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Characterization of Soil Processes in Bottomland Hardwood Wetland-Nonwetland Transition Zones in the Lower Mississippi River Valley

by

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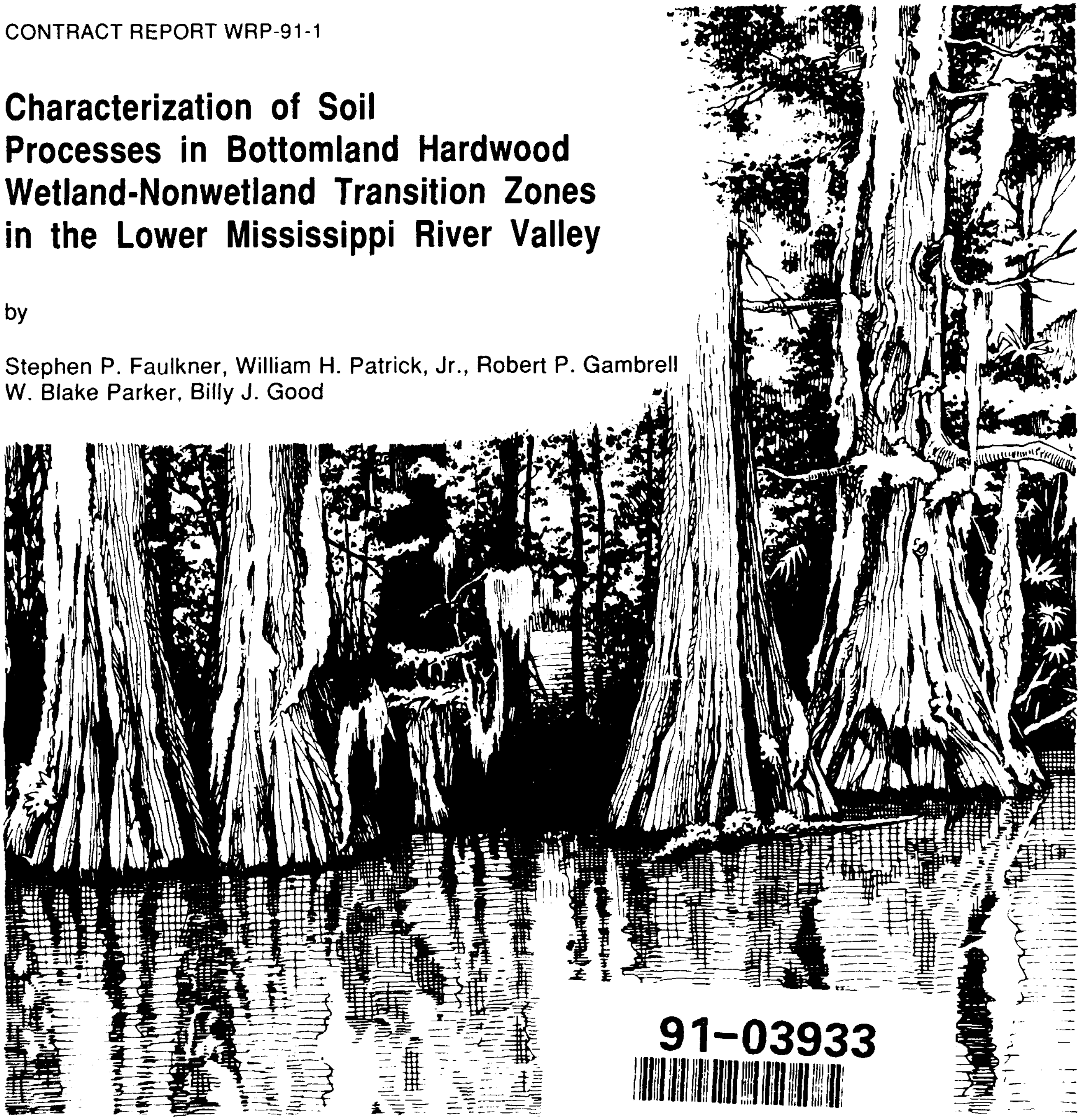

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This document reports the results of a 4-year study of bottomland hardwood soils. The purposes of the study were to characterize the effects of saturation and inundation on soil processes in nonwetland, transitional, and wetland habitats and provide data for identifying and delineating wetlands from nonwetlands in the Lower Mississippi River Valley. Detailed technical information for constructing and installing equipment to measure soil redox potential and oxygen content is provided.

Soil redox potential, oxygen content, water table depth were measured at several soil depths on five transects in Louisiana and Mississippi. These data were compared with soil profile descriptions, hydrologic zonal classification, and the presence of hydric soils to determine the relationships among soil redox conditions and diagnostic wetland indicators. Tree-coating constituents were also measured to determine if plant adaptations are effective indicators of wetland soil conditions.

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The results indicated that large areas of bottomland hardwood forests in the Lower Mississippi River Valley are not inundated or saturated for long periods during the growing season. There are very wet, almost permanently inundated sites, but those areas that are seasonally inundated are oxidized and aerobic throughout the root zone for most of the growing season. Saturated, anaerobic conditions for as little as 10 to 15 percent of the growing season appear sufficient to induce wetland soil characteristics (mottling, gleying, low chroma colors) in the soil profile. These wetland soil characteristics were generally more reliable than the plant root coatings in delineating wetlands.

SUMMARY

Bottomland hardwood forests in the southeastern United States encompass a variety of habitats ranging from semipermanently flooded to briefly inundated. Identifying wetlands protected by Section 404 of the Clean Water Act is often difficult in this floodplain ecosystem. This project was initiated to provide data to assist in developing a technical methodology for delineating wetlands from adjacent nonwetlands.

Five transects were located in mature, bottomland hardwood forests in Louisiana and Mississippi: Pearl River (PR), Quimby (QU), Rolling Fork (RF), Red River (RR), and Spring Bayou (SB). These transects traversed wetland, nonwetland, and transitional habitats parallel to the natural moisture gradient. Four or five plots were selected per transect based on changes in soil type and vegetative species composition. Equipment was installed in the spring and summer of 1982. Soil moisture content, soil oxidation-reduction (redox) potential, and soil oxygen content at 15, 30, 60, and 120 cm were monitored monthly from September 1982 to August 1985 with permanently installed equipment. Soil temperature at 15, 30, and 50 cm and water table depth in the upper 120 cm of the soil was also measured during this time. These data were compared with soil profile descriptions, hydrologic zonal classification, and the presence of hydric soils to determine the relationships among soil redox conditions and diagnostic wetland indicators (Part I).

The aerobic conditions reflected by the oxygen and redox profiles were conclusive enough to classify five sites as nonwetland: QU1, QU2, RR1, RR2, and RF1. These nonwetland profiles exhibited little change through the year; the water table remained low.and as expected, oxygen content and redox potential were high, indicating a well-oxidized profile. Three of these sites (QU1, QU2, and RF1) had positive wetland indicators that would classify these as hydric soils despite the absence of reducing conditions throughout the study period. At these three sites, the quantitative data contradicted the qualitative soil diagnostic indicators. Hydrology is the determinant parameter delineating these sites, and determining the current moisture regime is critical.

The oxygen and redox profiles alone were inconclusive evidence to delineate 11 plots (PR1, PR2, PR3, PR4, QU3, QU4.A, RF2, RF3, RF4, SB1, and SB2), and these were judged as transitional between functioning wetlands and nonwetlands. These plots were seasonally inundated, with the water table rising in late fall and, depending on the year, remaining in the soil profile through the winter and into the growing season. Using additional data (hydric soils, soil profile descriptions), two sites (PR1 and QU4.A) were classified as nonwetland and the rest as wetlands.

Eight sites were delineated as wetlands based solely on the oxygen and redox profiles: PR5, QU4.B, QU5, RR3, RR4, RF5, SB3, and SB4. These sites were characteristically saturated, reduced, and anaerobic at 30 cm for long periods during the growing season. The quantitative soils

data, qualitative profile descriptions, and hydric soil designations all supported the wetland status of these plots.

The results indicate that large areas of bottomland hardwood forests in the Lower Mississippi River Valley are not inundated or saturated for long periods during the growing season. There are certainly very wet, almost permanently inundated sites, but those areas that are seasonally inundated are oxidized and aerobic throughout the root zone for most of the growing season. Saturated, anaerobic conditions for as little as 10 to 15 percent of the growing season appear sufficient to induce wetland soil characteristics (mottling, gleying, low chroma colors) in the soil profile.

Hydroperiods and reducing conditions ranged widely among soils at both the subgroup and series level. The Fausse series ranged from anaerobic for less than 50 percent to 100 percent of the growing season. The Typic Fluvaquent subgroup was found in an array of oxygen and redox regimes, with anaerobic conditions ranging from 10 to 100 percent of the growing season. The range of conditions was also evident in the ecological zonation concept where only a few sites met the hydroperiod or soil oxygen criteria and those that did just barely qualified; most were drier than specified.

Green ash (*Fraxinus pennsylvanica*) root-coating constituents and alcohol dehydrogenase activity (ADH) were measured to determine if these plant adaptations are effective indicators of wetland soil conditions (Part II). Green ash seedlings were transplanted to plots on four of the five transects and root-coating constituents and ADH activity of the seedlings were assayed after 1.5 years. Each plot was classified as wet or mesic based on the 1983 soils data. A two-group discriminant analysis function was developed to determine how well the seedling root data predicted the predetermined wet or mesic category of the plot.

Of the elements tested, potassium was the best predictor variable and levels decreased with increasing site wetness. Mean iron and manganese levels increased by factors of seven (iron) and four (manganese) from mesic to wet plots, but their large variance diminished their effectiveness as predictor variables. The variables chosen for inclusion in the discriminant analysis function, in descending order of predictive power, were potassium, iron/manganese ratio, nickel, magnesium, ADH, and manganese. When the discriminant analysis function was applied to all observations in the data set, the *a posteriori* probability of correct classification was 92 percent for wet plots and 89 percent for mesic plots. The deposition of root-coating constituents and anaerobic respiration were different enough on wet and mesic plots to develop a model for the site wetness classification. However, this approach was less diagnostic than the soils data on transitional sites.

The importance of iron and manganese reactions in soil pedogenic processes, soil moisture regime determination, plant root-coating constituents, and diagnostic field indicators led to one other study on this project. The purpose was to determine if extractable forms of soil iron and manganese, seasonal changes considered, could serve as a technique for delineating wetlands from nonwetlands or complement existing procedures (Part III). Soil samples at 15 and 60 cm were collected from each of the transects at various intervals from August 1984 to June 1985. Exchangeable iron and manganese (extracted with 1 N sodium acetate) and pH were measured in the laboratory.

There were no substantial changes in extractable iron and manganese levels between the seasons; however, there were some clear trends among the transects. The Red River and Quimby sites had substantially greater amounts of exchangeable iron and manganese at the lower landscape positions (RR3, RR4, QU5) at both the 15- and 60-cm depths compared with the higher elevation plots. These differences ranged from two to three orders of magnitude for iron. Despite substantial differences in hydrology and soil redox status between wetland and nonwetland sites at the Rolling Fork transect, there was little increase in exchangeable iron and manganese with increasing wetness. The Spring Bayou and Pearl River sites tended to be intermediate to the other two groups in terms of the increase in exchangeable iron and manganese going from upland to wetland plots. The highest levels of iron found were far less than those at Red River and Quimby. Both pH and exchangeable iron and manganese levels reflected differences among wetland and upland plots at some of the transects. However, this technique is not a reliable method for delineating wetlands from nonwetlands in bottomland hardwood forests.

The wetland-nonwetland boundary in bottomland hardwood forests is often more gradual than abrupt. The transitional nature of these sites, with both wetland and nonwetland characteristics, makes delineation difficult. The results of these studies indicate that the soil diagnostic indicators, in conjunction with vegetative and hydrologic data, are better predictors of the wetland status of transitional sites than root-coating data or extractable iron and manganese.

PREFACE

This report is the result of a 4-year investigation characterizing the effects of inundation and soil saturation on soil processes. The study was sponsored by the Wetlands Research Program (WRP), funded by the Headquarters, US Army Corps of Engineers (HQUSACE). The WRP is managed through the Environmental Effects of Dredging Programs (EEDP) of the Environmental Laboratory (EL) of the US Army Engineer Waterways Experiment Station (WES). Dr. Robert M. Engler was Program Manager, EEDP; Dr. Dana R. Sanders and Mr. Russell F. Theriot were WRP Program Managers. The work was monitored by Dr. Robert J. Pierce, HQUSACE.

This report was prepared by Mr. Stephen Faulkner, Research Associate, Dr. William H. Patrick, Jr., Director, and Dr. Robert Gambrell, Professor, of the Louisiana State University Center for Wetland Resources, Laboratory for Wetland Soils and Sediments; Mr. W. Blake Parker of the Soil Conservation Service (SCS); and Dr. Billy J. Good of the Louisiana Geological Survey.

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PART I: EFFECTS OF INUNDATION AND SATURATION ON SOIL AERATION STATUS

INTRODUCTION

Background

1. Over the past two decades, there has been a growing awareness of the intrinsic value of and unique functions performed by wetlands in general and bottomland hardwood forests in particular. Unfortunately, tens of millions of hectares of wetlands were being destroyed during this period. These enormous losses provided the necessary stimulus to identify critical wetland areas, document important ecosystem processes and functions, and formulate protection mechanisms. Certainly, few areas are more critical than the bottomland hardwood forests and few protection mechanisms are more controversial than Section 404 of the Federal Water Pollution Control Act (currently known as the Clean Water Act).

2. Section 404 of the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500, 33 U.S.C. 1251) mandated regulation of dredge and fill activities occurring in "waters of the United States" to the US Army Corps of Engineers (CE). The term "waters of the United States" was later expanded to include wetlands. The CE defines wetlands as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (Federal Register, Vol 42, p 37128).

3. Though the general areas of jurisdiction are clear, legislation authorizing the Section 404 regulatory program provided little guidance for technically identifying and geographically delineating areas subject to jurisdiction. Identifying that portion of the bottomland hardwood forest that is a wetland within the meaning of Section 404 has been a controversial issue, even within the Federal Government. As late as 1984, the US Fish and Wildlife Service (USFWS), the US Environmental Protection Agency (USEPA), and the CE differed considerably in their estimates (2.2 to 3.1 million ha) of the area of Lower Mississippi River Valley bottomland hardwood forests subject to Section 404 regulation (Alcock et al. 1984).

4. However, delineating wetlands in bottomland hardwoods in the Lower Mississippi River Valley is a difficult task. This complex ecosystem of over 100 woody plant species and at least 12 general soil associations is in a constant state of flux. These areas are subject to overflow and

inundation of varying frequencies and durations and are characterized by certain conditions which include habitat inundation, root zone saturation, and prevalent woody plant species capable of carrying out requisite life functions in this environment (Huffman and Forsythe 1981).

5. Prominent in the definition of wetlands is the importance of inundation and/or saturation and saturated soil conditions. The frequency, timing, and duration of inundation and soil saturation are the driving forces behind the processes that affect both soil genesis and species composition. Any investigation into the wetland attributes of an area must look critically at this aspect of wetland processes.

Objective

6. This project was initiated to characterize the effects of saturation and inundation on soil processes in nonwetland, transitional, and wetland habitats in bottomland hardwood forests. The objective was to provide technical data that will assist in developing a technical methodology for identifying and delineating wetlands from nonwetlands in the Lower Mississippi River Valley.

Saturated Soil Processes

7. The obvious result of inundation and saturation is isolation of the soil from the atmosphere. This isolation has a profound impact on the resupply of oxygen to the soil as oxygen moves into the soil by diffusion (primarily) and mass flow (Grable 1966). Since the diffusion coefficient of oxygen in air (0.23 $cm^2 s^{-1}$ at 25° C) is about 10,000 times larger than the coefficient in water (0.26×10^{-4} $cm^2 s^{-1}$), it is readily apparent that oxygen movement will be slowed (Armstrong 1975).

8. The oxygen trapped in the soil is used by plant roots and microorganisms. The rate of utilization plays a large role in the initiation of anaerobic conditions. Currie (1970) reported oxygen consumption rates ranging from 0.7 $g\ m^{-2}$ of surface area per day to 23.7 $g\ m^{-2}$ of surface area per day. Soil temperature and cropping status were determining factors affecting the consumption rate. Other published data give rates as low as 2.5 $g\ m^{-2}\ day^{-1}$ for bare soil to as high as 20 $g\ m^{-2}\ day^{-1}$ for forest soil (Russell 1973). Complete oxygen depletion, therefore, can theoretically occur within a few hours or take several days, depending upon the specific conditions present.

9. Several experiments have documented the time lag between flooding and anaerobiosis. Evans and Scott (1955) measured dissolved oxygen in a saturated soil column in the laboratory and found less than 1 percent oxygen 75 min after flooding the column. By contrast, Kemper and Amemiya (1957) reported an average oxygen content in the root zone of field plots of no lower than 6 percent 8 days after sealing the soil from the atmosphere by flooding. A sufficient quantity of oxygen was trapped in this zone by the surface water to maintain the higher than expected

levels. However, individual readings were as low as 3 percent, indicating differential zones of aeration. This phenomenon has been observed by others (Grable and Siemer 1968, Campbell 1973). In general, soil texture, particle size, aggregate size, aggregate stability, pore-size distribution, and method of flooding all play a major role in determining the oxygen status of a flooded soil (Currie 1961, Leo 1963, Anderson and Kemper 1965, Vomocil and Flocker 1965).

10. Subsequent to oxygen depletion, anaerobic respiration by soil microorganisms begins. During this process, facultative and obligate anaerobic organisms use a variety of substances to replace oxygen as the terminal electron acceptor during respiration (Ponnamperuma 1972). This transfer of electrons results in significant changes in the valence state of the chemical species used and causes the overall reduction of the soil. Reduction is the most important chemical change caused by flooding, as it significantly influences pH, nutrient availability, and toxin production (Ponnamperuma, Tianco, and Loy 1967). Oxidation-reduction or redox potential (Eh) is a quantitative measure of the propensity of a system to oxidize or reduce susceptible substances and the intensity of that reaction (Ponnamperuma 1972, Gambrell and Patrick 1978). A large positive Eh value is indicative of a strongly oxidized system and a large negative number indicates strongly reducing conditions. The general range of Eh values for mineral soils is from +750 mV to -350 mV (Baas Becking, Kaplan, and Moore 1960).

11. Reduction of a saturated soil is generally a sequential process governed by the laws of thermodynamics (Turner and Patrick 1968, Ponnamperuma 1972). The oxygen present in the soil is quickly consumed by microbial respiration and chemical oxidation (Howeler and Bouldin 1971) and is not replenished at the same rate as consumption. Nitrate is the first soil component reduced after oxygen. However, this process can proceed before the complete removal of oxygen. Mortimer (1941) reported that nitrate was reduced in the presence of very low oxygen. Turner and Patrick (1968) also found that nitrate reduction began before the complete disappearance of oxygen.

12. Manganic manganese closely follows nitrate in the reduction sequence and will begin reducing before the nitrate has completely disappeared (Turner and Patrick 1968, Gambrell and Patrick 1978, Patrick 1982). While the preceding reduction reactions can and do overlap, the subsequent sequential reactions of ferric iron (Fe^{3+}) to ferrous iron (Fe^{2+}), sulfate ($SO_4{}^{2-}$) to sulfide (H_2S), and carbon dioxide (CO_2) to methane (CH_4) will not occur unless the preceding component has been completely reduced. Turner and Patrick (1968) reported that iron reduction was inhibited by the presence of nitrate. It is generally held that reduction of sulfate must be essentially complete before methane production can begin due to significant metabolic differences between the two bacterial populations responsible (Martens and Berner 1974) and the inhibition of methane production by sulfide (Butlin, Selwyn, and Wakerly 1956, Cappenberg 1975).

13. A unique feature of saturated soils is the presence of oxidized zones within the soil profile. Pearsall and Mortimer (1939) were the first researchers to describe the thin oxidized layer

at the soil/water interface. They differentiated between the two zones by the presence of oxidized constituents of nitrogen and iron. This initial investigation was followed up and confirmed by Mortimer (1941, 1942). Since then, it has been described by several investigators (Alberda 1953, Patrick and Sturgis 1955, Howeler and Bouldin 1971, Patrick and DeLaune 1972).

14. Many wetland plants have developed an avoidance mechanism for root survival in anaerobic substrates. Oxygen is transported from the shoots to the roots and oxidizes the rhizosphere immediately surrounding the root (Armstrong 1964, 1967, 1968). This process leaves distinctive ferric iron stains in the root channels and iron coatings on the root itself (Bacha and Hossner 1977; Taylor, Crowder, and Rodden 1984; Good, Faulkner, and Patrick 1986).

15. These processes are extremely important in bottomland ecosystems. The toxic by-products of anaerobic respiration and reduced soils play a major role in plant species distribution in the floodplain. In addition, the nature of the oxidation-reduction reactions influences soil development, morphology, and diagnostic characteristics.

Bottomland Hardwood Soils

Overview

16. Bottomland hardwood forests inhabit the floodplains of the major and minor rivers in the southern and southeastern United States from Texas to Virginia (Figure 1). The formation and development of these sites has been dominated by fluvial forces. They are dynamic systems where sediment is continuously added and removed by the meandering and overbank flooding of rivers and streams. These processes are responsible for the mosaic pattern of natural levees, bottoms, low ridges, sloughs, and backswamps that mark the floodplain landscape.

17. Natural levees form along the mainstream channels as coarse-textured sediments are deposited during overflow periods. These areas usually have a higher elevation than surrounding land features. As the water moves back from the river, it flows more slowly and eventually stagnates. Finer sediments are deposited in these slackwater areas, and minor relief features such as low ridges, flats, and sloughs are formed. In this environment, very small changes in elevation (15 to 30 cm) are enough to alter hydrologic patterns and species composition. The newer alluvium deposits in the present or recent floodplain are considered first bottoms, and soil horizons are not as well developed as those in the second bottoms. The second bottoms are remnants of former floodplains and are comprised of older, better developed soils (Putnam, Furnival, and McKnight 1960).

Parent material

18. Alluvial sediments laid down by the Mississippi River are the chief parent materials of soils in the Mississippi River Valley. The total thickness of alluvium in the valley ranges from

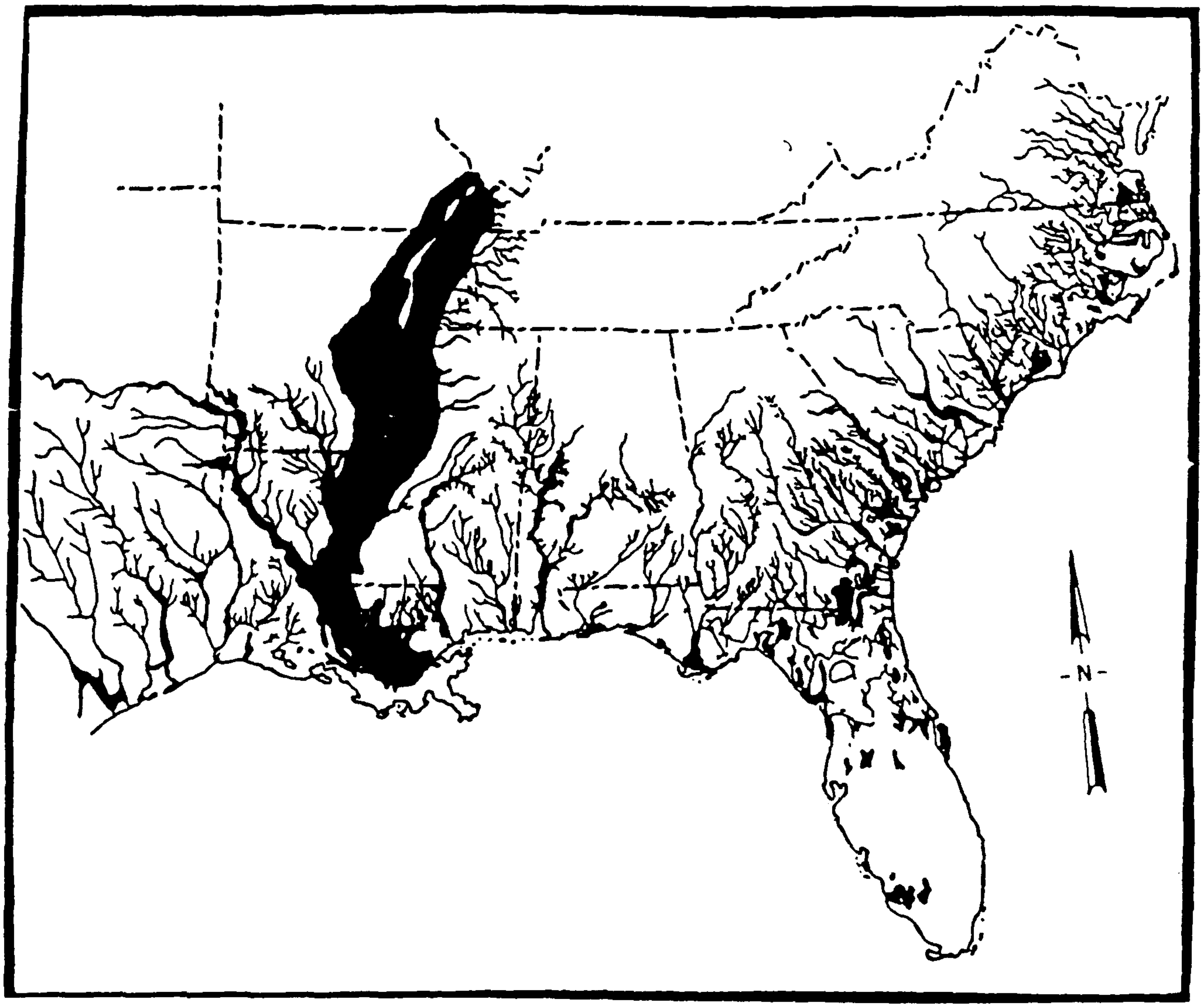

Figure 1. Distribution of bottomland hardwood forests (adapted from Putnam, Furnival, and McKnight 1960)

many tens to several hundreds of feet. The alluvium in the Mississippi Delta has a mixed lithology, originating in the wide reaches of the upper Mississippi River Basin which extends from Montana to Pennsylvania. Sedimentary rocks are extensive in this basin, but other kinds of rocks are also exposed and serve as sediment sources. Immense areas in the upper basin are mantled by recent glacial drift and loess. The alluvium along the lower stretches of the Mississippi River has come from a multitude of soils, rocks, and unconsolidated sediments of some 20 states resulting in a mixture of minerals; many are comparatively fresh and only slightly weathered. The dominant clay minerals of the soils that formed in alluvium are montmorillonite, mica-illite, and vermiculite. Less significant are feldspar, quartz, and oxides and hydroxides of iron.

19. Within the Mississippi alluvial valley, there are wide ranges in the texture of the alluvium because of differences in deposition. The pattern of coarser sediment near the channel and fine sediment in the backswamps is common along the Mississippi River and old abandoned river courses. The coarser soil particles deposited nearest the river produce sandy soils such as Crevasse. As the floodwater continues to spread and move more slowly, it drops loamy sediment:silt mixed with a small amount of clay and fine sand. The Dundee soils formed from this kind of material. As the floodwater finally drains away, leaving low depressions and old river channels filled with standing water, the clay and fine silt particles settle out leaving clayey slackwater deposits. The poorly drained and very slowly permeable Sharkey and Fausse soils formed in this kind of material.

20. In places where natural levees have been cut out, silty or sandy sediment has been spread over the backswamp clays. Thus, the normal pattern of sediment distribution has been destroyed and, in places, beds of alluvium of widely contrasting textures have been superimposed. Tensas silt loam, which formed in silt loam over silty clay loam over fine sandy loam, is an example of soil formation in this type of parent material.

Morphology and development

21. The characteristics of the soil at any given place are determined by (a) the physical and mineralogical composition of the parent material, (b) the climate under which the soil material has accumulated and existed since accumulation, (c) the plant and animal life on and in the soil, (d) the relief, or lay of the land, and (e) the length of time the forces of soil development have acted on the soil material.

22. Climate and vegetation are the active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and bring about the development of genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme instances, determines it almost entirely. Finally, time is needed to change parent material into a soil with distinct horizons.

23. Overbank flooding contributes more to bottomland forests than just sediment transport. The hydroperiod (frequency and duration of inundation) not only controls the initial depositional patterns, but also subsequent soil morphology and development. The most diagnostic from a delineation standpoint are soil color and mottling. Soil color is derived from organic matter (brown) and oxides of iron and manganese (yellow and red) (Soil Survey Staff 1975). When the soil is saturated for long periods and these compounds are reduced, gray colors predominate and the soil is considered gleyed and a hydric soil (Environmental Laboratory 1987). More balanced periods of alternating oxidation and reduction result in soils that are variegated or mottled. The predominant soil color (matrix) determines whether these are hydric soils.

24. A majority of the bottomland soils found in the Mississippi River floodplain have aquic moisture regimes. This implies an anaerobic, reducing regime because the soil is saturated by either groundwater or capillary-fringe water (Soil Survey Staff 1975). Several questions concerning the definition, taxonomy, and identification of aquic soils have arisen. The major concerns include the nonspecific duration of saturated, anaerobic conditions and the reliance on oxygen reduction when low chroma colors (≤2) are contingent upon iron and manganese reduction (Bouma 1983, Wilding and Rehage 1985).

Productivity

25. The southern Mississippi River Valley alluvium (Delta) soils are some of the most productive soils in the United States. Bottomland soils are generally higher in organic matter content and clay content than upland soils, and these two factors contribute greatly to the higher fertility (Patrick 1981). Annual biomass accumulation in southeastern bottomland hardwoods has been reported at 4.6 mg ha^{-1} with annual nitrogen accumulation of 6.93 kg ha^{-1} (Messina et al. 1983). Cole and Rapp (1981) reported mean annual biomass accumulation of 2.7 mg ha^{-1} and mean annual nitrogen accumulation of 5.19 kg ha^{-1} for 22 temperate coniferous and deciduous forests around the world. The fact that nearly 2.7 million ha of bottomland hardwoods in the Mississippi River Valley have been cleared for crop production since 1937 (MacDonald, Frayer, and Clauser 1979) is stark testimony to their value as productive soils. Estimates place the current rate of conversion at 40,600 ha/year (Alcock et al. 1984).

26. The remaining areas are in woodland and are usually poorly drained or very poorly drained soils subject to flooding or ponding. The variability in the physical, chemical, and mineralogical composition of these soils is caused by the myriad of sediments originating in such a vast watershed. The relatively flat topography associated with most sites results in significant soil-drainage problems complicated by poor surface drainage (infiltration). Poor soil permeability (percolation) within the profile is common among soils with a dense clay subsoil.

METHODS AND PROCEDURES

Study Area

27. Five transects were established in early 1982 in alluvial bottomlands with mature hardwood forest overstory in Louisiana and Mississippi (Figure 2). Each transect was chosen, after extensive ground reconnaissance and reference to aerial photography and soil maps of the area, according to the following criteria: (a) mature and undisturbed forest communities present and (b) an elevational gradient from the best drained to the most poorly drained sites in the area. Plot 1 was established on the upper, drier end of the transect, and Plot 4 (or 5) at the lower, wetter end. Two or three intermediate plots were selected between these extremes, depending on the changes in soil type and vegetation, resulting in a total of four or five plots per transect to reflect the changes in elevation and soil moisture regime.

28. Each plot was located in the approximate center of a 20-m by 50-m vegetative sampling plot. Two sets of soil measurement equipment were installed at 15-, 30-, 60-, and 120-cm depths on each plot to measure soil moisture content, soil redox potential, and soil oxygen content. Soil temperature at 15, 30, and 50 cm and water table depth in the upper 120 cm of the soil profile were also measured with two sets of equipment at each plot. Each set of equipment was considered to be a subplot, and the distance between subplots on a plot was generally less than 5 m.

29. Sampling was initiated in September 1982 and monthly measurements continued until August 1985. During March, April , and May of 1983 and 1984, the permanent plots were sampled approximately every 2 weeks. The results for each transect are broken down by year; however, the 1983 section includes data from September to December 1982. Soil profiles were described in the fall of 1983.

Soil Redox Potential

Construction

30. Redox potential was measured with permanently installed platinum electrodes (Figure 3). Eighteen-gauge platinum wire was cut into 1-cm segments with wire-cutting pliers that are used only for cutting platinum. These segments were allowed to stand in a 1:1 mixture of concentrated nitric and hydrochloric acids for at least 4 hr to remove surface contamination of metals other than platinum such as could occur during cutting or handling. Then, the cut wire segments were soaked in distilled, deionized water overnight.

31. The body of the electrodes was Pyrex glass tubing approximately 0.8 cm (outside diameter). The glass tubing was cut into 20-cm lengths, and one end was fire-polished with a propane torch just enough to smooth the break. The other end of each cut tube was heated in a

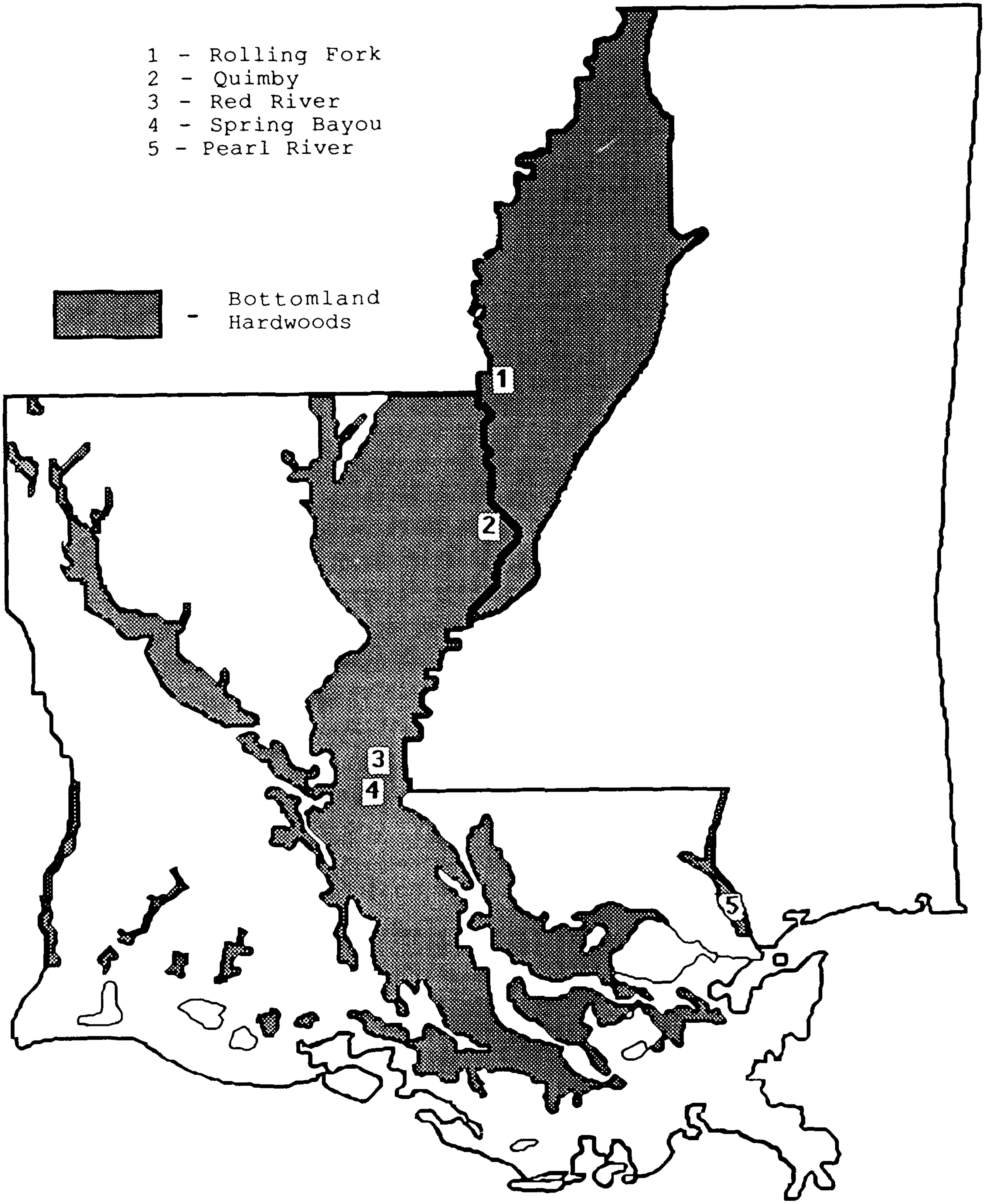

Figure 2. Relative location of research sites in Louisiana and Mississippi

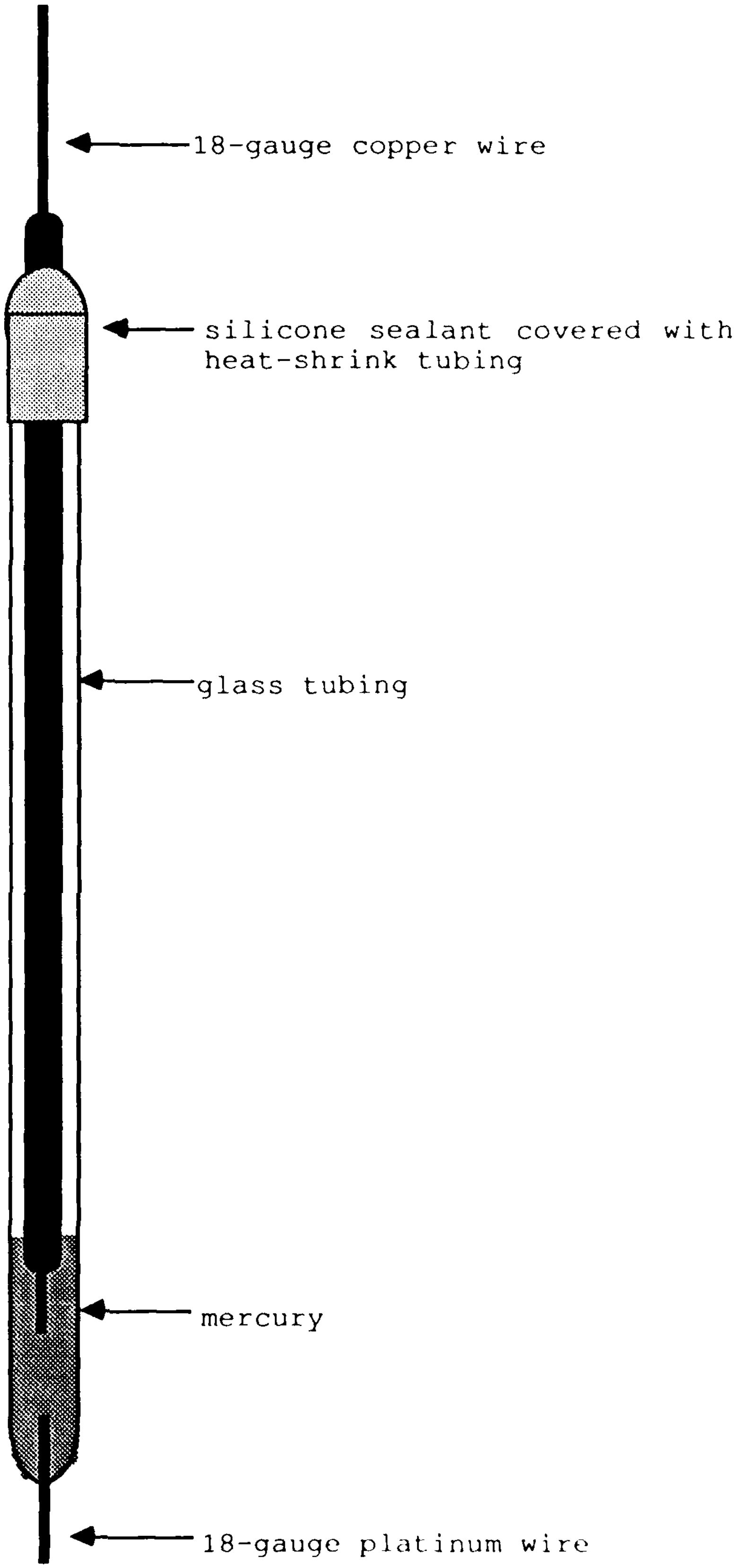

Figure 3. Platinum electrode

propane torch flame with continuous rotation until the glass became soft and the opening constricted to an inside diameter of just greater than the platinum wire. After cooling, the platinum wire was placed in the constricted end of the glass so that 0.5 cm of platinum extended out of the glass. This end was heated again in the flame until the end of the glass tubing collapsed for about 0.3 cm along the center length of the platinum wire. The result was about 0.5 cm of platinum wire exposed externally to the glass body to come in contact with the soil, and about 0.3 cm of exposed platinum wire within the glass body to serve as an electrical connection to the electrode lead. At this stage, the platinum wire segment was held in place mechanically, but this did not ensure a permanent, water-tight, and electrically insulating seal between the two ends of the platinum wire.

32. To permanently seal the glass-platinum junction, a small amount of powdered wax was dropped down the open end of the glass tube; the tube was tapped gently until the wax was down around the internally exposed end of the platinum wire. Then, this end of the electrode was heated gently until the wax just melted. Capillary action drew the liquid wax into the crevice between the glass and platinum. (Care must be exercised here as too much heat causes the wax to foam or boil, which coats all of the platinum wire with an insulating layer of wax.) When the wax solidified, a permanent seal was achieved that can withstand some shrinking and expansion of the glass due to temperature changes in the field.

33. Next, triple-distilled mercury was poured into the open end of the electrode to serve as an electrical contact between the bare end of the platinum wire and the stripped end of an insulated, 12-gauge, copper wire electrode lead lowered into the mercury. The length of this wire lead varied depending on the installation depth of the electrode such that about 30 cm of the electrode lead would be above ground once the electrodes were installed in the field. The insulation was stripped only for the last 5 to 8 cm of the copper wire in the glass tube such that the electrode lead was insulated where the lead came out of the top end of the electrode. Silicone rubber was used to seal this juncture of the electrode so that soil water could not leak into the top of the electrode giving a short-circuit and erroneous readings. To further ensure a permanent, leak-free seal at the top of the electrode, heat-shrink tubing was placed over this part of the electrode and heat was applied to collapse this insulating material around the silicone rubber which overlapped the end of the glass and covered about 3 cm of the insulated wire above the glass tube. About 3 cm of the insulation was stripped from the top of the electrode lead to make a connection with an alligator clip attached to the lead coming from the portable potentiometer.

Installation

34. Prior to installation, the electrodes were tested in the lab in a pH-buffered, quinhydrone solution to be sure they were giving accurate readings (Bohn 1971). Any electrode differing more than 15 mV from the proper value was cleaned and tested again and discarded if cleaning failed to correct the problem.

35. Electrodes were installed at 15-, 30-, 60-, and 120-cm depths in the profile (Figure 4). In the field, a sharpened metal rod was used to make a hole in the soil in each plot to about 3 cm less than the desired depth of the exposed platinum wire of the electrode. Then, a hollow, polyvinyl chloride (PVC) tube of appropriate length for each electrode was placed over the electrode's lead until the end of the PVC tube fit snugly against the bulge formed by the heat shrink tubing, silicone rubber, and the top end of the glass tube. This plastic tube made it possible to push the electrode 3 cm deeper into the soil (beyond the depth opened by the sharpened metal rod) so that the exposed platinum wire was positioned in undisturbed soil material. Once installed to the proper depth, dry clay (combusted at 800° C to remove organic matter) was poured into the hole and packed around the electrode lead. The rest of the hole was filled with mortar mix and tamped. The mortar mix draws moisture from the surrounding soil and hardens, minimizing the channelized flow of water or enhanced diffusion of surface air to the electrode that might contribute to bad readings.

Measurement

36. Occasionally, readings from some electrodes became suspect and the electrodes had to be replaced. It was not possible to test the permanently installed electrodes in the field, so a judgment was made concerning a suspect electrode based on comparisons between subplot measurements, electrodes from other depths and plots, and experience with redox potential measurements. It should be noted that in field applications where apparent bad readings are obtained, the problem may often be the microzone around the electrode. If the end of the electrode is installed in or close to a living tree root or in an old root channel (situations that cannot be discerned from the surface), readings not representative of the bulk soil will be obtained.

37. Redox potential measurements were made in the field using a portable pH/redox potential meter (either an Orion Model 231 or 399A) and a saturated calomel reference electrode. The reference electrode was pushed a short distance into wet or moist soil at the surface to ensure good electrical contact. If the soil was relatively dry, a spatula was used to break up a small volume of soil, and water from the lab was added to form a paste; then, the reference electrode was installed in this mixture to ensure good contact with the soil solution. Frequently, a drift in the meter reading was noted when the meter was first connected to the electrodes in the field. The rate of drift decreased relatively rapidly. Usually within a couple of minutes. the reading drift rate was so low one could assume the measuring system had equilibrated and the value shown could be recorded.

38. The meter values were adjusted by adding +244 mV to meter readings such that the redox potential would be based on the standard hydrogen reference electrode (SHE) instead of the saturated calomel reference electrode (SCE). It is common practice in the field of electrochemistry

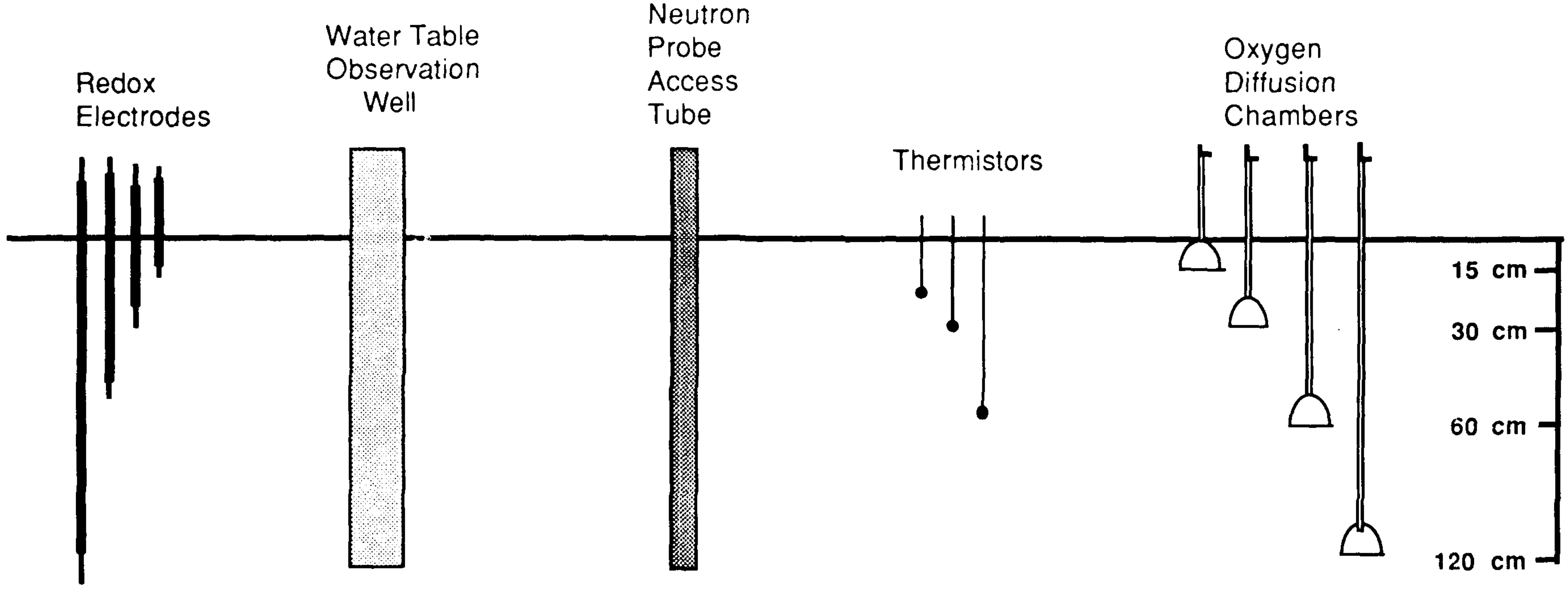

Figure 4. Plot layout of replicated soil measurement equipment

to use reference electrodes other than the SHE and make appropriate corrections, since the SHE is not a convenient electrode to use for most applications. Though the correction factor is temperature dependent, corrections for field temperatures were not made as the error involved from this source was relatively small.

Soil Moisture Content

39. Rather than collecting replicated core samples at each depth of interest on each trip for gravimetric moisture determinations, it was decided early in the project to use a neutron moisture probe. The neutron moisture probe used in this project (Troxler Model 3222 Soil Moisture Depth Probe) emits fast neutrons from a sealed 10 mCi americium/beryllium source. These neutrons penetrate the source container as well as the thin-walled aluminum access tubes installed in the field and interact with neutron-attenuating substances in the soil. It is the attenuated (slowed) or thermal neutrons backscattered to the detector on the probe that are counted. Although a number of elements may attenuate fast neutrons to varying degrees, hydrogen is a major attenuator in soils. Thus, an increasing soil water content will result in an increase of thermal neutrons backscattered to the detector. Obviously, water is not the only substance in soils containing hydrogen; therefore, calibration of the probe is necessary and will be discussed below.

40. Two advantages of the neutron probe over gravimetric measurements are that it is quicker and easier to get soil moisture contents using the probe. More important than the convenience, however, is that the neutron probe moisture measurements offer quantitative advantages over gravimetric methods.

41. One obvious problem with gravimetric measurements in a 2- to 3-year field study where soil oxidation is an important consideration is the number of holes that would have to be augered in and near the plots to obtain the gravimetric moisture samples. These holes might affect vertical water movement and oxygen transport in the profiles. Monthly sampling trips for 8 or 9 months of the year plus biweekly trips for 3 or 4 months of the year would result in 45 or more holes in each plot in 3 years.

42. Another problem with the gravimetric methods is the relatively small volume sampled. In many of the plots, we have noted the soils to be highly heterogeneous, both vertically and horizontally. For example, core samples from the same depth taken only 60 or 90 cm apart have shown very large texture differences in some of the Red River plots. In such soils, monthly gravimetric samples would be much less reproducible because of the soil variability and less representative of the bulk soil moisture more of the time than the neutron probe measurements because of the much smaller volume sampled. For example, a 1.5-cm-diam core sample 8.0 cm long represents a sampling volume of about 14 cm^3. A neutron moisture probe typically (depending on soil water content) measures neutrons attenuated by the hydrogen in water in a

spherical volume of soil with a radius of at least 10 cm. This represents a sampling volume of about 4,000 cm^3.

