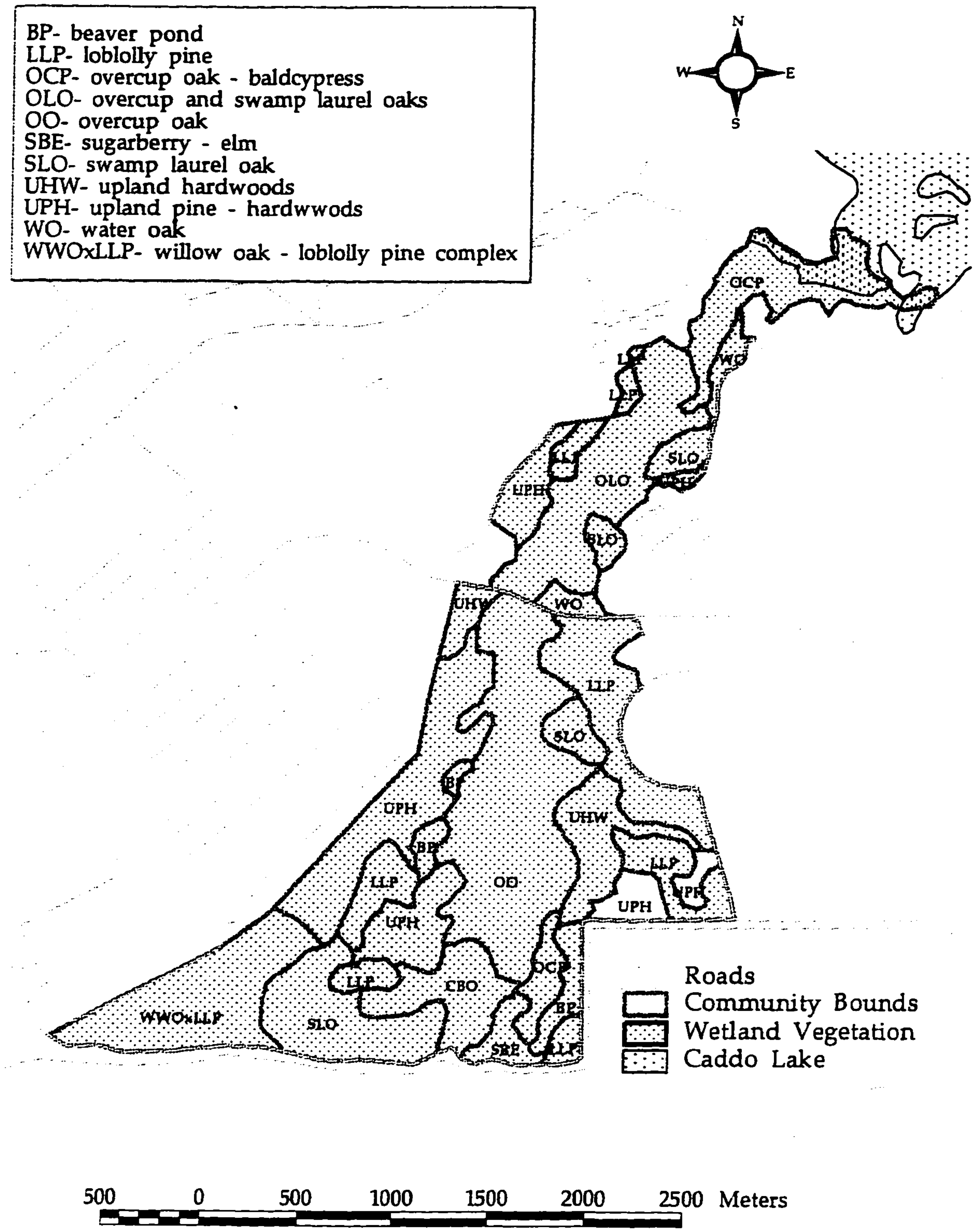


Figure 9. Communities of Harrison Bayou that posses wetland vegetation.

Table 16. Summary of the wetland plant community classifications of Harrison Bayou.

Community Class	Number of Communities	Total Area of Class (m^2)	Percent of Study Area Represented by Class
CBO	1	237087	4.47
OLO	2	445962	8.37
OCP	1	508462	9.55
OO	1	937432	17.60
SBE	1	76212	1.43
SLO	4	523669	9.83
Total	10	2728824	51.25

Table 17. Summary of the community classifications of Harrison Bayou that posses wetland hydrology.

Community Class	Number of Communities	Total Area of Class (m^2)	Percent of Study Area Represented by Class
CBO	1	237087	4.45
OCP	2	445963	8.37
OLO	1	508462	9.55
OO	1	937432	17.60
SBE	1	76212	1.43
SLO	4	523669	9.83
Total	10	2728825	51.23

Table 18. Summary of the community classifications of Harrison Bayou that posses wetland soils.