43. From month to month, sampling different soil volumes within the same plot using a gravimetric technique would make it somewhat difficult to even document changes in moisture content with time because of the considerable variability in physical properties of the soils measured in each sample, unless a large number of gravimetric samples at each depth were taken from each plot. A calibrated neutron probe, which samples a much larger soil volume than a coring device, and which samples the same volume of soil each sampling period, should perform much better in determining the change in moisture content with time in each plot.

Installation

44. The type of neutron depth probe used requires 4.8-cm OD aluminum irrigation pipe. Since the planned measuring depths for soil moisture were 15, 30, 60, and 120 cm, the tubes were installed to a depth of at least 130 cm with about 15 cm of the tube remaining above ground.

45. One neutron moisture access tube was installed in each subplot of each plot. The use of the neutron probe requires the access tubes to fit tightly in the soil with a minimum of artificial voids adjacent to the exterior wall of the aluminum tube. The tubes must also be installed without compacting the soil around the tube. A smooth-walled hole was formed in the plots by driving a 4.8-cm OD stainless steel pipe (with a sharpened, beveled end) about 10 to 15 cm into the ground. Then, to prevent compaction near the leading end of the pipe, the soil was augered out of the middle of the stainless steel pipe before it was driven down another 10 to 15 cm. This process was repeated until the desired depth was reached; then the pipe was removed, leaving a smooth-walled hole in the ground for the permanent aluminum access tubes.

46. The aluminum tubes were cut to the appropriate length and a dummy probe (from Troxler) was passed through each tube to ensure there were no small dents that would cause the neutron source/detector probe to stick. A neoprene rubber stopper was inserted into the bottom end of each tube such that the outside end of the stopper was even with the end of the tube. The stopper size was selected to give as tight a fit in the tube as possible. This stopper served as a seal to prevent groundwater from entering the tube. Another stopper of the same size was glued back-to-back to the sealing stopper. This served as a tapered guide on the lower end of the tube so that when the access tube was pushed into the hole in the ground, the end of the tube would not gouge out part of the smooth soil wall of the hole. Once installed, the tubes were plugged with a rubber stopper to prevent rainwater, or floodwater on lower plots during the winter, from entering the access tubes.

Calibration

47. Neutron moisture probes normally require calibration to provide accurate measurements of soil water content. Though some researchers use the factory-supplied calibration curve, and others calibrate probes in a drum of soil in a laboratory setting, it is generally agreed that a one-time

field calibration in the soils to be studied is the most satisfactory approach. While factory calibration curves compensate fairly well for the hydrogen (the primary element attenuating fast neutrons) associated with the minerals in soils, soil organic matter also contains appreciable hydrogen. Since the soil organic matter content drops rapidly beneath the top 20 to 30 cm, it is especially important to calibrate the probe if accurate moisture measurements are required in the top 30 cm of soil.

48. To calibrate the instrument for this study, neutron probe and gravimetric moisture calibration measurements were taken on a one-time basis at 15- and 45-cm depths in replicates at three or four plots at the Pearl River, Spring Bayou, and Red River sites. The neutron measurements were taken at these depths according to the procedures described in the next section and recorded from the moisture meter as kilograms of water per cubic meter of soil.

49. For each plot and depth sampled with the probe, two samples were obtained for gravimetric moisture measurements from separate sites approximately three meters on each side of the access tube. A shovel and posthole diggers were used to get to the sampling depth. Then, the samples were taken from the appropriate depth by driving a thin-walled aluminum pipe segment (7.3-cm OD, 6.3-cm length that had been sharpened on one end) into the soil to obtain a minimally disturbed core section. Upon removal from the soil, a sharp knife was used to trim the soil, without compaction, to be flush with both ends of the tube. Since the dimensions of each labeled tube were carefully measured, the volume of soil in the sample could be accurately calculated. The labeled core sections were then sealed in two polyethylene bags to minimize moisture loss prior to returning to the lab. In the laboratory, the wet weight, dry weight, and volume of soil in the gravimetric sample were determined and the moisture content in kilograms of water per cubic meter of soil was calculated for comparison with the neutron moisture probe measurements taken from the same plots and depths on that date.

50. We then calculated a correction factor for each of the two depths in each plot. The correction factor was that number that must be added to or subtracted from the neutron moisture probe reading to make the probe give the same value as the gravimetric measurement. After evaluating the data obtained from three of the five transects, we determined that additional calibration work at the remaining two transects would probably add little to the accuracy of the neutron probe data. The neutron and gravimetric moisture data used to develop calibration correction factors are listed in Appendix A. The results are considered in terms of the percent correction needed so that the neutron probe measurement agrees with the gravimetric moisture measurement.

51. The average correction over all locations, plots, depths, and a wide moisture range was 9.1 percent with a standard deviation of 4.2. Assuming the gravimetric measurement represents the "true" moisture level (and one should remember there are problems with this technique due to field soil heterogeneity and small sample size), this 9 percent error is within the error range of the other

types of measurements being made in this project, and probably well under the error associated with the redox potential measurements. The approximately 10-percent correction generally needed indicates the neutron probe data are reasonably good and quite acceptable even if no effort were made to correct the meter readings. Though the variability about the mean is less when the calibration factor is considered separately for locations and depths (Appendix A, Tables A1-A4) this does little to improve the amount of correction needed

52. Based on the relatively small amount of correction needed to make the neutron probe values give the same moisture content as gravimetric measurements and the small range of the correction needed when evaluating different combinations of the variables in all three of the five transects selected for calibration work, we determined that additional calibration work at the remaining two transects would probably add little to the accuracy of the neutron probe data. Therefore, we used the data obtained from three transects to develop a correction factor for all 15-cm depths for all transects and another correction factor (based on the 45-cm calibration work) to apply to all the subsoil sampling depths (30, 60, and 120 cm). A Statistical Analysis Systems Institute, Inc. (SAS) computer program was written to subtract 30.3 kg water m^{-3} from every 15-cm neutron moisture probe reading and 41.9 kg water m^{-3} from every moisture probe reading from the deeper zones.

Field measurements.

53. In the field, the stopper was removed from the access tube and a clean dowel stick was inserted to the bottom to be sure no water was in the tube. Occasionally, due to human curiosity or animals, the stoppers were not in place upon arrival to the field, and any standing water in the tubes was pumped out if necessary with a length of tygon tubing, a vacuum flask, and a hand-operated vacuum pump.

54. The counting electronics were warmed up for 20 min prior to making a measurement, a 2-min standard count was obtained, and the probe was lowered to the appropriate depth in the aluminum access tubes for measuring moisture content with 1-min counts. The data were directly recorded from the meter in kilograms of water per cubic meter.

Soil Oxygen Content

Construction

55. Soil oxygen content was measured using a method similar to that developed by Patrick (1977). Diffusion chambers were constructed from 100-ml Nalgene centrifuge tubes. The tubes were cut in half, and 0.32-cm copper tubing was attached to the bottom of the tube with a brass bulkhead union (Figure 5). A three-way valve was attached to the other end of the copper tubing with heat-shrink tubing and waterproof epoxy.

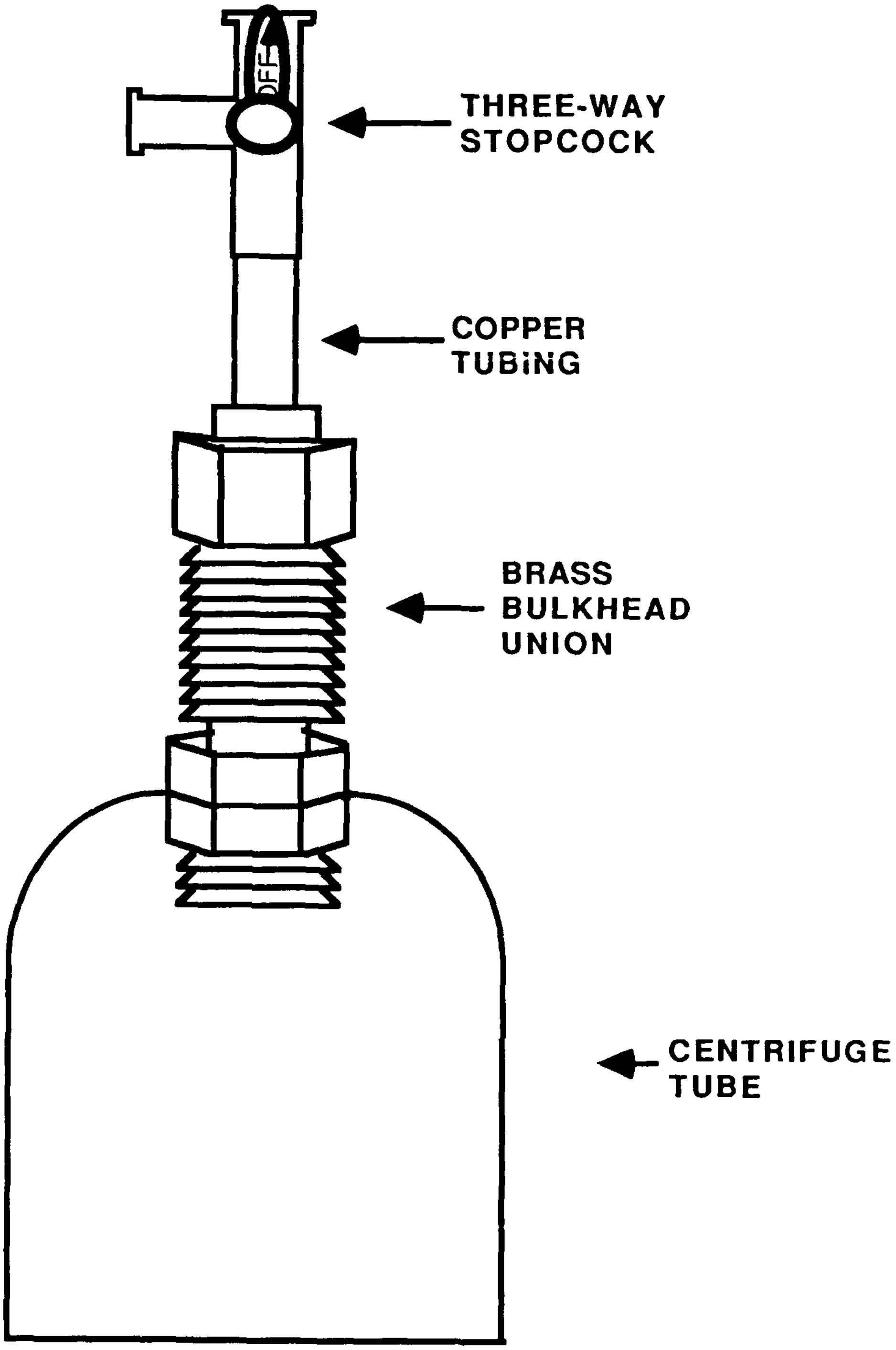

Figure 5. Oxygen diffusion chamber (not to scale)

Installation

56. The chambers were installed at 15, 30, 60, and 120 cm in the profile (Figure 4). A hole 7.6 cm deeper than the desired depth was cored with a 3.2-cm-diam soil auger, the chamber placed in the hole, and the hole filled with mortar mix and tamped. The mortar mix draws moisture from the surrounding soil and hardens sealing the hole from the atmosphere.

57. A different installation method was used in saturated soil. The centrifuge tube was filled with water and frozen. Next, the discarded half of the tube was inverted and reattached with duct tape. Inversion was necessary for later removal as the centrifuge tubes were tapered. This section was then filled with pea gravel and water and frozen (Figure 6). The frozen chambers were carried to the field packed in dry ice and installed with a piece of PVC tubing cut to the appropriate length. The duct tape and the reattached portion of the tube were removed leaving the frozen gravel protruding from the diffusion chamber much like a Popsicle. This design provided some support in keeping the semifluid soil out of the diffusion space below the chamber. Approximately 30 ml of air was injected into the chamber after the ice had melted.

Measurement

58. Oxygen content in the diffusion chamber was measured with a Yellow Springs Model 51B oxygen meter. The gas in the chamber was assumed to be in equilibrium with the soil atmosphere. After allowing the meter to warm up, it was calibrated to 21 percent oxygen by drawing atmospheric air through the cell and setting the dial. A sample was drawn from the chamber and into the measurement cell with a syringe (Figure 7). After the oxygen content was determined, the same gas was returned to the diffusion chamber and the cell purged with atmospheric air.

Water Table Depth

59. The water table is defined as the upper surface of the groundwater (Soil Science Society of America 1978) and is usually measured in an uncased borehole in equilibrium with the surrounding soil (Soil Survey Staff 1975). This was the approach taken in this study. Water table depth was measured in observation wells established on each plot. Two 5.1-cm-diam PVC pipes with 0.71-cm-diam holes drilled the length of the pipe (to simulate an uncased borehole, but still prevent sloughing of soil material) were installed to a depth of 120 cm on each plot (Figure 4).

60. A 7.5-cm-diam bucket auger was used to core the hole for the pipe. A wire mesh screen was attached to the lower end of each pipe to prevent soil from silting in the well from the bottom. After the pipe was placed in the hole, pea gravel was poured around the pipe to within 5.1 cm of the surface. This was done to improve water movement out of the pipe and prevent clogging of the drilled holes. A concrete collar was formed around each pipe at the groundline to prevent surface

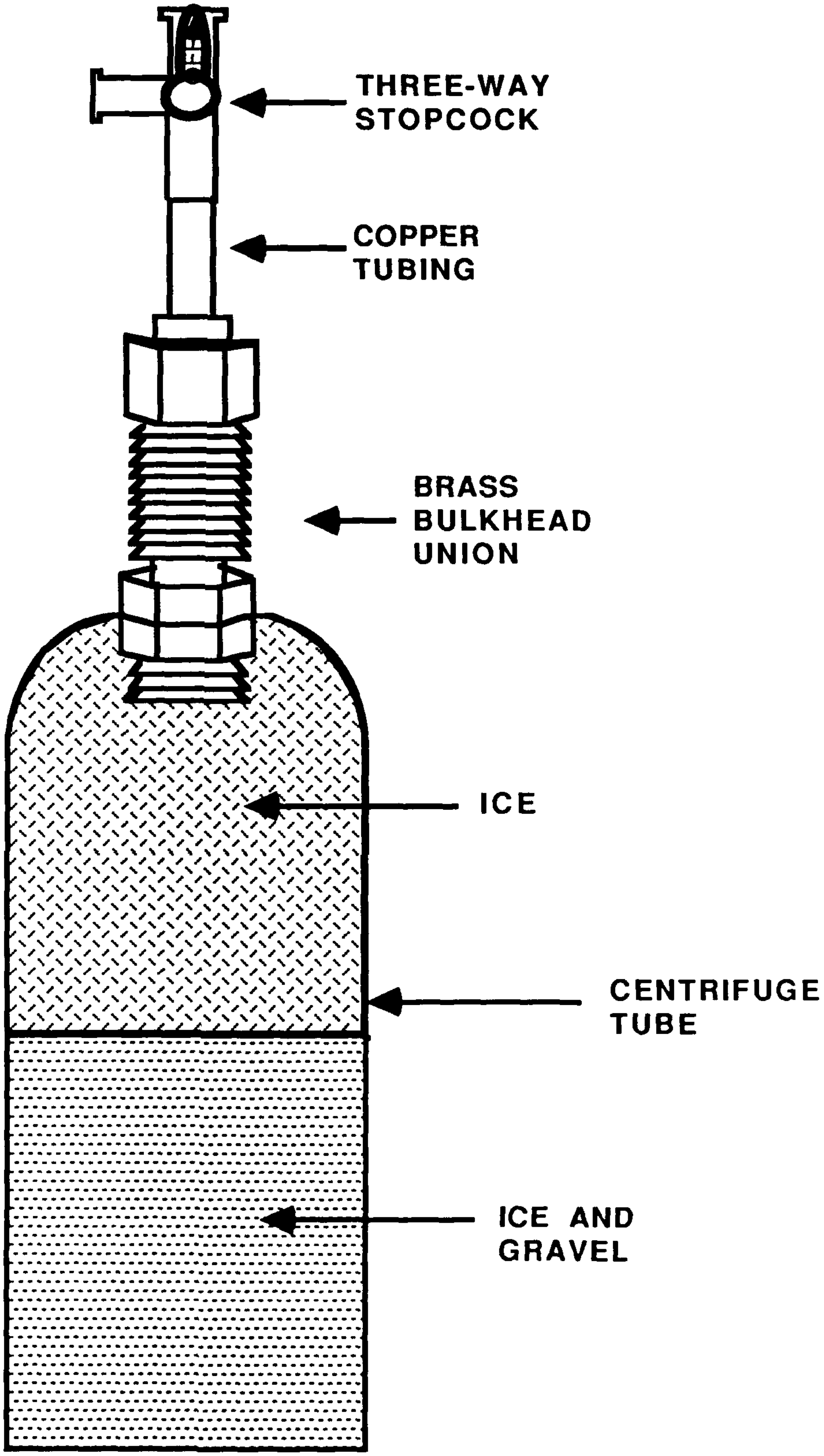

Figure 6. Oxygen diffusion chamber for installation in saturated soils (not to scale)

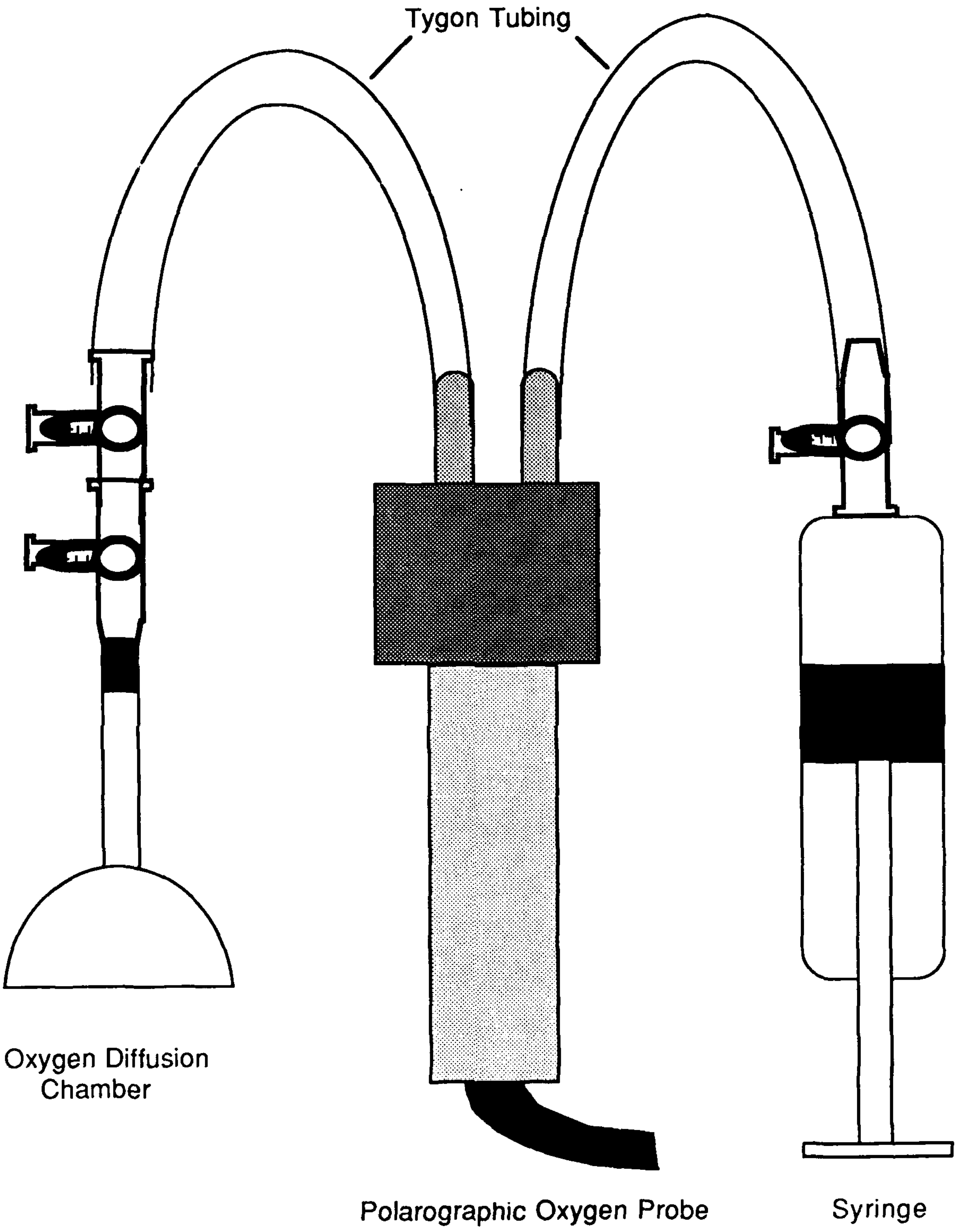

Figure 7. Soil oxygen sampling design (not to scale)

runoff from entering the well. The top of the pipe was covered to prevent rainwater from entering the pipe.

RESULTS

61. The effects of inundation and saturation on soil processes are reflected dramatically in the oxygen and redox regime. Anaerobic conditions can occur seasonally, continuously, sporadically, or not at all with significantly different patterns, both temporally and spatially, among the four. When oxygen and redox regimes are compared with water table fluctuations, a clearer understanding of the relationships among these three parameters develops. Graphs of oxygen content at 30 cm, redox potential at 30 cm, and water depth over time are presented for each sample plot in the following sections. The 30-cm depth was emphasized because it is the most critical with respect to plant growth and survival and hydric soil criteria.

62. The solid horizontal line at +300 mV on the redox potential graphs represents the approximate break between aerobic (>+300 mV) and anaerobic (<+300 mV) conditions. The solid horizontal line on the water-depth graphs designates the soil surface. Missing data are designated on the graphs by broken lines. The main causes of missing data were flooding and equipment malfunction. Floodwater velocity was great enough on many plots to cause damage to the permanent equipment and loss of data immediately following the flood event. This, coupled with lack of accessibility during high-water periods, resulted in significant periods of data loss for some plots. The gray areas approximate the growing season (frost-free days) for each transect location. Oxygen content, redox potential, water depth, and soil moisture at all four depths were plotted over time for each site. These graphs are presented as appendix materials and are in the same format except that missing data are indicated by blank spaces.

63. Growing season inundation and associated anaerobic conditions are an important determinant of species composition in the floodplain. Therefore, the percentage of the growing season that soils were reduced (<+300 mV), essentially anaerobic (< 5% oxygen), or saturated in the rooting zone (water table depth < 30 cm below the soil surface) was calculated for the 1984 growing season. Growing season dates and durations are listed in Table 1. It was considered desirable to use an average or "normal" year that was representative of typical conditions in the ecosystem for these calculations. Certainly, the fall of 1982 and spring of 1983 were extremely wet. In order to determine the wetness of different years, water budget data from each transect region were compared. The Thornthwaite climatic water balance was used to calculate a monthly water budget surplus for different regions in Louisiana. A surplus is indicated if rainfall exceeds potential evapotranspiration by plants and infiltration into the soil (McCabe, McLaughlin, and Muller 1985). Data are available from 1889 to present.

64. A comparison of the periods of September 1982-August 1983, September 1983-August 1984, and September 1984-August 1985 with the 1889-1984 average reveals the tremendous surplus in all transect regions for the 1982-83 period (Figure 8). In the East Central Division (Pearl

Table 1

Growing Season Data*

Transect	Mean Date of First Freeze	Mean Date of Last Freeze	Total Days Between
Pearl River	3/14	11/17	254
Quimby	3/23	10/29	220
Red River	3/5	11/16	256
Rolling Fork	3/9	11/9	245
Spring Bayou	3/5	11/16	256

* From Cry 1968.

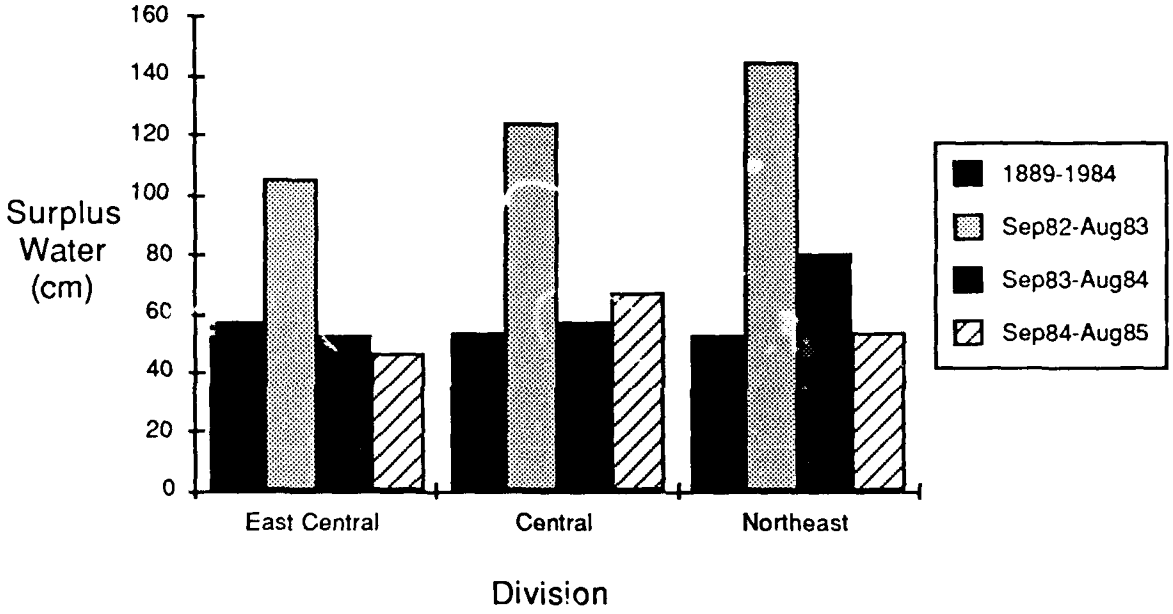

Figure 8. Comparison of water budget surpluses for three regions of Louisiana

River), the 1983 calendar-year surplus (January-December) of over 100 cm has been exceeded only once since 1889. In contrast, the 1983-84 period was very close to the 95-year average in both the East Central and Central (Red River and Spring Bayou) regions. The 1983-84 period was 60 percent greater than the 95-year average in the Northeast Division (Quimby and Rolling Fork). The 1984-85 period was less than the 95 year average in the East Central Division and above it in the Central Division. For this reason, the 1984 data were used to determine the percentage of the growing season the soils were reduced (< [illegible]00 mV), essentially anaerobic (< 5% oxygen), or saturated in the rooting zone (water table depth <30 cm below the soil surface).

65. The correlation between oxygen content (OX), redox potential (EH), soil moisture (NP), and water table depth (WDEP) was higher at some depths than others, with the 30-cm depth having the greatest number of the best-correlated comparisons when all of the transects were combined (Table 2). Oxygen content and redox potential (r = 0.73), oxygen content and water table depth (r = -0.81), and redox and water table depth (r = -0.74) had the highest correlations at 30 cm and the correlation between redox and soil moisture was only slightly lower at 30 cm (r = -0.46) than at 15 cm (r = -0.54). Redox and oxygen were well correlated (r ≥ 0.66) at all depths (see Appendixes B, F, I, L, and O for complete tabulations of correlation coefficients for each transect). The correlations indicate that these parameters are responsive to hydrologic changes and support the use of the 30-cm depth measurements in the graphs of oxygen content, redox *potential, and water table depth.*

Table 2

Best Overall Correlation Coefficients

Comparison	r Value
OX30 * EH30	0.73†
EH15 * NP15	-0.54† (30 cm depth = - 0.46†)
EH30 * WDEP	-0.74†
OX120 * NP120	-0.58†
OX30 * WDEP	-0.81†
WDEP * NP15	0.60†

†Significant at the 0.01 level of probability.

66. Despite the high overall correlation between oxygen content and redox potential, there were occasions when oxygen content and redox potential gave conflicting results with regard to the presence/absence of oxygen. Thermodynamically, oxygen is unstable below +300 mV (cf.

Ponnamperuma 1972, Turner and Patrick 1968); however, there were very few instances where the oxygen level was zero at the same sampling period redox potential was less than +300 mV.

67. There were several reasons for this, and the design of the two measurement systems was largely responsible. The platinum electrode is in constant contact with the soil and responds much more quickly to change than the oxygen diffusion chamber which relied on gaseous diffusion to equilibrate with the soil atmosphere. In addition, the platinum tip interacts with a very small area (<1 to 2-mm-diam) making it susceptible to the inherent variation and heterogeneity of the soil. Oxygen in this microzone can be quickly consumed. Currie (1961) showed that localized areas of an aerobic profile can become anaerobic and, since the redox electrode measures a much smaller area than the oxygen chamber, it may reflect reducing conditions present in these localized areas.

68. Another possible explanation is the effect of soil temperature and the design of the diffusion chambers. The above-ground portion of the chamber was sometimes damaged during flood events, and positive head pressure would drive out the gas in the chamber. After repairing the damage, atmospheric air was injected into the chamber to make it functional. The equilibration period for microorganisms to consume 21 percent oxygen introduced into the system is longer under saturated soil conditions and low soil temperatures since the lower limit for bacterial (the dominant microflora) growth and development is 15° C with an optimum of 25° C (Alexander 1977). With the exception of a few isolated readings, soil temperature at 15, 30, and 50 cm was greater than 5° C (biological zero) at all transects during the study period. It was buffered by depth in the soil as the temperature at 15 cm was higher in the summer and lower in the winter than at 50 cm.

Pearl River

69. The Pearl River transect was located within the boundaries of the Pearl River Wildlife Management Area in St. Tammany Parish, Louisiana (Figure 2). The site is a low-lying floodplain between the West Pearl River and the Pearl River. The transect began on a low ridge and traversed ridge and swale topography with numerous meander sloughs through the slackwater area (Figure 9). The soils are from the Pearl River alluvium. From September 1982 to August 1983, 202 cm of rain was recorded; April 1983 rainfall was especially high (Figure 10). Total rainfall was much lower for the same period in 1983-84 (152 cm) and 1984-85 (161 cm). This transect was severely flooded in April 1983 and again in June 1983, but not at all in 1984 or 1985.

70. Soil temperatures were highest from June to September, ranging from 20° to 25° C. The lowest temperatures were measured in January and February (9° to 14° C). Soil temperatures ranged from 12° to 22° C throughout most of the year and were fairly constant with depth, varying by only 1° or 2° C. Extremes were buffered by depth as the temperature at 50 cm was lower in the summer and higher in the winter than at 15 cm.

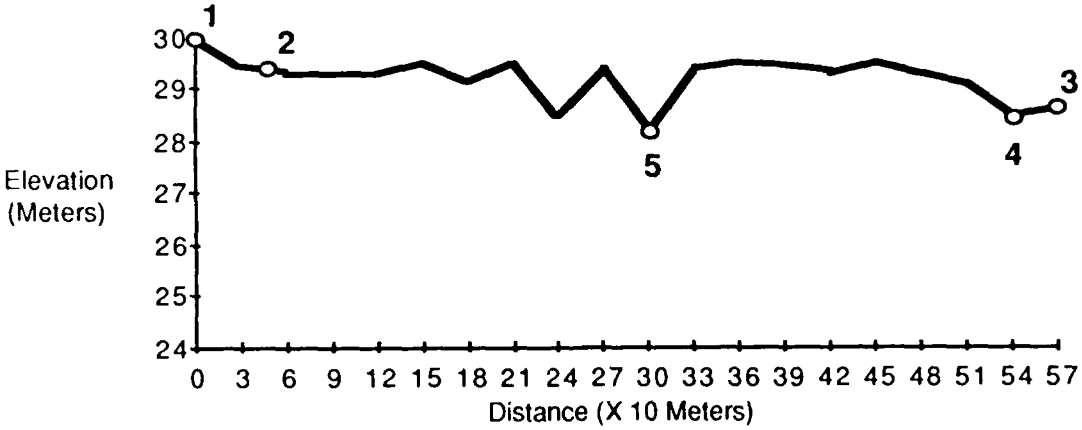

Figure 9. Relative plot elevations for the Pearl River transect

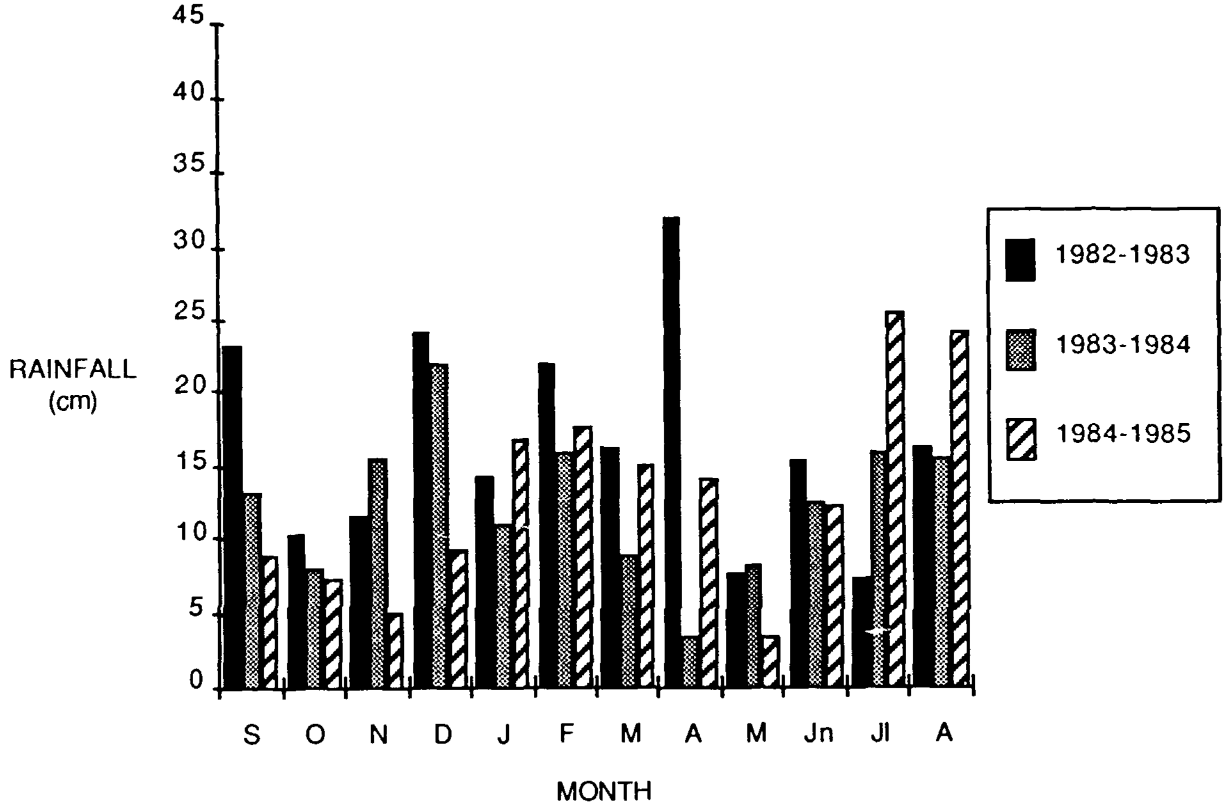

Figure 10. Rainfall patterns for the Pearl River transect

Plot PR1

71. This plot was located in Arkabutla silt loam (Aeric Fluvaquent). The Arkabutla soils are deep, somewhat poorly drained, moderately permeable, and derived from silty, upland alluvium. These soils are on the higher ridges in the Pearl River floodplain. The soil reaction was very strongly acid, outside the typical range of Arkabutla characteristics.

72. The major parameters were all significantly correlated at all depths (see Appendix B, Table B1). The best correlations were at the 30-cm depth for oxygen content and redox potential (r = 0.64), redox and water table depth (r = -0.57), redox and soil moisture (r = -0.46), oxygen and soil moisture (r = -0.72), oxygen and water table depth (r = -0.72), and water table depth and soil moisture (r =0.82).

73. 1983. The water table was not detected until January 1983 (-28 cm) and remained within 28 cm of the surface until March. The plot was inundated with surface water for the entire month of April (>+120 cm), and no measurements were taken. The water table dropped to 102 cm below the surface in May before 19 cm of surface water flooded the plot in June. It ranged from -13 cm (August) to -36 cm (December) for the rest of the year and was not detected in the upper 120 cm of the profile in October and November.

74. Oxygen content at 15 cm decreased from 21 percent in September 1982 to 13.5 percent in February 1983 (Appendix C). After increasing briefly to 15 percent in March, it fluctuated between 9.5 and 12.5 percent from May to September. It fell to 7 percent in August before rising to 18 to 20 percent for the remainder of the year. Oxygen content at 30 cm declined from 20 percent (September) to 8 percent (early March). It fluctuated between 9 and 13 percent (late March to June) and fell to 1.5 percent in July. Soil oxygen climbed steadily from 7.5 percent in August to 20 percent in November, then fell to 15 percent in December.

75. Soil oxygen content at 60 cm decreased from 19 percent in September to 5 percent by March. It ranged from 8 to 12.5 percent from May to September, climbing above 16 percent for the rest of the year. Oxygen content at 120 cm fell from 17 percent in September to 13.5 percent in January. It was less than 10 percent from February to September, except for early May (11%). It was less than 5 percent in July (3.5%), August (4.5%), and September (<1%). Oxygen content was 14 percent in October, 17 percent in November, and 13 percent in December.

76. Redox potential at 15 cm was greater than +415 mV during the year, except in March (+290 mV), June (+385 mV), and July (+205 mV). Redox at 30 cm declined from +710 mV in September to +370 mV in December. It ranged between +65 mV and +270 mV from March through August and climbed above +400 mV in September, October, and November. It dropped to +265 mV in December. Redox potential at 60 cm declined from +725 mV in September to +395 mV in February. It fell below +300 mV in March (+250 mV), increased to +395 mV in May, then dropped to +130 mV by July. It rose from +330 mV in August to over +450 mV from October through December. Redox potential at 120 cm dropped from +625 mV in September to +315 mV

by early March. It fluctuated between +105 mV and +275 mV from late March to September and was greater than +440 mV for the rest of the year.

77. Soil moisture content at 15 cm increased from 29 percent in September to 40 percent by December. It ranged from 41 to 46 percent from January through December except for November when it fell to 36 percent. Soil moisture at 30 cm followed the same pattern, rising from 30 percent in September to 40 percent in December. It fluctuated between 40 and 45 percent for the rest of the year except for November (36 %). Moisture content at 60 and 120 cm was higher than the upper profile in September and October (33 to 38%) but was generally lower during the rest of the year, ranging from 39 to 44 percent.

78. 1984. The water table was high early in the year, falling from -3 cm in January to -13 cm in March. It continued to fall to -89 cm by late April and was not detected in the upper 120 cm of the profile for the rest of the year. Oxygen content at 15 cm ranged from 12 to 15 percent from January to late April and was not less than 19 percent for the rest of the year. Oxygen content at 30 cm declined from 14 percent in January to 7.5 percent in early April before increasing to 13 percent by the end of April. It ranged from 18 to 20 percent the rest of the year. The soil oxygen content at 60 cm fell from 12 percent in January to 6 percent in early April. It rose to 11.5 percent in late April and remained greater than 17 percent for the remainder of the year. Oxygen content at 120 cm was a little erratic, rising from 4 percent in January to 15 percent in February and then steadily declining to a low of 5 percent in late April. It stabilized between 16 and 18 percent for the rest of the year with the exception of July when it fell to 14.5 percent.

79. Redox potential at all depths was low during the first 4 months of the year. At 15 cm, it declined from +300 mV in January to a low of +35 mV in March. After increasing to +185 mV in early April, it remained higher than +550 mV for the rest of the year. Redox at 30 cm was generally much lower, falling from +215 mV in January to -7 mV in March. It slowly increased to over +300 mV by mid-May and was not less than +440 mV from June to December. Redox potential at the 60- and 120-cm depths was similar, decreasing from greater than +300 mV in January to less than +100 mV in March. At 60 cm, it increased to +355 mV by late April and was greater than +460 mV from May to December. At 120 cm, redox was less than +165 mV until mid-May (+510 mV). It remained above +470 mV for the rest of the year.

80. Soil moisture content, at all depths, was greatest during the period of January to early April. It was highest at 15 cm (46%), decreasing with depth to 43 percent at 120 cm. During the rest of the year, soil moisture at 15 and 30 cm ranged from 32 to 39 percent except in June and October when it was less than 30 percent. It was slightly higher at 60 and 120 cm ranging from 36 to 41 percent (May to December) except in November when it was 33 percent at 60 cm.

81. 1985. The water table increased from less than -120 cm in January to -15 cm in early March. It fell to -105 cm in April and was less than -120 cm from May until August when it rose to -115 cm. Soil oxygen content at 15 cm fell from 20 percent in January to 15 percent in March

before increasing to greater than 17 percent through August. Oxygen content at 30 cm was more variable, decreasing from 20 percent in January to a low of 7 percent in March. It ranged from 16 to 20 percent from April to August. Oxygen content at 60 cm declined from 19 percent in January to 9 percent by the end of March. It increased to 14 percent in April and remained greater than 16.5 percent for the duration of the study. Soil oxygen at 120 cm dropped from 18 percent in January to 12 percent in early March to a low of 11 percent in April. It ranged from 15 to 17 percent from May through August. Redox potential at all four depths was greater than +570 mV from January through August.

82. Soil moisture content at 15 and 30 cm increased from 40 percent in January to a high of 44 percent in March. At 15 cm, it declined slowly from 41 percent in April to 36 percent in July, and rose to 40 percent in August. At 30 cm, it fell from 40 percent in April to a low of 33 percent (June) before rising to 38 percent by August. Moisture content at 60 and 120 cm fluctuated between 37 and 42 percent from January to August except for June (31%) at 60 cm.

83. Summary. This site was briefly anaerobic, but was reducing for a majority of the 1983 growing season. Redox potential was less than +300 mV for 15 percent of the 1984 growing season, but it was not anaerobic during this period (Table 3). It was saturated for 5 percent of the 1984 growing season. The overall pattern for 1984 and 1985 was one of brief soil saturation during the growing season with an aerobic profile (Figure 11).

84. The soil at this plot, Arkabutla (Aeric Fluvaquent), is not a hydric soil. Chroma colors were greater than 2 with no mottles or gleying in the BW horizon (10 to 25 cm) (Appendixes D and E) indicating no significant soil reduction. A few iron and manganese concretions were observed, but these were greater than 10 cm below the soil surface.

Plot PR2

85. This site was located in a slightly depressional area of Rosebloom silt loam (Typic Fluvaquent). The Rosebloom consists of poorly drained, slowly permeable soils derived from silty, upland alluvium from silty uplands. This soil was slightly lower in elevation, flooded more frequently, and more poorly drained than the Arkabutla soil.

86. The soil parameters were well correlated and highly significant at all depths (Table B2). The best correlations for oxygen content and water depth (r = -0.81) and moisture content and water depth (r = 0.85) occurred at 30 cm. The second best correlations were at that depth for oxygen content and redox potential (r = 0.85) and moisture content and oxygen (r = -0.81).

87. 1983. No water table was detected until the plot was inundated with +20 cm of surface water in December 1982. The water remained at or above the soil surface until early March (-30 cm). The plot was flooded with +6 cm of surface water in late March and more than +120 cm for the month of April. The water table dropped to -66 cm by the end of May, and flooding returned in June (+46 cm). The water table remained at the soil surface through August, falling quickly to -34

Table 3

Presence of Wetland Soil Indicators

Site	Oxygen Regime*	Redox Regime**	Hydrology†	Profile Description††	Zone‡	Hydric Soil‡‡
	(Percentage of Growing Season)					
Pearl River						
PR1	0	15	5	N	IV	N
PR2	19	11	11	Y	II	Y
PR3	11	11	11	Y	II	Y
PR4	19	11	19	Y	II	Y
PR5	88	70	63	Y	II	Y
Quimby						
QU1	0	0	0	Y	V	N
QU2	0	0	0	Y	IV	N
QU3	0	6	20	Y	III	Y
QU4.A	0	0	21	Y	III	Y
QU4.B	37	59	37	Y	III	Y
QU5	100	100	100	Y	II	Y
Red River						
RR1	0	0	0	§	V	N
RR2	0	0	0	§	V	N
RR3	100	100	100	§	III	Y
RR4	100	100	100	§	II	Y
Rolling Fork						
RF1	0	0	0	Y	IV	N
RF2	25	19	25	Y	III	Y
RF3	19	22	19	Y	IV	Y
RF4	25	25	37	Y	III	Y
RF5	62	62	55	Y	II	Y
Spring Bayou						
SB1	7	17	17	Y	IV	N
SB2	17	23	17	Y	IV	Y
SB3	31	46	41	Y	III	Y
SB4	89	93	89	Y	II	Y

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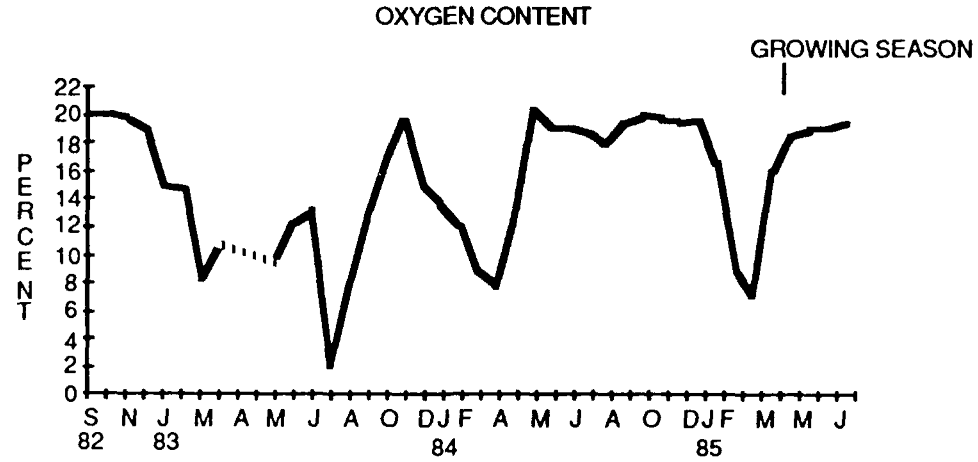
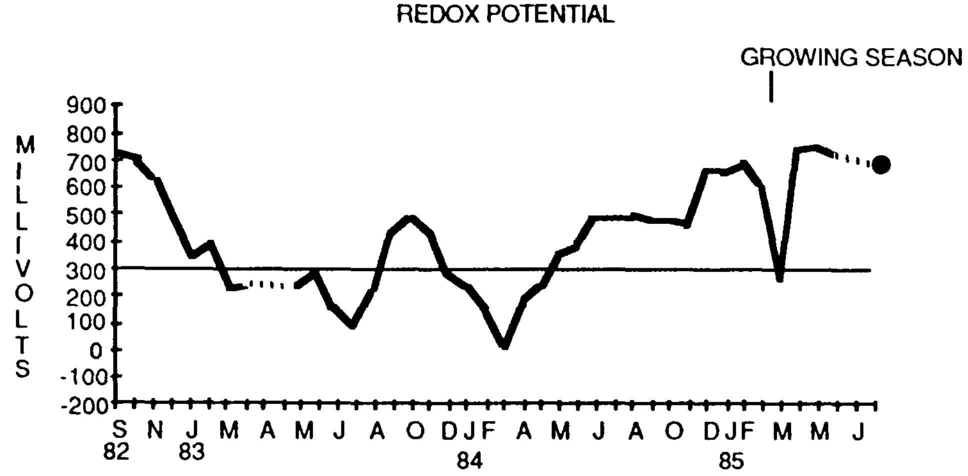
* Oxygen content less than or equal to 5 percent.
** Redox potential less than +300 mV.
† Water table greater than or equal to -30 cm.
†† Profile gleyed and/or matrix chroma of 2 or less.
‡ Ecological zone placement by Touchet et al. (1987).
‡‡ Soil listed on Soil Conservation Service hydric soil list.
§ Soil colors resistant to reduction and cannot be used as an indicator.





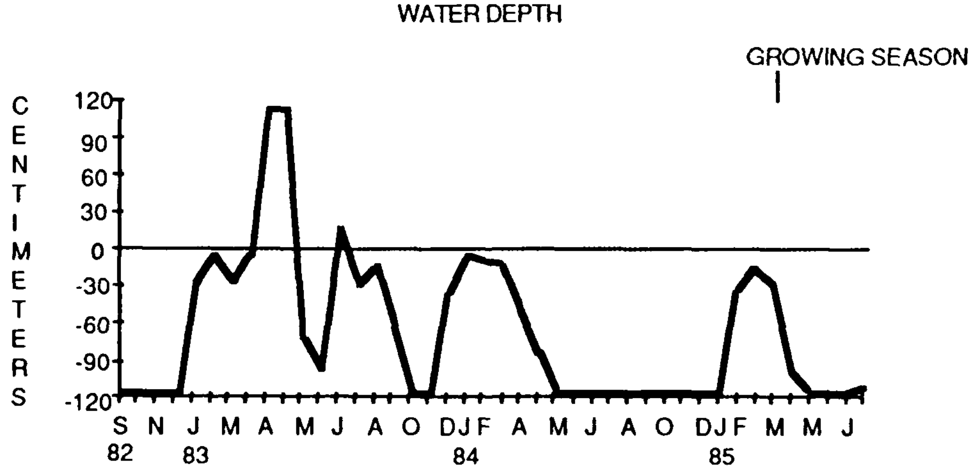


Figure 11. Oxygen content and redox potential at 30 cm with water depth for Pearl River Plot 1

cm in September and less than -120 cm in November. It rose to -3 cm in December. High water prevented measurement in April and June.

88. Soil oxygen content at 15 cm decreased from 20 percent in September to 7.5 percent in January. It continued falling to 1.5 percent in February and early March before fluctuating between 11 and 14 percent until June. It was 7 percent in July, decreased to 2 percent in August and September, and was greater than 12 percent for the rest of the year. Oxygen content at 30 cm declined from 20 percent in September to 11 percent by January. It ranged from 3.5 to 6.5 percent until September, with the exception of late May (11%), then rose above 12 percent through December. Oxygen content at 60 cm dropped from 18.5 percent in September to 8 percent in January. It continued falling to 1.5 percent by early March and remained 1.0 percent or less until August (6%), with the exception of late May (10%). It rose to 18 percent in November before falling to 11 percent in December. Oxygen content at 120 cm declined from 16.5 percent in September to 4 percent in January. After a brief rise to 6 percent (February), it was less than 4 percent until November and December when it increased to 8 percent.

89. Soil redox potential at 15 cm was greater than +450 mV from September to January. It fell to +374 mV in February, then fluctuated between +150 and +310 mV until September (+635 mV), except for late May (+760 mV). It remained greater than +590 mV for the rest of the year. Redox potential at 30 cm was similar: greater than +450 mV from September to January, ranged from +75 to +340 mV until September (+535 mV), except for late May (+720 mV), and remained greater than +600 mV from October to November. Redox at 60 cm declined steadily from +740 mV in September to +310 mV by February. It ranged from +80 to +295 mV through September and climbed to +725 mV (November) before falling to +430 mV in December. Redox potential at 120 cm decreased from +680 mV in September to +465 mV by January and down to +245 mV by late March. It remained less than +210 mV for the rest of the year.

90. Soil moisture content at 15 cm increased from 29 percent in September to 34 percent in October. It fluctuated between 44 and 48 percent for the rest of the year, with the exception of November 1983 (40%). Moisture content at 30, 60, and 120 cm increased from 35 percent in September and October to 45 percent in January. It ranged from 40 to 45 percent through December 1983 at all three depths.

91. <u>1984.</u> The year started with 4 cm of surface water, and the profile was saturated to the surface until early April when the water table receded to -10 cm. It was -55 cm by late April and was not detected in the upper 120 cm of the profile for the rest of the year. Soil oxygen content fluctuated between 1 and 6 percent at all four depths from January to late April. By May, it was greater than 17 percent at 15, 30, and 60 cm and 12.5 percent at 120 cm. It ranged from 14 to 20 percent at the upper three depths except briefly in August (12.5%) at 60 cm. The 120-cm depth oxygen content ranged from 11 to 15 percent until November and December (17%).

92. Soil redox potential was less than +130 mV at all four depths from January to early April. It was greater than +600 mV at 15, 30, and 60 cm from May to December. The increase in redox at 120 cm was slower, climbing to +205 mV in early May and remaining above +590 mV from June to December. Moisture content ranged from 45 to 49 percent at all four depths from January to early April. It fluctuated between 24 and 35 percent for the rest of the year at 15 cm with the exception of late May (38%), August (41%), and December (41%). The 30- and 60-cm depth moisture content was more stable, ranging from 35 to 41 percent from May through December except for June (33%) and October (31%) at 30 cm. Moisture content at 120 cm decreased to 44 percent in May and ranged from 36 to 42 percent for the rest of the year.

93. 1985. The water table rose to the surface in February and did not recede until April (-80 cm). It was not detected in the upper 120 cm of the profile from May through July, but was measured at -48 cm in August. Soil oxygen content at 15 and 30 cm was greater than 15 percent during the year except for late March (3%) at 15 cm and February (11%) and March (7%) at 30 cm. It was greater than 10 percent during the year at 60 and 120 cm except for March (7%) at 60 cm and March (6%) and April (2.5%) at 120 cm.

94. Soil redox potential was greater than +500 mV at all depths in January and February. It declined to approximately +350 mV at 15 cm and +120 mV at 30 cm in March before climbing above +700 mV at those depths for the rest of the year. It was greater than +600 mV at 60 cm through August except for March (~+250 mV) and August (+330 mV). Redox potential at 120 cm fluctuated between +245 mV and +450 mV for the rest of the year with the exception of June (+725 mV). Soil moisture content at 15 cm ranged from 40 to 42 percent for the year except for February and March (48%). The 30-cm depth moisture content ranged from 37 to 43 percent from January to August except for February and March (45%). Moisture content at 60 and 120 cm fluctuated between 38 and 45 percent during the year with the exception of June (35%) at 60 cm.

95. Summary. Plot PR2 was saturated within 30 cm of the surface for much of 1983, causing several months of reduction and anoxia in the profile. The soil was saturated and reduced for 11 percent of the 1984 growing season (Table 3). It was anaerobic for 19 percent of the 1984 growing season. Soil saturation and reduction in 1985 was less than that in 1984 (Figure 12). The soil (Rosebloom, Typic Fluvaquent, hydric) had a gleyed B horizon with a matrix chroma of 2 or less and a few iron and manganese concretions (below 10 cm), but was not mottled in the upper 38 cm of the profile (Appendix E).

Plot PR3

96. This site was in a slackwater swamp and was flooded each year during the growing season. The soil type was Rosebloom silt loam, the same as PR2. The major parameters were significantly correlated at all depths (Table B3), and the best correlations were at 15 and 30 cm ($r \geq 0.70$).

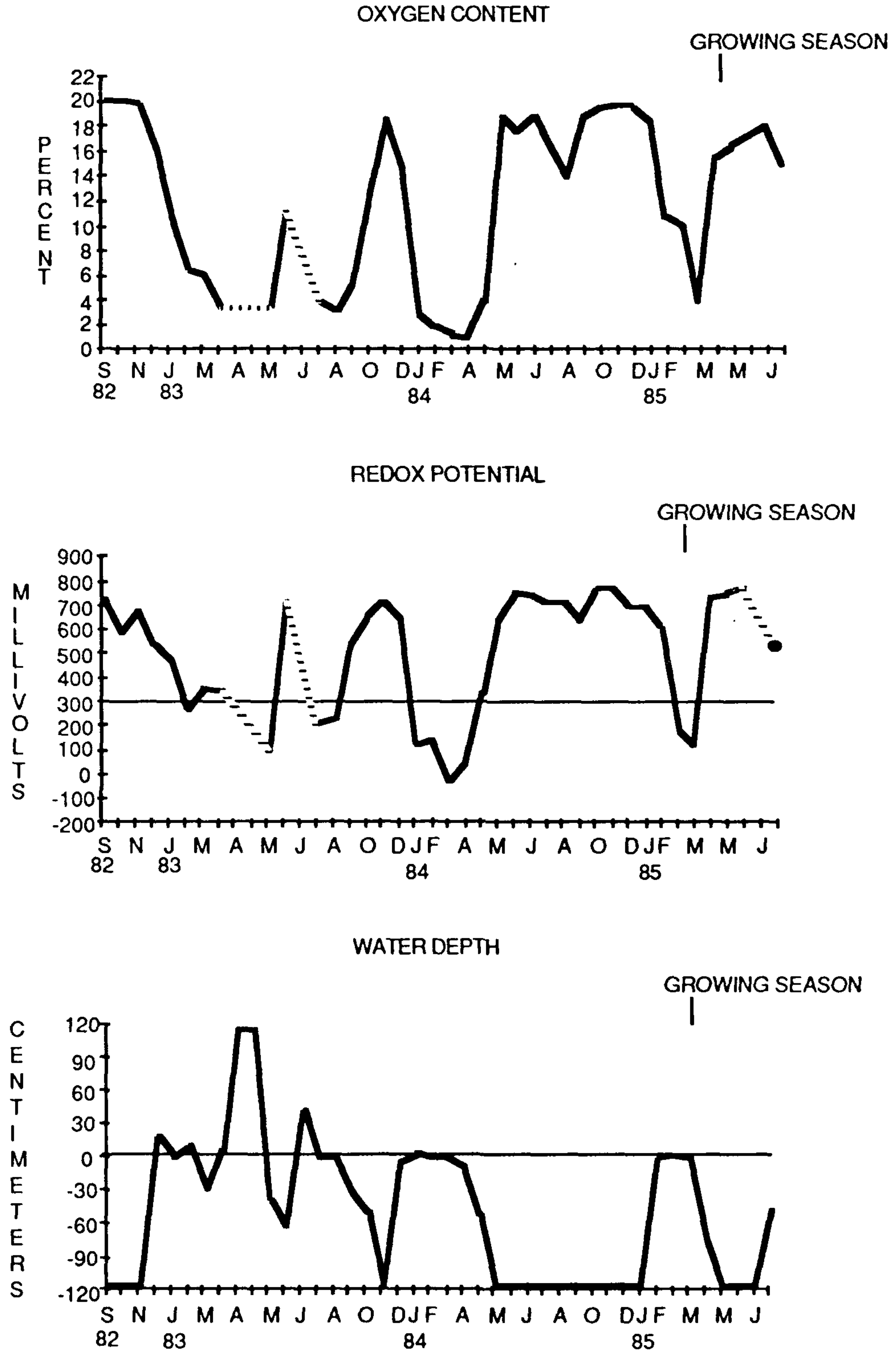


Figure 12. Oxygen content and redox potential at 30 cm with water depth for Pearl River Plot 2

97. 1983. The water table was less than -120 cm from September to November. From December to late April the site was inundated with surface water except in early March (-15 cm). No soil measurements were made in December, January, February, and April because of the high water. The water table receded to -39 cm by late May; however, the plot was flooded again in June (+120 cm). It stayed within 5 cm of the soil surface for the rest of the year with the exception of October (-18 cm) and November (-110 cm).

98. Soil oxygen content was greater than 15 percent at all depths from September to November. It was less than 5 percent at 15 cm from March until September (7%) except for late May (9%). It ranged from 14 to 19 percent for the rest of the year. Oxygen content at 30 cm was less than 5 percent from March through September, increased to 18 percent in November, then declined to 12 percent in December. Oxygen levels at 60 cm were generally higher, ranging from 4 to 7 percent from March through September before climbing above 14 percent for the rest of the year. Oxygen content at 120 cm was less than 5 percent from March through December.

99. Soil redox potential was greater than +500 mV at all depths from September to November. It ranged from -5 to +280 mV at 15 cm from March through September, rose above +590 mV in October and November, and receded to +350 mV in December. Redox potential at 30 and 60 cm ranged from -20 to +170 mV from March through August with the exception of late March (+230 mV) at 30 cm and August (+200 mV) at 60 cm. The 30-cm depth redox increased from +260 mV in September to over +600 mV until December (+320 mV). Redox potential at 60 cm slowly climbed from +220 mV in September to +415 mV in November; it fell to +340 mV in December. Redox at 120 cm ranged from +320 to +430 mV in March and May and remained below +300 mV for the rest of the year except for August (+320 mV).

100. Soil moisture content at 15 and 30 cm ranged from 32 to 36 percent in September and October and then increased to 41 to 49 percent for the rest of the year. Moisture content at 60 and 120 cm was higher in September and October (36 to 38%) and generally more stable the rest of the year, ranging from 42 to 45 percent with the exception of July (37%) at 60 cm.

101. 1984. The water table remained within 1 cm of the soil surface from January through March, falling to -23 cm in early April. It was less than -120 cm from May through October and rose to -27 cm by December. Soil oxygen content at 15 and 30 cm ranged from 2.5 to 6 percent from to early April. It increased rapidly to 20 percent at 15 cm and 18.5 percent at 30 cm by May, and generally ranged from 16 to 20 percent for the rest of the year. Oxygen content at 60 cm decreased from 11.5 percent in January to a low of 4 percent in April before reaching 17.5 percent in mid-May. It fluctuated between 12.5 and 17.5 percent for the rest of the year. Oxygen content at 120 cm remained less than 4 percent from January through April. After rising to 10.5 percent in May, it ranged from 10.5 to 15 percent until November (7.5%).

102. Soil redox potential at 15 cm increased from +20 mV in January to +240 mV in early April. It was greater than +520 mV for the rest of the year except for October and December when

it was +490 mV. Redox at 30 cm fluctuated between +15 and +125 mV from January to early April. It was greater than +500 mV for the rest of the year with the exception of late May (+400 mV), October (+400 mV), and December (+ 430 mV). Redox potential at 60 cm was less than +100 mV from January to early April and greater than +400 mV for the rest of the year except for June (+310 mV). The 120-cm depth redox was low in January (+25 mV), then fluctuated between +135 and +250 mV from February to April. It ranged from +435 to +655 mV until November (+385 mV).

103. Soil moisture content at 15 cm was highest during January through April (48%) and ranged from 33 to 40 percent from May through November with the exception of June (29%). It rose to 44 percent in December. Moisture content at 30 cm was stable at 43 to 44 percent from January to April, then fluctuated between 35 and 40 percent from June to November. It increased to 44 percent in December. Moisture content at 60 cm declined steadily from 44 percent during January to April to 36 to 38 percent from June to October. It recovered to 42 percent in November and December.

104. <u>1985.</u> The water table was 4 cm below the surface in January, and the plot was flooded with surface water in February (+10 cm) and early March (+46 cm). The water table receded rapidly to -75 cm in April and was less than -120 cm from May to July. There was 1 cm of surface water covering the plot in August.

105. Soil oxygen content at 15 cm declined from 13.5 percent in January to a low of 2 percent in March. It rose to 13 percent in April and was greater than 16 percent for rest of the year. Oxygen content at 30 cm fell from 9.5 percent in January to less than 1 percent in March. It ranged from 12.5 to 17 percent for the rest of the year. Oxygen content at 60 cm decreased from 8.5 percent in January to less than 1 percent in March, then remained above 13 percent until August (10%). The 120-cm depth oxygen level fluctuated from 5 percent in January to 10 percent in February, to less than 1.5 percent in March and April. It increased from 7 percent in May to 13 percent in June before falling to 7.5 percent by August.

106. Soil redox potential at 15 cm was less than +550 mV only twice during the year in January (+355 mV) and February (+105 mV). Redox at 30 cm was less than +430 mV only in February (+285 mV). The 60-cm depth redox potential declined from +220 mV in January to +185 mV in February. It ranged from +450 to +605 mV until August (+315 mV). Redox at 120 cm was less than +300 mV from January through April. It climbed to +390 mV in May and remained greater than +400 mV through August. Soil moisture content at 15 cm decreased from 48 percent in January and February to 43 percent in April. It fluctuated between 40 and 44 percent through August. Moisture content at 30 and 60 cm was 43 to 44 percent in January and February. It ranged from 39 to 44 percent for the rest of the year with the exception of June at both 30 cm (37%) and 60 (36%) cm. Moisture content at 120 cm ranged from 41 to 45 percent for the year except for June (39%).

107. Summary. Plot PR3 was similar to PR2, but was flooded more frequently and for longer durations in 1983 (Figure 13). It was essentially anaerobic and strongly reduced at 30 cm for most of 1983, but only briefly in 1984. It was anaerobic, reduced, and saturated for 11 percent of the 1984 growing season (Table 3). The soil type was the same as PR2, Rosebloom silt loam (Typic Fluvaquent, hydric). The soil profile was gleyed in the B1 horizon with iron and manganese concretions, mottles, and a matrix chroma of 2 or less (Appendix E).

Plot PR4

108. This site was in a shallow drainage area within the slackwater swamp and was flooded each year during the growing season. The soil type was Rosebloom silt loam, the same as PR2 and PR3. The major parameters were significantly correlated at all depths (Table B4), and the best correlations for oxygen and redox (r = 0.81), water table depth and redox (r = -0.79), and water table depth and soil moisture (r = 0.90) were at 30 cm.

109. 1983. The frequent and deep flooding of the plot allowed only six measurement periods prior to July: September to November (-120 cm), early March (+14 cm), and twice in May (-15 and -27 cm). Following deep flooding in June (>+120 cm), the water table remained within 6 cm of the soil surface for the rest of the year with the exception of November (-81 cm).

110. Soil oxygen content at 15, 30, and 60 cm was greater than 16 percent from September through November. It was 12 to 13 percent at 120 cm during this time. At 15 cm, it ranged from 1 to 5 percent until October (11%), except for late May (9.5%). Oxygen content at 30 and 60 cm was less than 4 percent from May to October, except for October (9%) at 30 cm. It rose to 12.5 percent at 30 cm and 9 percent at 60 cm before falling to 7 percent (30 cm) and 2 percent (60 cm) in December. Oxygen content at 120 cm was less than 5 percent from March through December with the exception of an 8-percent reading in early May which was probably erroneous.

111. Soil redox potential was greater than +590 mV at all depths from September to November. It ranged from -46 to +235 mV at all four depths from March through August. Redox at 15 cm increased from +170 mV in September to +550 mV in November before decreasing to +160 mV in December. At 30 cm, it increased from +50 mV in September to greater than +500 mV in October and November and was +355 mV in December. Redox potential at 60 cm rose from +300 mV in September to + 635 mV in November. It fell to +80 mV in December. Redox at 120 cm peaked at +280 mV in September and declined steadily to +150 mV by December.

112. Soil moisture content at 15 and 30 cm ranged from 44 to 50 percent during the year with the exception of September (38%) and October (40%) 1982. Moisture content at 60 cm increased from 38 percent in September to 43 percent in March. It was 43 to 44 percent for the rest of the year. Moisture content at 120 cm was 42 percent in September, 43 percent in October, and 45 to 46 percent the rest of the year.

113. 1984. Flooding depth and duration was much lower in 1984, with 4 to 6 cm of surface water covering the plot from January to March. The water table receded to -27 cm by late

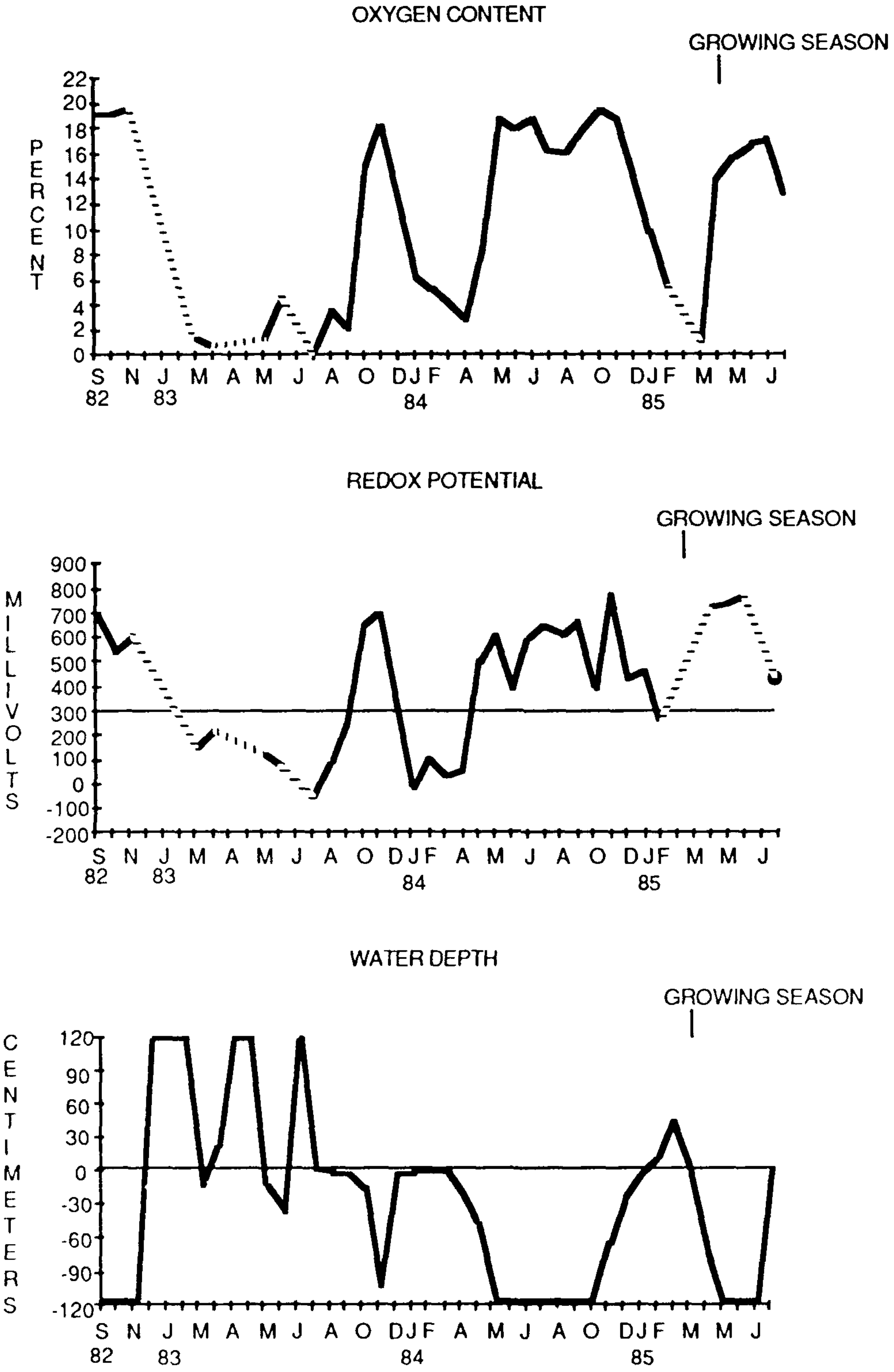


Figure 13. Oxygen content and redox potential at 30 cm with water depth for Pearl River Plot 3

April and was not detected in the upper 120 cm of the profile for the rest of the year except in late May (-102 cm), August (-70 cm), November (-38 cm), and December (0 cm).

114. Soil oxygen content at 15 cm increased from 2 percent in January to 8 percent in April. It was not less than 15 percent for the rest of the year with the exception of August (13%). Oxygen content at 30 cm rose from 2 percent in January to 6 percent in February and fell to 1.5 percent in March. It was greater than 14 percent for the rest of the year. Oxygen content at 60 cm was less than 4 percent from January through April except for February (5.5%). It fluctuated between 11 and 16 percent from May to October before falling to 7 percent in November and to zero in December. Oxygen content at 120 cm was less than 3 percent from January through April except for February (7%). It was less than 10 percent the rest of the year with the exception of June (13%), September (12.5%), October (14%), and December (13%).

115. Soil redox potential was less than +150 mV at all depths from January to early April. At 15 cm, it ranged from +350 to +400 mV the rest of the year except for early May (+270 mV). Redox potential at 30 cm ranged from +440 to +615 mV from late April through November. It was + 305 mV in December. Redox at 60 cm was greater than +475 mV from late April until October (+210 mV). It recovered to +360 mV in December. Redox at the 120 cm depth was less than +280 mV during the rest of the year with the exception of late April (+505 mV), June (+510 mV), September (+500 mV), and October (+445 mV).

116. Soil moisture content at 15 cm was stable at 49 to 50 percent from January to early April. It fluctuated between 39 and 44 percent for the rest of the year except for June (35%) and December (48%). Moisture content at 30 cm was 47 to 48 percent from January to early April. It ranged from 37 to 44 percent until December when it increased to 47 percent. The 60-cm depth moisture content was 44 percent from January to early April and ranged from 40 to 43 percent for the rest of the year. Moisture content at 120 cm was 45 to 47 percent for the year.

117. 1985. The plot was inundated with surface water from January (+5 cm) through March (+45 mV). It receded to -58 cm in April and was less than -120 cm in June and July before rising to -25 cm in August. Soil oxygen content was less than 4 percent at all depths from January to March. It was greater than 12 percent at the 15-cm depth for the rest of the year. Oxygen content at 30 cm climbed from 11 percent in April to 15 percent by July and decreased to 9.5 percent in August. At 60 cm, it was 6 to 8 percent the rest of the year with the exception of June (12%) and July (12%). Oxygen content at 120 cm was 1 percent in May and 10 to 12 percent through August.

118. Soil redox potential at 15 cm increased from +250 mV in January to +270 mV in February. It was greater than +400 mV from April through June, declining to +300 mV in August. Redox at 30 cm climbed from +140 mV in January and February to over +560 mV in April, May, and June, then fell to +195 mV in August. Redox potential at 60 cm fluctuated between +125 and +260 mV from January to April. It rose above +400 mV in May and June before falling to +375

mV in August. Redox at 120 cm ranged from +185 to +290 mV from January to May. After increasing to +495 mV in June, it declined to +350 mV in August. Soil moisture content at 15 and 30 cm was 49 percent in January and ranged from 41 to 46 percent from April to August. Moisture content at 60 cm ranged from 39 percent (June) to 43 percent during the year. It was 43 to 47 percent for the year at 120 cm.

119. Summary. Plot PR4 was essentially anaerobic and strongly reduced at 30 cm for most of the 1983 growing season, but only for a small part of the growing season in 1984 and 1985 (Figure 14). It was anaerobic and saturated for 19 percent of the 1984 growing season and reduced for 11 percent (Table 3). Plot PR4 had the same soil type (Rosebloom) as PR2 and PR3 and was drained and oxidized for much of the 1984 growing season. The B1 horizon of this Rosebloom silt loam was gleyed with many iron and manganese concretions, mottles, and a matrix chroma of 2 or less (Appendix E).

Plot PR5

120. This site was in a ponded area of an old stream channel and was inundated for much of the time during the study. The soil type was Rosebloom silt loam, the same as PR2, PR3, and PR4. The major parameters were significantly correlated at 15, 30, and 60 cm, but only correlations for oxygen and water table depth (r = -0.69) and redox and soil moisture (r = -0.58) were significant at 120 cm (Table B5). The best correlations were at 15 and 30 cm (r ≥ 0.68).

121. 1983. This site was inundated with floodwater for most of the year. No measurements were made from December to June. The water table was less than -115 cm in September, October, and November 1982. It was deeper than 16 cm for the rest of the year save November 1983 (-16 cm). Soil oxygen content at 15, 30, and 60 cm was higher than 15 percent from September to November. It ranged from 12 to 14 percent at 120 cm. Only seven oxygen readings scattered among the depths were made during the rest of the year because of high floodwaters and damaged equipment. All of those values were 1 percent or less.

122. Soil redox potential at 15, 30, and 60 cm was greater than +480 mV from September to November. It decreased from +360 mV (September) to +174 mV (November) at 120 cm. Redox potential at all depths was less than +170 mV from June through December except for September at 60 cm (+260 mV) and 120 cm (+235 mV). Only three soil moisture readings were made at each depth during the year. Moisture content was high at 15 cm in September and October (48 to 50%), declined to 41 to 42 percent at 60 cm, then recovered to 47 to 49 percent at 120 cm. It was higher at 15 and 30 cm in November 1983 (54 to 56%) than at 60 (46%) and 120 (47%) cm.

123. 1984. The site was flooded from January (+30 cm) through April (+24 cm) and again in August (+3 cm), November (+4 cm) and December (+54 cm). The water table was within 30 cm of the surface from May through July except for June (-86 cm). It receded from -70 cm in September to less than -120 cm in October. Soil oxygen content was not measured until May at 15 cm and not until June at the other three depths. Oxygen content at 15 cm was less than 5 percent

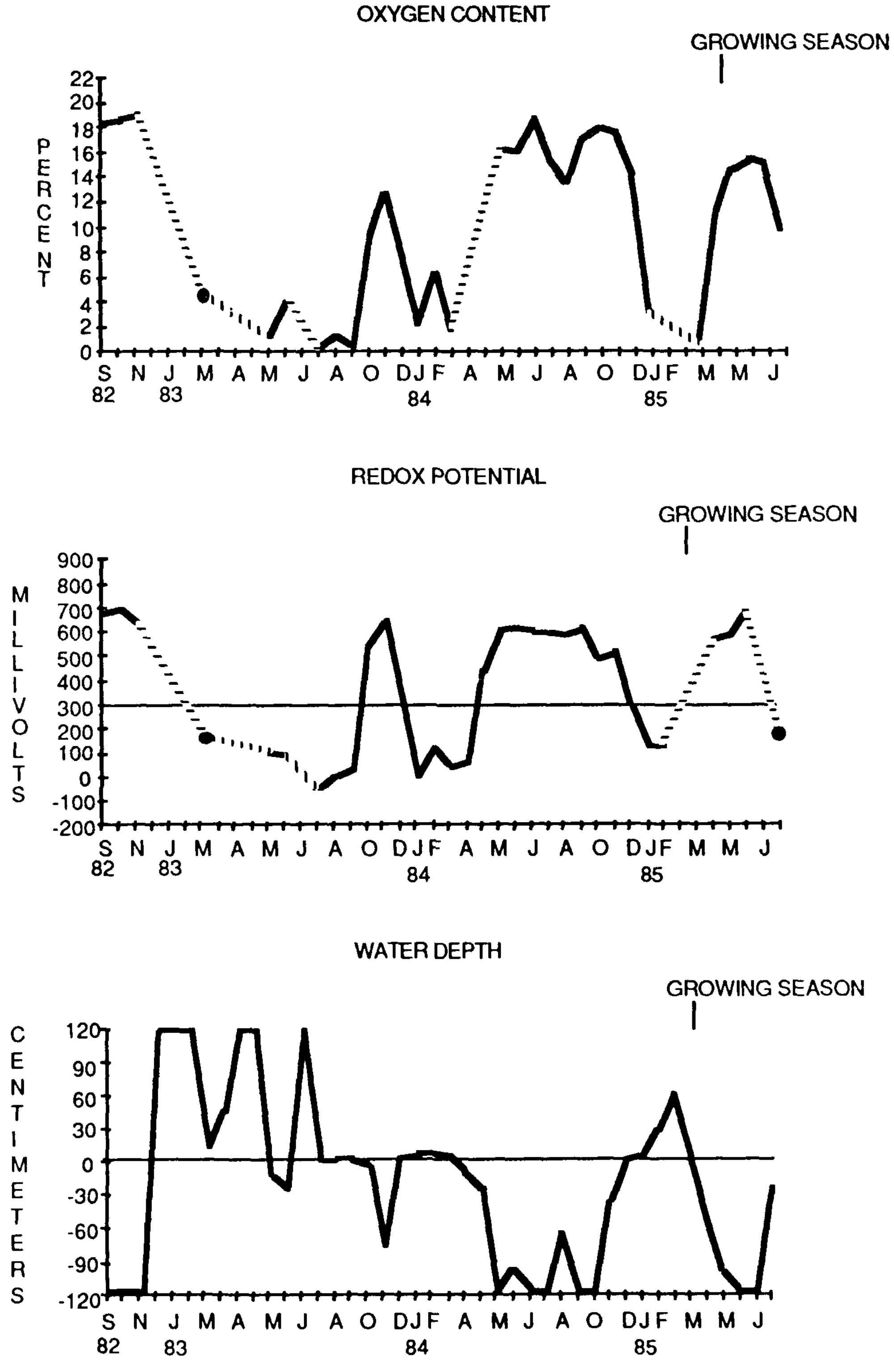


Figure 14. Oxygen content and redox potential at 30 cm with water depth for Pearl River Plot 4

from May to December with the exception of June (6%) and October (15%). It was 5 percent or less during the same period at 30 cm except for October (13%). Oxygen content at 60 cm was less than 3.5 percent for the year except October (8%). It was never greater than 3 percent at 120 cm.

124. Soil redox potential at 15 cm increased from a low of -40 mV in early April to +300 mV by late April. It was less than +100 mV until June (+645 mV), then ranged from +255 to +290 mV for the rest of the year with the exception of October (+565 mV). Redox potential at 30 cm was less than +100 mV from January to July except for late April (+455 mV) and June (+330 mV). It increased from +120 mV in September to +460 mV in October before declining to +290 mV (November). Redox potential at 60 cm was less than +150 mV during the year with the exception of late April (+445 mV) and October (+360 mV). Redox at 120 cm was less than +200 mV from January to May except for late April (+345 mV). It ranged from +215 to +275 mV for the rest of the year.

125. Soil moisture content could not be measured from January to April and in December because of high water. It ranged from 51 to 56 percent during May to November. Moisture content at 30 cm fluctuated between 48 and 55 percent during the year. It was lower at 60 cm, ranging from 43 to 46 percent . Moisture content at 120 cm was 47 to 49 percent during the year.

126. 1985. The plot was inundated with surface water from January (+24 cm) through May (+15 cm) and again in August (+46 cm). It was -86 cm in June and -64 cm in July. Soil oxygen content at 15 cm was measurable only in May (1%), June (15%), and July (11%). It was 1 percent or less in January and again in April, May, and August at 30 cm and climbed to 12.5 percent in June and 9 percent in July. Oxygen content at 60 cm was less than 5 percent except for June (8.5%). It was less than 4 percent at 120 cm.

127. Soil redox potential at 15 cm was less than +100 mV until June (+740 mV). It ranged from +180 to +250 mV at 30 cm until June (+675 mV). Redox at 60 cm was less than +75 mV in January, May, and June and +730 mV in July. Redox potential at 120 cm fluctuated between +165 mV and +280 mV during the same months. Soil moisture content was measured only twice (June and July) at all depths. It was highest at 15 cm (52 to 53%), declining to 43 to 44 percent at 60 cm, then increasing to 47 percent at 120 cm.

128. Summary. Plot PR5 was inundated for much of the study period and was anaerobic and strongly reduced at 30 cm for all but a few measurement periods (Figure 15). It was saturated for 63 percent, reduced for 70 percent, and anaerobic for 88 percent of the 1984 growing season (Table 3). The soil type was the same as the three previous sites (Rosebloom). The B1 horizon was gleyed, with dark brown mottles and a matrix chroma of 2 (Appendix E), all indicative of the strongly reducing conditions measured at this site.

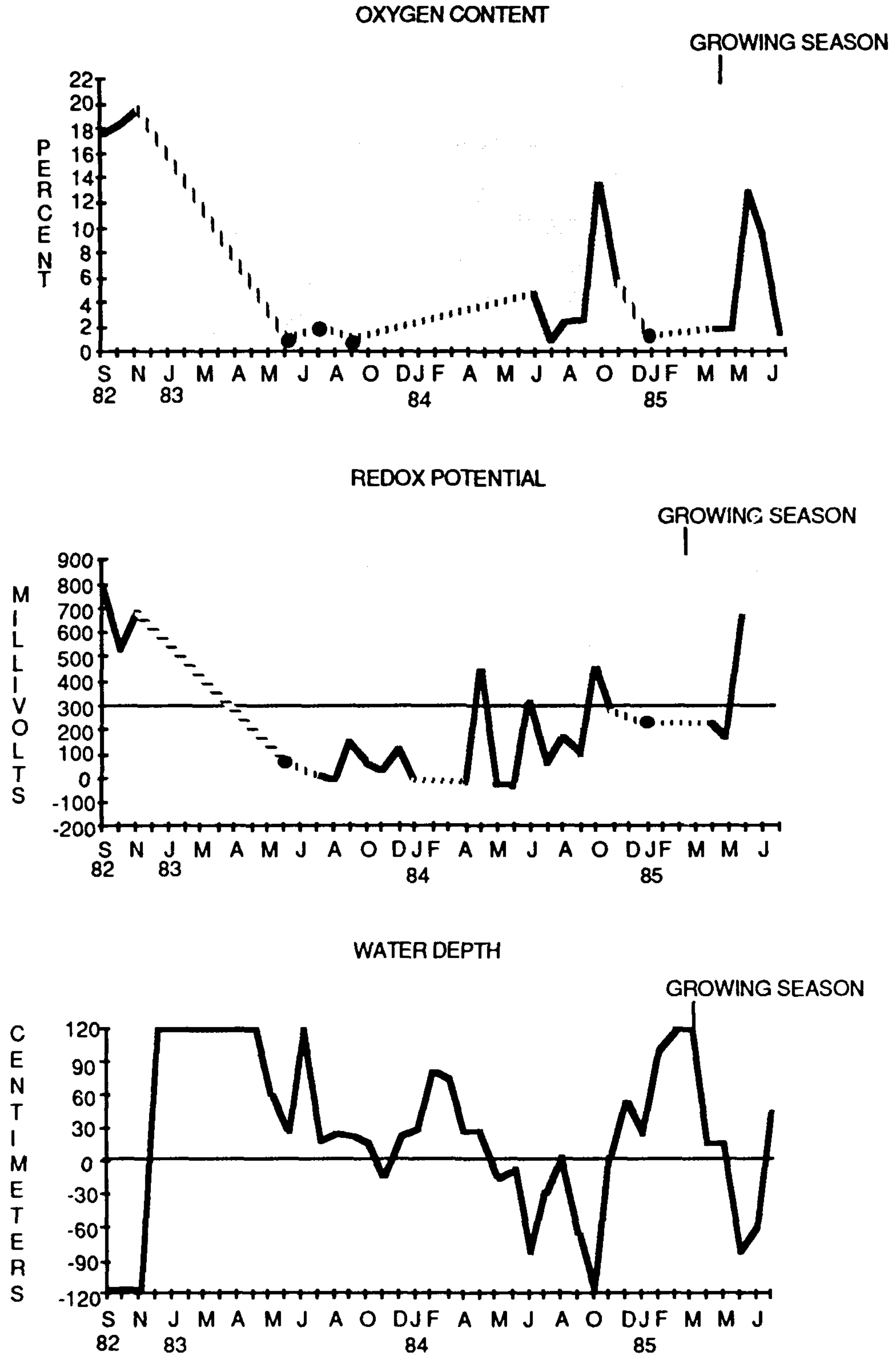


Figure 15. Oxygen content and redox potential at 30 cm with water depth for Pearl River Plot 5

Quimby

129. The Quimby transect was located on private property in Madison Parish, Louisiana. (Figure 2). The soils at this site were formed from the Mississippi River alluvium. This transect was located in ridge and swale topography with several old streams meandering through the area (Figure 16).

130. Two major rainfall periods occurred during the first year of the study: October 1982 to February 1983 (125 cm) and April through June (85 cm). Total rainfall from September 1982 to August 1983 was 242 cm. Rainfall in 1984 (153 cm) and 1985 (130 cm) was much less (Figure 17).

131. Soil temperatures were highest from June to September ranging from 20° to 25° C. The lowest temperatures were measured from January to March (4° to 14° C). Soil temperatures ranged from 12° to 22° C throughout most of the year. Soil temperatures were fairly constant with depth, varying by only 1° or 2° C. Extremes were buffered by depth as the temperature at 50 cm was lower in the summer and higher in the winter than at 15 cm.

Plot QU1

132. This site was located on a ridge in a Goldman loam (Aquic Hapludalf) that was not flooded during the study. The Goldman consists of deep, moderately well drained, permeable soils derived from loamy, alluvial sediments. These soils are on narrow, nearly level ridges between swales. This area was mapped as Dundee in the Madison Parish Soil Survey. This site was much better drained than Dundee and was underlain by stratified deep sandy layers and was, therefore, classified as Goldman.

133. The correlation of oxygen, redox, moisture, and water table was very low in general and nonsignificant for water table depth with both oxygen content and moisture content (Appendix F, Table F1). The strongest correlation was between oxygen and redox potential at 15 cm (r = 0.64). These results are not surprising as aerated soils are poorly poised with unstable redox potentials (Bohn 1971) and, combined with the lack of any significant water table movement, the variation among these parameters was random and independent.

134. 1983. The water table was greater than -120 cm only once during the year, in late May (-102 cm). Soil oxygen content at 15 cm was greater than 15 percent during the year with the exception of late May (13%) and June (12%) (Appendix G). At 30 cm, it decreased from 20 percent in September to 12 percent in December, recovering to 17 percent by February. The oxygen level fluctuated between 6 and 12.5 percent from March to June and was greater than 17 percent the rest of the year. Oxygen content at 60 cm declined from 17.5 percent in September to 7 percent by January. It was less than 10 percent until July and remained above 16 percent through December. The 120-cm depth oxygen content fell from 16 percent in September to 9.5 percent in

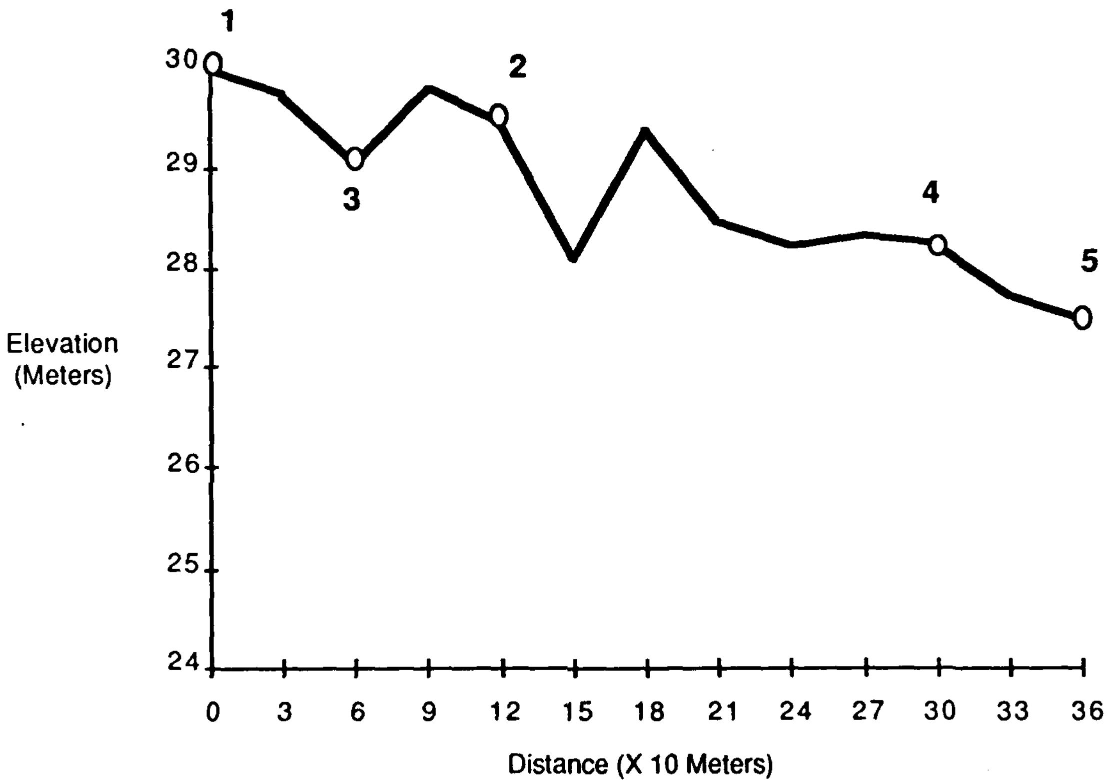


Figure 16. Relative plot elevations for the Quimby transect

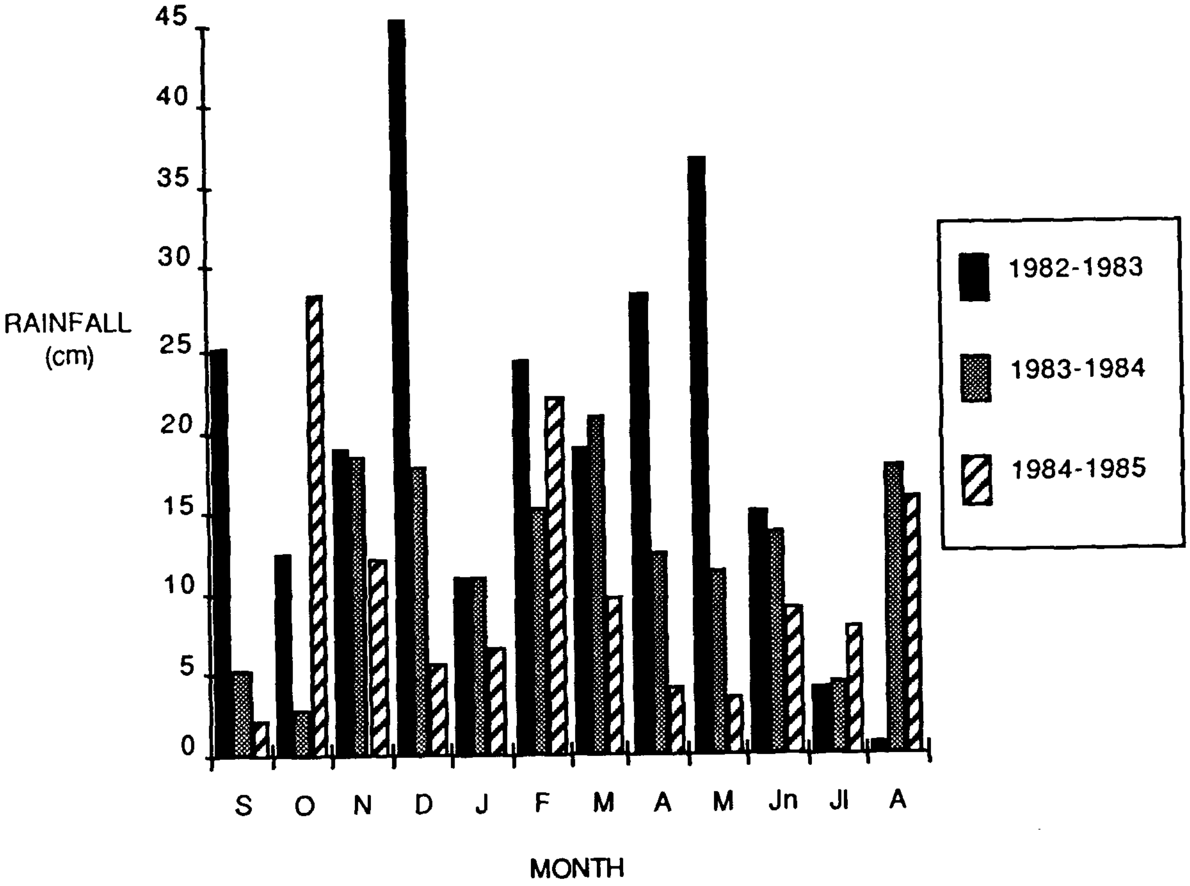


Figure 17. Rainfall patterns for the Quimby transect

January. It was less than 6 percent from March until July (12%), except once in late March (9%), and was greater than 15 percent the rest of the year.

135. Soil redox potential at 15 and 30 cm was greater than +500 mV during the year with the exception of December at 30 cm (+425 mV), late May (+260 to +280 mV), and June (+375 to +425 mV). Redox potential at 60 and 120 cm was greater than +550 mV the entire year except for January (+435 mV) and late May (+380 mV) at 120 cm. Soil moisture content at 15 cm increased from 36 percent in September to 43 percent in December. It was 43 to 45 percent from January to June, 35 to 40 percent from July to October, and increased to 53 percent in November. Moisture content at 30 cm increased from 37 percent in September to 40 percent in October and ranged from 41 to 44 percent from December to June. It fluctuated between 35 and 37 percent until November (53%). Moisture content at 60 cm increased from 33 percent in September to 40 percent by February. It ranged from 38 to 41 percent from March until August (32%) and fell to 27 percent before rising to 48 percent in November. Moisture content at 120 cm was much lower (27 to 32%) from September to January. It ranged from 38 to 43 percent until November (53%).

136. 1984. The water table fluctuated more in 1984, rising above -120 cm in January (-108 cm), early March (-117 cm), early April (-112 cm), June (-110 cm), and October (-119 cm). Soil oxygen content at 15 and 30 cm was 16 percent or greater during the year with the exception of early March (15%) and October (14%) at 30 cm. Oxygen content at 60 cm declined from 16 percent in January to 11 percent by early March. It did not increase until early May (16%) and remained above 13.5 percent until October (10%). It was 10 percent for the last 2 months of the year. Oxygen content at 120 cm fluctuated between 9 and 14 percent from January to October. It was 7 percent in November and December.

137. Soil redox potential was greater than +500 mV at all depths during the year except for October when it ranged from +430 to +470 mV in the upper 60 cm of the profile. Soil moisture content at 15 and 30 cm ranged from 40 to 44 percent except for July (36 to 38%) and September (34 to 36%). Moisture content at 60 cm ranged from 36 to 41 percent during the year and from 41 to 43 percent at 120 cm.

138. 1985. The water table depth was never greater than -120 cm during the year. Soil oxygen content at 15 and 30 cm was 14 percent or higher from January to August except for February (13.5%) at 30 cm. Oxygen content at 60 cm increased from 9 to 10 percent during the first 3 months to 14.5 percent in April. It remained greater than 17 percent the rest of the year. Oxygen content at 120 cm was low (5 to 8%) from January to April. It rose to 11.5 percent in May and remained above 13 percent through August.

139. Soil redox potential was greater than +550 mV at all depths from February to August. In January it declined from +480 mV (15 cm) to +435 mV (60 cm) before recovering to +490 mV at 120 cm. Soil moisture content at 15 cm decreased from 45 percent in January to 40 percent in April. It was 37 to 41 percent through August. Moisture content at 30 and 60 cm ranged from 37 to

43 percent during the year with the exception of July when it was 32 percent at both depths. Moisture content at 120 cm fluctuated between 42 and 44 percent during the year except for July (37%).

140. Summary. Plot QU1 was not flooded or saturated in the upper 90 cm of the profile and was well oxidized during the study period (Figure 18). The soil series was a nonhydric Goldman (Aquic Hapludalf). No quantitative wetland soil indicators were present in 1984 (Table 3), but the soil profile was described as having a mottled Bt1 horizon with a matrix soil color of 10YR 4/2, indicative of reducing conditions sometime during the year (Appendix H).

Plot QU2

141. This site was established in January 1983 to provide another moisture regime on the transect and was not fully functional until February. It was located in a Tensas (Vertic Ochraqualf) soil on a ridge lower in elevation than Plot QU1. The Tensas consists of somewhat poorly drained, very slowly permeable soils developed from clayey, alluvial sediments over loamy sediments. These soils are not usually flooded, except in extreme high water. This site has a clay overwash not normally found in Tensas.

142. The major parameters were not well correlated at this site, either. Several comparisons at various depths were not statistically significant (Table F2). The best correlations for each comparison were significant, but not very high.

143. 1983. The water table receded from -23 cm in February to -81 cm by the end of March. It stabilized at that depth until early May (< -120 cm) and late May (-51 cm). It was less than -120 cm for the rest of the year. Oxygen content at 15 cm was greater than 14 percent during the year except for late May (12%) and June (14%). Oxygen content at 30 cm fluctuated between 9 and 12 percent from February until May (2%). It increased to 12 percent in June and remained greater than 19 percent to November. The 60-cm depth oxygen level was much lower falling from 19 percent in February to less than 1 percent in early March. It was less than 6 percent until July (17%) and was greater than 16 percent for the rest of the year. Oxygen content at 120 cm decreased from 18 percent in February to 7 percent by late March. It was less than 7 percent until July (14.5%) and ranged from 16 to 19 percent to November.

144. Soil redox potential at 15 cm was greater than +400 mV during the year with the exception of early March (+360 mV), late May (+250 mV), and June (+330 mV). Redox at 30 cm was greater than +400 mV for the entire year. The 60-cm depth redox potential ranged from +400 mV to +500 mV from early March to June except for late May (+240 mV). Redox at 120 cm ranged from +95 to +210 mV from early March until early May (+440 mV). It increased steadily from +230 mV in late May to greater than +550 mV except for June (+384 mV).