Community Class	Number of Communities	Total Area of Class (m^2)	Percent of Study Area Represented by Class
CBO	1	237087	4.45
OCP	2	445963	8.37
OLO	1	508462	9.55
OO	1	937432	17.60
SBE	1	76212	1.43
SLO	4	523669	9.83
Total	10	2728825	51.23

Table 19. Summary of the community classifications of Harrison Bayou that posses wetland vegetation.

Community Class	Number of Communities	Total Area of Class (m^2)	Percent of Study Area Represented by Class
CBO	1	237087	4.45
LLP	8	740750	13.91
OCP	2	445963	8.37
OLO	1	508462	9.55
OO	1	937432	17.60
SBE	1	76212	1.43
SLO	4	523669	9.83
UHW	2	273493	5.13
UPH	4	780384	14.65
WO	2	87759	1.65
WWOxLLP	1	470484	8.83
Total	27	5081695	95.4

DISCUSSION

The Plant Community Identification Procedure

This study utilized both satellite imagery and aerial photography to create an initial estimate of plant community locations. The initial identification of the communities was performed with the *Imagine*[*] pixel classification routine run on the digital data and using manual stereoscopic interpretation on the aerial photos. However, neither was completely satisfactory. The digital data possessed seven bands, or wavelength ranges, of data that provided for a broad basis for the classification of the pixcls. The photos, while only visible in the three colors visible to the human eye, had a much smaller spatial resolution.

One method which would have improved the resolution of the classification output would have been to scan the aerial photos into digital format and run the classification routine on that data. Unfortunately, the equipment was not available at the commencement of this study for this option to have been utilized. A compromise procedure was used in which the classification was run on the digital data, and the stereoscopic community delineation was manually compared to this output. The digital classification was then adjusted as it seemed necessary to compensate for any features that were visible on the photos. Although not as elegant or precise as the alternative, this procedure produced satisfactory results.

The development of the plant community classifications involved a comparison of the vegetative data collected at each sample point. These data were collected using the procedure of the 1987 CoE Wetland Delineation Manual. This procedure proved to be quite adequate and resulted in a very useful examination of the vegetative community at each point.

The Wetland Identification Method

While wetland soils and hydrology were found in 51.23% of the study area, wetland vegetation was shown to be present in 95.40% of the study area (Figure 8). The presence of so many communities classified as having wetland vegetation without wetland soils or hydrology is primarily due to three plant species: poison-ivy, slender spikegrass, and long-leaf spikegrass. These species all have a wetland indicator status of FAC. Since the wetland vegetation method utilized in this study considered all plant species with a wetland indicator status of FAC or wetter to be indicators of wetland vegetation, any community dominated by any of these species would have strong tendencies to be calculated as possessing wetland vegetation. These species were found across the study area, and were not limited to only those communities that were eventually classified as wetland. In fact, most of the communities sampled had at least one of these species present in significant quantities.

This illustrates one of the difficulties associated with using the 1987 CoE Wetland Delineation Manual method. By definition, plants with an indicator status of FAC are equally as likely to be found in wetlands as in non-wetlands. Yet, these plants are considered to be indicators of wetland vegetation. If the FAC plants were excluded from the wetland vegetation determination procedure, the hydric vegetation determination might agree more with that of hydric soils and wetland hydrology.

The process by which hydric vegetation is determined is dependent upon the existence of a comprehensive and reliable database of the plants likely to be found in wetlands in the area under scrutiny. In this study, 19 of the 79 plants that were dominant at at least one sample point were not listed in the database used to determine wetland indicator status (Table 4) (Reed, 1988). Since there was no wetland indicator status for these plants, they were not included in the calculations for hydric vegetation, and the vegetation determination was not as complete as it could have been. The hydric vegetation determination can only be as complete as the database allows. This is a major drawback in the wetland vegetation determination process, but one that can only be overcome with continued research and development of the database.

Generally, it is assumed that the lack of indication provided by any one of the three indicators will be compensated for by the other two. In the East Texas region, the least indicative indicator is wetland vegetation. Most of the plants in this region are FAC or wetter, so most areas will turn out to possess wetland vegetation according to the proccdure. This trend is dramatically illustrated by the results of the wetland vegetation determination for Harrison Bayou. It is generally accepted, however, that the least precise and most subjective of the wetland indicators used by the 1987 CoE Wetland Delineation Manual is the wetland hydrology determination. This presents a definite difficulty, as there is a question of reliability for two of the three indicators used to identify wetlands.