145. Soil moisture content at 15 cm was 57 to 59 percent from February to June. It declined to 45 percent in July and ranged from 44 to 48 percent until November (67%). A similar pattern was observed at 30 cm where the moisture content was 50 to 52 percent from February to June. It

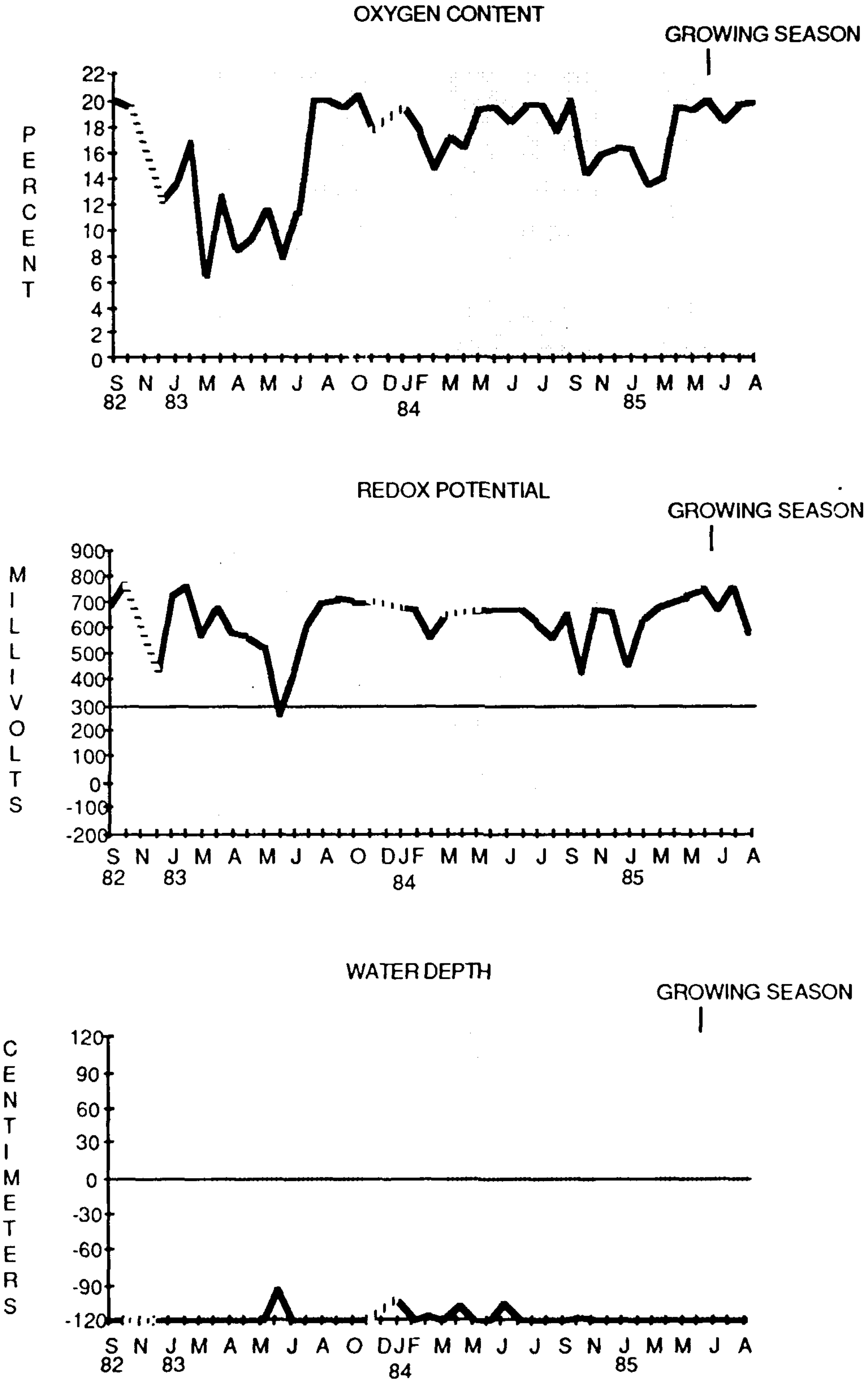


Figure 18. Oxygen content and redox potential at 30 cm with water depth for Quimby Plot 1

fluctuated between 43 and 46 percent until November (58%). The 60-cm depth moisture content was lower than at 15 and 30 cm. It ranged from 42 to 48 percent during the year except for November (59%). Moisture content at 120 cm was 42 to 46 percent from February to July, declining to between 32 and 37 percent until November (53%).

146. 1984. The water table fluctuated quite a bit in the early spring. It increased from -117 cm in January to a high of -38 cm in April. It was less than -120 cm the rest of the year except for November (-80 cm). Soil oxygen content at 15 and 30 cm was greater than 16 percent during the year. It decreased from 15 percent in January to 11.5 percent in April at 60 cm and ranged from 14.5 to 19 percent until October (9.5%). It remained at 9 percent in November and December. Oxygen content at 120 cm decreased from 14 percent in January to a low of 5 percent in April. It ranged from 11.5 to 16 percent from early May to September, declining to between 5 and 9 percent for the rest of the year.

147. Soil redox potential at 15, 30, and 60 cm was greater than +400 mV during the year except for July (+375 mV) at 15 cm. It declined from +580 mV in January to a low of +358 mV in early March at 120 cm and was well oxidized (> +400 mV) until December (+238 mV).

148. Soil moisture content at 15 cm fluctuated between 50 and 57 percent during the year except for September (44%). It ranged from 45 to 51 percent at 30 and 60 cm with the exception of September (42 and 40% , respectively). Moisture content at 120 cm was 44 to 46 percent from January to May. It ranged from 40 to 45 percent until December (48%).

149. 1985. The water table rose briefly to -10 cm in February, receded to -81 cm in March, and was not detected in the upper 120 cm of the profile the rest of the study. Soil oxygen content at 15 and 30 cm was not less than 15 percent during the year. It was 9 to 11 percent from January to March at 60 cm, but increased to 16 percent by early May and remained above that level the rest of the year. Oxygen content at 120 cm decreased from 6.5 percent in January to 3 percent in March. It increased to 12 percent in early May and was greater than 15 percent to August.

150. Soil redox potential at 15, 30, and 60 cm was well oxidized (≥ +400 mV) during the year except for August (+275 mV) at 60 cm. Redox potential at 120 cm declined from +390 mV in January to a low of +220 mV in March. It increased to +545 mV in April and was greater than +650 mV until August (+250 mV). Soil moisture content at 15 cm fluctuated between 54 and 58 percent during the year with the exception of late May (50%) and July (47%). It ranged from 47 to 51 percent at 30 cm except for July (44%). Moisture content at 60 cm was 43 to 48 percent during the year and fluctuated between 40 and 46 percent at 120 cm.

151. Summary. Plot QU2 was established in January 1983 on a low elevation ridge. The water table fluctuated quite a bit, but was generally greater than 60 cm in depth. Oxygen content at 30 cm was 8 to 12 percent during most of early 1983, although it declined to 4 percent in mid-May. It was greater than 15 percent for the rest of the study. Redox potential remained above +400 mV during the measurement period (Figure 19).

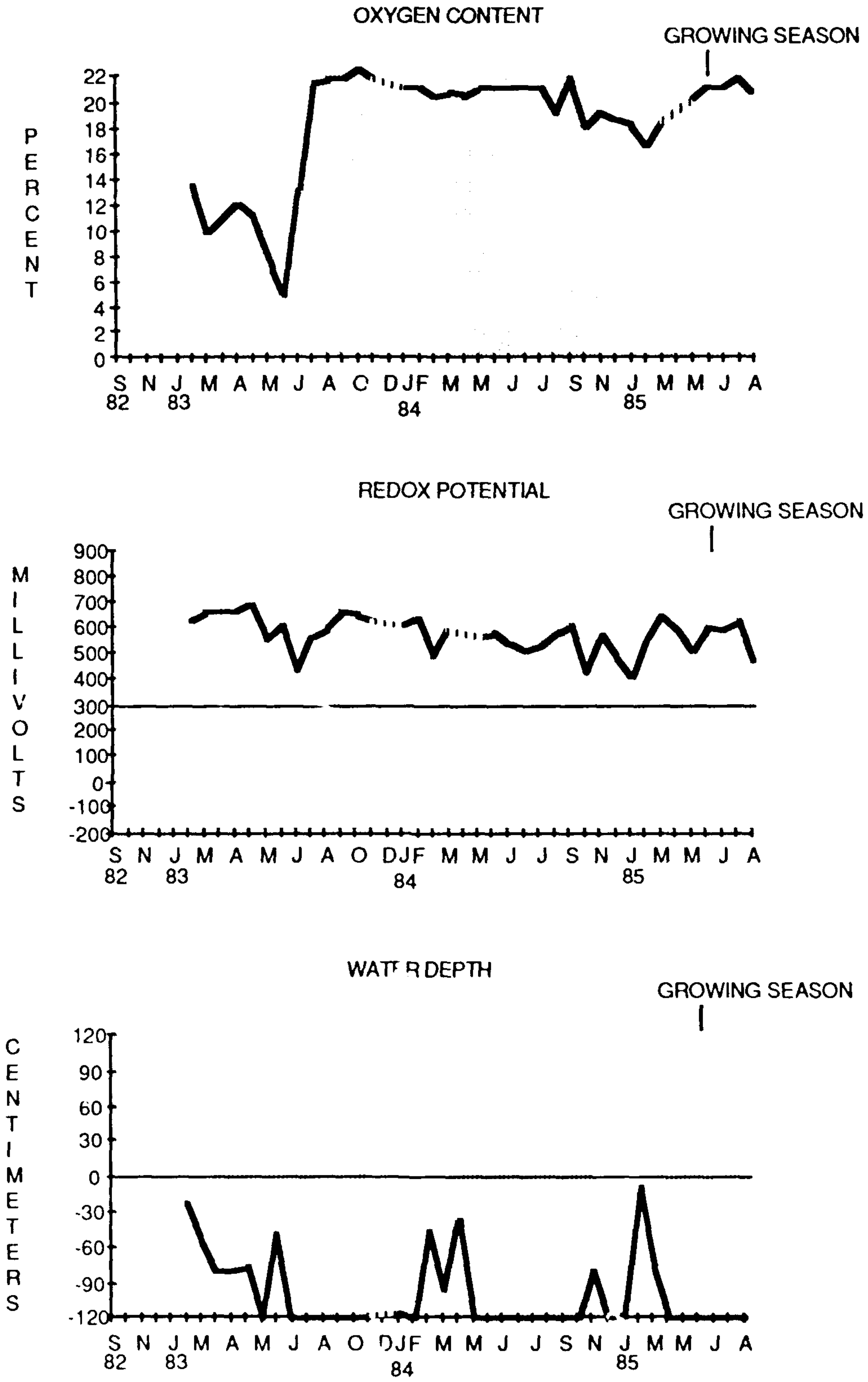


Figure 19. Oxygen content and redox potential at 30 cm with water depth for Quimby Plot 2

152. The soil series was Tensas (Vertic Ochraqualf), a nonhydric soil. The soil profile was described as having a Btg1 (gleyed) horizon with a chroma of 1 (Appendix H). As with QU1, no quantitative wetland soil indicators were present in 1984 (Table 3). These data indicate a drier moisture regime than that inferred by the morphology since the plot was not saturated in the root zone during the growing season.

Plot QU3

153. This site was in a narrow swale of Kobel clay (Vertic Haplaquept) that was an old stream channel. The Kobel consist of poorly drained, very slowly permeable soils in swales. This site was flooded each year during the study. These areas were formerly called Sharkey, but the clay content is too low for Sharkey, so the soil is classified as Kobel.

154. The correlations among parameters were much higher at QU3 than at QU1 or QU2. There were still nonsignificant comparisons at some depths (Table F3). The best correlations for oxygen and redox (r = 0.85), oxygen and water table depth (r = -0.83) and the second best correlation for redox and water table depth (r = -0.73) occurred at the 30-cm depth.

155. 1983. The water table receded from -30 cm in September to -77 cm in October. This plot was inundated with surface water from December (+13 cm) to late May (+41 cm). The water table was less than -120 cm the rest of the year. Soil oxygen content at 15 cm increased from 16 percent in September to 19 percent in December. Only two readings were taken from January to June because of the high water. Oxygen content was 4 percent in March and zero in June. It was greater than 19 percent the rest of the year. Oxygen content at 30 cm declined from 17.5 percent in September to 6 percent in June. It was 0 to 2 percent until July (19%) and remained above 19 percent the rest of the year. Oxygen content at 60 cm fluctuated between 12 and 14.5 percent from September to early March (except for January when it was 4%). It was 8 percent in late March and remained less than 5 percent from early April to June. It was greater than 16 percent the rest of the year. Oxygen content at 120 cm ranged from 8 to 11 percent from September to early March. It was less than 5 percent from late March to June. It increased from 12 percent in July to 17.5 percent in November.

156. Soil redox potential at 15 cm declined from +480 mV in September to a low of +95 mV by January. It increased to +285 mV in February and ranged from +175 to +225 mV until July (+430 mV). It was greater than +490 mV the rest of the year. Redox potential at 30 cm decreased from +545 mV in September to a low of +75 mV in January. It fluctuated between +95 and +155 mV from February to June and remained above +490 mV the rest of the year. Redox potential at 60 cm declined from +700 mV in September to +570 mV in December. It ranged from +115 to +275 mV from January to June, except for late April (-46 mV), and was greater than +600 mV the rest of the year. Redox potential at 120 cm was greater than +500 mV during the year with the exception of January to June when it ranged from +200 to +290 mV.

157. Only one set of moisture content measurements was taken (early May) from December to the end of May because of high water levels on the plot. Soil moisture content at 15 cm was 56 percent in September and October and 59 percent in early May and June. It ranged from 44 to 52 percent the rest of the year except for November (68%). The 30-cm depth moisture content was 48 percent in September and October and 50 to 51 percent in early May and June. It ranged from 41 to 44 percent the rest of the year except for November (63%). Moisture content at 60 cm was 44 percent in September and October and 46 percent in early May and June. It was 39 to 42 percent until November (58%). Moisture content at 120 cm was 44 percent in September and October and 46 percent in early May and June. It ranged from 37 to 44 percent until November (50%).

158. 1984. The plot was inundated with +20 cm of surface water in early March. The water table rose from -24 cm in late March to -5 cm in April, receded to -84 cm by early May, and was less than -120 cm until October (-4 cm). It was -48 cm in November and -90 cm in December. Soil oxygen content at 15 cm declined steadily from 20 percent in January to a low of 9 percent in April and was greater than 16 percent the rest of the year. Oxygen content at 30 cm decreased from 19 percent in January to 8 percent by April. It ranged from 17.5 to 20 percent from early May to September, declined to 7.5 percent in October, and was 11 percent in November and 12.5 percent in December. The 60-cm depth oxygen content ranged from 12 to 18 percent during the year except for April (11%). Oxygen content at 120 cm declined steadily from 13 percent in January and February to a low of 6 percent in late May. It ranged from 11 to 15 percent from June until November (9%) and was 6 percent in December.

159. Soil redox potential at 15 cm was greater than +450 mV during the year with the exception of early March (+350 mV), late March (+290 mV) and October (+375 mV). It was greater than +400 mV at 30 and 60 cm during the year except for late March (+260 mV) at 30 cm. Redox potential at 120 cm remained higher than +440 mV during the year with the exception of early May (+245 mV), late May (+205 mV), and December (+335 mV).

160. Soil moisture content at 15 cm ranged from 52 to 60 percent from January to December except for September (44%). It was 47 to 51 percent during the year at 30 cm with the exception of July (44%) and September (43%). Moisture content at 60 and 120 cm ranged from 42 to 48 percent during the year with the exception of September (38%) at 120 cm.

161. 1985. Surface water inundated the site in February (+29 cm), followed by a drop in the water table from -6 cm in March to -91 cm in April. It was less than -120 cm the rest of the year. Soil oxygen content at 15 cm declined from 16 percent in January to a low of 8 percent in March. It was greater than 17 percent the rest of the study. Oxygen content at 30 cm was greater than 15 percent during the year with the exception of February (7%) and March (0%). It decreased from 13 percent in January to 10 percent from February to April at 60 cm. It ranged from 15 to 20 percent the rest of the study. Oxygen content at 120 cm declined from 7 percent in January to a low

of 2.5 percent in March. It recovered to 10.5 percent in May and was greater than 14 percent to August.

162. Soil redox potential at 15, 30, and 60 cm was greater than +400 mV except in February (+280 mV at 15 cm) and March (+260 to +340 mV). Redox potential at 120 cm declined steadily from +445 mV in January to a low of +240 mV in April. It was greater than +550 mV the rest of the year. Soil moisture content at 15 cm was 56 to 58 percent from January to early May and 49 to 52 percent from late May to August. It ranged from 45 to 50 percent during the year at 30 and 60 cm except for August (43%) at 60 cm. Moisture content at 120 cm ranged from 43 to 48 percent from January until August when it was 40 percent.

163. Summary. Plot QU3 was inundated for approximately half of the 1983 growing season, briefly in 1984, and not at all during the 1985 growing season. Oxygen content and redox potential at 30 cm revealed anaerobic, reducing conditions in 1983, but not in 1984 or 1985, although there was one measurement period (March) in 1985 when no oxygen was measured (Figure 20). It was reduced for 6 percent of the 1984 growing season and saturated for 21 percent, but never anaerobic (Table 3). The 1984 saturation duration was not continuous, but consisted of two discrete events: one at the beginning of the growing season and the other at the end. The soil type was Kobel clay (Vertic Haplaquept), a hydric soil. This plot had a Bg1 (gleyed) horizon that was mottled with chroma colors less than 2, and iron and manganese concretions were present (Appendix H).

Plot QU4

164. This site was adjacent to an old lake bed and was often covered with shallow water for long periods during the field study. The soil type was Kobel (Vertic Haplaquept), the same as QU3. For QU4 as a whole, the measured parameters were all significantly correlated in the upper 30 cm, but there were fewer significant correlations below 30 cm (Table F4). The best correlations were found at 30 cm for redox potential and both soil moisture (r = -0.54) and water table depth (r = -0.78) and for oxygen content and water table depth (r = -0.74).

165. The semipermanent flooding of the adjacent lake bed and the microtopography of the plot resulted in very different soil moisture conditions between the two subplots of soil testing equipment. Quite often, subplot B would have 10 to 15 cm of standing water while the water table at subplot A would be 10 to 15 cm below the soil surface. Therefore, results will be broken into two parts, QU4.A and QU4.B

166. QU4.A - 1983. The plot was inundated with +3 cm of surface water in December and the water table fluctuated between -15 and -36 cm from February to May. It declined to -86 cm in June and was less than -120 cm the rest of the year. Soil oxygen content at 15 cm was greater than 15 percent during the year. Oxygen content at 30 cm decreased from 20 percent in September to a low of 8.5 percent in early April. It increased to 10 percent in late April and was not less than 15 percent the rest of the year. The 60-cm depth oxygen content ranged from 12 to 18 percent from

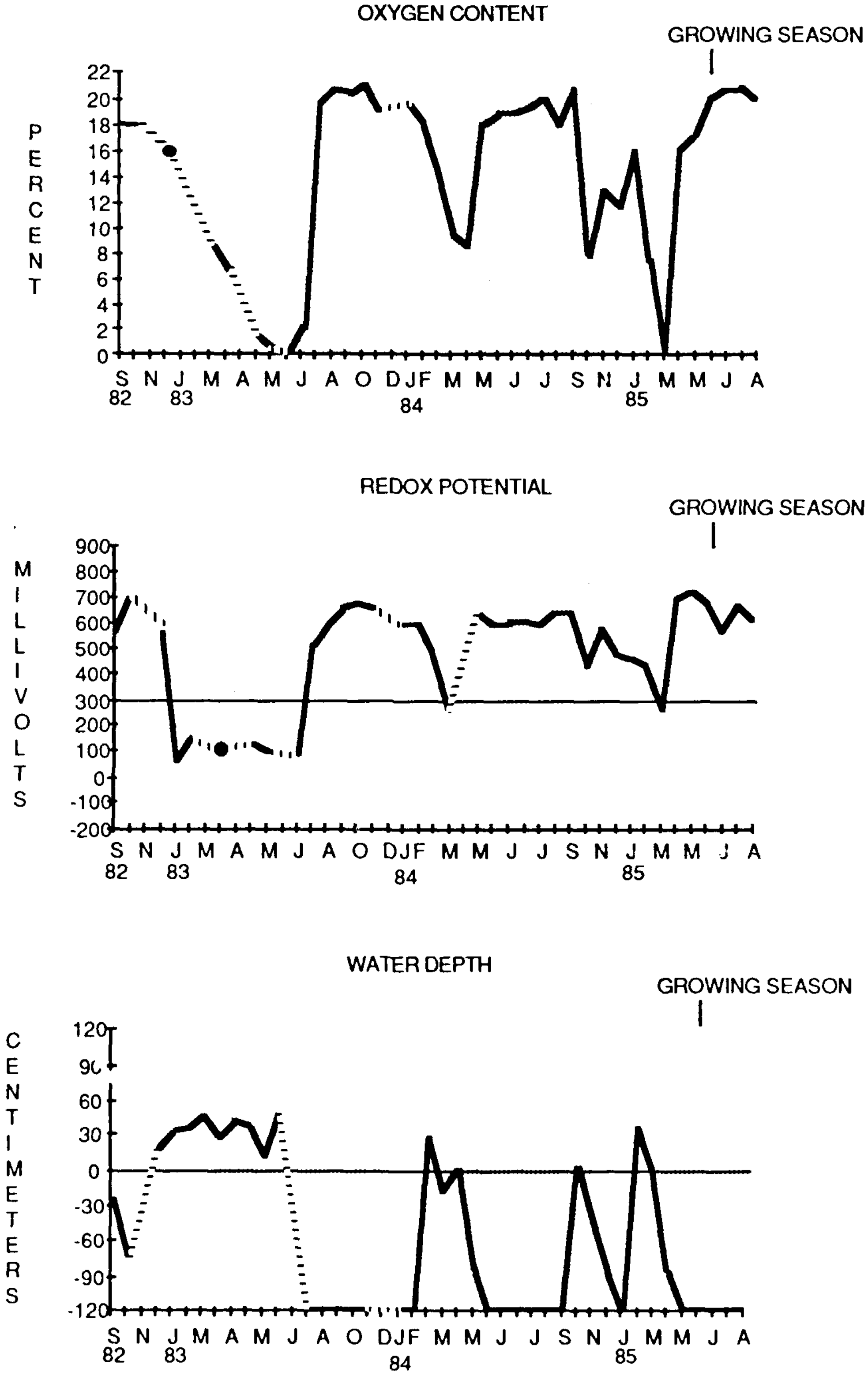


Figure 20. Oxygen content and redox potential at 30 cm with water depth for Quimby Plot 3

September to late April. It was less than 5 percent in May and June, then remained greater than 16 percent to November. Oxygen content at 120 cm increased from 8.5 percent in September to 15 percent in October. It declined from 18 percent in February to 12 percent in late March. Oxygen was 5.5 percent in April, climbed to 14 percent in May, then decreased to 4 percent in June. It was greater than 15 percent the rest of the year.

167. Soil redox potential at 15 cm was greater than +600 mV during the year with the exception of late March (+290 mV) and July (+415 mV). Redox potential at 30 cm decreased from +645 mV in September to +300 mV in January. It ranged from +160 to +270 mV from March to July, except for June (+320 mV). It was greater than +500 mV from August to November. Redox at 60 cm was +685 mV in September and +655 mV in October. It ranged from -175 to +30 mV from January until July (+200 mV) and was greater than +550 mV the rest of the year. Redox potential at 120 cm declined from +645 mV in September to +365 mV in October. It was also strongly reduced (-170 to +55 mV) from January until July (+215 mV), and redox was greater than +430 mV from August until November (+290 mV).

168. Soil moisture content at 15 cm increased from 46 percent in September to 48 percent in October. It ranged from 51 to 57 percent from January to June and declined to 40 to 41 percent from July until November (61%). Moisture content at 30 cm was 42 percent in September, 44 percent in October, and ranged from 48 to 51 percent from January until June (45%). It was 38 to 43 percent from July until November (62%). Moisture content at 60 and 120 cm fluctuated between 42 and 47 percent from September to July, except for July (39%) at 60 cm. At 60 cm, it was 34 to 38 percent from August until November (65%). At 120 cm, it declined from 39 percent in August to 24 percent in October before recovering to 55 percent in November.

169. QU4.A - 1984. The water table was within 36 cm of the soil surface from January until early May (-53 cm). It receded from -84 cm in late May to -104 cm in early June, was less than -120 cm from late June to September, and increased to -25 cm in October and -20 cm in November and December. Soil oxygen content at 15 and 30 cm was 15 percent or greater during the year. Oxygen content at 60 cm decreased from 16.5 percent in January to 10 percent in February and was less than 7 percent in March, April, and May. It was 17 to 20 percent until October (10%) and 2 to 3 percent in November and December. Oxygen content at 120 cm was 2 percent in January and 6 percent in late May. Equipment problems prevented measurement in between these two periods. It increased from 10 percent in June to 16 percent in July and 18 percent in September, before decreasing to 7 percent in October and less than 5 percent in November and December.

170. Soil redox potential at 15 cm was greater than +500 mV during the year. At 30 cm, it declined from +545 mV in January to +275 mV in March and was greater than +400 mV from May to October. It was +335 mV in November and +355 mV in December. Redox potential at 60 cm fell from +730 mV in January to +410 mV in February. It ranged from -40 to +185 mV from

March to May and was greater than +400 mV until November (-40 mV) and December (+155 mV). Redox potential at 120 cm ranged from +105 to +235 mV during the year, except for early June (+625 mV).

171. Soil moisture content at 15 cm ranged from 50 to 56 percent during the year with the exception of June to September when it was 41 to 47 percent. Moisture content at 30 cm ranged from 46 to 51 percent during the year, except for June to September (39 to 45%). At 60 cm, it fluctuated between 42 and 48 percent during the year with the exception of July (37%) and September (38%). Moisture content at 120 cm was 39 to 44 percent from January to December, except for August (36%).

172. QU4.A - 1985. The water table was within 25 cm of the surface from February to early May. It receded to -79 cm by the end of May and was less than -120 cm the rest of the study. Soil oxygen content at 15 cm was 14 percent in January and greater than 18 percent from February to August. Oxygen content at 30 cm ranged from 4 to 8 percent from January to March and was greater than 17 percent the rest of the year. Oxygen content at 60 and 120 cm was less than 5 percent from January to May and was 15 percent or higher in June, July, and August.

173. Soil redox potential at 15 cm was greater than +400 mV during the year, except for March (+370 mV) and April (+225 mV). Redox potential at 30 cm was +300 to +400 mV from January to early May and +480 to +570 from late May to August. At 60 cm, redox decreased from +320 mV in January to +95 mV in February and continued to decline to a low of -35 mV by April. It rose briefly in early May to +210 mV, fell to +75 mV by the end of May, and was greater than +550 mV the rest of the year. Redox potential at 120 cm ranged from +100 to +200 mV during the year, except for July (+725 mV).

174. Soil moisture content at 15 cm was 56 to 57 percent from January to early May and ranged from 42 to 46 percent the rest of the year. Moisture content at 30 cm was 49 to 50 percent from January to early May and 42 to 45 percent from late May to August. It ranged from 42 to 47 percent at 60 and 120 cm with the exception of July (38%) at 60 cm.

175. QU4.B - 1983. The water table increased from -46 cm in September to -15 cm in October, then fluctuated between -3 cm (late March) and +8 cm of surface water (December and early March). The site was flooded with +8 to +13 cm of water in April and May. The water table receded from -25 cm in June to -86 cm in July and was less than -120 cm from August until November (-79 cm).

176. Soil oxygen content at 15 cm decreased steadily from 21 percent in September to 9 percent by the end of April. It was 5 percent or less in May and June and was greater than 15 percent the rest of the year. Oxygen content at 30 cm fluctuated between 11 and 17 percent from September to April, declined to 5 percent or less in May and June, and was greater than 18 percent from July to November. Oxygen content at 60 cm declined from 8 percent in October to 6 percent in January. It ranged from 16 to 19 percent in March and early April, fell to 10 percent by late

April, and was 4 to 7 percent in May, June, and July. It remained above 18 percent the rest of the year. Oxygen content at 120 cm was zero in September and 5 percent in October. No measurements were made from December to February because of equipment problems at this depth. Oxygen ranged from 10 to 18 percent the rest of the year, except for August (6.5%).

177. Soil redox potential at 15 cm was +470 mV in September and +645 mV in October. It was generally between +200 and +270 mV from January to April, although the two lowest values of -55 mV and -115 mV were measured during this period. Redox ranged from +20 to +170 mV from May to June and was greater than +500 mV the rest of the year. Redox potential at 30 cm increased from +300 mV in September to +395 mV in October, remained below +100 mV from February to June, and was greater than +440 mV from July to November. Redox potential at 60 cm was +65 mV in September and +415 mV in October. It was less than -20 mV from January until August (+140 mV) and was less than -100 mV during most of this time. It ranged from +300 to +400 mV the rest of the year. Redox potential at 120 cm increased from -160 mV in September to +345 mV in October. It fluctuated between -10 and +100 mV from February to August, with the exception of February (+255 mV) and May (+170 mV), and was greater than +450 mV the rest of the year.

178. No soil moisture content data were collected in December, February, April, and May because of surface water on the plot. Soil moisture content at 15 cm increased from 58 percent in September to 60 percent in October. It was 62 to 63 percent from January to June, declined to 47 percent in July, and ranged from 43 to 47 percent until November (76%). Moisture content at 30 cm was 57 to 60 percent from September to June. It fluctuated between 47 and 54 percent from July to October and was 76 percent in November. Moisture content at 60 cm ranged from 50 to 54 percent during the year with the exception of October (44%) and November (67%) of 1983. Moisture content at 120 cm ranged from 46 to 50 percent during the year, except for November 1983 (63%).

179. <u>QU4.B - 1984.</u> The water table rose from -10 cm in January to -8 cm in February. The plot was inundated with +8 to +10 cm of surface water in March and April that was gone by May. The water table declined steadily from -3 cm in early May to -23 cm by early June and had fallen to -81 cm in July. It rose briefly in August (-58 cm) and was less than -120 cm in September. The site was flooded with +10 to +13 cm of water the rest of the year.

180. Soil oxygen content at declined 15 cm from 19.5 percent in January to 10 percent in late March. It decreased to a low of 4 percent in early May and recovered to 10 percent by the end of May. It was 20 to 21 percent from June to September, dropped to 12 percent in October, and was 2 to 3 percent in November and December. Oxygen content at 30 cm decreased from 14 percent in January to 10 percent in February and was less than 5 percent in March, April, and May. It was 18 to 20 percent from June to September and 6 percent in October. It was zero in November and December. Oxygen content at 60 cm declined from 16 percent in January to 6.5 percent in early

March. It was less than 5 percent in May, June, November, and December. The rest of the year it ranged from 10 to 20 percent. Oxygen content at 120 cm was 8 percent in January and 5 percent in February. It was less than 5 percent the rest of the year.

181. Soil redox potential at 15 cm decreased from +670 mV in January to +275 mV in February. It ranged from +200 to +300 mV from March to May and from +300 to +400 mV in June. It was greater than +400 mV from July to October and less than +150 mV in November and December. Redox potential at 30 cm ranged from 0 to +160 mV during the year with the exception of July to October (+240 to +405 mV). It was +25 to +140 mV during the year at 60 cm, except for July (+290 mV), September (+220 mV), and October (+310 mV). Redox potential at 120 cm ranged from -150 to +100 mV during the year, except for October (+310 mV).

182. Soil moisture content data were not collected from September to December because of high water. Moisture content at 15 cm fluctuated between 56 and 64 percent during the year with the exception of July (52%) and September (44%). It was 57 to 61 percent from January to June at 30 cm and 52 to 58 percent from July until September (47%). Moisture content at 60 cm was 52 to 58 percent during the year. At 120 cm, it was 47 to 51 percent most of the year; however, soil moisture in June was 54 percent.

183. QU4.B - 1985. The plot was inundated with +13 to +25 cm of surface water from January to early May. It receded steadily from the soil surface in late May to -91 cm by July. It increased to -46 cm in August. Soil oxygen content was less than 4 percent at all four depths from January to May. It was 15 percent and higher at all depths in June and was greater than 18 percent at 15 and 30 cm in July and August. Oxygen content at 60 cm increased from 8.5 percent in July to 17 percent in August while the 120-cm depth was 0 percent during this period.

184. Soil redox potential at 15 cm declined from +140 mV in January to +50 mV in February. It ranged from +290 to +400 mV from March to May and was greater than +440 mV the rest of the year. Redox potential at 30 cm ranged from +180 to +265 mV during the year with the exception of June (+525 mV) and August (+350 mV). It was +100 to +235 mV from January to May at 60 cm and rose to +560 mV in June before falling to less than -100 mV in July and August. Redox potential at 120 cm ranged from -175 to +60 mV during the year, except for June (+175 mV).

185. Only three sets of soil moisture readings (May, July, and August) were taken in 1985 because of the high water. Soil moisture content at 15 cm was 62 percent in May, declined to 52 percent in July, and was 60 percent in August. It ranged from 55 to 60 percent at 30 cm and from 52 to 53 percent at 60 cm. Moisture content at 120 cm was 48 to 49 percent.

186. Summary. Because of the proximity to a water body and the microtopography of the plot, each subplot was treated as a separate plot. Plot QU4.A was saturated around the 30-cm depth for almost half of the 1983 growing season, but only briefly during the 1984 and 1985 growing seasons (Figure 21). It was saturated in the root zone for 21 percent of the 1984 growing

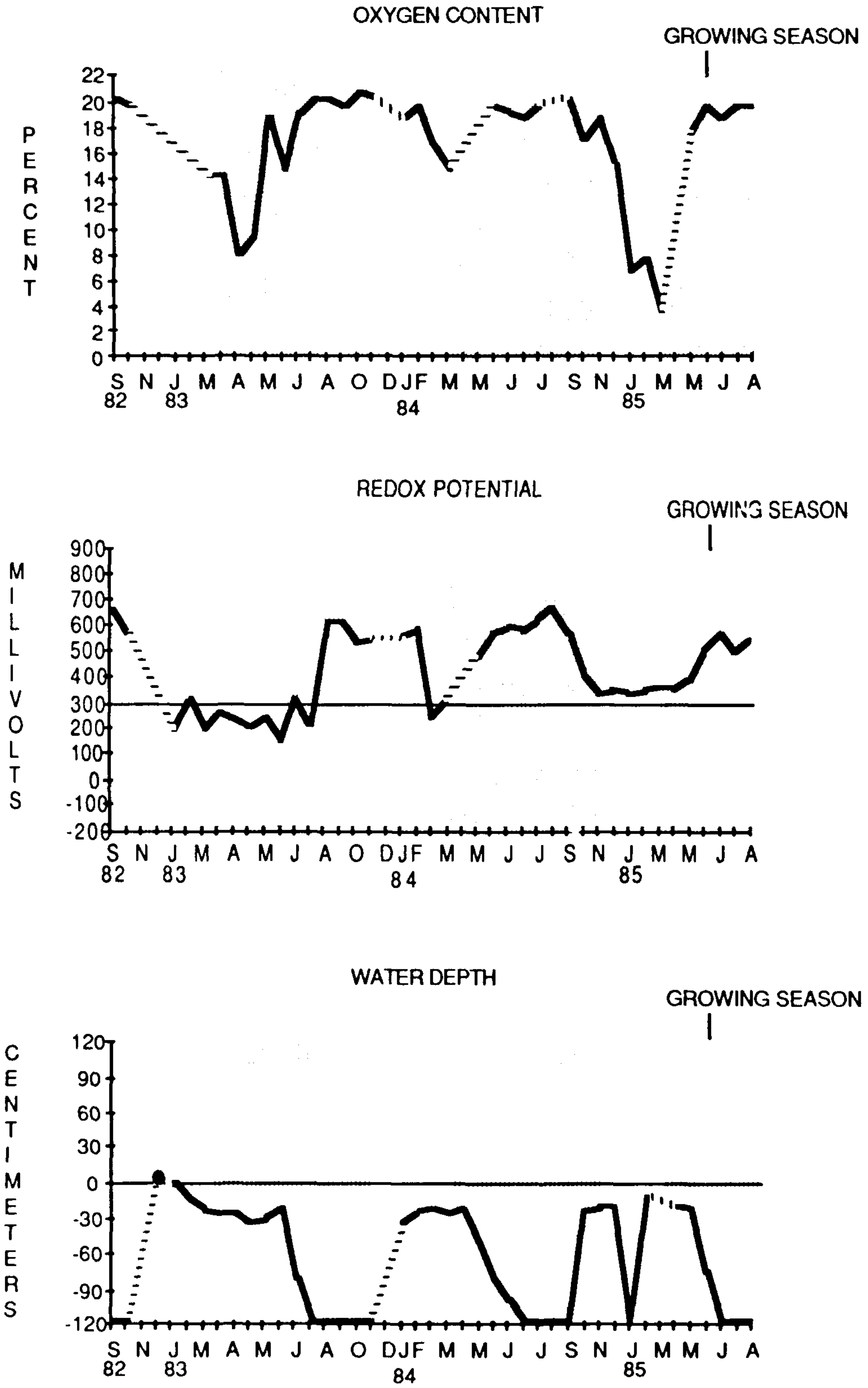


Figure 21. Oxygen content and redox potential at 30 cm with water depth for Quimby Plot 4.A

season, but was not anaerobic or reduced (Table 3). Like QU3, the 1984 saturation occurred in two discrete events at the beginning and end of the growing season. The short saturation period and water table depth prevented development of anaerobic or reducing conditions at the 30-cm depth.

187. Plot QU4.B, on the other hand, was inundated with surface water in all 3 years with correspondingly low oxygen content and redox potential during these periods (Figure 22). It was anaerobic and saturated for 37 percent of the 1984 growing season and reduced for 59 percent of that period (Table 3). The soil type was Kobel clay (Vertic Haplaquept, hydric), the same as QU3, and only one profile was described as the inherent differences between the subplots was not apparent in the early part of the study. It would be advantageous in the future to describe more than one profile along the soil:surface water interface to relate the soil diagnostic characteristics to the hydrology along this boundary. This soil had a Bg1 (gleyed) horizon that was mottled with a matrix chroma of less than 2 (Appendix H).

Plot QU5

188. This site was in an old shallow lake. The soil type was Fausse clay (Vertic Fluvaquent) that was flooded for most of the study period. The Fausse consists of deep, very poorly drained, very slowly permeable soils that formed in clayey alluvium. The only significant correlations were at the 15-cm depth for water table depth with both oxygen content (r = -0.82) and soil moisture (r = 0.76) (Table F5).

189. 1983. The plot was flooded from September 1982 (+29 cm) to August 1983 (+10 cm). No complete set of measurements was made during this period. The water table receded from -27 cm in September to -76 cm in October before rising to -6 cm by November. Only two sets of soil oxygen measurements were taken in 1983. Oxygen content in October ranged from 19.5 percent at 15 cm to 10.5 percent at 60 cm. It was 14.5 percent at 30 cm and 15 percent at 120 cm. Oxygen content in November was 7 percent at 15 cm and 14 percent at 30 cm. It was 0 to 1 percent at 60 and 120 cm.

190. Soil redox potential was measured in September 1982 and August, September, October, and November 1983. Redox potential at 15 cm declined from +235 mV in September to -130 mV in August. It rose steadily from +65 mV in September 1983 to +150 mV in October and +160 mV in November. Redox potential at 30 cm was less than +115 mV during the months measured and was lowest in August (-40 mV). Redox at 60 cm was less than +110 mV except for November (+150 mV). It was slightly higher at 120 cm, ranging from +95 to +190 mV.

191. Soil moisture content was measured in August, September, and October 1983. It was 59 to 64 percent at 15 cm and 56 to 61 percent at 30 cm. Moisture content ranged from 53 to 58 percent at 60 cm and from 50 to 55 percent at 120 cm.

192. 1984. The plot was inundated with surface water from January (+34 cm) to August (+23 cm). The water table receded to -14 cm in September, and the site was flooded again from

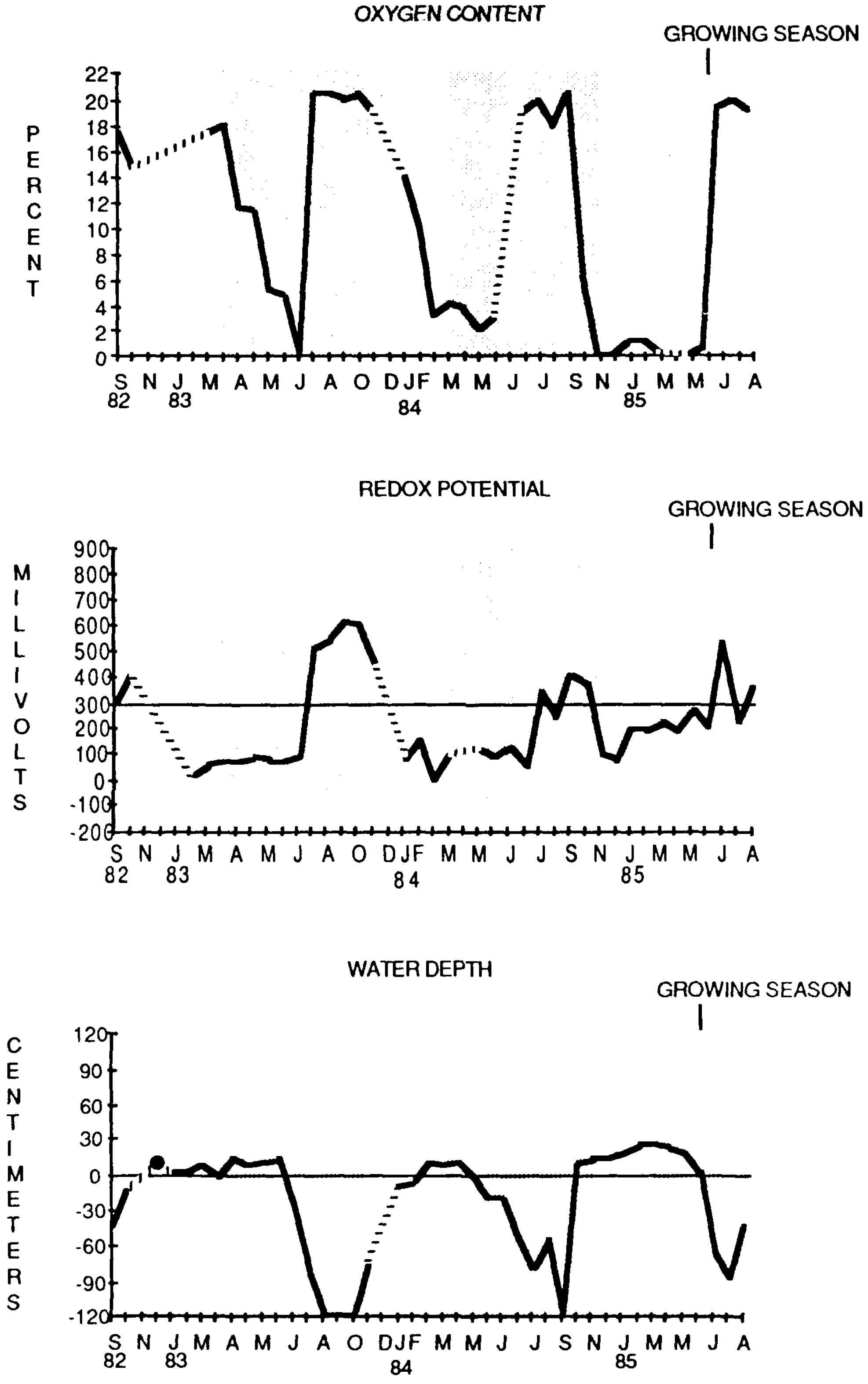


Figure 22. Oxygen content and redox potential at 30 cm with water depth for Quimby Plot 4.B

October (+58 cm) to December (+99 cm). The surface water was low enough for soil oxygen content to be measured in June, July, August, and September. Oxygen content was 1 percent or less (essentially zero) at all depths in June and July. It was 3 to 4 percent at all depths in August. It was 4 percent at 15 cm and 0 percent at 30 and 60 cm in September.

193. Soil redox potential at 15 and 30 cm was less than +135 mV, and the lowest reading at those two depths occurred in August (-12 mV). Redox potential at 60 and 120 cm ranged from +100 to +200 mV in July and September. In August, however, redox was -95 mV at 60 cm and -130 mV at 120 cm. Soil moisture content was measured once in September and declined steadily from 66 percent at 15 cm to 56 percent at 120 cm.

194. 1985. The plot was completely flooded from January (> +120 cm) to August (+30 cm). Soil oxygen content and redox potential were measured in June, July, and August. Soil oxygen content was less than 1 percent (essentially zero) at all depths during these 3 months. Soil redox potential at 15 cm declined from +195 mV in June to -165 mV in July and -105 mV in August. It ranged from +75 to +150 mV at 30 cm. Redox was greater than +150 mV at 60 and 120 cm except for August at 60 cm (+55 mV). No soil moisture content data were collected because of the high water.

195. Summary. Plot QU5 was inundated for almost all of the study with only a few opportunities to measure the equipment. The data that were collected revealed a reduced, anaerobic environment except for a brief period in the late fall of 1983 (Figure 23). These higher oxygen levels may not be accurate because atmospheric air was introduced into the diffusion chambers during repair of flood-damaged equipment. The equilibration time required to assimilate the 21 percent oxygen was probably lengthened by the low soil temperatures (8° to 10° C) during this period. This site was saturated, reduced, and anaerobic for 100 percent of the 1984 growing season (Table 3). The soil type was Fausse (Typic Fluvaquent), a hydric soil, with a Bg1 (gleyed) horizon with gray mottles and a matrix chroma less than 2 (Appendix H).

Red River

196. The Red River transect was located on the Grassy Lake Wildlife Management Area in Avoyelles Parish, Louisiana (Figure 2). Soils on this transect are from the Red River alluvium, and the color characteristics are inherited from Permian red bed parent material. The red colors are resistant to change from oxidation-reduction processes, so it is not possible to compare the oxygen and redox profiles with the soil profile descriptions. The gleying and low chroma diagnostic hydric soil indicators are not used with soils of this nature (Environmental Laboratory 1987). The transect began on a riverfront ridge (Plot RR1), abruptly changing into a backwater swamp (Plot RR4) with very little transition (Figure 24). The Red River was the source of the backwater flooding.

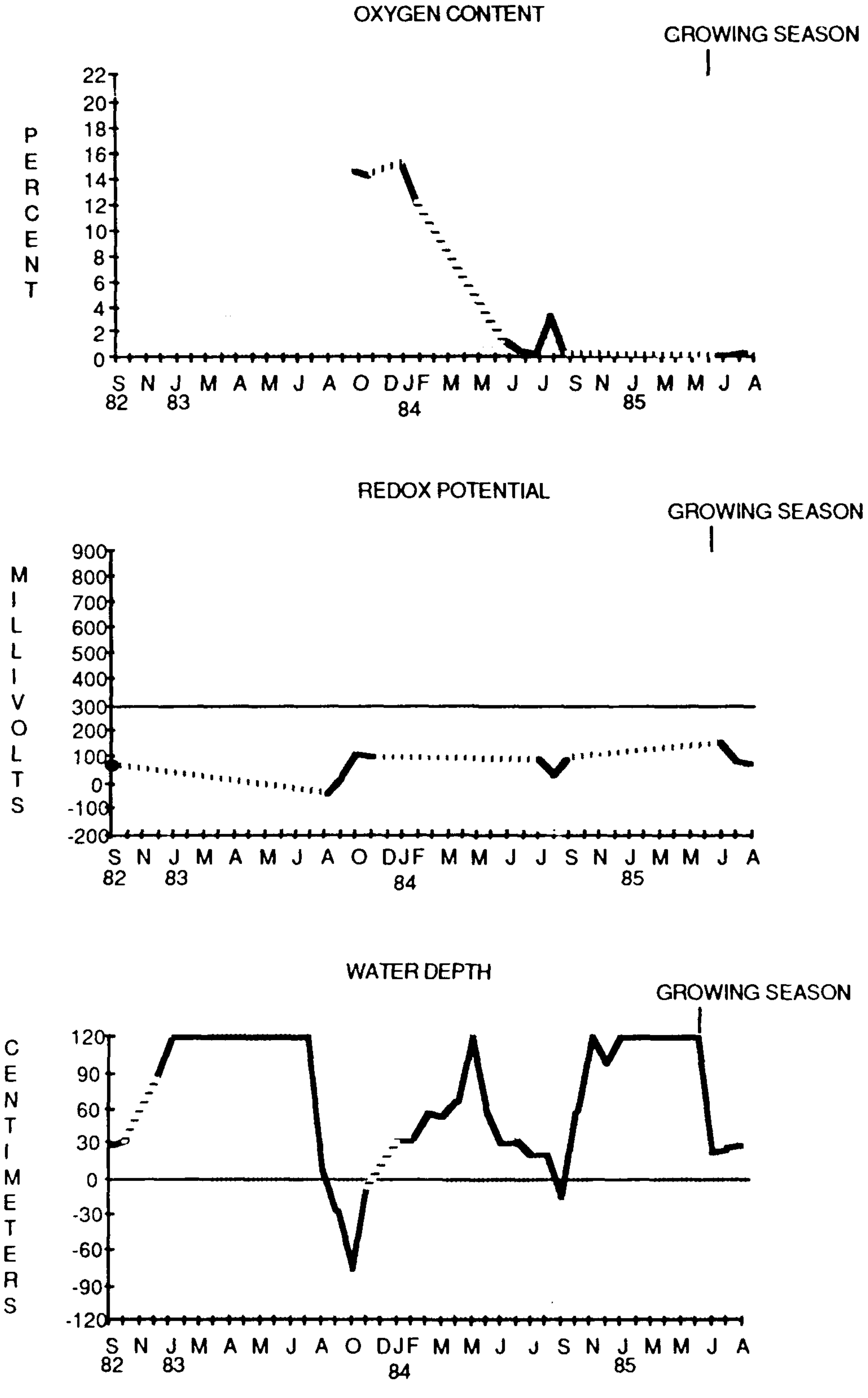


Figure 23. Oxygen content and redox potential at 30 cm with water depth for Quimby Plot 5

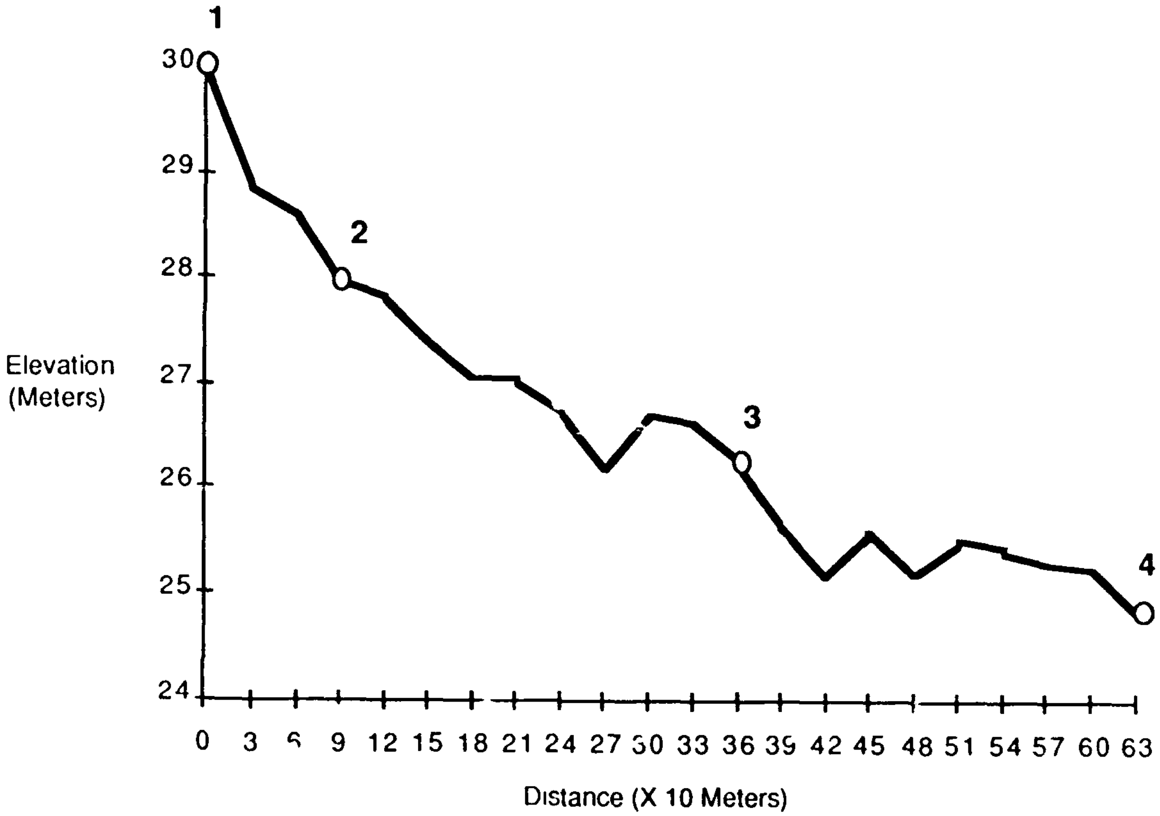


Figure 24. Relative plot elevations for the Red River transect

197. There were two major rainfall periods during the first year of the study: mid-October 1982 through March 1983 (107 cm) and mid-May through June (27 cm). Total rainfall from September 1982 to August 1983 was 194 cm. A total of 152 cm of rainfall was recorded during the same period in 1983-84 and 142 cm from September 1984 to August 1985 (Figure 25).

198. June through September was the period of highest temperatures (21° to 26° C), and the lowest temperatures occurred in January and February (5° to 12° C). Soil temperatures ranged from 14° to 20° C throughout most of the year. There was little change in soil temperature with increasing depth.

Plot RR1

199. This site was located in a Norwood silt loam (Typic Udifluvent) on a ridgetop position. These are relatively young soils with poorly developed horizons. The major parameters were not well correlated at plot one (Appendix I, Table I1). Several correlations at several depths were nonsignificant, and many of the best correlations occurred at the 120-cm depth. The well-oxidized profile resulted in a poorly poised system where variation in the measured parameters was random and independent and, therefore, not well correlated. The water table was usually less than -120 cm and was detected above this depth only in January, February, and March 1983 (≤ -95 cm). This plot was inundated with approximately 15 cm of surface water in June.

200. The combination of well-drained soil and landscape position contributed to the consistently high oxygen level throughout the study. Oxygen content at 15, 30, and 60 cm ranged from a high of 18 to 20 percent at 15 cm to 15 to 18 percent at 60 cm (Appendix J). The 120-cm depth oxygen content generally ranged from 11 to 16 percent and fell below 10 percent in February (8.0%), March (9.0%), and June (8.5%) of 1983. The consistently high redox potential reflected the well-oxidized soil conditions. There was little variation with depth down to 60 cm. Redox potential was almost always greater than +500 mV in the upper 60 cm of the profile. Redox at 120 cm usually ranged from +400 mV to +550 mV with some brief reducing periods that corresponded with the low-oxygen periods.

201. Soil moisture content fluctuated seasonally: very low in the late summer and early fall, and higher in the winter and early spring. The 15-cm depth appeared to be the driest zone during the low-moisture periods. Moisture content rose from less than 20 percent in September 1982 to 40 percent by December. It remained fairly constant around 40 percent until July 1983 when it declined to 23 percent at 15 cm, slightly higher deeper in the profile. Soil moisture increased to 39 percent by November and followed the same pattern in 1984 and 1985.

202. Plot RR1 was positioned on a high natural levee with the water table usually less than 120 cm. It was detected above this depth only in January, February, and March

1983 (≤ -95 cm), and this site was inundated with surface water in June 1983. Oxygen content at 30 cm was greater than 15 percent except for two brief periods. Redox potential at 30 cm was always greater than +400 mV (Figure 26). The combination of well-drained soil and landscape

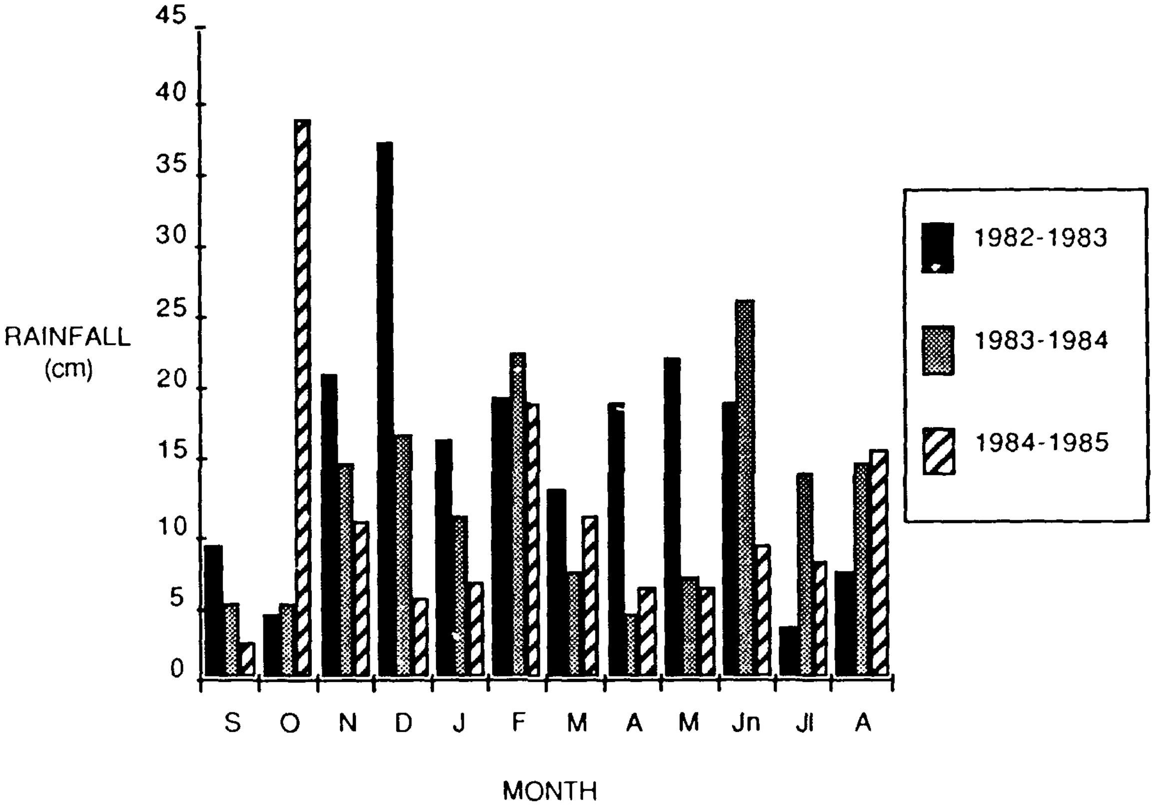


Figure 25. Rainfall patterns for the Red River transect

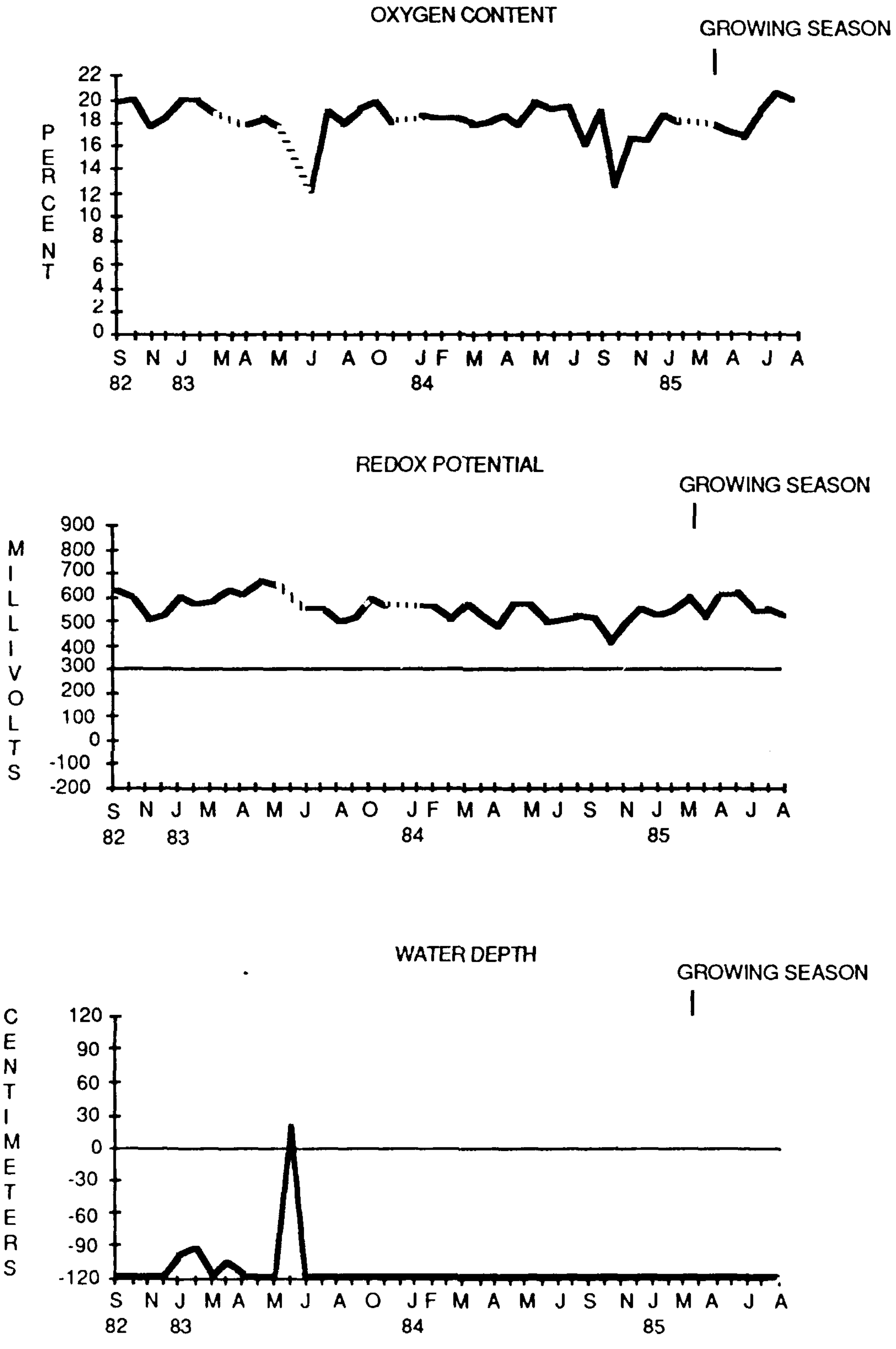


Figure 26. Oxygen content and redox potential at 30 cm with water depth for Red River Plot 1

position contributed to the consistently oxidized profile throughout the study. Wetland soil indicators were not present during the 1984 growing season (Table 3). The soil type was Norwood silt loam (Typic Udifluvent, nonhydric) (Appendix K).

Plot RR2

203. This site was very similar to RR1. The soil type was also Norwood silt loam, but in a slightly lower landscape position. The water table was present in the upper 120 cm more often as a result of the lower elevation. Parameter correlations were a little higher than those for Plot RR1, but the most significant were found at the lower depths (Table I2).

204. 1983. The water table was not detected until January (-67 cm). It fluctuated between -104 and -81 cm from February to June. The plot was inundated with surface water (>120 cm) in early June. The water table was below -120 cm by July and remained there for the rest of the year. Oxygen content at 15 and 30 cm fluctuated between 18 and 20 percent throughout the year. Oxygen level at the 60-cm depth ranged from 16 to 19 percent most of the year; it fell to 10 percent in January , the highest water table period. The fluctuating water table had the greatest effect on the 120-cm depth. Oxygen content at this depth decreased from 17 percent in October 1982 to 6 percent by mid-April. It ranged from 14 to 17 percent for the rest of the year. The lowest oxygen levels were measured in late June following the surface inundation. They ranged from a high of 6.5 percent at 15 cm to a low of 2 percent at 120 cm.

205. Redox potential at 15, 30, and 60 cm was generally very high (+500 to +700 mV) throughout the year. It fell briefly in response to the flooding in June: +435 mV at 15 cm, and less than +200 mV at 30 and 60 cm. Redox at 120 cm declined from +585 mV in October 1982 to +194 mV in mid-March. Redox values were greater than +425 mV for the rest of the year except for June. Soil moisture content was low at all depths in September 1982, ranging from 21 percent at 120 cm to 30 percent at 15 cm. It had stabilized around 40 percent by November and remained in the 38- to 44-percent range until July. A general decline in soil moisture was measured from July to October with the driest conditions (<30%) detected at 60 and 120 cm. Moisture content increased to approximately 40 percent in November except at 120 cm (19%).

206. 1984. The water table was detected in the upper 120 cm of the profile only three times in 1984: March (-85 cm), May (-55 cm), and October (-83 cm). Oxygen content at 15, 30, and 60 cm was greater than 15 percent during the year with the exception of August and October when it briefly declined to a low of 9 percent (60 cm). Oxygen at 120 cm fluctuated between 12 and 17 percent, decreasing to 7 percent in June and October.

207. Redox potential at all depths reflected the well-oxidized conditions. Redox potential at 15 and 30 cm was greater than +500 mV in every month except October (+480 mV). It was much lower at 60 cm, ranging from +340 to +420 mV. Redox at 120 cm was more variable during the year, fluctuating between +450 mV and +620 mV during the first 5 months. It declined to +415 mV in May and June and remained higher than +480 mV through December. Soil moisture content

at 15, 30, and 60 cm was fairly stable (40 to 42%) from January to April. It began falling in May, reached a low of 32 percent by July, and returned to the 40-percent range in August. Following a brief dip to 34 percent in September, soil moisture increased to 40 percent in November. Soil moisture content at the 120-cm depth increased from 40 percent in January to 43 percent in March. It remained at that level until July (39%), fell to a low of 36 percent in September, and rose to 40 percent by November.

208. 1985. The water table was measured above -120 cm only twice in 1985: March (-116 cm) and April (-83 cm). Oxygen content at 15, 30, and 60 cm ranged from 16 to 21 percent except for April when it fell to a low of 12 percent at 60 cm. Oxygen content at 120 cm was generally 3 to 5 percent lower, ranging from 11 to 18 percent. Redox potential at 15, 30, and 120 cm was high (>+500 mV), while redox at the 60-cm depth was much lower (+330 to +415 mV). Soil moisture content at all four depths fluctuated between 40 and 44 percent until May. It declined steadily to a low in August of 27 percent at 15 and 30 cm, lower at 60 (23%) and 120 (18%) cm.

209. Summary. Plot RR2 was well oxidized throughout the study (Figure 27). Oxygen content at 30 cm was greater than 15 percent except for one or two brief periods. Redox potential at 30 cm was always greater than +400 mV except for one measurement in June 1983. Oxygen and redox potential in June 1983 reflected the impact of the unusually high water earlier in the month.

210. The soil type was Norwood silt loam (Typic Udifluvent, nonhydric) at a slightly lower elevation than RR1. The water table was present in the upper 120 cm of RR2 more often than RR1 as a result of the lower elevation, but there was no effect above the 120-cm depth at either plot. Wetland soil indicators were not present at this plot during the 1984 growing season (Table 3).

Plot RR3

211. This site was located on the edge of a backwater swamp in a frequently flooded Moreland silt loam (Vertic Hapludoll). All parameter comparisons at 15 and 30 cm were highly significant while only one comparison was significant, at 60 and 120 cm (Table 13).

212. 1983. The water table rose from -72 cm in September 1982 to +8 cm by November and remained above the soil surface into July. It fell to -4 cm by the end of July and remained in the upper 50 cm of the profile before rising to +5 cm in November. High water levels prevented equipment readings in January, May, and June. Oxygen content at 15 cm ranged from 17 to 20 percent from September to December 1982 and decreased to zero by February. It was less than 4 percent for the rest of the year except for April (8%), September (9%), and October (17%). Oxygen content at 30 cm followed a similar pattern, falling from 17 percent in September to 1 percent in February. It was less than 5 percent for the rest of the year except for October when it increased to 11 percent. Oxygen measurements at 60 and 120 cm from September to December 1982 were somewhat erratic, reflecting the problems associated with changing the diffusion chambers and measuring saturated soils. However, soil oxygen content was less than 5 percent at both depths for all of 1983.

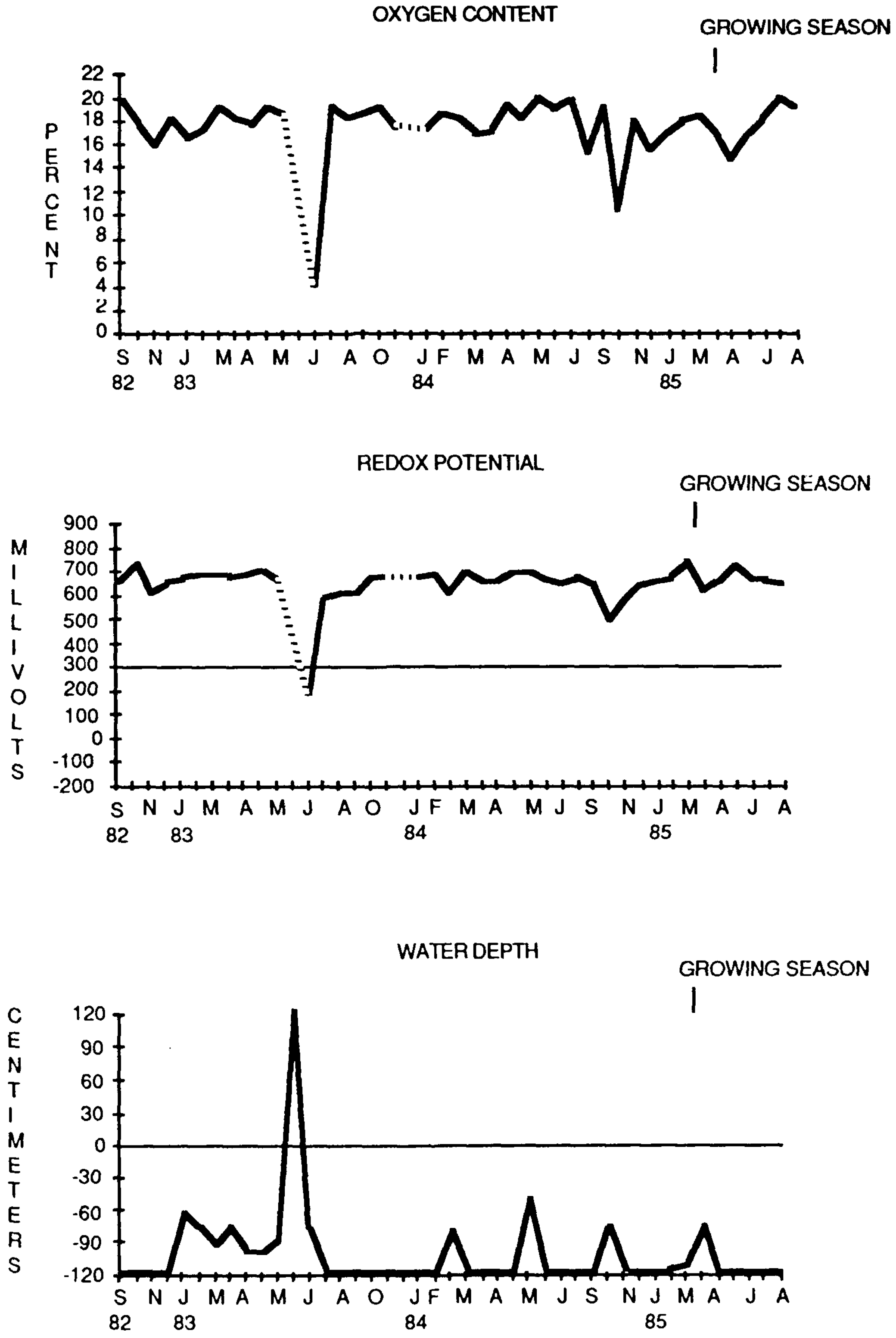


Figure 27. Oxygen content and redox potential at 30 cm with water depth for Red River Plot 2

213. Redox potential at 15 cm was high (>+550 mV) in September and October 1982, but fell rapidly to +165 mV by November 1982. It ranged from a low of -8 mV (March) to a high of +232 mV (October) until November (+364 mV) when the redox climbed above +300 mV for the first time since October 1982. Redox potential at 30 cm followed the same pattern, ranging from -34 mV in July to +153 mV in March before increasing to +519 mV in November. With the exception of October 1982 (+486 mV at 60 cm) and November 1983 (+268 mV at 60 cm), the 60- and 120-cm depth redox potential was never more than +140 mV.

214. No soil moisture content measurements were taken from January to June because of excess surface water. Moisture content at 15 cm increased steadily from a low of 43 percent in September 1982 to a high of 59 percent in July. It ranged from 52 to 57 percent for the rest of the year. The moisture-content pattern at 30 cm was similar, increasing from a low of 42 percent in September to a high of 51 percent in July before falling slightly to 49 percent in November. Soil moisture at 60 and 120 cm was slightly higher than the 15- and 30-cm depths in the fall of 1982, ranging from 50 percent (September to December) at 60 cm to 59 percent (September) at 120 cm. Moisture content at 60 cm was stable (51 to 53%) for the rest of the year while it fluctuated between 54 and 59 percent at 120 cm.

215. <u>1984.</u> The plot was inundated by surface water for all but three months (July, August, and September), and the water table was always within 30 cm of the soil surface. No measurements were made from the end of April to July as a result of the high water. Oxygen content at all four depths was, except for a few readings from 4 to 6 percent, less than 3 percent for the entire year. Redox potential at all four depths was less than +200 mV throughout the year except for the 15-cm depth in December (+248 mV). Soil moisture measurements could only be taken in January, February, July, August, and September and were stable with depth. The 15-cm depth soil moisture content ranged from 56 to 58 percent; 30-cm depth ranged from 49 to 50 percent; 60-cm depth ranged from 50 to 51 percent; and 120-cm depth ranged from 55 to 59 percent.

216. <u>1985.</u> The plot was covered with surface water from January until June. The water table dropped from -69 cm in June to -98 cm in August. Soil oxygen content was less than 1 percent at all depths until June when it rose to 9 percent at 15 cm. It had risen to 18 percent at that depth by August. Oxygen content at 30 cm increased to 14 percent in July and August, however, and did not increase at 60 cm until August (8%). The 120-cm depth remained anaerobic for the entire year. Soil moisture content was measured during February and in May through August. Soil moisture decreased steadily from 59 percent in February to 38 percent in August. A general decline was detected at 30 cm as it fell from 49 percent in February to 32 percent in August. The same trend was noticed at the 60-cm depth where moisture content decreased from 50 percent to 41 percent during this same period. Soil moisture at 120 cm showed a slight increase from 52 percent (February) to 54 percent (August).

217. Summary. Plot RR3 was was inundated for much of the study period with strongly reduced and anaerobic conditions at 30 cm (Figure 28). The soil type at Plot RR3 was Moreland silt loam (Vertic Hapludoll), a hydric soil. It was saturated, anaerobic, and reduced for 100 percent of the 1984 growing season (Table 3).

Plot RR4

218. This site was located in a backwater swamp, and the soil was a very poorly drained Yorktown silt loam (Typic Fluvaquent). Very few parameter correlations were significant (Table 14). Nearly permanent inundation is similar in this respect to nonflooded soil: the lack of consistent movement in one direction or the other results in random variation among the variables.

219. 1983. The water table was always within 25 cm of the surface, and the plot was generally inundated with more than 30 cm of surface water. Complete measurement of all parameters was possible only from September to November 1982 and from August to November 1983. Oxygen content at 15 cm was less than 4 percent in 1983 except for October 1982 (8%). It was less than 3 percent at the other three depths except in November 1982 when it was 5 percent at both 60 and 120 cm. This site was strongly reduced for the entire period, ranging from -200 mV to +170 mV at all four depths. Soil moisture content was fairly stable, ranging from 61 to 67 percent at 15 cm and from 50 to 56 percent at 30, 60, and 120 cm.

220. 1984. The plot was inundated with surface water for the entire year ranging from +10 cm in September to greater than +120 cm in April, May, June, and November. Complete measurement of all parameters was made only in July, August, and September. Oxygen content was less than 2.5 percent at all depths except for January at 30 cm (4%) and 60 cm (5%). Redox potential was less than +190 mV at all depths except for the 60-cm depth in August (+265 mV) and December (+250 mV). Soil moisture was highest at 15 cm (66 to 67%) and stable at the other three depths (49 to 55%).

221. 1985. The plot was flooded with surface water from January (+36 cm) to the end of May (+30 cm). The water table declined from -3 cm in June to -42 cm in August. Because of the high water, complete measurements were only made in May, June, July, and August. Oxygen content was less than 1.5 percent at all depths until August when it increased to 18 percent at 15 cm, 6.5 percent at 30 cm, and 4.0 percent at 60 cm. It was 0 percent at 120 cm. Redox potential at all four depths remained low, ranging from +70 mV at 15 cm to -200 mV at 60 cm (August). Soil moisture content at 15 cm increased from 62 percent in February to 68 percent in June before falling to 51 percent by August. It was lower at 30 cm, increasing from 52 percent (February) to 57 percent (June) and then decreasing to 53 percent (August). Soil moisture ranged from 48 to 51 percent at 60 cm and from 51 to 54 percent at 120 cm.

222. Summary. Plot RR4 was located in a backwater swamp, and the soil was a very poorly drained Yorktown silt loam (Typic Fluvaquent, hydric). This site was flooded for virtually

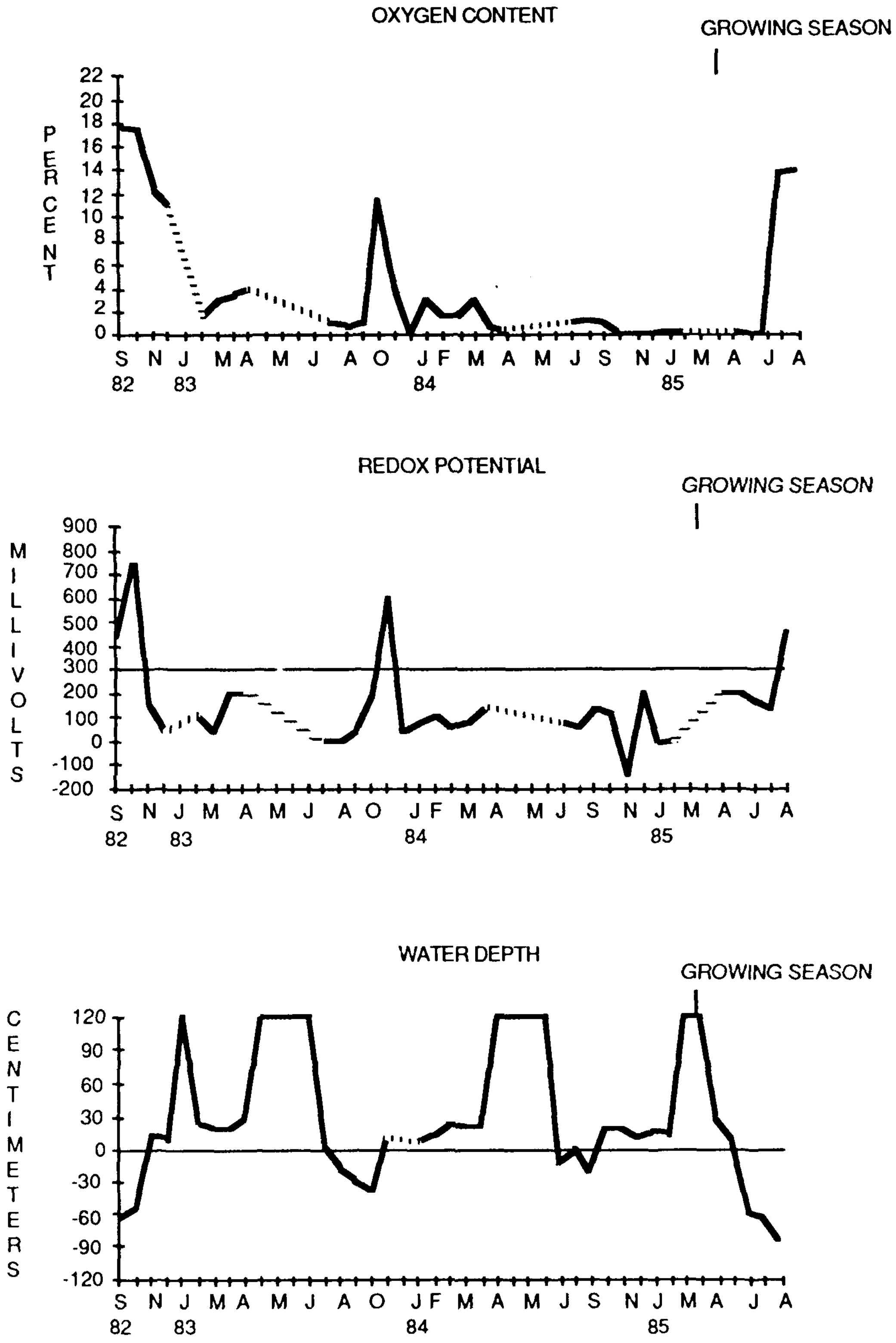


Figure 28. Oxygen content and redox potential at 30 cm with water depth for Red River Plot 3

all of the study with anaerobic and very strongly reduced conditions at 30 cm (Figure 29). It was saturated, anaerobic, and reduced for 100 percent of the 1984 growing season (Table 3).

Rolling Fork

223. The Rolling Fork transect was located on the Yazoo National Wildlife Refuge in Washington County, Mississippi (Figure 2). The soils are from the Mississippi alluvium. The transect began on a ridge (Plot RF1) and ended at the edge of Steele Bayou (Plot RF5), which was the source of flooding on the transect (Figure 30).

224. The Rolling Fork transect was subjected to significant changes during the 3 years of the study. Rainfall patterns were substantially different among the years, with 192 cm of rain recorded from September 1982 to August 1983 (Figure 31). The majority (128 cm) of that amount fell between October and February. During the period September 1983 to August 1984, rainfall was 157 cm. During the same period in 1984-85, only 120 cm of rain fell.

225. The source of flooding, Steele Bayou, was dredged downstream of the transect in 1984 to increase the carrying capacity of the bayou and to prevent overbank flooding upstream. It is difficult to isolate the impact of the dredging from the significant rainfall differences, but both the collected data and empirical observations indicate reduced overflow peaks and shorter flood durations in 1985.

226. The soil temperature pattern was fairly consistent from year to year. June through September was the period of highest temperatures (21° to 26° C); the lowest temperatures occurred from January to March (3° to 10° C). Soil temperatures ranged from 14° C to 20° C throughout most of the year. Soil temperatures were fairly constant with depth, varying by only 1° or 2° C. Extremes were buffered by depth as the temperature at 50 cm was lower in the summer and higher in the winter than at 15 cm.

Plot RF1

227. This site was located on a ridge in a Dundee silt loam (Aeric Ochraqualf). The plot was not flooded during the study period and was better drained than a normal Dundee due to an underlying layer of very fine sandy loam. The correlation of oxygen, redox, moisture, and water table was very low in general and nonsignificant in the case of oxygen and water table depth; the relationship between oxygen and soil moisture at 60 cm was the only one highly correlated (Appendix L, Table L1). These results are similar to those for Plots QU1 and RR1, substantiating the random and independent variation in poorly poised, well-oxidized soils.

228. The water table remained below -102 cm for the entire sampling period. The oxygen content at all depths remained high during all 3 years(Appendix M). At the 15-cm depth, oxygen content generally fluctuated between 18 and 21 percent. A wider range of 15 to 19 percent was observed at 30, 60, and 120 cm. Oxygen content at Plot RF1 never fell below 12 percent and was

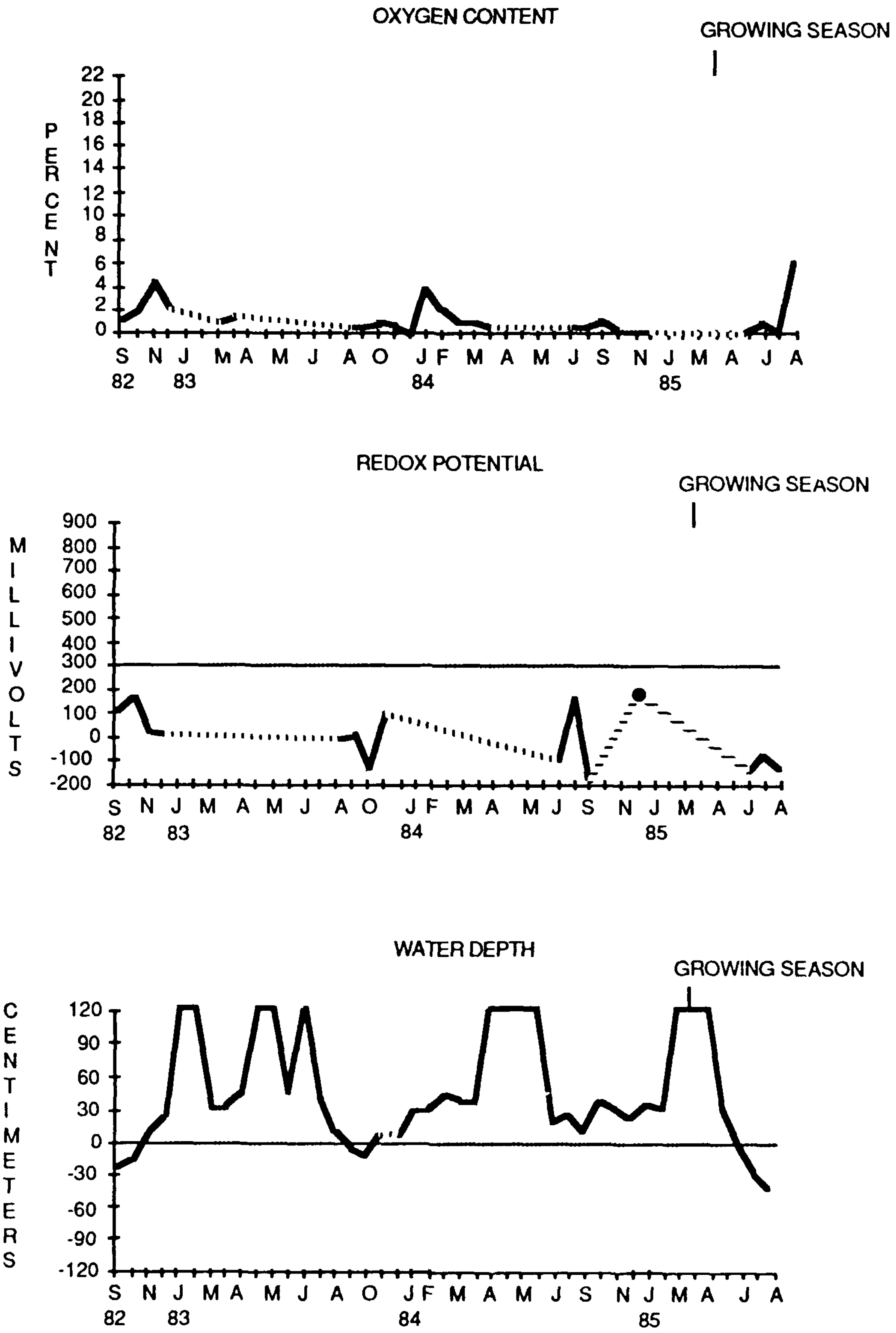


Figure 29. Oxygen content and redox potential at 30 cm with water depth for Red River Plot 4

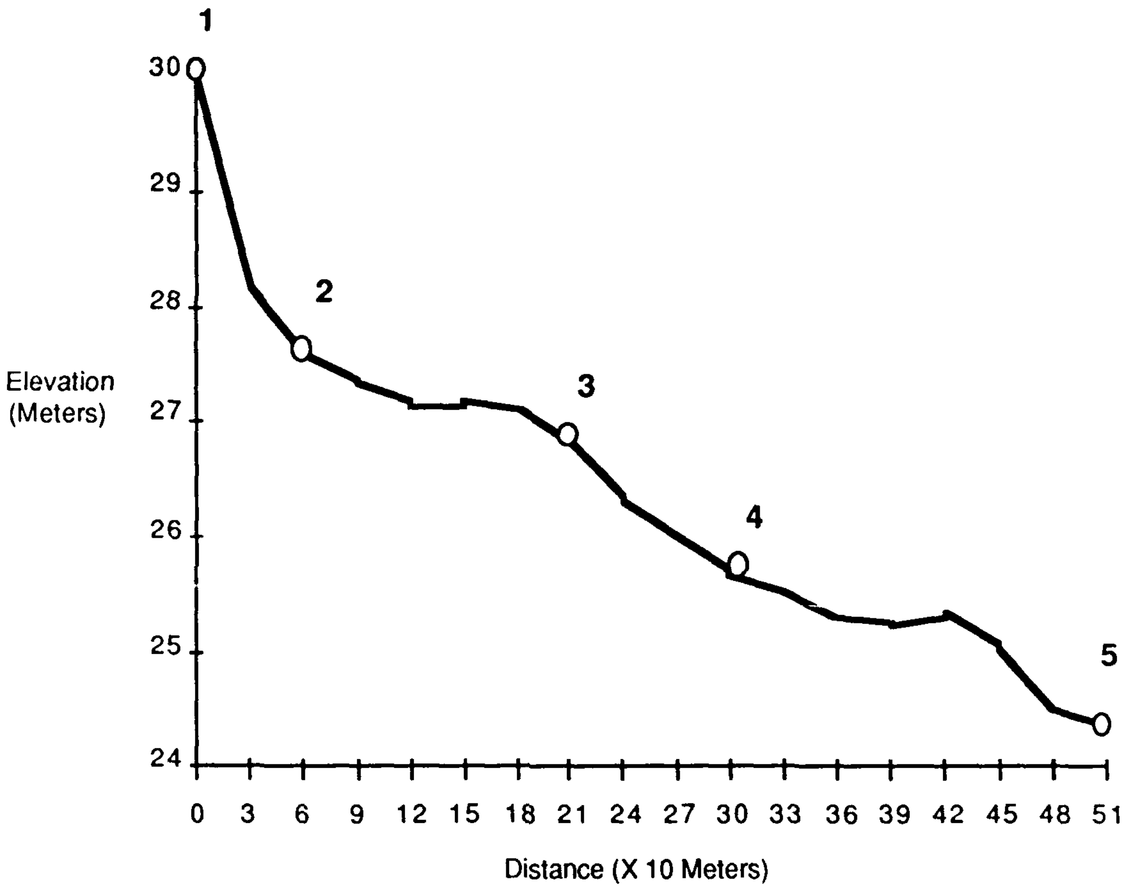


Figure 30. Relative plot elevations for the Rolling Fork transect

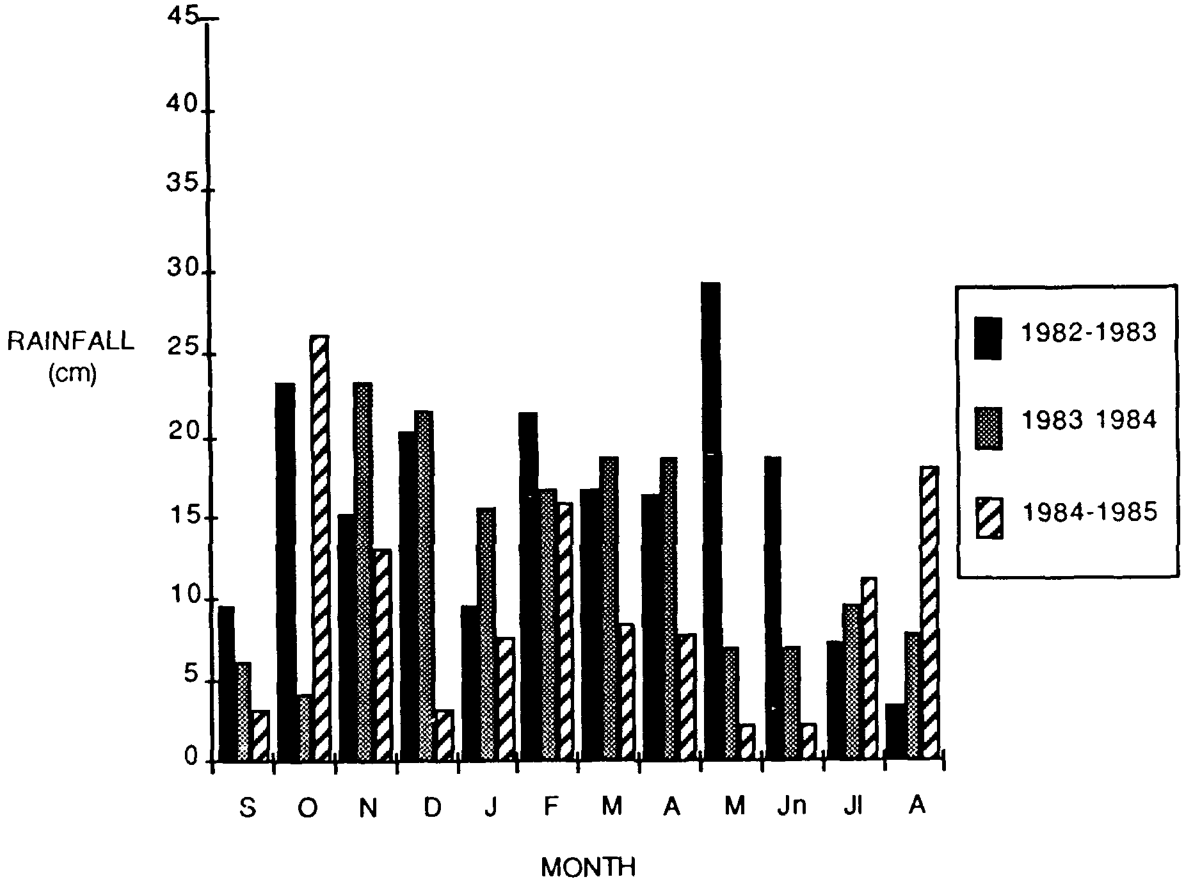


Figure 31. Rainfall patterns for the Rolling Fork transect

that low only once or twice. Redox potential was also high at all four depths, never falling below +400 mV. No large differences were noted with depth, and the range in redox potential was normally between +500 and +800 mV. Soil moisture content was in the range of 40 to 50 percent at 15 and 30 cm during most of the year, falling to 25 to 38 percent during a particularly dry period from July to October 1983. The 60- and 120-cm depths were noticeably drier, ranging from 30 to 40 percent normally and as low as 15 percent during the dry late summer. The effect of the underlying layer of sand is evident in the much lower moisture contents at 60 and 120 cm.

229. Plot RF1, a Dundee silt loam (Aeric Ochraqualf, nonhydric), was well oxidized throughout the study period. The site was never flooded, and the water table was always less than -100 cm. Oxygen content was never less than 12 percent at any depth, and redox potential was always greater than +400 mV (Figure 32). No wetland soil indicators were noted during the 1984 growing season (Table 3). The soil profile was described as having a Btg1 (gleyed) horizon and a matrix soil color of 10YR 4/2 (Appendix N), both indicative of reducing conditions sometime during the year. The gleyed horizon is atypical for Dundee and is probably a relict condition from the moisture regime present during soil formation.

Plot RF2

230. This site was located in a slight depressional area at the toeslope of the ridge. The soil type was a poorly drained Kobel clay (Vertic Haplaquept). The correlations among the soil parameters were much higher than those for Plot RF1 and were statistically significant at all depths (Table L2). Redox potential at 30 cm was highly correlated with oxygen content (r = 0.67) and water table depth (r = -0.72). Oxygen content at 30 cm was also well correlated with water table depth (r = -0.73) and soil moisture (r = -0.71), although these were the second highest correlations for those particular pairs.

231. 1983. The water table rose significantly to the soil surface in December 1982 and was measured at 50 cm above the surface in January 1983. It remained at or near the soil surface until June, well into the 1983 growing season. Oxygen and redox fell in response to the high water levels. Oxygen content at 15 cm dropped steadily from 17 percent in February 1983 to 1.5 percent in May. It climbed to 20 percent by July and remained at that level for the rest of the year. This pattern was repeated at the other three depths, although the return to aerobic conditions was marked by generally lower oxygen contents, especially at 120 cm (14 to 17%). The redox potentials indicated strong reducing conditions present for several months in 1983. Redox at 15 cm dropped from +249 mV in December 1982 to less than -50 mV by March 1983 and remained below 0 mV until the end of May. It ranged from +400 mV to +600 mV for the rest of the year. Redox at 30 cm (< -150 mV) was much lower than at 15 cm from March to May, but was similar to 15 cm after May. The 60- and 120-cm depth redox potentials were not as reducing (-98 to +85 mV) during the high-water period but were lower during the drier summer and fall, especially at 120 cm (+300 to +450 mV).

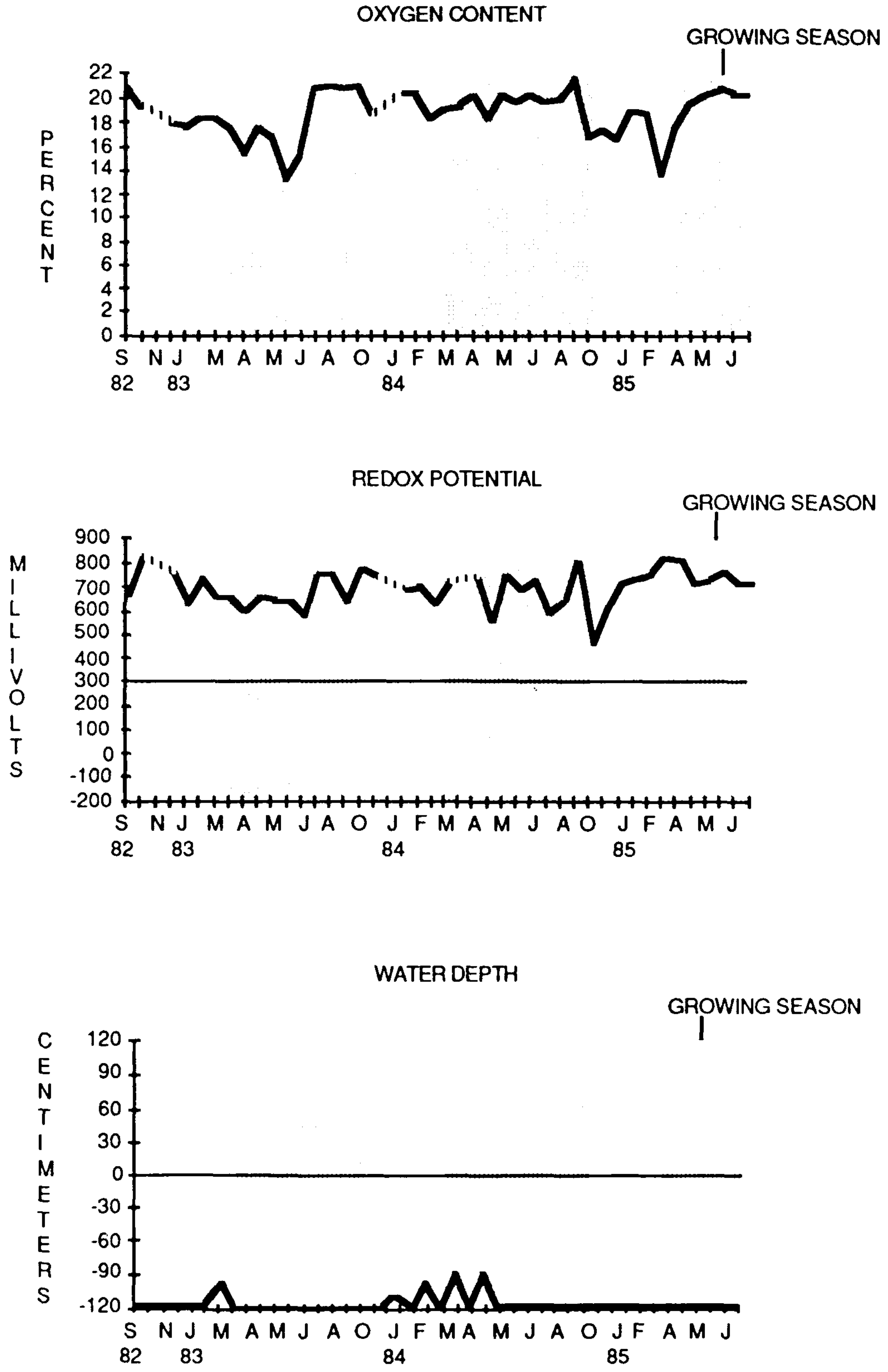


Figure 32. Oxygen content and redox potential at 30 cm with water depth for Rolling Fork Plot 1

232. Soil moisture content at 15 and 30 cm ranged from 45 to 55 percent during low-water table periods and 55 to 60 percent during high-water table periods. The 60-cm depth was drier than at 15 or 30 cm during high-water periods (50 to 55%), but similar to those upper depths the rest of the year. Moisture content at 120 cm was the lowest of all four depths for both high-water periods (48 to 50%) and low-water periods (35 to 45%).