The problem with wetland hydrology is that of relic indicators. In Harrison Bayou, for example, the most common indicators of wetland hydrology observed were watermarks on tree trunks and waterstained leaves. Watermarks may remain for years after being made. In fact, watermarks can be created by a single flood event, and so are only an indication depth, but provide no indication to duration or frequency of flooding. Waterstained leaves are a better indicator, in that older leaves tend to be covered by newer leaves, so stained leaves from past events are usually decomposed or masked by unstained leaves from recent, non-flood years. However, leaves may be stained after a relatively brief period of time of inundation, and so these also provide no indication of duration or frequency of flooding.

Harrison Bayou is a tributary of Caddo Lake. In the past, the water level of Caddo Lake fluctuated greatly over the course of the year. In recent times, however, the level of the lake has been strongly controlled by a dam on Lake O' the Pines upstream and a spillway downstream. This has not allowed the level to fluctuate very much for many years. This fact tends to support the conclusion that many of the observed indicators of wetland hydrology may, in fact, be relic indicators from the time when the level of Caddo Lake fluctuated more. It is extremely difficult to determine the age of relic indicators, but when those such as watermarks, waterstained leaves, and debris accumulation are observed without the concurrent observation of indicators of more recent and long-lasting flooding, such as saturated soil, inundation, or a high water table, the resulting determination of wetland hydrology must be accepted only with reservation.

As with indicators of wetland hydrology, those of wetland soils also tend to remain long after the cause of their formation has been removed. Soil formation processes take place over such great periods of time that an area that has recently changed from a wetland to a non-wetland will retain its hydric soil features for years or decades. This can lead to the problem of relic soil features. At Harrison Bayou, there were several occurrences of hydric soil indicators that may have been relic. However, the procedure used to determine the presence of hydric soils does not allow for the existence of relic features, so they could not be taken into consideration.

As with all the parameters, the procedure for hydric soil determination involves looking for more than one feature. It is designed this way in an effort to reduce the effects of false indicators. The intent is that a single false or relic feature will not incorrectly identify an area as a wetland since the other features and indicators used will hopefully not also give a false indication of wetland conditions. In this way, the procedure recognizes and allows for its own flaws, and minimizes the incorrect identification of wetland areas.

Political compromise and technical limitations have made the 1987 CoE wetland delineation procedure the most widely used method in the country. This is why it was utilized in this study despite its limitations. These criticisms are intended not as a critique of its creators, but merely to point out the potential ways in which this method may generate erroneous results. With an understanding of the limitations of the method, it is possible to utilize it successfully. Care must simply be taken not to read too much into the results, and to understand the limitations of the wetland identification generated.

CONCLUSION

These results are the findings of an ecological characterization and wetland identification of the plant communities of Harrison Bayou. The community characterizations provide a detailed description of the plant communities that can be found in Harrison Bayou within the bounds of LHAAP. The wetland identification indicates which communities can be considered as planning level "wetland communities" and are likely to contain jurisdictional wetlands.

Harrison Bayou has been and will continue to be a valuable remainder of the East Texas ecological heritage. By adding to the present understanding of the plant communities of the Lake Caddo region, it is hoped that this information will be a valuable asset to those who are interested in understanding and preserving this remarkable area. Also, knowledge of plant community location, composition, and extent will enable present and future managers to make informed decisions to minimize negative impacts to Harrison Bayou.

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APPENDIX

Relative dominances of the dominant vegetation sampled in each community class of Harrison Bayou.

Table 1. Relative dominance of the dominant vegetation sampled in the cherrybark oak community (CBO).

Point	Trees		Herbaceous		Woody Vine		Sapling and Shrub	
	species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
B4.1	*Q. pagoda*	51.1	*T. radicans*	47.9	*T. radicans*	49.1	*U. americana*	45.5
	L. styraciflua	31.5	*Carex sp.*	19.9	*V. rotundifolia*	22.6	*C. canadensis*	18.2
							C. caroliniana	18.2
B4.2	*Q. pagoda*	68.2	*T. radicans*	41.5	*T. radicans*	49.1	*U. americana*	42.9
	Q. phellos	25.5	*P quinquefolia*	39.3	*P. uinquefolia*	10.5	*C. caroliniana*	14.3
							C. aquatica	14.3
							C. canadensis	14.3
							C. americana	14.3
B4.3	*Q. nigra*	43.2	*C. laxum*	67.0	*S. rotundifolia*	44.4	*G. aquatica*	42.9
	Q. lyrata	36.4			*T. radicands*	33.3	*S. americana*	28.8
					B. capreolata	22.2	*U. americana*	28.8
B4.4	*C. aquatica*	60.5	*S. cernuus*	83.3	*S. rotundifolia*	100.0	*C. aquatica*	66.7
	Q. lyrata	39.5						

Table 2. Relative dominance of the dominant vegetation sampled in the loblolly pine community (LLP).