233. 1984. The 1984 results at Plot RF2 were similar to those of 1983. The water table rose in January to 1 cm below the soil surface and remained within 13 cm of the surface until early May. It was not detected in the upper 120 cm of the profile for the rest of the year. Oxygen at 15 cm declined from 16.5 percent in January to 6 percent by March. It fluctuated between 4 and 6 percent until the middle of May. A similar pattern was observed at the lower depths, ranging from 2 to 4 percent at 30 and 60 cm and 0 to 1 percent at 120 cm. Oxygen content at all depths rose with the falling water table, although the 60- and 120-cm depths responded much more slowly and had less oxygen than the upper depths. Oxygen levels peaked in September, and then diminished slightly at 15 cm and more drastically at 60 and 120 cm.

234. Redox potentials during the high-water period were generally not as low as in 1983. At 15 cm, redox went from +206 mV in January to -82 mV in March before increasing to +68 mV by mid-April. The 30-cm depth potential was generally much lower: less than -100 mV from March to April. The 60- and 120-cm depths were somewhat higher during this period, ranging from -14 to +318 mV. Redox potentials increased at all depths following the drop in the water table; however, at 120 cm, redox was greater than +300 mV only from July to September. Soil moisture content was highest from January to April and was higher at 15 and 30 cm (56 to 60%) than at 60 and 120 cm (48 to 52%). From May to December, soil moisture was higher at 30 cm than at 15 cm and then dropped off at 60 cm. It was lowest at 120 cm. The month of September was the driest with 45 percent soil moisture content at 30 and 60 cm compared with 40 percent at 15 and 120 cm.

235. 1985. The spring of 1985 was much drier than in the previous 2 years. A high water table was not present until early February (-28 cm), rose to the surface by the end of February, and fell to -30 cm by the middle of April. The short flooding duration resulted in a much shorter period of low oxygen and redox conditions. Oxygen content at 15 cm fell below 12 percent only once (March) to 1 percent. At 30 cm, it was less than 10 percent during March, April, and the beginning of May. Oxygen levels were much lower at 60 and 120 cm, essentially remaining at or below 5 percent from January until the end of May, except for a brief rise in February. Redox potential followed a pattern similar to that of oxygen. At 15 cm, redox stayed near or above +300 mV in every month but March (+205 mV). The 30-cm depth had the lowest readings, falling below +100 mV in March and April and climbing above +450 mV from May to August. Redox potentials hovered near +300 mV at 60 cm through the end of May and remained above +400 mV until August. At 120 cm, redox ranged from +121 mV (April) to +359 mV (June). Soil moisture content at all depths peaked in February and was highest at 15 cm (59%) and lowest at 120 cm (48%). The

lowest moisture contents were recorded in July and ranged from 40 percent (120 cm) to 50 percent (30 cm). Once again, during the dry period, soil moisture was higher at 30 cm than at 15 cm and lowest at 120 cm.

236. Summary. Plot RF2 was inundated with surface water in the fall of each year, which lingered for a few months into the growing season except in 1985. During these periods, oxygen content was less than 5 percent (essentially anaerobic), and redox potential was well below +300 mV (Figure 33). The site was anaerobic and saturated for 25 percent of the 1984 growing season and was reduced for 19 percent (Table 3). The soil type was Kobel clay (Vertic Haplaquept, hydric) with a gleyed B horizon and a matrix chroma of 2 or less (Appendix N). The Kobel soil series is very similar to Sharkey, but does not have quite enough clay in the control section to classify as Sharkey.

Plot RF3

237. This site was located on the shoulder of a finger ridge, and the soil type was Tunica silty clay (Vertic Haplaquept). It was better drained than the Kobel at Plot RF2 due to its landscape position and slightly coarser texture. The microtopography of this site was such that the subplot equipment was installed at slightly different elevations. As a result, some of the oxygen contents and redox potentials (especially during wet periods) were higher than expected due to the influence of the elevated subplot. The parameters were well correlated and highly significant at all depths (Table L3). The 30-cm depth had the best correlations for water table depth and redox (r = -0.79) and for oxygen and soil moisture (r = -0.74); it was second best for all other comparisons.

238. 1983. The plot was inundated with +53 cm of surface water in December 1982, which increased to +120 cm by January 1983. The water table fluctuated during the spring, falling to -64 cm in early March followed by a rise to -2 cm by mid-April. It then dropped to -43 cm by mid-May before being inundated with +91 cm of surface water by the end of May. It remained below -120 cm for the rest of the year. Oxygen contents and redox potentials also fluctuated with the variable water table. Oxygen content at 15 cm was much higher than at Plot RF2 falling from 20.75 percent in October 1982 to a low of 3 percent in March of 1983. It wavered between 8 and 12 percent until July when it returned to the 20-percent range for the remainder of the year.

239. Oxygen content at 30 cm was similar to 15 cm, but was lower (3 to 11%) during the period from early March to late June. Oxygen at 60 cm was much lower (1 to 4%) during this same period and slowly returned to preflooding oxygen status (18 to 19%). Although operational problems with the 120-cm depth diffusion chambers prevented some readings from being taken, the measurements taken during the high-water period were higher than expected (9 to 15%) especially in light of the lower readings at the upper depths.

240. Redox potentials at all depths were above +600 mV in October 1982. It changed rapidly at 15 cm, falling to +69 mV by February 1983, hovered between +90 and +110 mV from March until May, and rose steadily from +334 mV (June) during the rest of the year. The potentials were

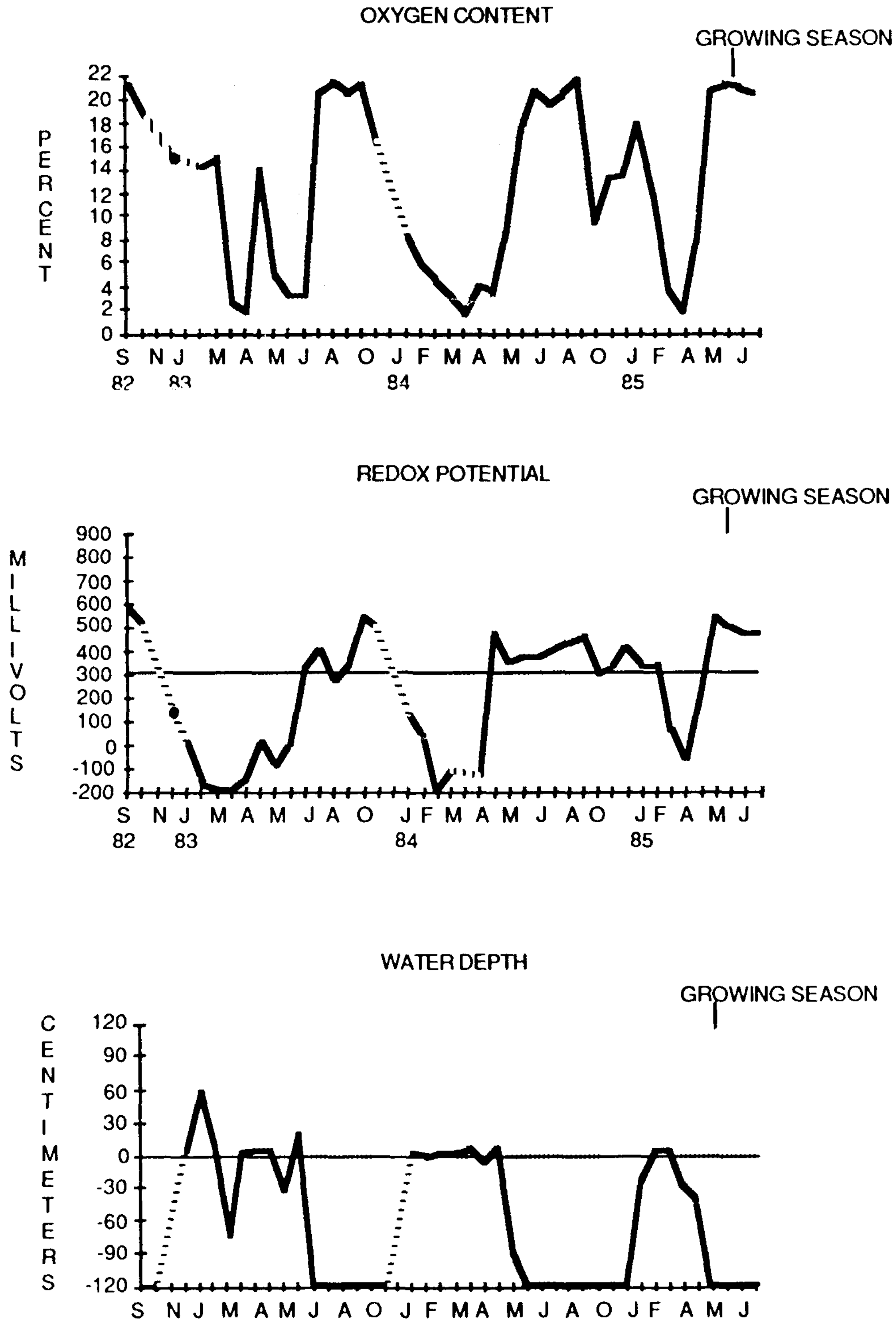


Figure 33. Oxygen content and redox potential at 30 cm with water depth for Rolling Fork Plot 2

somewhat lower than expected given the intermediate level of oxygen that was measured. Much lower redox potentials (-108 to -12 mV) were encountered at 30 and 60 cm during the wet period of February to May. They began climbing in June (+364 mV) at 30 cm and in July (+502 mV) at 60 cm and remained well oxidized for the rest of the year. Soil moisture content at 15 cm went from 44 percent in October 1982 to 55 percent by February 1983 and remained in that range (55 to 57%) until July when it dropped back to 44 percent.

241. The driest month was August (35%), and soil moisture increased steadily to 54 percent by the end of the year. A similar pattern was observed at 30 cm; however soil moisture was generally 4 to 6 percent higher than the 15 cm depth. The 60- and 120-cm depths were much drier with moisture contents around 35 percent in October 1982 and rising to 46 percent by February 1983. They remained in the 45- to 48- percent range until September when they dropped to 30 to 35 percent and stayed there for the rest of the year.

242. 1984. The water table rose to -4 cm in January and was as high as +23 cm (March) before falling to -37 cm in early May. By June it was less than -120 cm and was not detected for the rest of the year. Oxygen content at 15 cm fell from 17 percent in January to a low of 7.5 percent in early April. It rose to 20 percent by May and fluctuated between 18 and 21 percent throughout the remainder of the year. Oxygen at 30 and 60 cm was lower in January (10%) and fell steadily to 3 percent by March. It remained between 1 and 4 percent until May at 30 cm and until June at 60 cm. Oxygen content climbed throughout the summer and peaked in September at around 20 percent. There was a distinct drop in October to roughly 10 percent and the 30-cm depth stayed at that level through December. However, the 60-cm depth fell to 4 percent in November and 2.5 percent in December. Equipment problems prevented viable readings at 120 cm until March when the oxygen level was 6.5 percent. It ranged from 1 to 7 percent until mid-June when it rose to 10.5 percent. It continued to rise to 18 percent by September before falling steadily to 2 percent by December.

243. Redox potentials at 15 cm started the year at +293 mV and declined to a low of +109 mV by March. They were less than +200 mV until early May. However, readings at all depths in early May were unusually high (+443 to +569 mV) and probably are not valid. Redox ranged from +390 to +555 mV from mid-May to November before falling to +360 mV in December. Redox potentials at 30 and 60 cm were in the +250- to +260-mV range in January and were less than +80 mV by early March. They stayed that low until mid-May at 30 cm and until early June at 60 cm. They fluctuated between +340 and +500 mV for the rest of the year. At 120 cm, redox fell from +232 mV (January) to a low of +101 mV in early March. It remained in the +200- to +220-mV range from the end of March to mid-May. From February to April, redox potentials at 120 cm were as high or higher than those at shallower depths. By June, redox was up to +309 mV and ranged from +345 to +425 mV until December when it fell to +287 mV.

244. Soil moisture content at 15 cm was 61 percent in January, fell to 53 percent in February, and rose to 58 percent in March and April. High water in early March and equipment problems with the neutron probe in late April and early May prevented moisture readings during those sampling periods. Moisture content declined from 53 percent in mid-May to a low of 34 percent by September. It remained at 56 percent for the rest of the year. A similar pattern was observed at 30 cm, but soil moisture averaged 4 percent higher at this depth from May to September. The 60- and 120-cm depths were much drier than the 15- and 30-cm depths. Soil moisture at the lower depths ranged from 42 to 48 percent from January to June. By July, it had fallen to 37 percent at 60 cm and continued to a low of 32 percent in August and September. It increased to 39 percent in October and was up to 41 percent by December. Moisture content was higher at 120 cm, falling from 39 percent in July to 34 percent in September before increasing to 45 percent by December.

245. 1985. Soil saturation in 1985 was much shorter than in the previous 2 years and there was no surface inundation. The water table was 51 cm below the surface in January and rose to -5 cm by the end of February. It continued to fall (-38 cm in April) and was completely out of the upper 120 cm of the profile by the end of May. The soil profile was aerobic at 15 cm, falling from 19 percent in January to a low of 14 percent in March. It ranged from 16 to 21 percent during the rest of the year. Oxygen content at 30 cm was much lower than the 15-cm depth from January (14%) to early May (6%). It remained in the 19- to 20-percent range from late May to August. The 60-cm depth was quite similar to 30 cm, but was generally lower from January (11%) to early May (2%). The lowest readings were recorded at 120 cm which started at 8.5 percent (January) and fell to 1.5 percent by early May before rising to 16 percent in June, July, and August.

246. Redox potentials at 15 cm were variable, beginning at +290 mV (January), abruptly rising to +510 mV in February, and then ranging from +330 mV (March) to over +500 mV during the rest of the sampling period. Redox at 30 cm was more stable, falling from +300 mV in January to a low of +156 mV in March. It climbed to +184 mV by April and ranged from +360 to +565 mV until August. Redox potentials at 60 and 120 cm followed a similar pattern, staying below +370 mV from January to the end of May. They were greater than +400 mV from June to August. Soil moisture was highest during the period January to early May, especially at 15 and 30 cm (55 to 59%). The moisture content at the 60- and 120-cm depths was about 10 percent less than the upper depths during these months. From June to August, it ranged from 40 to 45 percent at 15 and 30 cm and from 33 to 38 percent at 60 and 120 cm.

247. Summary. Plot RF3 was a frequently flooded Tunica clay (Vertic Haplaquept), a hydric soil. The B horizon was gleyed and mottled with a matrix chroma of 2 or less (Appendix N). The flooding frequency and duration of RF3 was similar to that of RF2 with corresponding similarities in the oxygen and redox regimes (Figure 34). Although this site was not as strongly reduced as RF2, reduction duration was similar (22% of the 1984 growing season). It was

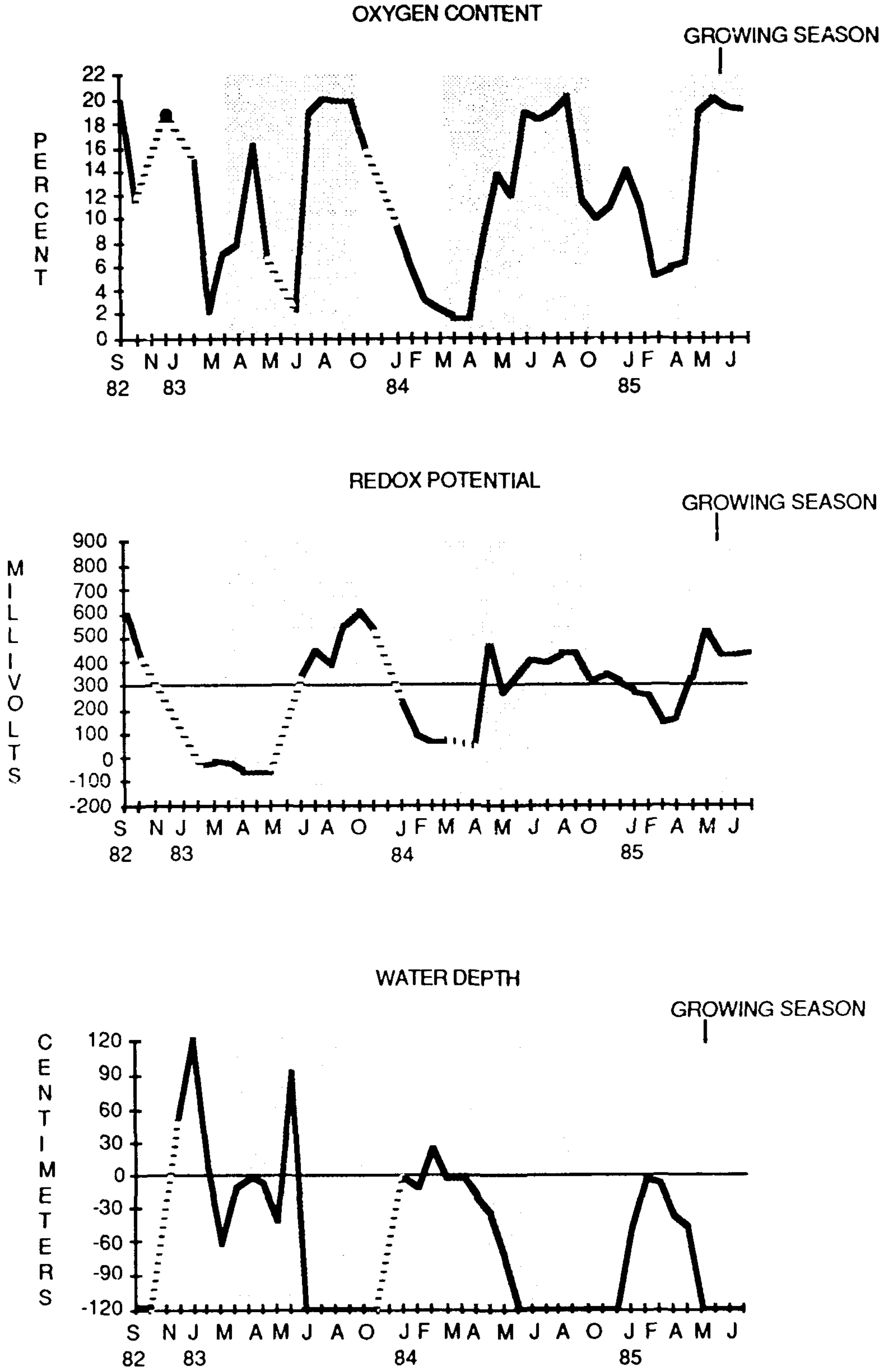


Figure 34. Oxygen content and redox potential at 30 cm with water depth for Rolling Fork Plot 3

saturated and anaerobic for a shorter period than Plot RF2 (19% of the 1984 growing season) (Table 3).

Plot RF4

248. The soil type at this site was Sharkey clay, a poorly drained Vertic Haplaquept. This site was frequently flooded, and the depth of the surface water was great enough to prevent measurement of the equipment from December 1982 through the beginning of March 1983. All correlations at all four depths were highly significant (Table L4). The 30-cm depth had the best correlations for water table depth and both redox potential (r = -0.70) and oxygen content (r = -0.86). The second highest correlations for oxygen and redox (r = 0.65), water table depth and soil moisture (r = 0.76), and oxygen and soil moisture (r = -0.82) were at the 30-cm depth.

249. 1983. The water table rose to -17 cm in October 1982, and surface water inundated the plot until June 1983. The water level dropped below the surface only twice during this period, at the end of March (-5 cm) and again in early May (-13 cm). Oxygen content at 15 cm dropped from 20.75 percent in September 1982 to 0 percent in late March. It fell from 5.75 percent (May) to 1.0 percent (June) before climbing to 20 percent by July and remained that high until November (16.5%). This pattern was essentially repeated at the 30-cm depth; however, it was lower in October 1982 (7%) and November 1983 (13.5%). Oxygen content at 60 cm was very low in October 1982 (6%) and ranged from 4 to 9 percent from March to July. It remained around 19 percent from August to October before falling to 12 percent in November. No measurements at 120 cm were recorded until May when the oxygen level was 2 percent. It was less than 2 percent until August (17.5%) and remained well oxidized (16 to 18%) until November (9%).

250. Redox potentials at 15 cm dropped from +559 mV in October 1982 to +212 mV by March 1983 and fell to a low of +29 mV in May. After rising to +119 mV (June), it ranged from +400 to +660 mV until November (+273 mV). Redox at 30 cm started at +489 mV, decreased to +77 mV by the end of March, and rose to +398 mV by July. It fluctuated between +400 and +510 mV until November when it fell to +286 mV. The 60-cm depth redox potential was much lower than the upper depths in October 1982 (+114 mV). It dropped to +39 mV (March) before rising to a high of +450 mV in September. It dropped back to +272 mV by November. The 120-cm depth was similar to the 60-cm depth, although redox was much lower from June to August.

251. Soil moisture content at 15 and 30 cm ranged from 59 to 62 percent from October to June and declined to the 40- to 50-percent range during the dry period of July to October. The moisture content at 60 cm was 1 to 2 percent higher than at 15 or 30 cm during the high-water period (October to June) and was as much as 10 percent higher during the low-water period (July to October). Moisture content at 120 cm was the lowest of all four depths during the high-water period (53 to 55%) and ranged from 42 to 54 percent during the low-water period.

252. 1984. The water table was at the soil surface in January and remained within 20 cm of the surface until early May. During this time, the plot was inundated with surface water, once in

March and again in April. The water table was not detected in the upper 120 cm of the profile from June to September. Surface water was 86 cm deep in October which receded to -9 cm by December.

253. Oxygen at 15 cm declined from 10 percent in January to a low of 3.5 percent by April. It was less than 8 percent until May when it rose to 19.5 percent. It remained in the 19- to 21-percent range until November when it dropped to 9 percent in response to the inundation. A similar pattern was observed at 30 cm, although oxygen content was generally 1 to 3 percent lower and was not greater than 10 percent until early June. After stabilizing around 20 percent from late June to September, it decreased to 4 and 5 percent in November and December, respectively. Problems with the diffusion chambers at 60 cm prevented readings until April when the oxygen level was 2 percent. It remained less than 5 percent until early June and fluctuated between 15 and 19 percent until September. It was less than 3 percent in November and December. Oxygen content at the 120-cm depth was 5 percent in January and less than 5 percent from February to late July. It climbed from 13 percent (July) to 16 percent (September) before falling to 0 percent in November.

254. At 15 cm, redox potential went from +315 mV in January to +179 mV in March and rose to +352 mV by early May. It ranged from +400 to +520 mV before declining to +360 mV in December. The 30-cm depth redox was generally lower; less than +200 mV from January to early May. It ranged from +400 to +425 mV from June to September and dropped to +354 mV by the end of the year. At 60 cm, redox potential dropped from +202 mV in January to a low of +60 mV in late March. It was less than +250 mV until June (+313 mV). From June to September, redox ranged from +310 to +380 mV and fell to +317 mV by December. Reducing conditions prevailed at the 120-cm depth from January (+121 mV) through mid-June (-6 mV). Redox potential increased from +360 mV (July) to +412 mV (September) before decreasing to +204 mV in December.

255. Soil moisture content at 15, 30, and 60 cm ranged from 56 to 62 percent from January to early June. High water levels and equipment problems prevented readings in early March, all of April, and early May. By mid-June than at 60 and 120 cm (48 to 52%). From May to December, soil moisture was higher at 30 cm than at 15 cm and then dropped off at 60 cm. It was lowest at 120 cm. The month of September was the driest with 45 percent soil moisture content at 30 and 60 cm compared with 40 percent at 15 and 120 cm.

256. <u>1985.</u> The spring of 1985 was much drier than in the previous 2 years. A high water table was not present until early February (-28 cm); it rose to the surface by the end of February and fell to -30 cm by the middle of April. The short flooding duration resulted in a much shorter period of low oxygen and redox conditions. Oxygen content at 15 cm fell below 12 percent only once (March), to 1 percent. At 30 cm, it was less than 10 percent during March, April, and the beginning of May. Oxygen levels were much lower at 60 and 120 cm, essentially remaining at or below 5 percent from January until the end of May, except for a brief rise in February.

257. Redox potential followed a pattern similar to that of oxygen. At 15 cm, redox stayed near or above +300 mV in every month but March (+205 mV). The 30-cm depth had the lowest readings, falling below +100 mV in March and April and climbing above +450 mV from May to August. Redox potentials hovered near +300 mV at 60 cm through the end of May and remained above +400 mV until August. At 120 cm, redox ranged from +121 mV (April) to +359 mV (June). Soil moisture content at all depths peaked in February and was highest at 15 cm (59%) and lowest at 120 cm (48%). The lowest moisture contents were recorded in July and ranged from 40 percent (120 cm) to 50 percent (30 cm). Once again, during the dry period, soil moisture was higher at 30 cm than at 15 cm and lowest at 120 cm.

258. Summary. Plot RF4 was located in a frequently flooded Sharkey clay (Vertic Haplaquept), a hydric soil with a gleyed B horizon and a chroma color of 1 (Appendix N). It was inundated with surface water in the fall of 1982 and well into the 1983 growing season. Flooding frequency and duration was much less in 1984 and 1985; the plot was not flooded during the growing season in 1985, although it was saturated within 3 cm of the surface. It was saturated, reduced, and anaerobic for 21 percent of the 1984 growing season (Table 3). Oxygen content at 30 cm was less than 5 percent (often zero), and redox potential at 30 cm was less than +250 mV during the high-water periods (Figure 35).

Plot RF5

259. This site was located along the edge of Steele Bayou and flooded frequently by overflow from the bayou. It was inundated with surface water from December 1982 through the end of June 1983. The water was deep enough to prevent equipment readings except during March, May, and June. It was flooded again at the end of November, preventing measurement.

260. The major soil parameters were well correlated and almost all were highly significant (Table L5). The best correlations for many of the comparisons were at the 30-cm depth, including oxygen and redox (r = 0.70), water table depth and redox (r = -0.61), and oxygen and soil moisture (r = -0.84).

261. 1983. During the period the site was flooded, the oxygen level ranged from 0 to 1 percent at all depths. Oxygen content at 15 cm had risen to 19 percent by the end of July, and the 30- and 60-cm depths returned to those levels by August. It remained above 20 percent at those depths until November when the plot was inundated again. Oxygen response at 120 cm was much slower and did not return to aerobic conditions until the end of October, just prior to the resumption of flooding.

262. Redox potential at all depths fell from the +415- to +485-mV range in October to the +150- to +220-mV range at the end of March . Values had dropped to less than +75 mV at 15, 30, and 60 cm by the end of June. Redox at 120 cm was slightly higher (+145 mV). Oxidizing conditions returned in July, ranging from +375 mV at 60 cm to +612 mV at 30 cm. These

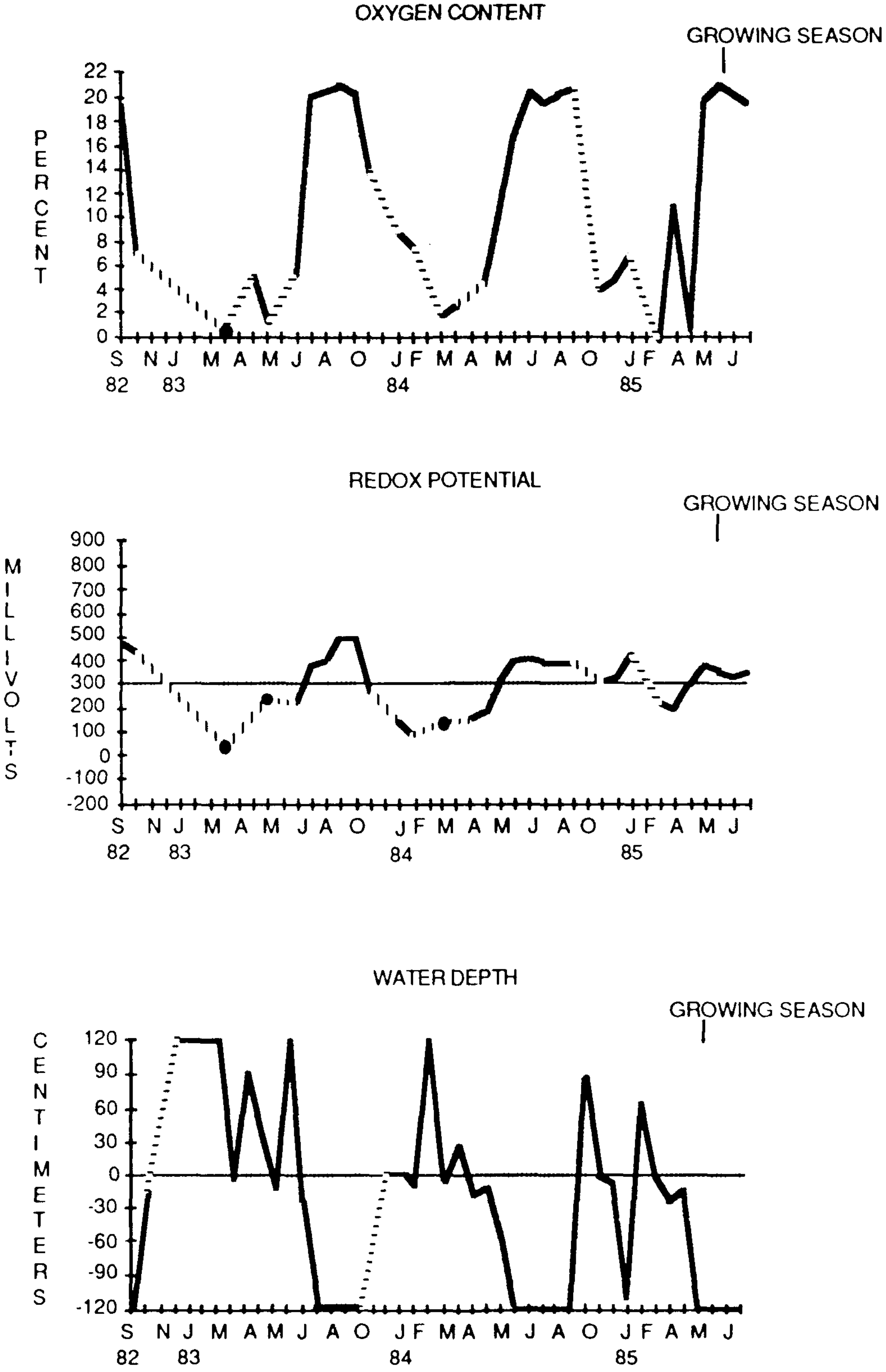


Figure 35. Oxygen content and redox potential at 30 cm with water depth for Rolling Fork Plot 4

conditions prevailed for the rest of the year at these depths; however, redox at 120 cm was less responsive and was never greater than +240 mV during this period.

263. Only five soil moisture measurements were taken in 1982-83 due to the high water levels. Soil moisture ranged from 65 to 72 percent at all depths in September and October. The next measurements were taken in August 1983 and were lowest at 15 cm (48%) and highest at 120 cm (67%). The pattern of increasing moisture with increasing depth was maintained through September and October.

264. 1984. The plot was flooded from January to mid-June with water levels receding below the surface in February and April. Water levels fell steadily until floodwater inundated the site in October and November. Only a few, sporadic oxygen measurements were made during the high-water period. All depths were measured in early February. Oxygen content at 15 cm (15.5%), 30 cm (8.0%), and 120 cm (5.5%) were relatively high with a much lower level at 60 cm (1.5%). The next complete set of measurements was made in mid-June. Oxygen ranged from a low of 1.25 percent at 120 cm to a high of 9.75 percent at 15 cm. Oxygen levels rose steadily at 15, 30, and 60 cm from July to September and were always ≥10 percent. There was little response at 120 cm which remained less than 1.0 percent until September when oxygen content was 9.5 percent.

265. Redox potential at all depths remained relatively stable during the flooding period in the +150- to +280-mV range. It stayed at that level until July when redox at 15 cm (+320 mV) and 30 cm (+450 mV) started to rise. The potential at 60 cm did not respond until September (+400 mV) and was never greater than +265 mV at 120 cm. Only six soil moisture measurements were taken in 1984: February, June through September, and December. These ranged from 67 to 71 percent at all four depths in February and in June. By July, soil moisture had started to decline, and the lowest levels were recorded in September. The greatest variation with depth was measured in September, ranging from 47 percent at 15 cm to 60 percent at both 60 and 120 cm. Soil moisture returned to the 65- to 70-percent range by December.

266. 1985. Surface water inundated the plot again in January and February, but flooding duration was much shorter as the water had receded by March. It declined steadily throughout the year but was not less than -120 cm until the end of July. Oxygen content at 15 and 30 cm fluctuated between 13 and 17 percent from March to early May. Oxygen levels were much lower at 60 and 120 cm (0 to 7%) during this period. By the end of May, the 15-, 30-, and 60-cm depths were well oxidized (>17%) and remained between 15 and 20 percent for the duration of the study. Oxygen at 120 cm increased very slowly, peaking at 12 percent in August.

267. The same dichotomy between the upper 30 cm and the lower depths of the profile was evident in the redox measurements. Redox potential at 15 and 30 cm increased from around +320 mV in March to greater than +400 mV by April. Values ranged from +320 to +380 mV at 15 cm through August, but remained greater than +500 mV at 30 cm during this period. The 60- and 120-cm depth redox potential was much lower during March (+240 mV) and April (<+200 mV). It had

increased by May (+300 mV) at 60 cm and remained greater than +400 mV through August. Redox at 120 cm increased slightly, but remained less than +300 mV.

268. Soil moisture content in early May ranged from 65 percent at 15 and 120 cm to 69 percent at 30 and 60 cm. It fell to a low of 49 percent at 15 cm by the end of May before rising to 58 percent by August. Moisture content at 30 cm was fairly constant at 58 percent from the end of May to August. It ranged from 60 to 65 percent at the 60-cm depth during this time. Soil moisture at 120 cm declined to 58 percent by August.

269. Summary. The soil type at RF5 was Fausse clay (Typic Fluvaquent), a hydric soil. It was deeply flooded for most of the study, but in 1985 the duration was much shorter. The few measurements that were made during flooding showed that the soil was anaerobic and reduced at 30 cm during the growing season in 1983 and 1984 (Figure 36). It was saturated for 55 percent of the 1984 growing season and reduced and anaerobic 62 percent of that time period (Table 3).

270. There is no doubt that this site is deeply flooded annually for long durations and reduced long enough to produce a gleyed B horizon with chroma colors of 2 or less (Appendix N). However, this site was also drained and well-oxidized for significant periods during the year and was dry enough in the fall of 1983 to have cracks in the soil deeper than 120 cm. The typical pedon description of Fausse includes prominent strong brown mottles in the B horizon, indicative of oxidized conditions in the profile (Murphy et al. 1974).

Spring Bayou

271. The Spring Bayou transect was located on the Spring Bayou Wildlife Management Area in Avoyelles Parish, Louisiana (Figure 2). The soils at the Spring Bayou site are from the Mississippi River alluvium. The transect began on a low ridge and gradually declined to a backwater swamp (Figure 37). This transect had the least amount of elevational change among the five studied. Rainfall patterns were quite varied among the 3 years (Figure 38). In 1982-83, the highest rainfall period occurred in November and December 1982 (61 cm), and total rainfall from September 1982 to August 1983 was 185 cm. February 1984 (31 cm) had the highest monthly rainfall for the same period in 1983-84 (total=158 cm). Total rainfall for the 1984-85 period was 144 cm.

272. June through October was the period of highest temperatures (21° to 26° C) and the lowest temperatures occurred in January and February (5° to 12° C). Soil temperatures ranged from 14° to 20° C throughout most of the year. Soil temperatures were fairly constant with depth, varying by only 1° or 2° C. Extremes were buffered by depth as the temperature at 50 cm was lower in the summer and higher in the winter than at 15 cm.

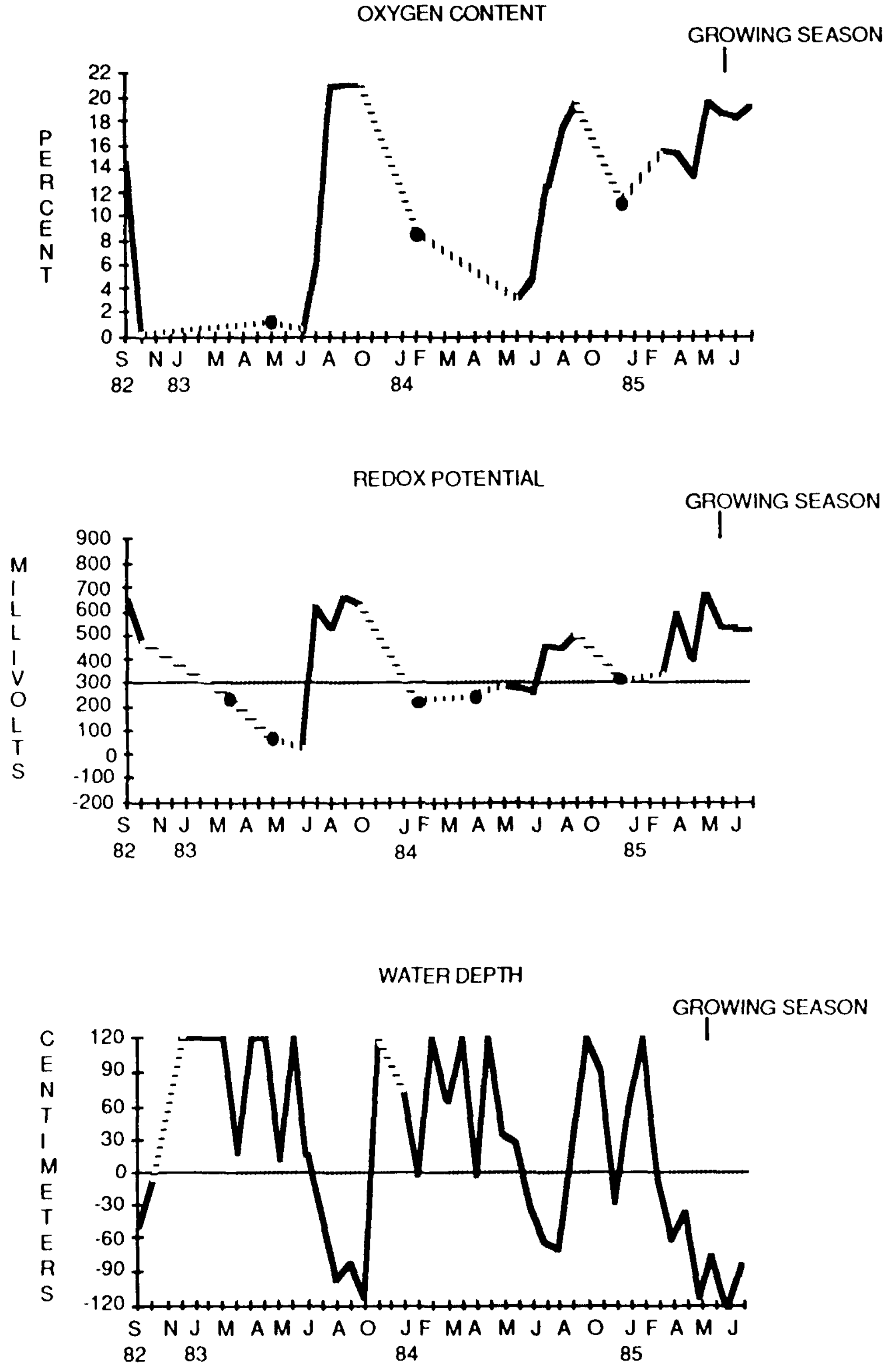


Figure 36. Oxygen content and redox potential at 30 cm with water depth for Rolling Fork Plot 5

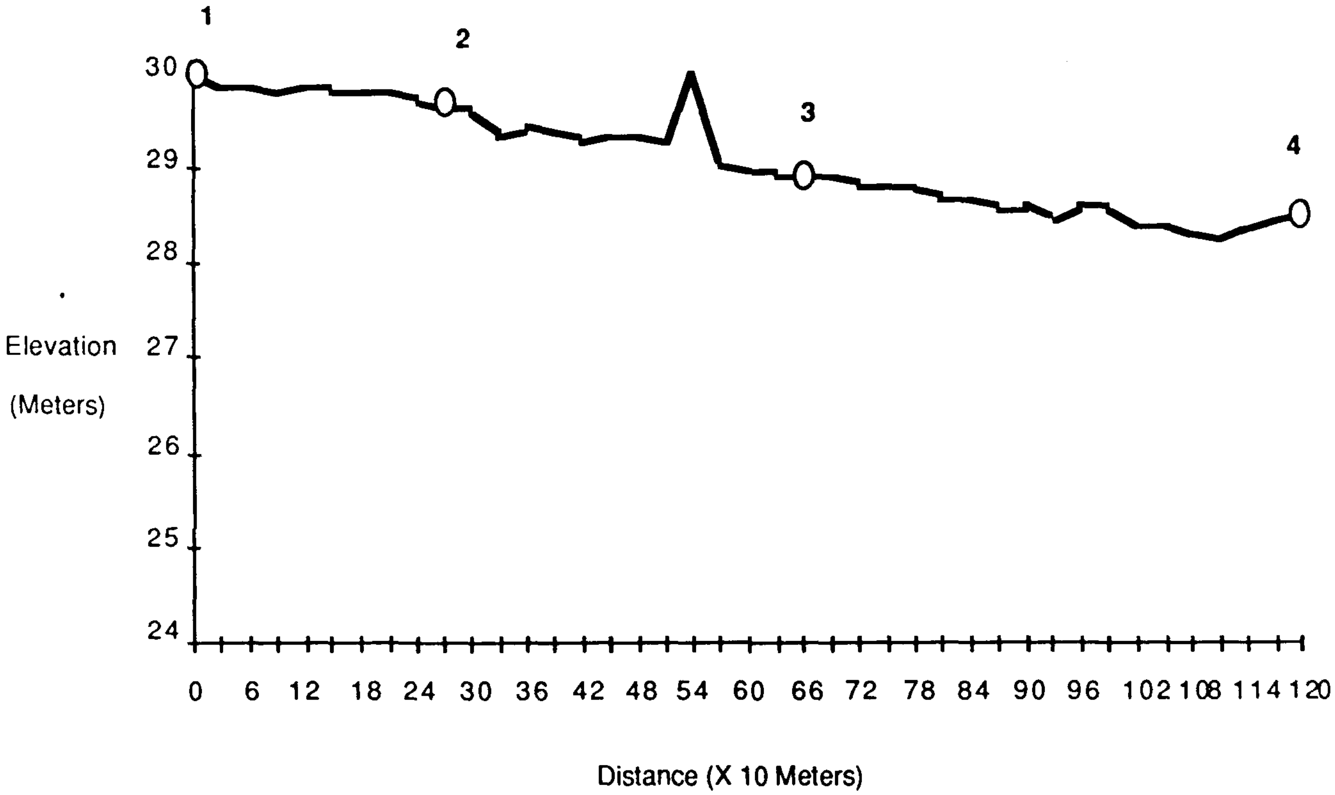


Figure 37. Relative plot elevations for the Spring Bayou transect

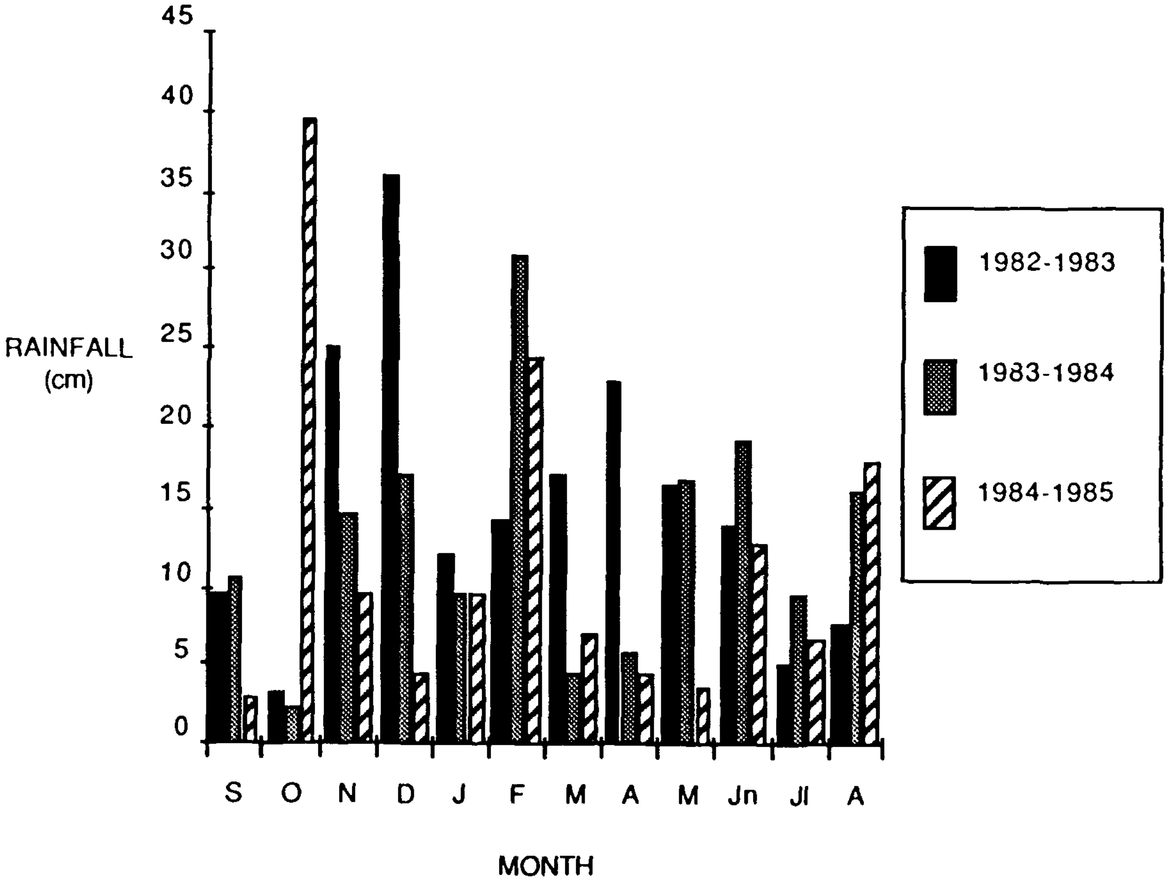


Figure 38. Rainfall patterns for the Spring Bayou transect

Plot SB1

273. This site was on a low, nearly level ridge of Tensas silty clay (Vertic Ochraqualf). The Tensas consists of somewhat poorly drained, very slowly permeable soils developed from clayey, alluvial sediments over loamy sediments. All parameters were significantly correlated at all four depths (Table O1). The best correlations were generally at the 15- and 30-cm depths.

274. 1983. The water table was less than -120 cm in September and October. It was within 25 cm of the soil surface from December to April and fluctuated between -46 and -93 cm until August. It was less than -120 cm the rest of the year. Soil oxygen content at 15 cm was 21 percent in September and 20 percent in October (Appendix P). It ranged from 11 to 18 percent from December to August, with the exception of early May (19.5%), and was greater than 19 percent to December. Oxygen content at 30 cm was 16 to 20 percent from September to January. It ranged from 2 to 7 percent from February until early May (18%) except for late March (12%). Oxygen content declined from 16 percent in July to 8 percent in August and remained above 19 percent the rest of the year.

275. Oxygen content at 60 cm decreased from 18.5 percent in September to 13.5 percent in January and was 6 to 10 percent from February to April (2% in late March). It was less than 4 percent from May until August (12.5%) and declined from 20 percent in September and October to 10 percent in December. Oxygen content at 120 cm decreased from 17 percent in September to December to 7 percent in January. It was less than 5 percent in February and March and again in late May and July. It ranged from 11 to 19 percent the rest of the year.

276. Soil redox potential at 15 cm increased from +450 mV in September to +790 mV in October before falling to a low of -1 mV by February. It ranged from +150 to +250 mV in March and April, except for late March (+50 mV), and was greater than +400 mV the rest of the year with the exception of July (+100 mV). Redox potential at 30 cm decreased from +740 mV in September to +180 mV by December. It was less than +100 mV from January until early May (+310 mV) and was greater than +450 mV from late May to December, with the exception of July (+335 mV) and December (+340 mV).

277. The 60-cm depth redox potential was +295 mV in September and +485 mV in October. It declined from +215 mV in December to +100 mV in late March and was less than +100 mV from April until August (+290 mV). It ranged from +320 to +365 mV from September to November and was +235 mV in December. Redox at 120 cm increased from +395 mV in September to +535 mV in October, then decreased to a low of +20 mV by early March. It ranged from +70 to +155 mV from late March until September (+275 mV). It was greater than +300 mV in October and November and +275 mV in December.

278. Soil moisture content at 15 cm decreased from 40 percent in September to 35 percent in October and ranged from 42 to 48 percent from December to July. It declined to 31 to 39 percent until December (44%). Moisture content at 30 cm decreased from 41 percent in September to 37

percent in October and was 42 to 44 percent from December until September (33%). It increased from 34 percent in October to 42 percent in November and 43 percent in December. Moisture content at 60 cm was 41 to 46 percent during the year, except for September and October when it was 39 percent. It was 31 percent in September and October at 120 cm and ranged from 40 to 43 percent from December to August. It was 30 to 34 percent from September to November and increased to 40 percent in December.