Point	Trees		Herbaceous		Woody Vine		Sapling and Shrub	
	species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
1	*P. taeda*	94.8	*T. radicans*	38.6	*B. scandens*	30.0	*L. styraciflua*	24.4
			P. quinquefolia	29.5	*P. quinquefolia*	27.5	*Q. lyrata*	13.1
							U. alata	12.5
2	*P. taeda*	86.3	*P. quinquefolia*	33.8	*T. radicans*	25.0	*L. styraciflua*	69.0
			T. radicans	21.1	*B. scandens*	25.0		
3	*P. taeda*	81.5	*P. quinquefolia*	38.6	*S. rotundifolia*	29.4	*U. alata*	31.3
			T. radicans	18.5	*B. scandens*	20.6	*U. americana*	18.1
					S. bona-nox	14.7		
4	*P. taeda*	72.1	*S. rotundifolia*	32.3	*S. rotundifolia*	87.5	*L. styraciflua*	62.5
			T. radicans	19.4			*U. alata*	21.9
5	*P. taeda*	98.5	*T. radicans*	87.5	*V. rotundifolia*	62.1	*U. alata*	47.6
							C. canadensis	28.6
6	*P. taeda*	100.0	*C. sessiliflorum*	35.4	*A. arborea*	38.2	*A. arborea*	27.6
			T. radicans	24.8	*T. radicans*	32.4	*P. taeda*	27.6
			S. bona-nox	22.1				
8	*P. taeda*	97.5	*T. radicans*	65.8	*T. radicans*	55.6	*L. styraciflua*	54.4
					V. mustangensis	27.8	*U. alata*	30.9
B3.4	*P. taeda*	95.6	*T. radicans*	85.8	*T. radicans*	53.3	*Q. laurifolia*	34.9
					B. scandens	26.7	*Q. nigra*	20.9
					S. glauca	20.0		

Table 3. Relative dominance of the dominant vegetation sampled in the overcup - laurel oaks community (OLO).

Point	Trees		Herbaceous		Woody Vine		Sapling and Shrub	
	species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
B11.1	*T. distichum*	41.4	*C. laxum*	20.8	*B. scandens*	30.0	*I. coreacea*	50.0
	Q. laurifolia	30.2	*H. militaris*	17.7	*T. radicans*	25.0	*I. glabra*	36.4
	L. styraciflua	28.4	*R. trivialis*	13.0	*S. bona-nox*	20.0		
			unknown Poacea	10.6				
B11.2	*Q. laurifolia*	67.5	*C. laxum*	22.8	*T. radicans*	57.1	*L. styraciflua*	28.6
	Q. lyrata	26.6	*P. anceps*	10.9			*I. verticellata*	28.6
			T. radicans	8.7			*I. glabra*	21.4
			Sphagnum sp.	7.6				
B11.3	*C. aquatica*	51.5	*C. laxum*	31.9	*T. radicans*	100.0	*I. glabra*	52.0
	Q. nigra	34.2	*L. japonicum*	16.5				
			R. trivialis	13.4				
B11.4	*P. taeda*	33.7	*C. sessiliflorum*	36.6	*V. rotundifolia*	38.7	*H. militaris*	19.0
	Q. laurifolia	29.1	*V. rotundifolia*	16.7	*S. rotundifolia*	24.2	*Q. laurifolia*	19.0
	Q. lyrata	24.8					*I. glabra*	14.3
							I. verticellata	14.3
							L. styraciflua	14.3
B16.1	*Q. lyrata*	72.9	*C. laxum*	30.4	*S. rotundifolia*	26.3	*I. glabra*	27.3
	F. pennsylvanica	20.3	*unk. Cyperacea*	27.1	*A. arborea*	21.1	*Q. laurifolia*	27.3
					T. radicans	21.1		
B16.2	*Q. laurifolia*	63.3	*C. laxum*	41.8	*S. bona-nox*	50.0	*I. glabra*	77.8
			unk. Cyperacea	14.3	*T. difforme*	37.5		
B16.3	*Q. laurifolia*	54.6	*T. radicans*	21.2	*V. rotundifolia*	34.6	*I. glabra*	61.9
	Q. lyrata	42.9	*C. laxum*	16.2	*T. radicans*	23.1		
			C. sessiliflorum	11.9				
			V. rotundifolia	11.5				
B16.4	*Q. laurifolia*	57.6	*C. laxum*	36.9	*B. scandens*	36.4	*I. glabra*	77.3
	C. verticellata	42.4	*R. trivialis*	19.1	*T. difforme*	27.3		

continued

Table 3. Continued.

Point	Trees		Herbaceous		Woody Vine		Sapling and Shrub	
	species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
B17.1	*P. taeda*	32.8	*T. radicans*	42.9	*T. radicans*	62.5	*L. styraciflua*	66.7
	Q. phellos	21.6	*C. laxum*	22.0			*C. americana*	33.3
	T. distichum	21.6						
B17.2	*Q. laurifolia*	55.7	*T. radicans*	35.1	*T. radicans*	61.5	*I. glabra*	62.5
	T. distichum	30.5	*C. laxum*	16.1				
B17.3	*Q. laurifolia*	64.9	*C. laxum*	24.1	*B. scandens*	50.0	*I. glabra*	78.3
	T. distichum	26.3	*R. trivialis*	17.4	*T. radicans*	25.0		
			unk. Cyperacea	16.8				

Table 4. Relative dominance of the dominant vegetation sampled in the overcup oak - cypress community (OCP).

Point	Trees		Herbaceous		Woody Vine		Sapling and Shrub	
	species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
B12.1	*Q. lyrata*	100.0	*G. sempervirens*	25.6	*S. rotundifolia*	100.0	*I. verticellata*	55.6
			C. laxum	25.3			*L. styraciflua*	22.2
							I. glabra	22.2
B12.2	*Q. lyrata*	100.0	*B. ovata*	25.6	*B. ovata*	100.0	*F. accuminata*	95.1
			I. verticellata	22.1				
			H. mosceatus	15.7				
B15.1	*T. distichum*	79.5	*L. oryzoides*	52.7	*A. arborea*	40.6	*F. pennsylvanica*	44.4
	U. americana	20.5			*V. rotundifolia*	31.3	*C. occidentalis*	33.3
							T. distichum	22.2
B15.2	*Q. lyrata*	66.2	*L. oryzoides*	25.0	*none*		*T. distichum*	62.5
			S. cernuus	24.1			*C. occidentalis*	25.0
			B. cylindrica	21.6				

Table 5. Relative dominance of the dominant vegetation sampled in the overcup oak (OO).

Point	Trees		Herbaceous		Woody Vine		Sapling and Shrub	
	species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
7	*P. aquatica*	41.5	*Sphagnum sp.*	49.2	*T. radicans*	56.3	*M. pomifera*	27.1
	M. pomifera	37.9	*T. radicans*	13.1	*S. bona-nox*	25.0	*P. aquatica*	18.8
	G. aquatica	20.6					*U. alata*	16.7
B1.1	*Q. lyrata*	39.5	*P. quinquefolia*	39.3	*P. quinquefolia*	47.4	*I. glabra*	42.9
	Q. laurifolia	32.4	*T. radicans*	26.0	*T. radicans*	28.9	*U. alata*	28.6
B1.2	*Q. lyrata*	50.2	*C. laxum*	60.8	*S. glauca*	100.0	*I. glabra*	66.7
	Q. nigra	30.4					*U. americana*	33.3
B1.3	*N. sylvatica*	43.3	*V. primulifolia*	37.0	*B. scandens*	92.3	*C. caroliniana*	100.0
	L. styraciflua	43.3	*C. laxum*	15.9				
B14.1	*Q. lyrata*	90.7	*T. radicans*	42.0	*T. radicans*	48.6	*U. americana*	40.0
			P. quinquefolia	14.3	*P. quinquefolia*	24.3	*A. gigantea*	26.7
							I. glabra	26.7
B14.2	*U. americana*	27.1	*T. radicans*	30.5	*T. radicans*	45.8	*Q. lyrata*	37.5
	Q. laurifolia	25.3	*C. laxum*	17.9	*S. bona-nox*	25.0	*L. styraciflua*	18.8
	L. styraciflua	23.0	*P. quinquefolia*	15.4	*P. quinquefolia*	20.8	*Q. laurifolia*	18.8
	Q. nigra	21.8						

Table 6. Relative dominance of the dominant vegetation sampled in the sugarberry - elm community (SBE).

Point	Trees		Herbaceous		Woody Vine		Sapling and Shrub	
	species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
B3.1	*C. laevigata*	34.7	*P.*	37.3	*B. scandens*	88.9	*Q. laurifolia*	92.3
	F. pennsylvanica	24.6	*pennsylvanicum*	31.8				
			Carex sp.					
B3.2	*C. laevigata*	53.9	*S. cernuus*	63.7	*B. scandens*	61.8	*U. americana*	26.7
	U. americana	46.1					*Q. laurifolia*	26.7

Table 7. Relative dominance of the dominant vegetation sampled in the swamp laurel oak community (SLO).