279. 1984. The water table was high in the early part of the year, staying within 25 cm of the soil surface from January to early April. It fluctuated between -57 and -75 cm from late April until June (-114 cm) and was less than -120 cm until December when it rose to -19 cm. Soil oxygen content at 15 cm ranged from 7.5 to 16 percent from January to early April and was greater than 17 percent the rest of the year, except for December when it fell to 15 percent. At the 30-cm depth, it decreased from 16 percent in January to a low of 3 percent by early March and recovered to 14 percent by early April. It was greater than 15 percent the rest of the year. Oxygen content at 60 cm was less than 10 percent from January to June, falling as low as 3 percent in February and late April. It ranged from 14 to 19 percent until December (6.5%). Oxygen at 120 cm was low in the first half of the year, decreasing from 7 percent in January to less than 5 percent from February to June. It fluctuated between 11 and 16.5 percent from July until November (7%) and was 3 percent in December.

280. Soil redox potential at 15 cm declined from +300 mV in January to less than +230 mV from February to early April. It was greater than +400 mV the rest of the year. Redox potential at 30 cm ranged from +130 to +270 mV from January to early April and was greater than +400 mV from late April until December when it declined to +275 mV. Redox potential at 60 cm was lower than at 30 cm ranging from +150 mV to +255 mV from January to June. It fluctuated between +280 and +350 mV from July until December (+225 mV). Redox at 120 cm was similar to the 60-cm depth, ranging from +100 to +210 mV from January to June, with the exception of late April (+285 mV). It fluctuated between +250 and +325 mV from July to November and decreased to +185 mV in December.

281. Soil moisture content at 15 cm was 41 to 48 percent from January to May and decreased to between 31 and 38 percent from June until October (42%). It increased to 45 percent in December. Moisture content at 30 cm was 40 to 44 percent during the year with the exception of July to September when it decreased to between 34 and 38 percent. It ranged from 40 to 45 percent during the year at 60 cm. Moisture content at 120 cm fluctuated between 41 and 44 percent from January to July, declining to a low of 32 percent by September. It increased from 36 percent in October to 42 percent in December.

282. 1985. The water table increased from -32 cm in January to -15 cm by early April. It receded to -83 cm in late April and was less than -120 cm for the duration of the study. Soil oxygen content at 15 cm ranged from 12 to 14 percent from January to early April, remaining

above 17 percent the rest of the year. Oxygen content at 30 cm was 9 to 14.5 percent from January to early April and 14 percent again in June. It was greater than 18 percent the rest of the year. Oxygen at 60 cm was less than 5 percent from January to April, increasing to 14 percent by June, and greater than 17 percent in July and August. Oxygen content at 120 cm ranged from 2.5 to 7 percent from January to April and increased steadily from 10 percent in May to 17 percent in August.

283. Soil redox potential at 15 cm decreased from +360 mV in January to +225 mV in February and March and was greater than +500 mV the rest of the year. Redox potential at 30 cm ranged from +185 to +210 mV from January to March. It increased to +305 mV in early April and remained greater than +480 mV into August. Redox at 60 cm fluctuated between +195 and +220 mV from January to late April. It was +300 to +350 mV from May until August (+435 mV). Redox potential at 120 cm was less than +200 mV from January to late April and ranged from +260 to +325 mV until August (+425 mV).

284. Soil moisture content at 15 cm was 45 to 47 percent from January to early April and declined steadily from 37 percent in late April to 34 percent in June. It was 28 percent in July and August. Moisture content at 30 cm ranged from 40 to 44 percent from January to April and declined from 36 percent in May to 29 percent in July. It was 31 percent in August. Moisture content at 60 cm was 41 to 45 percent from January to June and increased from 31 percent in July to 35 percent in August. It fluctuated between 40 and 43 percent during the year at 120 cm, except in July (26%) and August (30%).

285. Summary. The soil type at SB1 was a Tensas silty clay (Vertic Ochraqualf), and the frequently flooded phase of Tensas is considered a hydric soil. The water table was within 30 cm of the surface for several months during the 1983 growing season, but less than 30 days during the 1985 growing season. The oxygen content at 30 cm was less than 5 percent only once in 1984 and was greater than 5 percent in 1985. Redox potential at 30 cm was very low in 1983; however that depth was not as reduced, and reduction duration was much shorter in 1984 and 1985 (Figure 39). This site was saturated and reduced for 17 percent of the 1984 growing season, and anaerobic for 7 percent of that growing season (Table 3). The SB1 soil profile had a mottled, gleyed B horizon with a matrix chroma of 2 or less (Appendix Q).

Plot SB2

286. This plot was slightly lower in elevation and more frequently flooded than SB1 with the same soil type (Tensas). All parameters were significantly correlated at all four depths (Table O2). The best correlations were at 30 cm with the exception of water table depth and moisture content where it was higher at the 15-cm depth.

287. 1983. The water table rose to -1 cm in December and was +1 cm above the surface in January. It remained within 15 cm of the soil surface from March to April, receding to -77 cm in

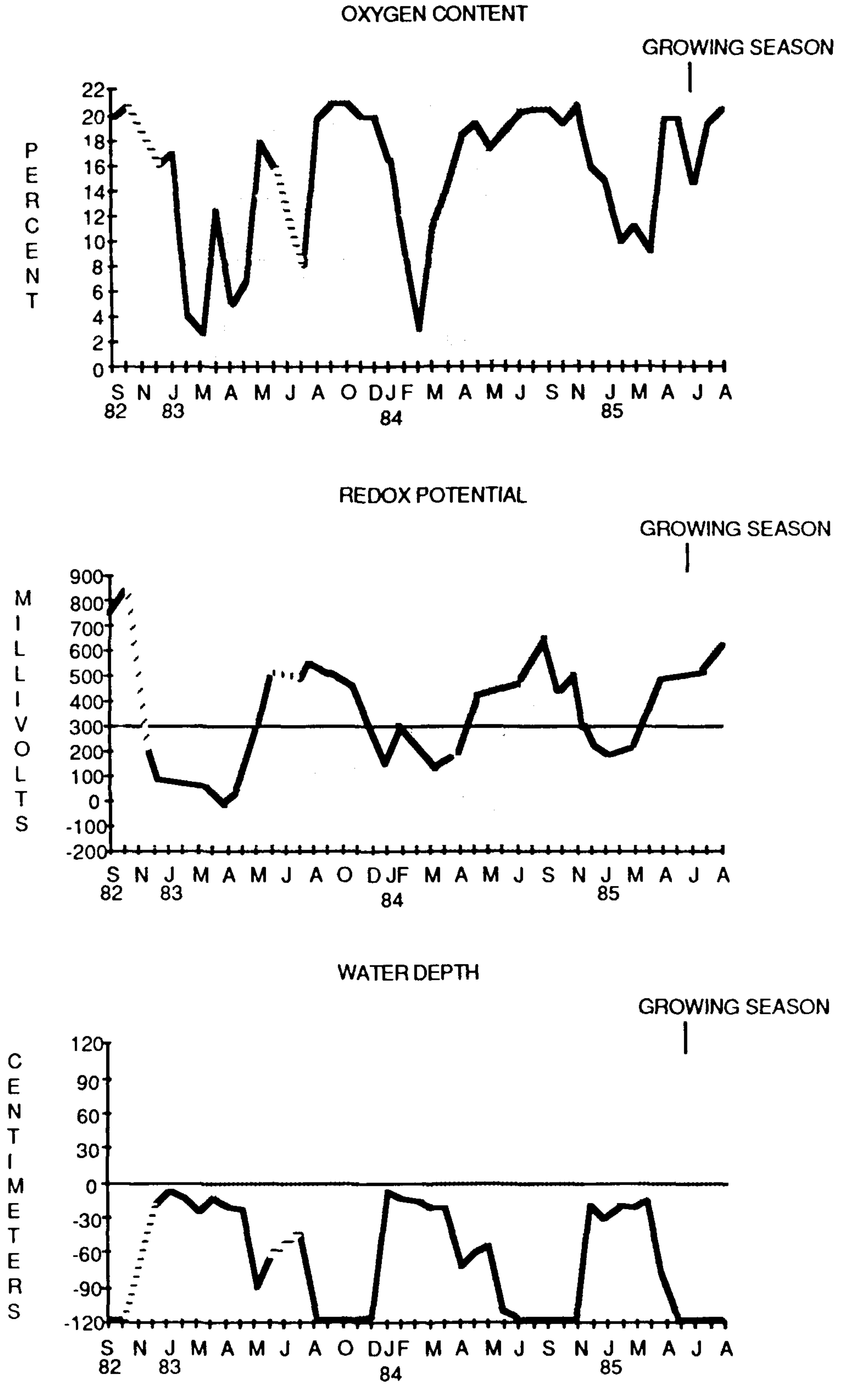


Figure 39. Oxygen content and redox potential at 30 cm with water depth for Spring Bayou Plot 1

early May and rising to -46 cm in late May. The plot was inundated with +8 cm of surface water in July and the water table was less than -120 cm from August to December.

288. Soil oxygen content at 15 cm decreased from 21 percent in September to 3.5 percent in January. It fluctuated between 5.5 and 8 percent in February and March, then increased to 13 percent in April. It was greater than 17 percent the rest of the year, except for July (0%). Oxygen content at 30 cm declined from 18.5 percent in September to 6 percent in December. It was less than 6 percent from January to July and remained above 17 percent from August to December. Oxygen at 60 cm decreased from 15.5 percent in September to 6.5 percent in January and was less than 5 percent from February to July with the exception of early April (8.5%) and May (8.5%). It increased to 13 percent in August and was greater than 15 percent the rest of the year. Oxygen content at 120 cm declined from 16.5 percent in September to 2 percent in December. After recovering to 9 percent in January and 6 percent in February, it was 5 percent or less from March to July, except for early April (7%). It increased to 7.5 percent in August and was 16 percent or greater until December (12%).

289. Soil redox potential at 15 cm decreased from +595 mV in September to -65 mV in December. It ranged from -135 to -5 from January to July, increased to +80 mV by August, and fluctuated between +360 and +420 mV the rest of the year. The 30- and 60-cm depths were well oxidized (> +480 mV) in September and October, became strongly reduced (-10 to -140 mV) from January to July, and returned to oxidized conditions (+340 to +580 mV) from September to December. Redox potential at 120 cm declined steadily from +545 mV in September to +265 mV in January. It was less than +100 mV from February to July, increased to +385 mV in August, and was greater than +450 mV the rest of the year.

290. Soil moisture content at 15 cm declined briefly from 46 percent in September to 41 percent in October. It ranged from 47 to 51 percent from December to August, fell to 38 percent in September and October, and increased to 45 percent in November and 50 percent in December. Moisture content at 30 cm ranged from 40 to 44 percent during the year with the exception of October (37%), September (32%), and October 1983 (32%). Moisture content at 60 and 120 cm ranged from 41 to 46 percent during the year, except for October (39%) at 120 cm.

291. <u>1984.</u> The water table was within 4 cm of the soil surface from January to early April. It receded to -66 cm by early late April, fluctuated between -46 and -85 cm in May and June, and was less than -120 cm from July until November (-107 cm). It was -6 cm in December.

292. Soil oxygen content at 15 cm decreased from 19 percent in January to a low of 7 percent in late March. It was greater than 15 percent from April until December (14.5%). Oxygen content at 30 cm fell from 12 percent in January to 3 percent in February and was less than 4 percent until late April (12%). It was 15 percent or greater from April until December (8.0%). Oxygen content at 60 cm declined from 14 percent in January to 13 percent in February, was 5 percent or less in March and April, then fluctuated between 13 and 19 percent from May until

December (9%). Oxygen at 120 cm was less than 5 percent from January to June with the exception of January (9%) and late May (9%). It ranged from 14 to 17 percent from July to October, then decreased to less than 5 percent in November and December.

293. Soil redox potential at 15 cm fluctuated between -35 and +180 mV from January to May with the exception of February (+440 mV) and early May (+325 mV). It was greater than +350 mV from June until December (+95 mV). Redox potential at 30 cm declined from +450 mV in February to less than +145 mV from March to May. It was greater than +440 mV from June until December (+335 mV). Redox potential at 60 cm was greater than +430 mV during the year, except for March and April (+60 to +130 mV). Redox potential at 120 cm was less than +50 mV from January to June (+510 mV in February). It was greater than +430 mV from July to October, then declined to +300 mV in November and +220 mV in December.

294. Soil moisture content at 15 cm ranged from 48 to 52 percent during the year with the exception of July (43%), August (44%), and September (40%). Moisture content at 30 cm ranged from 41 to 45 percent during the year, except for July to September when it ranged from 33 to 38 percent. Moisture content at 60 and 120 cm fluctuated between 40 and 47 percent from February to December.

295. 1985. The water table was with 10 cm of the soil surface from January to early April. It receded from -71 cm in late April to -109 cm in May and was less than -120 cm the rest of the study. Soil oxygen content at 15 cm fluctuated between 10 and 14 percent from January to early April and was greater than 17 percent the rest of the year. Oxygen content at 30 cm was less than 5 percent from January to until late April (11%) and was greater than 14 percent from May to August. Oxygen content at 60 cm was less than 5 percent from January to early April. It increased from 7.5 percent in late April to 12 percent in May and was 15 to 18 percent from June to August. Oxygen content at 120 cm was less than 5 percent from January to May and increased from 9.5 percent in June to 17.5 percent by August.

296. Soil redox potential at 15 cm ranged from +40 to +200 mV from January to early April and was greater than +450 mV the rest of the study. Redox potential at 30 cm fluctuated between +25 and +235 mV from January until May (+345 mV). It was greater than +550 mV in June, July, and August. Redox at 60 cm increased from +120 mV in January to +235 mV in March and early April. It was greater than +400 mV the rest of the year, except for May (+340 mV). Redox potential at 120 cm ranged from +80 to +190 mV from January to May with the exception of March (+275 mV). It increased from +340 mV in June to +405 mV by August.

297. Soil moisture content at 15 cm was 48 to 51 percent from January to April and ranged from 39 to 42 percent from May to August. It was 40 to 44 percent from January to May at 30 cm and declined to 33 to 37 percent from June to August. Moisture content at 60 and 120 cm ranged from 43 to 46 percent from January to June and was 36 to 40 percent in July and August.

298. Summary. Plot SB2 was also a Tensas soil, but was the frequently flooded phase and considered hydric. It was saturated in the upper 30 cm for more than 30 days in the 1983 and 1984 growing seasons, but less than 30 days during the 1985 growing season. The soil was essentially anaerobic and strongly reduced at 30 cm during these saturated periods (Figure 40). It was saturated and anaerobic for 17 percent of the 1984 growing season, but reduced for 23 percent (Table 3). The soil profile was mottled and gleyed in the B horizon with a matrix chroma of 2 or less (Appendix Q).

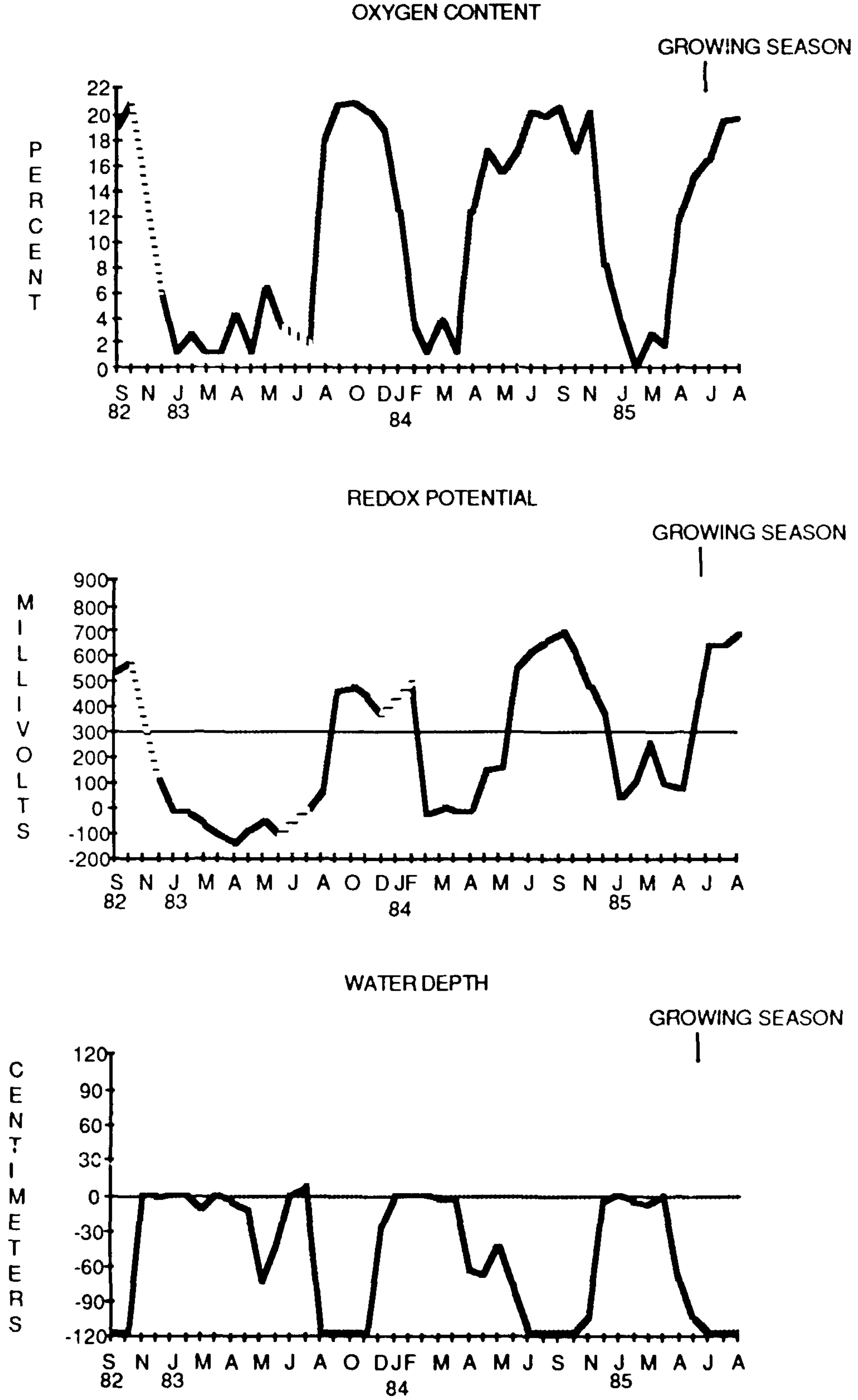
Plot SB3

299. This plot was in a slackwater area of Kobel clay (Vertic Haplaquept) that was flooded for long durations during the growing season. The Kobel consists of poorly drained, very slowly permeable soils formed from clayey, alluvial material. All parameters were significantly correlated at all depths (Table O3). A majority of the best correlations were found at the 30-cm depth.

300. 1983. The plot was inundated with surface water from December (+30 cm) to July (> +120 cm), except for early May when the water table was at the surface. No water table was detected in the upper 120 cm of the profile from September to November, and there was +3 cm of surface water in December.

301. Soil oxygen content at 15 cm declined from 20 percent in October to 14 percent in December. It was 5 percent or less during the rest of the year with the exception of September to November (20 to 21%). *Oxygen content at 30 cm decreased from 20 percent* in October to 12 percent in December. It ranged from 0 to 6 percent from February to August and was 14 to 20 percent from September to November. It was 6 percent in December. Oxygen content at 60 cm was 17 percent in October and declined to 9 percent by December. It was less than 5 percent from February to August, ranged from 11 to 19 percent from September to November, and was 4 percent in December. Oxygen content at 120 cm fluctuated between 9 and 16 percent from October to February. It was 6 percent or less from March to September and again in December. It was 17 percent in October and 11 percent in November.

302. No redox data were collected from December to February, the entire month of April, the end of May, and July because of deep flooding. Soil redox potential at 15 cm was +490 mV in September and +510 mV in October. It ranged from -50 to +175 mV from March to August, then increased from +250 mV in September to greater than +425 mV in October and November. It was -25 mV in December. The 30-cm depth was well oxidized in September 1982 and October 1982 (+585 to +595 mV) and from September to November 1983 (+420 to +485 mV). Redox potential was +175 mV in early March, and the 30-cm depth was strongly reduced (-150 to -50 mV) from the end of March to August and again in December. Redox potential at 60 cm decreased from +445 mV in September to +195 mV by early March. It ranged from -115 to +95 mV the rest of the year, except for October (+340 mV) and November (+395 mV). Redox potential at 120 cm declined



OXYGEN CONTENT

REDOX POTENTIAL

WATER DEPTH

Figure 40. Oxygen content and redox potential at 30 cm with water depth for Spring Bayou Plot 2

from +355 mV in September to +155 mV in March. It was less than +100 mV from May to September and from +125 to +225 mV the rest of the year.

303. Soil moisture content was not measured from December to April, the end of May, and July because of the high surface water. Moisture content in September and October ranged from 48 to 51 percent at 15 and 30 cm to 43 to 45 percent at 60 and 120 cm. In early May, soil moisture content declined from 58 percent at 15 cm to 44 percent at 60 cm and increased to 47 percent at 120 cm. Moisture content at 15 cm was 59 percent in August and ranged from 44 to 52 percent from September until December (58%). It was 55 percent at 30 cm in August and fluctuated between 44 and 53 percent from September to December. Moisture content at 60 and 120 cm ranged from 42 to 49 percent from August to September.

304. 1984. Plot SB3 was flooded from January (+10 cm) through early April (+3 cm). The water table declined to -42 cm in late April before increasing to -4 cm by the end of May. After +15 cm of surface flooding in June, the water table was less than -90 cm until November (+20 cm) and December (+18 cm).

305. Soil oxygen content at 15 cm ranged from 5 to 11 percent through the end of March. It was 10 percent or higher the rest of the year with the exception of November (9.5%) and December (0%). Oxygen content at 30 cm fluctuated between 3 and 7 percent until the end of April (10.75%).After declining to 1.5 percent in May, oxygen content increased above 16 percent except for October (9%), November (missing), and December (missing). Oxygen content at the 60- and 120-cm depths was less than 5 percent except for August through October when it ranged from 10 to 19 percent.

306. Soil redox potential increased from -2.5 mV in January to +301 mV in February before falling to less than +140 mV in March and early April. It ranged from +200 to +300 mV the rest of the year except for August through October (+325 to +385 mV) and December (+175 mV). Redox potential at 30 cm was less than +200 mV throughout the year with the exception of July to October (+300 to +570 mV). The 60-cm depth redox potential was less than +150 mV throughout the year except for February (+339 mV) and August through October (+185 to +370 mV). Redox potential at 120 cm was always less than +300 mV.

307. Soil moisture content was not measured from January to March, May, June, November and December because of surface flooding. Moisture content at 15 and 30 cm ranged from 50 to 60 percent except for October (44%). Moisture content at 60 and 120 cm was generally lower ranging from 42 to 49 percent throughout the year.

308. 1985. The site was inundated with as much as +25 cm of surface water from January (+8 cm) to early April (+3 cm). The water table receded from -41 cm in late April to -75 cm in May and was less than -120 cm for the rest of the study.

309. Soil oxygen content at 15 cm was less than 4 percent from January until the end of April (12%). It was greater than 17 percent the rest of the study. Oxygen content at 30 cm ranged

from 8 to 14 percent from February to June, except for March (1%), and was 18.5 percent in July and August. It was less than 5 percent at 60 cm from January until June (6%) and increased from 12.5 percent in July to 18 percent in August. Oxygen content at 120 cm was less than 5 percent during the year with the exception of July (5.5%) and August (15%).

310. Soil redox potential at 15 cm fluctuated between +200 and +300 mV from January until the end of April (+365 mV) and was greater than +400 mV the rest of the study. It was +100 mV or less from January until June, except for late April (+200 mV), and was +455 mV in June and +425 mV in August. Redox potential at 60 cm was less than +40 mV from January to May, increased to +320 mV in June, and was greater than +400 mV in July and August. Redox at 120 cm ranged from +100 to +250 mV during the year.

311. Soil moisture content at 15 cm fluctuated between 54 and 59 percent from January to July and declined to 41 percent in August. It was 51 to 54 percent during the year at 30 cm with the exception of August (42%). Moisture content at 60 and 120 cm ranged from 44 to 49 percent from January to July. It was 38 percent at 60 cm and 37 percent at 120 cm in August.

312. Summary. Plot SB3 was flooded for most of the 1983 growing season, saturated in the upper 30 cm for several months during the 1984 growing season, and flooded briefly early in the 1985 growing season. Oxygen content at 30 cm was 5 percent or less for most of 1983, but was that low only three times in 1984 and once in 1985. Redox potential at 30 cm was very low (< +100 mV) during the inundation/saturation periods for all three years (Figure 41).

313. The soil type was Kobel clay (Vertic Haplaquept, hydric) and the soil profile was gleyed in the B horizon with mottles and a matrix chroma of less than 2 (Appendix Q). It was anaerobic for 31 percent of the 1984 growing season, but reduced for 46 percent and saturated for 41 percent (Table 3).

Plot SB4

314. This plot was located in a backwater swamp area that was flooded for most of the study. The clay content was less than 60 percent; therefore, this is a taxadjunct to the Fausse (Typic Fluvaquent) series. The Fausse consists of deep, very poorly drained, very slowly permeable soils that formed in clayey alluvium. The relationships among parameters were not as well correlated as at other plots on this transect. Some were not highly significant, and none were significant at the 120-cm depth (Table O4). The 30-cm depth correlations were either the highest or second highest for all paired comparisons.

315. 1983. The plot was deeply flooded (+43 to > +120 cm) from December 1982 to August 1983. The water table was -95 cm in September and -66 cm in October of 1982; it was -3 cm in September and -8 cm in October of 1983. The surface water returned in November (+3 cm) and December (> +120 cm). Because of the flooded conditions, data were collected only in September and October 1982 and in September to November 1983.

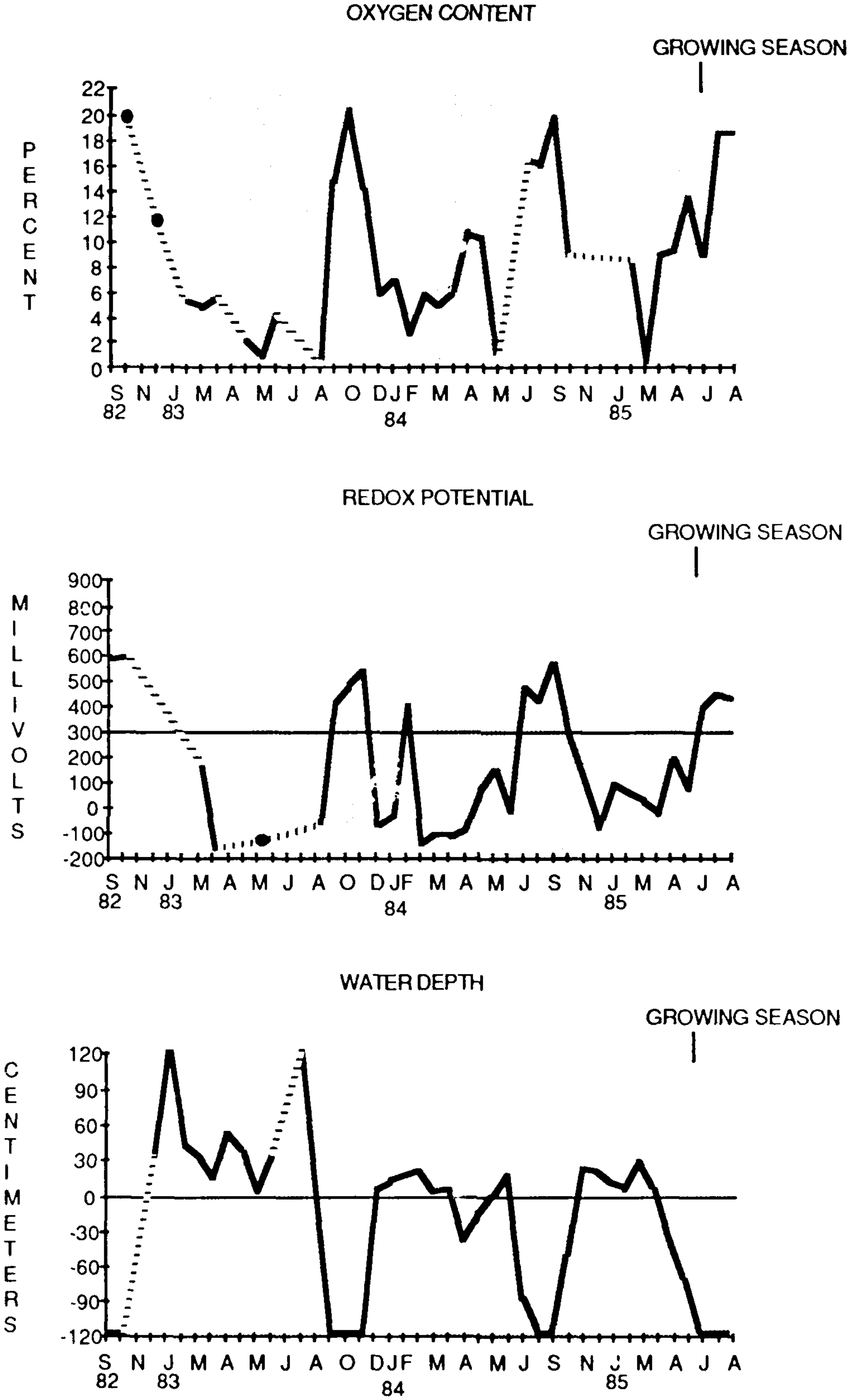


Figure 41. Oxygen content and redox potential at 30 cm with water depth for Spring Bayou Plot 3

316. Soil oxygen content was 16 percent or greater at 15 and 30 cm in September and October. Equipment problems prevented measurement at the 60- and 120-cm depths during these 2 months. Oxygen content at all depths was less than 5 percent in September to November 1983 with the exception of October at 60 cm (6%) and November at 30 cm (7%).

317. Soil redox potential at 15 cm increased from +195 mV in September 1982 to +495 mV in October. It ranged from -60 to +160 mV from September to November 1983. Redox potential at 30 and 60 cm ranged from +370 to +550 mV in September and October 1982. It increased from +240 to +310 mV at 120 cm during this period. Redox at 30 and 60 cm fluctuated between +20 and +150 mV from September to November 1983. It was less than 0 mV at the 120-cm depths during these months.

318. Soil moisture content in September and October 1982 decreased from 56 and 59 percent at 15 and 30 cm to 47 percent at 60 cm. It increased to between 50 and 54 percent at 120 cm. It ranged from 60 to 63 percent at 15 cm and from 57 to 60 percent at 30 cm during September to November 1983. Moisture content at the 60- and 120-cm depths fluctuated between 48 and 51 percent during the same period.

319. <u>1984.</u> The site was inundated with surface water ranging from +3 cm to greater than +120 cm deep from January to June. The water table receded from -9 cm in August to -38 cm in September before rising to -5 cm by October. The plot was flooded again in November and December (> +120 cm).

320. Soil oxygen content was measured from March to May and again from July to October. Oxygen content at all depths was 5 percent or less from March to September with the exception of March at 60 cm (5.5%) and September at 15 cm (9%) and 30 cm (5.5%). Oxygen content in October decreased steadily from 15 percent at 15 cm to 11 percent at 60 cm. It was less than 1 percent at 120 cm.

321. Soil redox potential was measured from April to May and July to October. Redox potential at 15 cm ranged from -40 to +205 mV during the year, except for May (+415 mV). It ranged from -20 to +140 mV with the exception of May (+460 mV) and October (+255 mV). Redox at 60 cm was less than +150 mV during the year, except for May (+530 mV) and October (+250 mV). It fluctuated between -230 and +70 mV at 120 cm with the exception of May (+420 mV).

322. Soil moisture content was measured from July to October at 15 and 30 cm and from August to October at 60 and 120 cm. Moisture content at 15 and 30 cm ranged from 57 to 61 percent during this period. It was 47 to 50 percent at 60 and 120 cm.

323. <u>1985.</u> The site was flooded from January (+25 cm) to April (+10 cm). The water table receded from -3 cm in May to -22 cm in June and -112 cm in July. It was less than -120 cm in August. Soil oxygen content at all depths was less than 1 percent from January to July with the

exception of July at 15 cm (11%) and 30 cm (6.5%). It was greater than 17 percent in the upper 60 cm of the profile and 12 percent at the 120-cm depth.

324. Soil redox potential at all depths ranged from -155 to +215 mV from January to July with the exception of April when it was +300 to +310 mV. In August, it was greater than +460 mV at 15, 30, and 60 cm and +210 mV at 120 cm. Soil moisture content at 15 and 30 cm ranged from 56 to 61 percent from April to July and declined to 40 (15 cm) and 43 (30 cm) percent in August. Moisture content at 60 and 120 cm fluctuated between 47 and 51 percent from April to August, except for August at 60 cm (41%).

325. Summary. Plot SB4 was inundated for almost the entire study period. It was anaerobic and reduced at 30 cm except for a few brief periods (Figure 42). The soil was a Fausse (Typic Fluvaquent, hydric) that was not developed enough to have a B horizon. The C horizon was gleyed and mottled with a matrix chroma of 1 (Appendix Q). It was saturated and anaerobic for 89 percent of the 1984 growing season and reduced for 93 percent (Table 3). However, the soil surface was exposed for a brief period each year, and the profile was oxidized. These processes are reflected by the strong brown mottles in the Cg1 horizon.

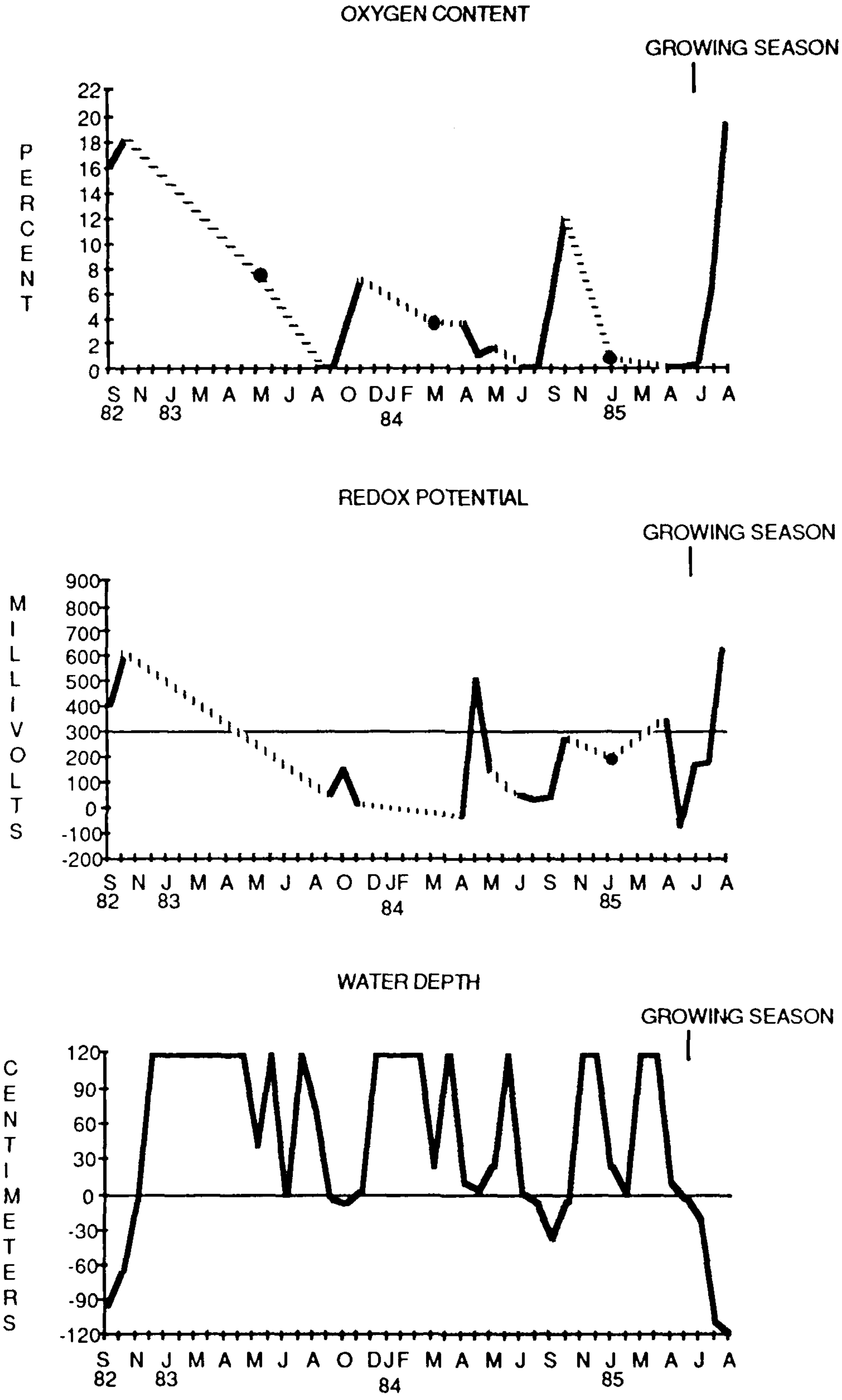


Figure 42. Oxygen content and redox potential at 30 cm with water depth for Spring Bayou Plot 4

DISCUSSION

326. The presence of unique hydrologic, vegetative, and soil characteristics separates wetlands from nonwetlands. For regulatory purposes, wetlands are identified and delineated on the basis of three diagnostic environmental characteristics: hydrophytic plants, hydric soils, and wetland hydrology. The technical approach generally involves field observations of vegetation, soils, and hydrology, and at least one positive wetland indicator from each parameter must be present for an area to be classified as wetland (Environmental Laboratory 1987). As with most natural systems, the degree to which wetland indicators are present or recognizable varies along a continuum from obvious to obscure. This is particularly true in floodplain ecosystems where the extent of flooding may change up and down the elevational gradient over time.

327. Soils have been an important parameter in several wetland classification and delineation efforts. Shaw and Fredine (1956) discussed wetland soil types and the need for soils information in resource-management decisions. The State of Connecticut, in the Connecticut Inland Wetlands Act * (see Anderson 1977), defined wetlands as "lands which consist of any of the soil types designated as poorly drained, very poorly drained, alluvial, and flood plain by the National Cooperative Soil Survey...." This definition relies entirely upon soil type for identifying an area as a wetland. Cowardin et al. (1979) identified undrained hydric soil as an indicator of wetlands. The presence of hydric soils is a diagnostic environmental characteristic used by the CE to identify and delineate wetlands (Environmental Laboratory 1987). A hydric soil is one that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation (US Department of Agriculture 1985).

328. Few investigations have used specific soil parameters to delineate forested wetlands from nonwetlands. Anderson (1977) found significant differences in soil moisture content, pH, and organic matter content among forested wetland, transitional, and nonwetland habitats but concluded vegetation was a better and more easily used indicator. However, he did not relate soil moisture and water table depth to morphological characteristics. Roman, Zampella, and Jaworski (1985) compared depth to seasonal high water table with depth of gley formation along a moisture gradient in the New Jersey Pinelands. They concluded that measured water table levels indicated a consistently higher depth to seasonal high water table than that determined by soil morphology. However, this was based on a one-time water table measurement (of unspecified methodology) during an above-normal rainfall period (Roman, Zampella, and Jaworski 1985). A wetland boundary in a Florida cypress dome was delineated based on organic matter content of the A horizon (Siegel, Latham, and Best 1987). This boundary was in close agreement with one based on a vegetative index. Most of the published literature concerning delineation in forested wetlands

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* Public Act No. 155, Chapter 440, Sections 22a-36 to 22a-45.

is either very site specific (Siegel, Latham, and Best 1987) or emphasizes the vegetation parameter (Roman, Zampella, and Jaworski 1985; Siegel, Latham, and Best 1987; Adams, Buford, and Dumond 1987; Carter, Garret, and Gammon 1988; Wentworth, Johnson, and Kologiski 1988).

329. Timing and duration of inundation/saturation are major factors influencing plant species distribution and soil profile characteristics in bottomland hardwood forests. Most bottomland sites are flooded at some time during the plant dormant season with few detrimental effects; the increase in soil moisture is often beneficial (Broadfoot 1967). However, if flooding/soil saturation continues into the growing season, then anaerobic reducing conditions limit plant growth and survival.

330. Reduction of duration and intensity also affects soil profile characteristics by influencing the type and extent of mottling and soil matrix color. The driving force in this ecosystem is water, and water table depth is a critical point where, generally, the soil is aerobic above the water table and anaerobic below. While soil moisture regimes are defined in terms of groundwater level, the use of diagnostic soil features such as color and mottling to infer soil moisture regime is common (Daniels, Gamble, and Nelson 1971; Simonson and Boersma 1972; Bouma 1983; Pickering and Veneman 1984). These features are also used to identify hydric soils. Mineral soils are considered hydric if the horizon immediately below the A horizon is gleyed, has a matrix chroma of 2 or less when the soil is mottled, or has a matrix chroma of 1 or less when the soil is not mottled. Other field indicators of hydric soils include organic soils, histic epipedons, hydrogen sulfide, aquic or peraquic moisture regimes, ferrous iron, and iron-manganese concretions. The presence of any one of these indicators identifies the soil as hydric under current delineation procedures (Environmental Laboratory 1987).

331. Soil color and mottling are primarily a function of iron and manganese reduction (e.g., paragraph 12), which requires anaerobic conditions, an energy source (i.e., organic matter), and a viable population of anaerobic microorganisms (Bouma 1983). Some limitations and problems are associated with inferring moisture regimes based on color and mottling. Soil reduction may be inhibited by low organic matter or low soil temperatures. Vepraskas and Wilding (1983) described the relationship among water table, soil color, and redox potential for four Alfisols along a toposequence where all four soils were seasonally reduced, but only two had chroma colors ≤2. They attributed this to the low (<1%) organic matter content in the soils with chroma colors >2. Franzmeier et al. (1983) also reported seasonally saturated soils with chroma colors >2 in Indiana. These and other studies illustrate that soil colors correlate more with iron reduction duration, than saturation duration and chroma colors may reflect either current or relict moisture regimes (Bouma 1983, Wilding and Rehage 1985).

332. These concepts of identifying hydric soils and wetlands will be discussed in the context of the results of this project. Larson et al. (1981) identified six distinct ecological zones based on extent of soil saturation or inundation to help delineate bottomland hardwood wetlands. These

zones ranged from open water (Zone I) to upland where water is not a factor (Zone VI). This zonal concept was later revised, and specific soil types and physicochemical properties were identified by zones (Touchet et al. 1987 *). The relationship among these ecologic/hydrologic zones, soil classification, and the oxygen and redox profiles will also be covered since using bottomland hardwood zones in a regulatory framework is being seriously reviewed by both the US-EPA and US-FWS (Roelle et al. 1987). Hydrologic zones adapted from Larson et al. (1981) are currently used in the CE Wetlands Delineation Manual (Environmental Laboratory 1987).

333. The quantitative data collected in this study clearly represent the current moisture regime and soil redox conditions. The graphs of oxygen content at 30 cm, redox potential at 30 cm, and water depth over time for each plot are referred to as oxygen and redox profiles for the purposes of this discussion. These oxygen and redox profiles characterize soil functions in terms of anaerobic and reducing conditions, two critical attributes of wetland soils. Based on these profiles, the sites were classified as functioning wetland, functioning nonwetland, or transitional. Sites were considered transitional when the oxygen and redox profiles were inconclusive, particularly when compared with the nonwetland and wetland profiles. Additional soils data (hydric soils, soil profile descriptions) and, in some cases, vegetation data were used to determine whether these areas were wetland or nonwetland.

Nonwetland Sites

334. The aerobic conditions reflected by the oxygen and redox profiles were conclusive enough to classify five sites as nonwetland: QU1, QU2, RR1, RR2, and RF1. These nonwetland profiles exhibited a fairly flat response with little change through the season (see Figs. 18, 19, 26, 27, and 32). The month-to-month fluctuations reveal the dynamic nature of soils and are natural responses to events such as rainfall. The water table remained low and, as expected, oxygen content and redox potential were high, indicating a well-oxidized profile. With the exception of one or two measurements at QU2 and RR2, these sites were never saturated, anaerobic, or reduced at 30 cm during the study, and none of the soils was listed as hydric by SCS.

335. The soil at RR1 and RR2 (Norwood, Typic Udifluvent) did not have an aquic moisture regime and, because of resistant colors inherited from parent material, soil color was not a relevant diagnostic indicator (Environmental Laboratory 1987). The qualitative diagnostic indicators are consistent with the quantitative assessment that these two plots are not wetlands. This is contrasted by the soils at QU1 (Goldman, Aquic Hapludalf), QU2 (Tensas, Vertic Ochraqualf), and RF1 (Dundee, Aeric Ochraqualf), which had aquic moisture regimes and chromas of ≤ 2. The Tensas (QU2) and Dundee (RF1) belong to aquic suborders indicating periodic saturation throughout the

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* Any further reference to the revised zonal classification scheme refers to this publication.

profile. These two soils also had gleyed B horizons. The Goldman soil (QU1) belongs to the Aquic subgroup which is saturated only in the lower horizons (Soil Survey Staff 1975) and showed no evidence of gleying but had a B horizon chroma color of 2. All of these positive wetland indicators would classify these as hydric soils despite the absence of reducing conditions throughout the study period. At these three sites, the quantitative data contradict the qualitative diagnostic indicators since the oxygen and redox profiles and nonhydric soil status indicate that these sites are not functioning as wetlands. However, they would not be delineated as wetlands under current procedures because of the absence of wetland hydrology. The morphological wetland indicators are probably relict conditions of an earlier moisture regime.

336. Typic Hapludalfs (QU1) were placed in Zone V in the revised zonal classification scheme. The Aquic subgroup has a mottled subhorizon (Soil Survey Staff 1975) which would place it into Zone IV. The Tensas (QU2) and Dundee (RF1) were also classified as Zone IV soils. Soils in this zone are predominantly aerobic with some anaerobic periods, rarely flooded (1 to 10 years/100 years), but saturated for more than 12.5 percent of the growing season. The data for these three plots correspond better with Zone V soils: aerobic throughout the year, water table typically more than 1 meter below the surface, and very rarely flooded (1 year/100 years) (Touchet et al. 1987).

Transitional Sites

337. The oxygen and redox profiles alone were not conclusive enough evidence to delineate 11 plots (PR1, PR2, PR3, PR4, QU3, QU4.A, RF2, RF3, RF4, SB1, SB2) and they were judged as transitional between functioning wetlands and nonwetlands. These plots were seasonally inundated, with the water table rising in late fall and, depending on the year, remaining in the soil profile through the winter and into the growing season. At some sites, both oxygen content and redox potential at 30 cm declined in response to the rising water table and remained low until the water drained from the profile. At other sites, the water table was greater than 30 cm below the soil surface and negligibly affected soil redox conditions in the root zone. In general, these sites were saturated, anaerobic, and reducing at 30 cm for ≤25 percent of the 1984 growing season (Table 3).

338. Almost all of the Pearl River transect was classified as transitional. The overall pattern for PR1 in 1984 and 1985 was one of brief soil saturation during the growing season with an aerobic profile (Figure 11). Just as all the plots can be placed on a moisture or wetness continuum, a similar continuum exists within the transitional group, and PR1 is at the dry end of the spectrum. The Arkabutla soil (Aeric Fluvaquent) at PR1 is not listed as a hydric soil. It was not mottled or gleyed and chroma colors were >2. However, it does have an aquic moisture regime that is a diagnostic indicator of hydric soil (Environmental Laboratory 1987). The combination of the aerobic profile and nonhydric soil characteristics is evidence that this site is nonwetland. The

quantitative data for the PR1 site support the soil morphology (with the exception of the aquic moisture regime) and the nonwetland status of the site.

339. Aeric Fluvaquents were placed in Zone IV of the revised zonal classification. This site fits the description of Zone IV soils: fluctuating water table that may extend to the surface and rarely flooded (1 to 10 years/100 years). It is a dry Zone IV soil since it was not reduced and the water table was not at the soil surface for more than 12.5 percent of the growing season.

340. The Rosebloom (Typic Fluvaquent) soil at plots PR2, PR3, and PR4 is listed as a hydric soil. The hydric designation was substantiated by the gleyed B horizons, mottles, iron and manganese concretions, and matrix chromas of ≤2 at all three sites. All of these characteristics are positive indicators of hydric soils. All three of these sites displayed the typical seasonal pattern of anaerobic, reducing conditions in the early growing season in both 1984 and 1985 (Figure 12-14). These soil redox conditions existed for 10 to 20 percent of the 1984 growing season. Based on the presence of hydric soils and the oxygen and redox profiles, plots PR2, PR3, and PR4 are wetlands. The hydric soil status, qualitative observations, and wetland nature of these sites are supported by the data. Typic Fluvaquents were placed in Zone II in the revised zonal classification. Soils in this zone are described as saturated and anaerobic throughout the year with the soil surface exposed only during extended dry periods. These plots do not fit that description as they were drained and oxidized for most of the growing season.

341. Plots RF2, RF3, and RF4 of the Rolling Fork transect were also classified as transitional sites based on the oxygen and redox profiles (Figure 33-35). Unlike plots PR2, PR3, and PR4 of the Pearl River transect, these plots were located on three separate soil types. However, the Kobel (RF2), Tunica (RF3), and Sharkey (RF4) soils are all Vertic Haplaquepts and had gleyed and mottled B horizons with low (≤2) chroma colors. These are hydric soils based on their soil morphology, and Kobel and Sharkey are listed as hydric by the USDA Soil Conservation Service (SCS). Only the frequently flooded phase of Tunica is listed as hydric. Site RF3 was classified as frequently flooded since it flooded 2 out of the 3 years of the study, and one of those years was 1984, the "typical" weather year. The quantitative data, qualitative profile descriptions, and presence of hydric soils are all evidence that these three plots are wetlands.

342. Vertic Haplaquepts were placed in both Zone III and Zone IV in the revised zonal classification.The flooded phase of Sharkey was considered a Zone III soil: predominantly anaerobic with short aerobic periods and inundated/saturated for 25 to 75 percent of the growing season. Both RF2 and RF4 were predominantly aerobic with short anaerobic periods, but were inundated for 25 percent or more of the 1984 growing season. Tunica soils (RF3) were placed in Zone IV in the revised zonal classification. This site fits most of the criteria: predominantly aerobic with some anaerobic periods and saturated 12.5 to 25 percent of the growing season. However, Zone IV soils are rarely flooded (1-10 years/100 years) and plot three was described as frequently flooded. This is a critical distinction as only the frequently flooded phase of Tunica is considered a

hydric soil. Frequently flooded is defined as flooding which is likely to occur often (>50 years/100 years) under usual weather conditions (USDA 1985).