Point	Trees		Herbaceous		Woody Vine		Sapling and Shrub	
	species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
B2.1	*Q. laurifolia*	78.1	*C. laxum*	69.8	*none*	0.0	*I. glabra*	54.5
							F. pennsylvanica	27.3
B2.2	*U. alata*	100.0	*C. laxum*	80.1	*none*	0.0	*I. glabra*	75.0
							U. alata	25.0
B2.3	*Q. laurifolia*	100.0	*C. laxum*	70.1	*none*	0.0	*U. alata*	85.7
B2.4	*Q. phellos*	88.6	*unk. Poacea*	32.5	*T. radicans*	100.0	*I. glabra*	73.3
			C. laxum	29.6			*U. alata*	26.7
B5.1	*Q. pagoda*	48.0	*T. radicans*	33.9	*T. radicans*	42.9	*I. glabra*	52.6
	Q. laurifolia	29.4	*Carex sp.*	13.9	*S. rotundifolia*	25.7		
	Q. lyrata	22.5	*C. laxum*	11.8				
B5.2	*Q. laurifolia*	87.5	*C. laxum*	32.3	*S. rotundifolia*	70.6	*I. glabra*	70.5
			Carex sp.	13.9				
B5.3	*Q. lyrata*	53.6	*V. rotundifolia*	37.4	*S. rotundifolia*	48.1	*A. triloba*	68.3
	L. styraciflua	23.8	*T. radicans*	25.5	*S. bona-nox*	23.1		
B5.4	*L. styraciflua*	43.6	*P. quinquefolia*	30.7	*B. scandens*	61.9	*A. pavia*	29.0
	Q. nigra	35.3	*S. rotundifolia*	22.2			*I. glabra*	19.4
			C. sessiliflorum	21.1			*A. triloba*	19.4
B9.1	*Q. laurifolia*	75.4	*C. sessiliflorum*	41.3	*V. rotundifolia*	32.4	*P. taeda*	34.5
			V. rotundifolia	13.4	*S. rotundifolia*	26.5	*U. americana*	72.0
B10.1	*Q. phellos*	70.9	*C. sessiliflorum*	41.3	*B. scandens*	31.8	*U. americana*	72.0
			P. quinquefolia	13.4	*S. rotundifolia*	27.3		
B10.2	*Q. laurifolia*	68.5	*C. sessiliflorum*	42.0	*V. rotundifolia*	30.8	*U. americana*	66.7
			Sphagnum sp.	35.7	*S. rotundifolia*	30.8		
					T. radicans	23.1		

Table 8. Relative dominance of the dominant vegetation sampled in the upland hardwood community (UHW).

Point	Trees		Herbaceous		Woody Vine		Sapling and Shrub	
	species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
13	*Q. falcata*	53.0	*C. sessiliflorum*	33.0	*L. japonica*	60.0	*A. barbatum*	40.0
			T. radicans	12.8	*T. radicans*	30.0	*U. americana*	15.6
14	*Q. alba*	51.0	*Q. alba*	38.9	*T. radicans*	33.3	*A. barbatum*	50.0
	Q. marilandica	33.4	*S. bona-nox*	18.1	*S. glauca*	28.6	*L. styraciflua*	19.7
					B. scandens	23.8		
15	*Q. nigra*	54.7	*T. radicans*	32.5	*S. glauca*	54.3	*C. florida*	15.8
			C. sessiliflorum	15.9			*Q. alba*	15.8
			S. glauca	7.0			*L. styraciflua*	12.3
							A. rubrum	8.8
							Q. phellos	8.8
32	*P. taeda*	47.3	*T. radicans*	25.2	*V. rotundifolia*	28.0	*C. americana*	19.8
	L. styraciflua	26.3	*U. alata*	13.4	*S. glauca*	18.6	*Q. phellos*	15.6
			C. americana	10.8	*S. lanceolata*	15.5	*U. alata*	12.5
			S. lanceolata	9.8			*L. styraciflua*	8.3
33	*Q. stellata*	53.5	*C. sessiliflorum*	35.7	*V. rotundifolia*	29.1	*L. styraciflua*	36.0
	L. styraciflua	46.5	*V. rotundifolia*	10.9	*R. trivialis*	28.2	*Q. phellos*	12.4
			L. japonica	10.0			*U. alata*	8.7
34	*L. styraciflua*	72.5	*C. sessiliflorum*	45.3	*S. bona-nox*	25.6	*L. styraciflua*	26.4
			T. radicans	11.1	*V. rotundifolia*	20.5	*Q. phellos*	13.2
					B. scandens	17.9	*Q. marilandica*	10.7
							U. alata	6.6
35	*L. styraciflua*	51.6	*C. sessiliflorum*	35.3	*V. rotundifolia*	48.3	*P. palustris*	22.0
	Q. marilandica	42.7	*U. alata*	14.1	*S. glauca*	24.7	*L. styraciflua*	21.0
			T. radicans	14.1			*Q. marilandica*	13.0

Table 9. Relative dominance of the dominant vegetation sampled in the upland pine - hardwood community (UPH).

Point	Trees		Herbaceous		Woody Vine		Sapling and Shrub	
	species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
9	*N. sylvatica*	71.5	*UN#15*	19.8	*V. rotundifolia*	70.0	*U. alata*	32.8
	P. taeda	23.5	*V. rotundifolia*	16.6	*V. mustangensis*	20.0	*C. canadensis*	10.3
			E. carolinianus	18.7			*V. arboretum*	10.3
10	*L. styraciflua*	45.0	*P. quinquefolia*	18.7	*V. rotundifolia*	33.3	*U. americana*	41.7
	Q. stellata	19.0	*unk. Cyperacea*	16.8	*V. mustangensis*	23.8	*O. virginiana*	20.8
			V. rotundifolia	16.8				
11	*P. taeda*	50.7	*V. rotundifolia*	37.5	*V. rotundifolia*	75.0	*V. arboreum*	60.0
	Q. marilandica	49.3	*Q. marilandica*	25.0			*Q. marilandica*	24.0
12	*Q. falcata*	39.5	*C. sessiliflorum*	27.7	*V. rotundifolia*	54.5	*Q. marilandica*	37.5
	C. lieodermis	26.9	*V. rotundifolia*	27.0			*C. marshallii*	13.9
36	*P. taeda*	81.8	*T. radicans*	36.1	*V. aestivalis*	50.0	*Q. marilandica*	28.3
			V. aestivalis	29.5	*A. arborea*	25.0	*D. virginiana*	26.4
37	*P. taeda*	81.2	*C. sessiliflorum*	33.3	*B. scandens*	28.8	*P. taeda*	25.6
			T. radicans	20.6	*S. glauca*	22.0	*Q. marilandica*	14.7
							D. virginiana	11.5
38	*P. taeda*	55.8	*C. sessiliflorum*	41.5	*V. aestivalis*	54.8	*A. rubrum*	26.9
	Q. phellos	20.5	*Sphagnum sp.*	25.6	*S. glauca*	26.2	*U. alata*	19.2
							Q. phellos	11.5
39	*P. taeda*	87.9	*R. hispida*	26.8	*S. bona-nox*	42.9	*P. taeda*	61.0
			C. sessiliflorum	24.4	*V. aestivalis*	28.6		
B6.1	*P. taeda*	70.4	*P. quinquefolia*	36.3	*T. radicans*	31.3	*Q. marilandica*	15.3
	L. styraciflua	26.6	*T. radicans*	35.9	*S. bona-nox*	18.8	*L. styraciflua*	14.1
					S. rotundifolia	18.8	*U. alata*	10.6
							C. florida	10.6
B6.2	*P. taeda*	62.7	*P. quinquefolia*	47.7	*T. radicans*	50.0	*Q. phellos*	20.6
			Q. marilandica	14.5	*V. rotundifolia*	25.0	*Q. marilandica*	17.6
					A. arborea	25.0	*F. americana*	16.2

continued

Table 9. Continued.

Point	Trees		Herbaceous		Woody Vine		Sapling and Shrub	
	species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
B6.3	*L. styraciflua*	35.7	*P. quinquefolia*	32.9	*B. scandens*	41.7	*C. florida*	25.7
	Q. stellata	30.0	*C. sessiliflorum*	25.9	*T. radicans*	25.0	*Q. marilandica*	20.3
	P. taeda	29.6			*P. quinquefolia*	25.0	*A. rubrum*	14.9
B6.4	*L. styraciflua*	40.9	*P. quinquefolia*	38.4	*S. bona-nox*	53.3	*C. texana*	22.6
	C. texana	13.7	*C. sessiliflorum*	25.6	*T. radicans*	26.7	*C. florida*	19.4
					P. quinquefolia	20.0	*L. styraciflua*	11.3

Table 10. Relative dominance of the dominant vegetation sampled in the water oak community (WO).

Point	Trees		Herbaceous		Woody Vine		Sapling and Shrub	
	species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
B8.1	*Q. nigra*	80.7	*C. sessiliflorum*	61.4	*S. rotundifolia*	51.5	*I. glabra*	27.1
					V. rotundifolia	41.4	*Q. phellos*	23.7
B13.1	*Q. nigra*	58.3	*T. radicans*	34.3	*S. rotundifolia*	50.0	*C. americana*	55.9
			P. quinquefolia	14.4	*T. radicans*	16.7	*A. rubrum*	20.6
			S. rotundifolia	11.7				
B13.2	*U. americana*	52.1	*T. radicans*	28.0	*S. rotundifolia*	50.0	*C. americana*	25.5
	Q. nigra	31.8	*C. sessiliflorum*	26.0	*T. radicans*	26.1	*Q. laurifolia*	14.9
			P. quinquefolia	23.0			*I. glabra*	12.8
							C. canadensis	12.8
							L. styraciflua	12.8

Table 11. Relative dominance of the dominant vegetation sampled in the willow oak - loblolly pine complex community (WWOxLLP).

Point	Trees		Herbaceous		Woody Vine		Sapling and Shrub	
	species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
LLP component								
17	*P. taeda*	88.8	*C. sessiliflorum*	29.8	*V. rotundifolia*	78.4	*U. alata*	23.5
			T. radicans	24.4			*Q. marilandica*	21.0
							P. taeda	14.8
18	*P. taeda*	100.0	*V. rotundifolia*	26.0	*S. bona-nox*	46.7	*U. alata*	44.2
			S. bona-nox	21.9	*V. rotundifolia*	28.9	*Q. marilandica*	15.1
					T. radicans	20.0	*Q. phellos*	11.6
							P. taeda	11.6
20	*P. taeda*	77.4	*T. radicans*	61.0	*T. radicans*	93.8	*L. styraciflua*	32.7
							U. alata	15.4
							A. arborea	11.5
22	*P. taeda*	100.0	*T. radicans*	96.0	*V. rotundifolia*	64.7	*L. styraciflua*	88.3
					T. radicans	23.5		
29	*P. taeda*	81.7	*C. sessiliflorum*	39.0	*S. glauca*	24.4	*Q. marilandica*	30.6
			Sphagnum sp.	19.5	*T. radicans*	22.0	*L. styraciflua*	23.4
					V. aestivalis	17.1		
30	*C. tomentosa*	63.4	*T. radicans*	28.2	*V. rotundifolia*	42.6	*Q. marilandica*	22.9
	P. taeda	36.6	*C. marshallii*	18.2	*S. glauca*	31.1	*Q. phellos*	22.9
							A. rubrum	10.4
WWO component								
31	*P. taeda*	67.6	*T. radicans*	34.0	*S. glauca*	47.4	*P. taeda*	27.1
	L. styraciflua	27.1	*C. sessiliflorum*	24.0	*T. radicans*	17.9	*A. rubrum*	17.6
					V. aestivalis	17.9	*Q. marilandica*	14.1
							U. alata	14.1

continued

Table 11. Continued.

Point	Trees		Herbaceous		Woody Vine		Sapling and Shrub	
	species	dominance (%)	species	dominance (%)	species	dominance (%)	species	dominance (%)
19	*Q. phellos*	95.6	*Sphagnum sp.*	81.4	*V. rotundifolia*	66.7	*Q. phellos*	69.2
					T. radicans	33.3		
21	*Q. marilandica*	36.9	*V. aestivalis*	28.4	*S. glauca*	42.9	*I. vomitoria*	18.2
	Q. pagoda	29.4	*T. radicans*	22.0	*T. radicans*	33.3	*P. taeda*	18.2
					V. aestivalis	23.8	*Q. phellos*	15.9
23	*Q. phellos*	83.3	*Sphagnum sp.*	70.0	*none*	0.0	*I. vomitoria*	50.0
			C. laxum	30.0			*Q. phellos*	40.0
28	*Q. pagoda*	61.4	*T. radicans*	46.8	*S. glauca*	48.7	*Q. marilandica*	26.5
	Q. marilandica	38.6	*C. sessiliflorum*	36.1	*R. trivialis*	21.2	*U. alata*	20.6
							Q. phellos	11.8

VITA

Boyd David Tracy was born in Ogden City, Utah on August 21, 1972. He is the only son of David Dean Tracy and Karrie Lee Lund Tracy (now Karrie Lee Lund Dennis). After graduating from Grapevine High School in Grapevine, Texas, in 1990, Boyd joined the U.S. Army Reserve. Upon completion of his initial training, he enrolled at Tarrant County Junior College in Hurst, Texas, in January 1991. After completing two semesters there, he transferred to Stephen F. Austin State University in Nacogdoches, Texas. Boyd received the degree of Bachelor of Science in Forestry in December 1994. He entered the graduate school at Stephen F. Austin State University in January 1995 and began pursuing the degree of Master of Science in Forestry.

Permanent Address:

2304 Mockingbird Dr.
Grapevine, Texas 76051

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