343. Sites QU3 and QU4.A were classified as transitional but do not readily fit in either the nonwetland or transitional group. These plots were inundated by two discrete events in 1984: one at the beginning of the growing season and the other at the end. Although they are listed as being inundated/saturated for 20 percent of the 1984 growing season, the longest single event encompassed only 12 percent. However, neither site was anaerobic during the 1984 growing season, and QU3 was briefly reducing. This places QU3 and QU4.A at the dry end of the transitional group along with PR1. Unlike PR1, the Kobel soil at QU3 and QU4.A had a gleyed B horizon with chromas of ≤2 and is also listed as hydric by the SCS. The soil classification and profile characteristics reveal a hydric soil, and the landscape position augments this conclusion. However, the oxygen and redox profiles (Figure 20 and 21) suggest that the saturation duration in 1984 and 1985 was not sufficient to induce anaerobic conditions. Based on the quantitative data, these plots were not functioning as wetlands; however, the hydrologic regime does not fit the nonwetland category. The vegetative parameter supports the wetland category as the overstory at QU3 was dominated by *Quercus phellos* (facultative wetland) and *Liquidambar styraciflua* (facultative). These same species were joined by *Ulmus americana* (facultative wetland) as the major overstory components of QU4.A. All of these species are considered typically adapted for life in anaerobic soil conditions under current delineation procedures (Environmental Laboratory 1987). Plot QU3 was located on private property, and the landowner was constructing a greentree reservoir nearby. It is possible that this activity altered the hydrology of the area in 1984 and 1985, since there is some discontinuity between the soil properties and the hydrologic regime. Plot QU4.A represents a true problem site. Despite all of the positive wetland indicators, the short saturation period and the water table depth (which fluctuated around the 30-cm depth) did not produce anaerobic or reducing conditions at the 30-cm depth.

344. Flooded phases of Vertic Haplaquepts are considered Zone III soils, which are described as predominantly anaerobic with short aerobic periods evidenced by brownish mottles in the profile. Both sites have the necessary soil characteristics (gleyed B horizon with a matrix chroma of 1), but were more aerobic than anaerobic and were not saturated more than 25 percent of the growing season in 1984 and 1985. The hydrology and aeration status of QU3 and QU4.A more closely fit the Zone IV criteria.

345. The last two plots in the transitional group are SB1 and SB2 of the Spring Bayou transect. The soil at both sites was Tensas (Vertic Ochraqualf) with a gleyed, mottled B horizon and a matrix chroma of 2 or less. The soil morphological features and aquic moisture regime classify these soils as hydric, but only the frequently flooded phase of Tensas is listed as hydric by SCS. The hydrologic data for SB1 indicate that this soil is not frequently flooded; however, SB2 was described as frequently flooded since it was flooded each year during the study (Figure 39 and

40). For unknown reasons, the 30-cm depth oxygen content at SB1 did not correlate well with redox potential early in the 1983 and 1984 growing seasons. This makes delineation of this site even more difficult. Remaining consistent with the protocol established for these transitional sites, the strong hydric soil characteristics indicate that SB1 is a wetland despite the marginal nature of the oxygen and redox profiles. This classification is also supported by the hydrophytic nature of the overstory plant community, which was dominated by *Quercus lyrata, Q. nuttalli,* and *Carya aquatica,* all obligate wetland species (Environmental Laboratory 1987). This plot was located approximately 10 m from a road, which may have altered the hydrologic regime during soil development and plant establishment. The hydric soil characteristics and the oxygen and redox profiles indicate that SB2 is a wetland.

346. Vertic Ochraqualfs were placed in Zone IV of the revised classification. Soils in this zone are predominantly aerobic with some anaerobic periods, rarely flooded (1 to 10 years/100 years), but saturated 12.5 to 25 percent of the growing season. Site SB1 was saturated for more than 12.5 percent of the growing season, but not to the surface. However, SB2 was described as frequently flooded since it was flooded each of the 3 years of the study. This is a critical distinction as only the frequently flooded phase of Tensas is considered a hydric soil.

347. The problem with transitional areas is not unexpected. There are certainly temporal scaling problems in bottomland hardwood forests with hydrologic alterations occurring more rapidly than changes in vegetation or soil morphology (Brinson et al. 1987). It is quite possible that the present hydrologic regime is different from that which influenced overstory establishment and soil profile development. If this is the case, analysis of the understory vegetation may be instructive. Hydrologic measurements other than percent growing season inundation may also be important determinants of positive wetland indicators in this ecosystem. Unresolved are the effects of infrequent, large-scale flood events (e.g., 1983) that may occur on a cyclical pattern or full-year flooding (as opposed to just during the growing season).

Wetland Sites

348. Eight sites were delineated as wetlands based solely on the oxygen and redox profiles: PR5, QU4.B, QU5, RR3, RR4, RF5, SB3, and SB4. These sites were characteristically saturated, reduced, and anaerobic at 30 cm for long periods during the growing season (Figure 15, 22, 23, 28, 29, 36, 41, and 42). Many sites had a limited number of data points because deep flooding prevented measurement of the equipment. Inundation duration for these plots ranged from 37 to 100 percent of the 1984 growing season. Typic Fluvaquents were the most frequently encountered soils in this wetland group. The soils at PR5 (Arkabutla), QU5 (Fausse), RF5 (Fausse), RR4 (Yorktown), and SB4 (Fausse) all belonged to this soil subgroup. Typic Fluvaquents were placed in Zone II and are described as being saturated and anaerobic throughout

the year, exposing the soil surface only during extended dry periods. The current moisture regime and redox regime of QU5, RR4, and SB4 best fit the zonal classification criteria as they were saturated, reduced, and anaerobic for 100 percent of the 1984 growing season (90% for SB4, see Table 3). However, even these three sites had water tables below 30 cm at some time during the study. The PR5 and RF5 sites were well below the Zone II hydrologic criteria during the 1984 growing season. The oxygen and redox profiles for RF5 were also less definitive than those of the other sites in this group. The source of flooding, Steele Bayou, was dredged downstream of the transect in 1984, and it is difficult to isolate the impact of the dredging; however, RF5 was saturated for only 11 percent of the 1985 growing season and was not anaerobic or reducing. This is a significant decline from the saturated, anaerobic, and reducing conditions present for 50 to 60 percent of the 1984 growing season.

349. Plots QU4.B and SB3 were located on Kobel soil (Vertic Haplaquept), and the soil type at RR3 was Moreland (Vertic Hapludoll). All of these soils are listed as hydric by SCS and all were described with gleyed, mottled B horizons with chroma colors ≤ 2 (except for the Yorktown and Moreland which are resistant to color change). The quantitative soil data, qualitative profile descriptions, and hydric soil designations provide conclusive evidence that these sites are functioning as wetlands. The Moreland soil corresponds with the frequently flooded Sharkey (Vertic Haplaquept) of the Mississippi River floodplain, and flooded phases of Vertic Haplaquepts are considered Zone III soils. Zone III soils are predominantly anaerobic, frequently flooded (51 to 100 years/100 years), and inundated 25 to 75 percent of the growing season. These three sites fit the hydrological criteria but were more aerobic than anaerobic.

350. The 30-cm depth oxygen levels at SB3 in 1984 and 1985 were higher than expected given the redox potential and hydroperiod. The oxygen and redox profiles would have easily classified the site as wetland had the oxygen levels been lower in 1984. However, the elevated oxygen levels were probably caused by the limitations of the diffusion chamber design. Atmospheric air was injected into the diffusion chambers to repair them following damage from animals, vandals, or flooding in the spring of 1984 and 1985. The equilibration time required to assimilate the 21 percent oxygen was probably lengthened by the low soil temperatures (12 to 17° C) during this period and the very low organic matter content (0.6%) in the B horizon (Table D5).

Soil Morphology and Hydrologic Regimes

351. Overall, there was good agreement among the soil profile characteristics, hydrologic regime, and wetland status of the site. The quantitative data supported the qualitative diagnostic indicators at 19 of the 24 plots. However, at three nonwetland sites that were never inundated/saturated, the diagnostic soil profile indicators were positive for hydric soils. With the exception of sites RR1 and RR2 (which are resistant to soil color change) and PR1, all the sites

had low (≤ 2) chroma colors and most were gleyed (Table 4). This indicates that many bottomland hardwood soils would be considered hydric by the delineation procedure. This is particularly significant when the vegetation parameter is considered. All of the overstory species present on these plots, with the exception of two species on RF1 only, are classified as facultative, facultative wetland, or obligate wetland (Environmental Laboratory 1987). A majority of the species commonly found as Zone V dominant types (Wharton et al. 1982) are also listed as facultative or wetter. It appears, then, that a high percentage of the bottomland hardwood ecosystem satisfies two of the three wetland parameters with hydrology determining whether a site is delineated as a Section 404 wetland.

352. There was less agreement between soils and hydrology within the ecologic zonation concept. Almost all of the sites were classified in higher (drier) zones (Table 4) based on hydrologic criteria (Environmental Laboratory 1987) as opposed to soil taxonomy (Touchet et al. 1987). In most cases, the plot was shifted only one zone. However, at Pearl River, substantial differences of two or three zones existed. Typic Fluvaquents appear to be a very diverse soil subgroup. The low-energy, backswamp areas of Red River (RR4) and Spring Bayou (SB4) were characteristic of the description of Zone II soils. However, the higher energy sites of Pearl River (PR2-PR5) and Rolling Fork (RF5) were inundated and anaerobic for as little as 10 percent of the growing season and were well oxidized for the remainder. The frequent, short-duration flood events do not allow reduction of the soil profile in comparison to less frequent, longer duration flooding. Differences in zonal classification also exist, depending on the year used to assess hydrologic regime. The utility of the zonal concept in a regulatory framework appears to be limited in bottomland hardwood forests.

Table 4

Wetland Classification and Hydrologic Zonation

Site	Wetland Class*	Ecologic Zone Determined By Hydrology**	Ecologic Zone Determined By Soil	Hydric Soil†	Hydric Characteristics††
Pearl River					
PR1	NW	V	IV	N	Aquic moisture regime
PR2	W	V	II	Y	Gleyed, chroma ≤2
PR3	W	V	II	Y	Gleyed, chroma ≤2
PR4	W	IV	II	Y	Gleyed, chroma ≤2
PR5	W	III	II	Y	Gleyed, chroma ≤2
Quimby					
QU1	NW	VI	V	N	Aquic, chroma ≤2
QU2	NW	VI	IV	N	Gleyed, chroma ≤2
QU3	W	IV	III	Y	Gleyed, chroma ≤2
QU4.A	NW	IV	III	Y	Gleyed, chroma ≤2
QU4.B	W	III	III	Y	Gleyed, chroma ≤2
QU5	W	II	II	Y	Gleyed, chroma ≤2
Red River					
RR1	NW	VI	V	N	‡
RR2	NW	VI	V	N	‡
RR3	W	II	III	Y	Chroma ≤2
RR4	W	II	II	Y	Aquic, chroma ≤2
Rolling Fork					
RF1	NW	VI	IV	N	Gleyed, chroma ≤2
RF2	W	IV	III	Y	Gleyed, chroma ≤2
RF3	W	IV	IV	Y	Gleyed, chroma ≤2
RF4	W	III	III	Y	Gleyed, chroma ≤2
RF5	W	III	II	Y	Gleyed, chroma ≤2
Spring Bayou					
SB1	W	IV	IV	N	Gleyed, chroma ≤2
SB2	W	IV	IV	Y	Gleyed, chroma ≤2
SB3	W	III	III	Y	Gleyed, chroma ≤2
SB4	W	II	II	Y	Gleyed, chroma ≤2

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* Based on soils data (Part I) where NW = nonwetland and W = wetland.

** Hydrology - 1984 growing season inundation (after Environmental Laboratory 1987); Soil - Touchet et al. (1987).

† SCS list (USDA 1985).

†† Diagnostic hydric soil indicators from CE Wetlands Delineation Manual (Environmental Laboratory 1987).

‡ Soil colors resistant to reduction and cannot be used as indicator.

CONCLUSIONS

353. The results indicate that large parts of the bottomland hardwood forests in the Lower Mississippi River Valley are not inundated or saturated for long periods during the growing season. There are certainly very wet, almost permanently inundated sites, but those areas that receive seasonal or cyclical inundation are oxidized and aerobic throughout the root zone for most of the growing season.

354. There is a wide range of hydroperiods and reducing conditions among soils at both the subgroup and series level. The Fausse series ranged from reducing for less than 50 percent of the growing season to 100 percent. The Typic Fluvaquent subgroup was found in an array of oxygen and redox regimes, ranging from total anaerobiosis during the growing season to only 10 percent. The range of conditions was also evident in the ecological zonation concept where only a few sites met the hydroperiod or soil oxygen criteria and those that did just barely qualified; most were drier than specified.

355. Overall, the quantitative data supported the qualitative diagnostic indicators, hydrologic regime, and wetland/nonwetland status of the sites. Diagnostic wetland soil indicators were present in soils that were saturated and reduced for as little as 10 to 15 percent of the growing season. While this seems a short inundation period, it does qualify as flooding for long duration, which is one of the hydric soil criteria (USDA 1985). These soils had gleyed subsurface horizons with matrix chromas of 2 or less, and were listed as hydric soils.

356. The presence of three sites with low chroma colors and gleyed horizons that were never saturated or reduced identifies one weakness of the current wetland delineation approach: soils are either hydric or nonhydric with no intermediate classification. These morphological characteristics are likely relict conditions from a previous moisture regime, not indicators of the current regime, and they are definitely not hydric soils. The qualifications for hydric soils are much broader than those specified by the USDA (1985) and, in addition to the nonhydric soils with hydric soil colors above, the presence of ferrous iron does not necessarily mean the soil is a hydric soil. It may be beneficial to have an intermediate category for soils with hydric characteristics.

357. Many bottomland hardwood soils would be considered hydric by the current delineation procedure. This is particularly significant when the vegetation parameter is considered since many bottomland species are classified as facultative or wetter (Environmental Laboratory 1987). It appears, then, that a high percentage of the bottomland hardwood ecosystem satisfies two of the three wetland parameters. Hydrology is the determining factor for these sites, and proper assessment of the current moisture regime is critical.

PART II: GREEN ASH ROOT RESPONSES AS A SOIL WETNESS INDICATOR

INTRODUCTION

358. The unique properties and ecological importance of wetlands have stimulated keen interest in developing reliable and efficient indicators of soil wetness. Because of the long recognized relationship between the floristic composition of a site and soil wetness, there has been much effort toward developing methods to delineate wetlands based on plant communities. The importance of this trend is underscored by the strong emphasis placed on vegetation in the present legal definition of wetlands (cf. paragraph 2). Delineating wetlands based on community composition is fraught with complications because of community differences due to geography, climate, age, and disturbance of stands. An alternate approach would consider the expression of plant adaptations to flooding at the individual plant level. Root oxidation and anaerobic respiration are cited frequently as important adaptive responses to flooded soil conditions (Armstrong 1968, Hook and Brown 1973, Keeley 1979). However, the possibility of using them as indicators of waterlogged site conditions apparently has not yet been investigated.

359. Root oxidation can result in the formation of an oxidized coating on the root surface, the amount of which is thought to be a function of the amount of reduced iron and manganese present (Bacha and Hossner 1977; Taylor, Crowder, and Rodden 1984) and the oxidizing capacity of the roots (Barlett 1961, Mendelssohn and Postek 1982). One of the most intensively studied aspects of anaerobic respiration is alcohol dehydrogenase (ADH) activity (John and Greenway 1976; Keeley 1979; Chang, Hammett, and Pharr 1983). This enzyme (EC 1.1.1.1.) catalyzes a step of the fermentation process that yields ethanol, CO_2, and energy from sugar. In green ash (*Fraxinus pennsylvanica* Marsh.) the ratio of ethanol accumulation under anoxic conditions versus aerobic conditions is quite high, even among flood-acclimated individuals (Hook and Brown 1973, Hook and Scholtens 1978), and one would expect that ADH would increase in this species under flooded conditions.

360. Based on the above considerations, root-coating constituents were chosen as an indicator of rhizosphere oxidation, and ADH activity was selected as an expression of anaerobic respiration. The hypothesis tested was that root-coating constituents and ADH activity of green ash were indicative of waterlogged soil conditions. This study focuses on the effectiveness of root data from a flood-tolerant tree species (Hook and Brown 1973, Hook 1984), green ash, in indicating soil wetness in bottomland hardwood environments.

MATERIALS AND METHODS

Study Sites

361. A total of 14 plots were chosen from the Pearl River (PR1, PR2, PR3, PR4), Quimby (QU1, QU3, QU4, QU5), Red River (RR1, RR2, RR3), and Spring Bayou (SB1, SB2, SB3) transects for this study. At each plot (ca. 10 m in diameter), 30 to 35 green ash seedlings were planted about 1 m apart in a grid pattern.

Plant Material

362. One-year-old, bare-rooted, dormant green ash seedlings were obtained from the Office of Forestry, Louisiana Department of Natural Resources, from their nursery at Columbia, LA. The seedlings were sorted prior to planting in order to reduce variability, and were planted with a planting bar during the late dormant period (March) of 1982. In general, growth and survival were best on the better drained sites (data not shown); however, deer browsing, shading (see basal areas, Table 5), and vandalism obscured this relationship.

363. Root data were collected in late July to early August, and again in mid-September 1983. Four healthy seedlings from each plot were selected for analyses at both sampling periods. Unhealthy seedlings were not collected because they did not have sufficient root tissue for an adequate sample. The inclusion of two sampling dates per transect introduced some temporal variation into the data (analyses not shown); however, it was felt that this would result in a discrimination model based on root variables that were less susceptible to temporal effects.

ADH Extraction and Assay

364. Approximately 0.5 g of small, limber roots was collected from throughout the root system of a seedling, washed, rinsed in distilled H_2O, and placed into a small preweighed plastic bag with 5.0 ml of grinding buffer in the field. This was frozen immediately on dry ice. At the laboratory, frozen root samples were weighed, thawed in ice-cold mortars, ground, and analyzed for ADH within 2 hr.

365. The grinding buffer used for the extraction of ADH (EC 1.1.1.1.) from the roots consisted of 100 m*M* tris(hydroxymethyl) aminomethane (Tris) HCl (adjusted to pH 7.3); 5 m*M* $MgCl_2$; 0.5 m*M* thyaminepyrophosphate; 20 m*M* dithiothreitol; 10% w/v soluble polyvinylpyrrolidone (Anderson 1968, John and Greenway 1976). The sample extracts were assayed at 30° C in the following reaction mixture: 5.4 m*M* $MgCl_2$, 0.26 m*M* nicotinamide adenine dinucleotide

Table 5

Site Characteristics of Study Plots

Plot	Relative Category	pH of A Horizon	Percent B. S.**	Green Ash Importance Value*		Relative Elevation m	Total B.A.†
				Overstory	Understory		
			Pearl River				
PR1	W ††	3.9	20.0	--	--	0	15.7
PR2	W	4.1	24.4	--	--	-0.67	32.7
PR3	W	4.2	31.7	9.9	4.4	-1.34	41.6
PR4	W	4.5	29.7	5.7	--	-1.52	14.9
			Red River				
RR1	M	7.2	82.5	12.2	33.9	0	17.9
RR2	M	7.6	80.9	--	37.4	-1.43	31.2
RR3	W	7.2	81.9	--	--	-3.72	34.3
			Spring Bayou				
SB1	W	4.5	58.1	--	19.8	0	21.4
SB2	W	5.5	77.8	--	42.9	-0.30	15.9
SB3	W	5.0	67.7	3.3	11.2	-1.04	8.6
			Quimby				
QU1	M	4.8	48.4	--	--	0	25.8
QU3	M	5.6	68.7	--	--	-1.04	33.4
QU4	W	4.5	65.5	3.5	34.3	-1.86	35.2
QU5	W	5.6	62.2	102.1	58.3	-2.62	29.9

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* Importance values are based on summation of relative density and relative dominance (for overstory), and relative frequency (for understory).

** Base saturation.

† Total basal area (m^2 ha^{-1}) is that of all stems >10 cm diameter 1.3 m above ground level, taken on a 500-m^2 quadrat at each plot.

†† W and M refer to the site wetness categories "wet" and "mesic," respectively.

(reduced), 0.40 m*M* acetaldehyde, in 14 m*M* Tris buffer at pH 8.0 and 2.8 ml total volume (John and Greenway 1976).

Root Coating Analysis

366. A separate sample of root tissue was collected from each seedling for the determination of root coating composition. The samples were rinsed of excess soil with distilled water, patted dry, placed in plastic bags, and immediately frozen on dry ice in the field. These samples were kept frozen until analyzed. After about 1 month, the samples (ca. 0.5 g fresh weight) were weighed and placed in a beaker containing 40 ml of 0.3 *M* Na-citrate and 5 ml of 1.0 *M* Na-bicarbonate at 80° C. To this mixture was added 1 g of Na-dithionite while the solution was stirred. The suspension was kept at 80° C for 15 min (Jackson 1958). After determination of volume, the solution was filtered through 45-μ filters and stored with 0.04 g ethylenediaminetetra-acetate per sample. For every batch of 10 samples, two blanks were run, and the mean concentrations of elements in them were subtracted from each sample of that batch. The extract was analyzed with an ICAP (Inductively Coupled Argon Plasma) spectrophotometer for the following elements: Al, As, Ca, Fe, K, Mg, Mn, Ni, P, and Zn.

Statistical Analysis

367. Only the 1983 monthly soil measurements (Part I) of redox potential, oxygen content, soil moisture content, and water table depth were used for these analyses. A set of principal components for each plot and sampling period were calculated from the plot means after standardization. The first two principal components accounted for 75.5 percent of the variables, and were the only ones that had eigenvalues greater than 1 (Table 6). The third principal component accounted for only an additional 7.6 percent. Therefore, only the first two were retained for further analysis.

368. Based on the means of their first and second principal components (averaged across time), the plots were assigned to soil wetness groups using cluster analysis. Ward's method was the algorithm of the "Cluster" procedure (SAS 1982) that we used. Group membership was determined at the two-cluster stage, because a two-group classification was desired. The procedure was repeated using the average linkage algorithm (SAS 1982) instead of Ward's, and the membership of the two clusters was identical. The plots in the cluster containing the drier sites were denoted "mesic"; the remainder, "wet."

369. After the plots had been classified based on soil-wetness data, a discriminant function was developed to predict plot wetness from the root data. The initial step was to choose the best predictors from among the root variables. Because this was an exploratory study, all available

Table 6

Principal Components Analysis of Standardized (m = 0, s = 1) Soil Variables from All 14 Plots (124 Observations)

	Eigenvectors	
Variable*	Principal Component 1	Principal Component 2
WC15	-0.269	0.388
WC30	-0.241	0.477
WC60	-0.251	0.456
WC120	-0.244	0.385
EH15	0.281	0.208
EH30	0.298	0.180
EH60	0.292	0.126
EH120	0.271	0.063
OX15	0.283	0.198
OX30	0.308	0.239
OX60	0.294	0.189
OX120	0.262	0.144
WDEP	-0.301	-0.130
Eigenvalues	7.8607	1.9607
Cumulative Percent	60.47	75.55

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* Abbreviations for variables are as follows, WC15 is the water content (weight/vol) at 15 cm, etc.; EH is the redox potential; OX is the oxygen content; and WDEP is the water-table depth.

predictor variables (ADH, Al, As, Ca, Fe, Fe/Mn, K, Mg, Mn, Ni, P, and Zn) were entered into the SAS "Stepdisc" procedure, along with the plot wetness classification variable (wet or mesic) for each sampled tree. The options chosen for the procedure (SAS 1982) were the forward stepwise discriminant selection method and an entrance criterion of $P > F = 0.15$ (the default level).

370. The selected variables were then used in the discriminant analysis function. First, however, the null hypothesis of homogeneity of within covariance matrices of the two wetness groups was tested (Kendall and Stuart 1968). The resulting chi-square test value was 201.20 (21 df): P > chi-square = 0.0001. As this value was highly significant, the within-covariance matrices were used in the discriminant function rather than the pooled covariance matrix (Kendall and Stuart 1968).

371. Since the prior probabilities of wet and mesic categories (0.71 and 0.29, respectively) were known, they could have been incorporated into, and increased the effectiveness of, the discriminant function. However, under most situations in which one would want to utilize root response variables to identify site-wetness categories, a prior classification would not be available. Therefore, to determine the reliability of this method under realistic conditions, the prior probability of membership was not used. The procedure assigned profiles on the basis of the following quadratic discriminant function:

$$D_J^2(X) = (X - \overline{X}_J)' \; COV_J^{-1} (X - \overline{X}_J) + \ln |COV_J|$$

where J is the subscript referring to wetness class; $\overline{X}$ and X are the mean and individual root variable vectors, respectively; and $|COV|$ denotes the determinant of the appropriate covariance matrix (SAS 1982). This formula was applied to the vector of predictor variables for the observation in question, using the appropriate mean vector and covariance matrix, COV, for both wetness classes in turn. The observation was assigned to the group for which its generalized distance, $D^2(X)$, was smaller.

372. The probability of misclassification was determined by the jackknife method (Lachenbruch and Mickey 1968, Sokal and Rohlf 1981), wherein each observation is left out in the development of the function and then used in turn to test it; i.e., the "Discrim" procedure was used twice for each observation.

RESULTS AND DISCUSSION

Principal Components and Cluster Analysis

373. Analysis of the coefficients indicated that all of the original variables contributed to principal component 1 by about the same amount, while water content data appeared to dominate principal component 2 (Table 6). The coefficients of principal component 1 indicated that water content and depth of the surface water were inversely related to redox potential and oxygen content, which suggested that this axis reflected the original intercorrelations of the soil data in response to waterlogging. Principal component 1 was inversely related to the overall degree of waterlogging at a site, while principal component 2 was directly related to water content (Table 6).

374. The group memberships based on the Cluster procedure are indicated in Table 5. Ten of the plots were classified as wet, and only four (RR1, RR2, QU1, QU3) were grouped in the mesic category.

Differences in Root Coating and ADH Data Between Wetness Categories

375. The means and standard deviations of the root coating and ADH data of the seedlings from the two soil wetness classes (as determined by cluster analysis) are presented in Table 7. The following means were larger in the mesic class: Ca, K, and Mg; while ADH, Al, As, Fe, Fe/Mn, Mn, Ni, P, and Zn were all smaller (Table 7).

376. The variation within these classes was fairly large (Table 7). Nevertheless, based on Wilk's lambda and the average squared canonical correlation values obtained for group separation at each step of model development (Table 8), the two site wetness categories were statistically separable based on the root data. The differing response of these elements would preclude an explanation based on dilution or concentration due to differential root development under different soil-wetness regimes. Furthermore, the mean levels at the wet and mesic plots (although the differences are not necessarily statistically significant in each case) and the correlations with the soil moisture data were in general agreement with certain well-documented processes known to affect their chemical dynamics. The following discussion focuses on processes suggested by patterns in the data of Table 7.

Cation Exchange Reactions: K, Mg, and Ca

377. Potassium was the best predictor variable of the elements analyzed and decreased with site wetness (Tables 8 and 7, respectively). The behavior of Mg followed a similar trend as K, and

Table 7

Means and Standard Deviations of ADH and All Measured Root-Coating Constituents, by Soil Wetness Category, and Correlation Coefficients (r) of the Root Variables with Principal Component 1†

	Mesic Class (n = 27)		Wet Class (n = 75)		r with Principal Component 1
Variable††	Mean	SD	Mean	SD	(n = 102)‡
ADH	45.8	29.8	59.7	97.2	-0.27**
Al	28.4	21.5	72.3	67.6	-0.15
As	15.4	15.9	34.7	29.9	-0.20*
Ca	616	159	570	382	-0.20*
Fe	835	970	5630	5060	-0.46***
Fe/Mn	13.1	17.0	56.4	76.6	-0.28**
K	3540	1390	1960	1170	0.54***
Mg	207	73.6	186	158	0.12
Mn	82.8	43.2	316	375	-0.31**
Ni	1.27	1.28	2.27	1.58	-0.25*
P	222	116	310	327	-0.36***
Zn	5.59	3.09	10.4	21.0	-0.25*

† Principal component 1 accounted for 60.5 percent of the variation in the soil data and is positively related to redox potential and oxygen level and inversely related to soil moisture and water depth.

†† Units of ADH are in micromoles per gram fresh weight per hour; units of root coating constituents are in micrograms per gram fresh weight, except Fe/Mn, which is the ratio of Fe to Mn calculated on a per plant basis.

‡ Significance at the 0.05 (*), 0.01 (**), and 0.001 levels (***), respectively.

Table 8

Summary of Forward Stepwise Discriminant Analysis*

Step	Variable Entered	Partial r^2	F	p>F	Wilk's Lambda	R^2
1	K	0.25	32.79	<0.01	0.75	0.25
2	Ni	0.07	7.57	0.01	0.70	0.30
3	Fe/Mn	0.11	12.40	<0.01	0.62	0.38
4	Mg	0.04	4.46	0.04	0.59	0.41
5	Mn	0.03	3.14	0.08	0.57	0.42
6	ADH	0.04	3.55	0.06	0.55	0.45

* Statistics given at each step are r^2 , the squared partial correlation; F , prob > F based on one way analysis of covariance; Wilk's lambda (the associated F approximation prob > F was < 0.0001 for each step); R^2 , the average squared canonical correlation (prob > R^2 was < 0.0001 for each step).

the underlying mechanisms may be similar, although the relationship with the main soil moisture principal component was not nearly as strong (Table 7). The mean level of Ca was also slightly lower on the wet plots than on the mesic. However, its overall relationship with principal component 1 (Table 7) would suggest that Ca increased with soil waterlogging. The data indicated that Ca accumulated with increased flooding on the wet plots ($r = -0.47$, $n = 75$, $p < 0.01$), but decreased with increased flooding on the mesic plots ($r = 0.31$, $n = 27$, $p = 0.11$). Thus, two different processes may control Ca accumulation, depending upon the flooding regime.

378. Calculations based on root interception and root uptake and the use of autoradiographs have shown that ^{86}Rb, an analog of K (Walker and Barber 1962), Ca (Barber and Ozanne 1970), and Mg (Al Abbas and Barber 1964, Oliver and Barber 1966), can accumulate at the root-soil interface when the supply to the root by mass flow or diffusion exceeds the uptake by the root. This would seem to be a likely explanation of the relatively high levels of K, Mg, and Ca on the root surfaces of the mesic class samples. The decline in K and Mg, on the roots from the wet plots, may be "a secondary effect of submergence and reduction, chiefly solvent action of CO_2 and cation-exchange reactions" (Ponnamperuma 1964). This may also explain the inverse relationship of Ca with flooding observed in the samples from the mesic plots.

Oxidation-Reduction Reactions: Fe, Mn, and Fe/Mn

379. The reduced forms of Fe and Mn are soluble, whereas their oxidized forms are not. Many flood-tolerant tree species (Armstrong 1968, Keeley 1979), including green ash (Sena-Gomes and Kozlowski 1980), are able to oxidize their rhizospheres under reducing soil conditions. This process can result in a coating of oxidized Fe, Mn, and coprecipitation of reduced Fe onto oxidizing root surfaces has been well documented in many flood-tolerant species (Bartlett 1961; Bacha and Hossner 1977; Chen, Dixon, and Turner 1980; Mendelssohn and Postek 1982; Taylor, Crowder, and Rodden 1984). The increase in the mean levels of Fe and Mn on the wet plots was striking (Table 7), although their large variance diminished their effectiveness as predictor variables in this experiment. Iron increased by a factor of 7, and Mn by 4. The oxidation-reduction reactions of Fe and Mn, although variable, were obviously of primary importance to the overall chemistry of root coating formation.

380. The Fe/Mn ratio should be a sensitive indicator of root oxidation in reduced soils because: (a) Mn oxidation is much slower than Fe oxidation, (b) the critical redox potential for Fe oxidation is lower than that of Mn oxidation, (c) these soils generally contain greater amounts of Fe that Mn, and (d) the units cancel, and thus some variation among observation due to differences in surface area or root density may decrease (Good and Patrick 1987). The Fe/Mn and Mn values were much higher on roots from the wet plots (Table 7), and were selected as predictor variables.

Iron was likewise much higher among the wet root-coating samples, but was not among the predictor variables because of its high standard deviation (Table 7).

Sorption Reactions: Ni, P, Al, As, and Zn

381. The accumulation of Ni, P, Al, As, and Zn on roots from the wet plots (Table 7) is probably related to the oxidation of Fe and Mn at the root surface, and the concomitant occlusion of various complexes. The hydrous oxides of Al, and those of Fe and Mn, act as absorbants for phosphate and some other elements, including Ni (Bowen 1979), As (Bowen 1979), and Zn (Sims and Patrick 1978). The chemistry of Ni, P, Al, As, and Zn is indirectly influenced by changes in the soil redox potential. Their solubility is not governed by valence changes as is the case with Fe and Mn. When reduced Fe and Mn are oxidized, they form oxides and oxyhydroxides (Bacha and Hossner 1977; Sims and Patrick 1978; Chen, Dixon, and Turner 1980). Aluminium and Fe-phosphates are only slightly soluble (Patrick et al. 1973) and can be occluded during the formation of hydrated Fe and Al oxides (Khalid et al. 1977). It has been shown that Fe and Al interact synergistically in P sorption during the formation of Fe-P and Al-Fe-P complexes (Pritchard et al. 1984).

Alcohol Dehydrogenase

382. Mean ADH was greatest from the wet plot samples (Table 7) and was included in the discriminant function. However, its contribution to the predictive capacity of the model was small (Table 8). The standard deviation of this variable was high (Table 7), especially among roots from the wet areas. There are several possible sources of variation in ADH activity. The activity of ADH can decline to control levels after prolonged exposure to waterlogged soil conditions. This response probably results from the formation of roots under anaerobic conditions that are capable of increased aeration because of a decrease in their diffusive resistance (Keeley 1979). Flooding intensity can also affect ADH activity. The ADH activity of smooth cordgrass (*Spartina alterniflora*) roots growing in controlled soil suspensions was inversely related to redox potential (DeLaune, Smith, and Tolley 1984). Thus, differences in duration and intensity of flooded conditions could have accounted for some of the variation in ADH activity.

Discriminant Analysis Function

383. The root variables selected by the stepwise discriminant function proved to be effective predictors of soilwetness. These variables, in order of their partial correlation coefficients were: K, Fe/Mn, Ni, Mg, ADH, and Mn (Table 8). When the discriminant function was applied to all

observations in the data set, the *a posteriori* probability of correct classification of the wet plots was 96.0 percent and that of the mesic plots was 96.3 percent. However, this estimate of accuracy is known to be biased in that it tends to underestimate the actual probability of misclassification (Lachenbruch and Mickey 1968, Green 1978). Therefore, the probability of correct classification was determined using the jackknife technique, which is unbiased (Lachenbruch and Mickey 1968). Each observation was assigned to a class using the distance model derived for the data set exclusive of that observation. This method indicated that the overall probability of correct classification of the wet plots was 92.0 percent, and 88.9 percent for the mesic class (Table 9).

384. The effectiveness of the discriminant function (Table 9) did not appear to be affected by differences in the pH or percent base saturation in the A horizon (Table 5), two parameters that could have influenced root-coating formation. This point is underscored by the fact that the accuracy of determination was poorest at the Quimby transect (Table 9), which was intermediate relative to the other transects with regard to percent base saturation and pH of the A horizon (Table 5). Most of the errors were from the samples taken at QU3 (wet). Three of the eight samples were classed as mesic. This plot had a wide range of microtopographic variation, and perhaps would be best classified as partly mesic and partly wet.

Table 9

Summary of Jackknife Determinations of Correct Classifications of Site Wetness Category Based on Predictor Variables (K, Fe/Mn, Ni, Mg, Mn and ADH)

Characteristic	Pearl River	Red River	Spring Bayou	Quimby	Overall
Number of root samples from					
Mesic plots	0	12	0	15	27
Wet plots	29	6	24	16	75
Percent correctly grouped into					
Mesic	--	91.7	--	86.7	88.9
Wet	100.0	100.0	91.7	75.0	92.0

CONCLUSIONS

385. The use of root-coating data as an indicator of soil wetness merits further study because it could provide an efficient indicator of wetlands and could shed light on plant-soil interactions under flooded soil conditions. In addition, the composition of the root coating represents the effects of soil wetness integrated over time. The periodic soil measurements collected to generate the initial soil wetness classification entailed much more time and expense than the collection of the root data for this purpose.

386. Green ash has several characteristics that make it a good species for collecting the type of data used in this discriminant function. Rhizosphere oxidation under waterlogged soil conditions appears to be an essential criterion. This enhances the seedlings' chance of survival at the wetter end of the soil moisture gradient (Good and Patrick 1987) and favors the formation of root coatings characteristic of a reduced soil environment. The suitability of green ash for this type of study was suspected because of its flood tolerance (Hook and Brown 1973, Hook 1984) and its natural occurrence as an understory and overstory constituent on mesic and wet plots (Table 5). However, many other species would make good candidates. The possibility of using endemic individuals should be investigated because they represent a potentially abundant source of readily available information.

387. The material that collects at the root-soil interface is not a part of the root, yet it is distinct from the surrounding soil. From an ecological point of view, root coatings offer a unique vantage point in the analysis of plant-soil interactions. Under waterlogged soil conditions, oxidation-reduction chemistry plays a dominant role in the formation of coatings around oxidizing roots. Therefore, some constituents of these coatings and ADH activity (which is known to be affected by anaerobic conditions) should be useful in differentiating wet from mesic sites. The results of this experiment substantiated this hypothesis: the root coatings and, to a lesser extent, anaerobic respiration were different enough on wet and mesic sites to be useful in the development of a model for site wetness classification.

PART III: SOIL CHEMISTRY STUDIES

INTRODUCTION

388. Soil color qualitatively reflects the moisture regime of a site and is easily observed in the field. It is currently used as a diagnostic indicator of hydric soil in wetland delineation procedures (Environmental Laboratory 1987). Iron and manganese compounds are primary determinants of soil color. For most mineral soils, red and yellow reflect oxidized compounds, blue-green indicates reduced compounds, and gray colors (gleyed) may indicate removal of iron oxides from the soil horizon (Soil Survey Staff 1975, Environmental Laboratory 1987, Schwertmann 1988).

389. The oxidation-reduction status of the soil is a major factor affecting the levels of exchangeable iron and manganese in soils. Anaerobic or reducing conditions favor the formation and stability of ferrous and manganous (both divalent) cations in the soil. Oxidizing conditions favor the formation and stability of highly insoluble oxide precipitates of these metals as ferric (Fe^{+3}) and manganic (Mn^{+4}) cations that are not easily extracted.

390. There are other important factors affecting exchangeable iron and manganese in soils as well. An acid pH (especially a moderately acid pH coupled with reducing conditions) tends to increase ferrous and manganous cations while near-neutral and alkaline pH levels favor formation of insoluble precipitates. The amount and type of clay determines how much iron and manganese were initially present and clay genesis processes. Conditions favoring no new additions of iron and manganese (little or no new soil deposits from sedimentation) and leaching (acid, reducing soils where considerable water movement occurs through the soil profile) will, after a long period of time, deplete the amount of iron and manganese that can become associated with the dissolved and exchangeable forms. Another factor that may be involved is the amount of fulvic acids present in the soil that may keep metals in solution as dissolved complexes.

391. The purpose of the soil chemistry studies was to determine if extractable forms of soil iron and manganese, seasonal changes considered, can serve as a technique for delineating wetlands from nonwetlands or complement existing procedures. The forms extracted in this study represent the most mobile and potentially plant-available forms and are likely affected by an interaction of some or all of the above-mentioned processes.

METHODS AND PROCEDURES

Exchangeable Iron and Manganese

392. Replicate soil core samples were collected from the 15- and 60-cm depth at each plot on the dates listed in Table 10. A screw auger was used to get within about 2 cm of the target depth; then, a core auger was used to get a 3- to 5-cm core. A triple beam balance was taken to the field and used to weigh out 10 ± 0.5 g of wet soil into 50-ml sealing centrifuge tubes. A portable cylinder of compressed nitrogen gas, fitted with a small-diameter, flexible plastic tube, was taken to the field. As soon as possible after returning to the truck, any tubes containing soil that might have been reduced were purged with nitrogen gas; then the tubes were sealed such that the reduced soil would remain under an inert atmosphere until the samples could be extracted in the laboratory, usually the following day. Soil materials from oxidized horizons were not purged with nitrogen. If samples could not be processed the next day (i.e., sampling done on a Friday), the samples were placed in a refrigerator until extracted.

Table 10

Exchangeable Iron and Manganese Sampling Dates

Transect	Sampling Date
Pearl River	September 1984 May 1985
Quimby	August 1984 February 1985 July 1985
Rolling Fork	August 1984 February 1985 June 1985
Red River	August 1984 September 1984 November 1984 June 1985
Spring Bayou	November 1984 January 1985 June 1985

393. For the extraction, a 1 N sodium acetate extractant adjusted to pH 2.0 was used to remove exchangeable iron and manganese. This was prepared by weighing out 82 g of sodium acetate into a 1-l Erlenmeyer flask, adding 900 ml of distilled, deionized water, then adjusting the pH to 2.8 by adding concentrated hydrochloric acid with continuous stirring while reading pH on a meter. When the pH was reduced to 2.8, the solution was transferred to a 1-liter volumetric flask and brought to volume with distilled, deionized water.

394. Twenty-five milliliters of this solution was added to each tube containing soil, the sealing caps replaced, and the tubes shaken for 4 hr. After shaking, the tubes were centrifuged for 22 min at 10,000 rpm in a Dupont Sorvall SA-600 rotor to obtain a clear supernatant. Exactly 2.0 ml of the clear supernatant was transferred to an acid-rinsed, 20-ml glass scintillation vial, to which was added 15 ml of distilled deionized water and 1.0 ml of concentrated nitric acid to maintain the metals in solution until analyzed for iron and manganese.

395. These samples were analyzed on a Jarrell-Ash Model 855 inductively coupled argon plasma emission spectrometer. All data are reported in micrograms metal per gram of wet soil.

Soil pH

396. At the same time soil samples were obtained for extractable iron and manganese, approximately 15 g of soil from the same field sample was placed in 60-ml plastic bottles to take to the laboratory for pH analyses. No regard for oxidized or reduced soil conditions was made as it was believed pH would not change significantly until the analysis could be made in the laboratory the following day. In the laboratory, 15 ml of distilled, deionized water was added to each bottle; then the soil/water mixture was shaken for about an hour on a mechanical box shaker. The pH was measured by inserting a calibrated combination electrode directly in the bottles after briefly shaking the bottles again by hand immediately before taking the pH measurement.

RESULTS AND DISCUSSION

Evaluation and Presentation of Iron, Manganese, and pH Data

397. Ideally, the exact weight of the dry soil material extracted should have been known for the purpose of tabulating the data and getting the identical ratio of extraction solution to soil mass for every sample. During the spring of 1984, a sampling trip was made in which a bulk sample from the desired depth was obtained and put under an inert atmosphere (if the soil were reduced) in the field. Then, in the lab, an attempt was make to determine the moisture content so that exactly 10.0 g of oven-dried soil equivalent could be weighed out for each sample. In practice, this involved so much handling of the samples in the laboratory before the sodium acetate extraction that it was probable the reduced samples were being oxidized to some degree during sample processing. It was decided to use the procedure described above to minimize possible oxidation artifacts, even though the exact amount of oven-dry soil extracted was not known. Thus, the results are expressed on a wet weight basis acknowledging that some error is involved due to the variable moisture content of the samples.

398. The samples collected for iron and manganese extractions were taken about 6 m from the center of the plots to avoid making holes too near the sampling equipment used for soil oxygen content and redox potential measurements. In many of the plots, it was noted that the soil texture could vary substantially at the same depth at linear distances of even less than a meter. To compensate for large differences in sand, silt, and clay content between samples used to measure levels of metals and synthetic organics, samples are often analyzed mechanically and the results reported on an equivalent clay content basis. This might have been beneficial in this work, reducing some of the high variability between replicate samples. However, due to the size of the holes required for the 40 g of material needed for a mechanical analysis and the time required using the hydrometer method for approximately 500 samples, it was decided to simply report the results on a wet soil weight basis, ignoring differences in clay content.

399. Complete data for pH and extractable iron and manganese on about 500 samples are presented in Appendix R. Representative data have been selected for preparing the figures presented below for evaluating the data.

Exchangeable Levels of Iron and Manganese

400. A number of soil factors and processes affect the levels of iron and manganese that can be recovered by a sodium acetate extract. This extractant is designed primarily to remove cations that are relatively weakly adsorbed to exchange sites on colloidal clay minerals and humic materials. Also, if an aqueous extraction has not previously been used, the sodium acetate will

also remove cations present in the soil solution as well. Generally, the iron and manganese extracted are going to be in the reduced, divalent cation form in the soil. The often large quantities of oxidized iron and manganese associated with hydrous oxides in soils are not extracted using this procedure.

401. Although an effort was made to collect samples during the winter/spring season (when the soil temperatures were cooler and the water tables high) and during the summer/fall season (when the soils were much warmer and the water table usually low), there was no clear indication from a visual inspection of the data that there were substantial changes in levels of extractable iron and manganese between the seasons.

402. Considerable variability was noted in levels of iron and manganese extracted between replicate samples. Possible contributing factors to this were discussed above. However, there were clear trends, and the five field locations fell into three groupings.

403. The Red River and Quimby sites had substantially greater amounts of exchangeable iron and manganese at the lower landscape positions (Plots 3 and 4) at both the 15- and 60-cm depths compared with the higher elevation plots (see Figures 43-46). These differences ranged from 2 to 3 orders of magnitude for iron. Normally, there is much less manganese in soils than iron, and this is reflected in the lower manganese levels compared with iron recovered from the wet sites. Exchangeable manganese was usually a little higher from Plot 3 than Plot 4 at Red River, but the reasons for this difference, if real, are not known.

404. While the Rolling Fork site exhibited substantial differences in most of the measured soil properties going down the transect from the upland to the wetland sites, exchangeable iron and manganese may have increased slightly in the wet plots compared with the upland plots, but these differences were small (Figures 47 and 48).

405. The Spring Bayou and Pearl River sites tended to be intermediate to the other two groups in terms of the increase in exchangeable iron and manganese going from upland to wetland plots. There were obvious increases in iron and manganese usually found in Plots 3 and 4 at Spring Bayou (Plots 3,4, and 5 for Pearl River) compared with Plots 1 and 2. However, the highest levels of iron found were far less than those at Red River and Quimby (Figures 49-52). Another interesting difference between these two locations and the others was that higher levels of sodium acetate extractable iron and manganese were recovered from the 15-cm depths of the higher Plots even during warm months when the water table was low. Perhaps the greater soil acidity at the Pearl River site contributed to increased exchangeable iron and manganese. A likely explanation for this observation at the Spring Bayou site is not as easily discerned, but the relatively low, wet conditions of even the highest Plot at the Spring Bayou location may contribute to greater levels of reduced iron and manganese.

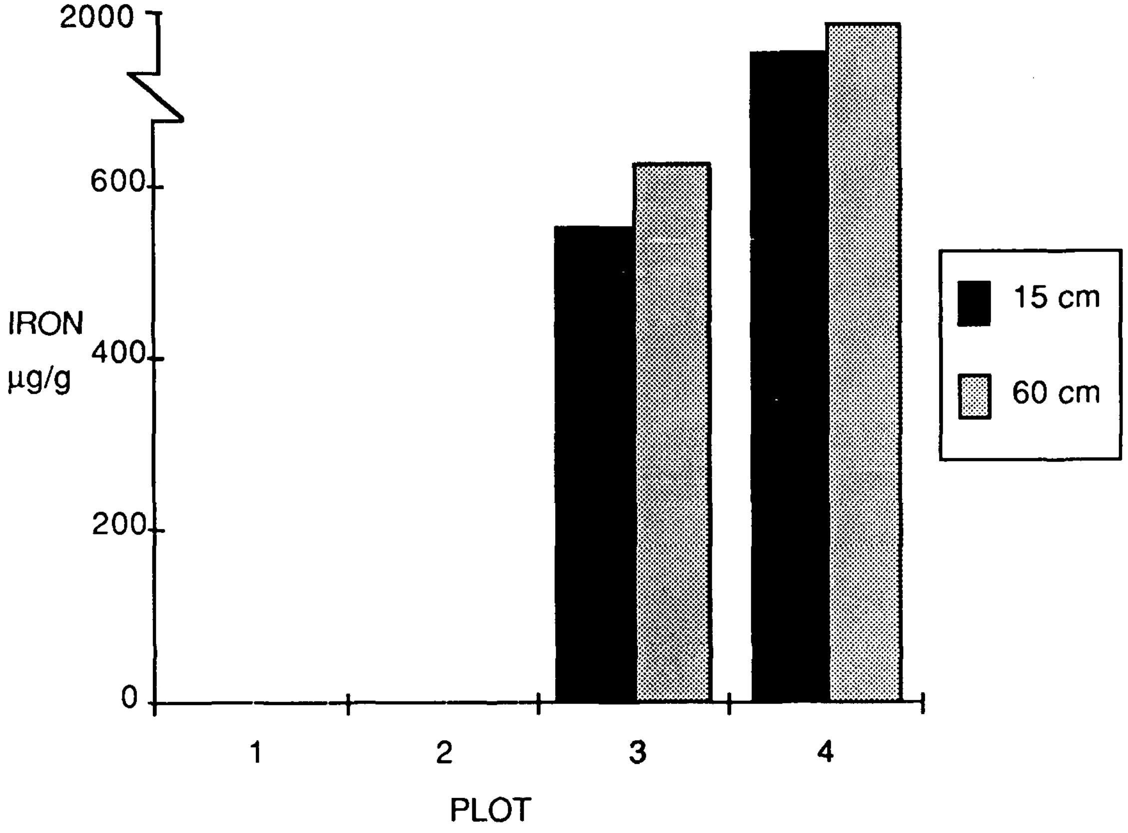

Figure 43. Exchangeable iron from Red River plots, November 1984

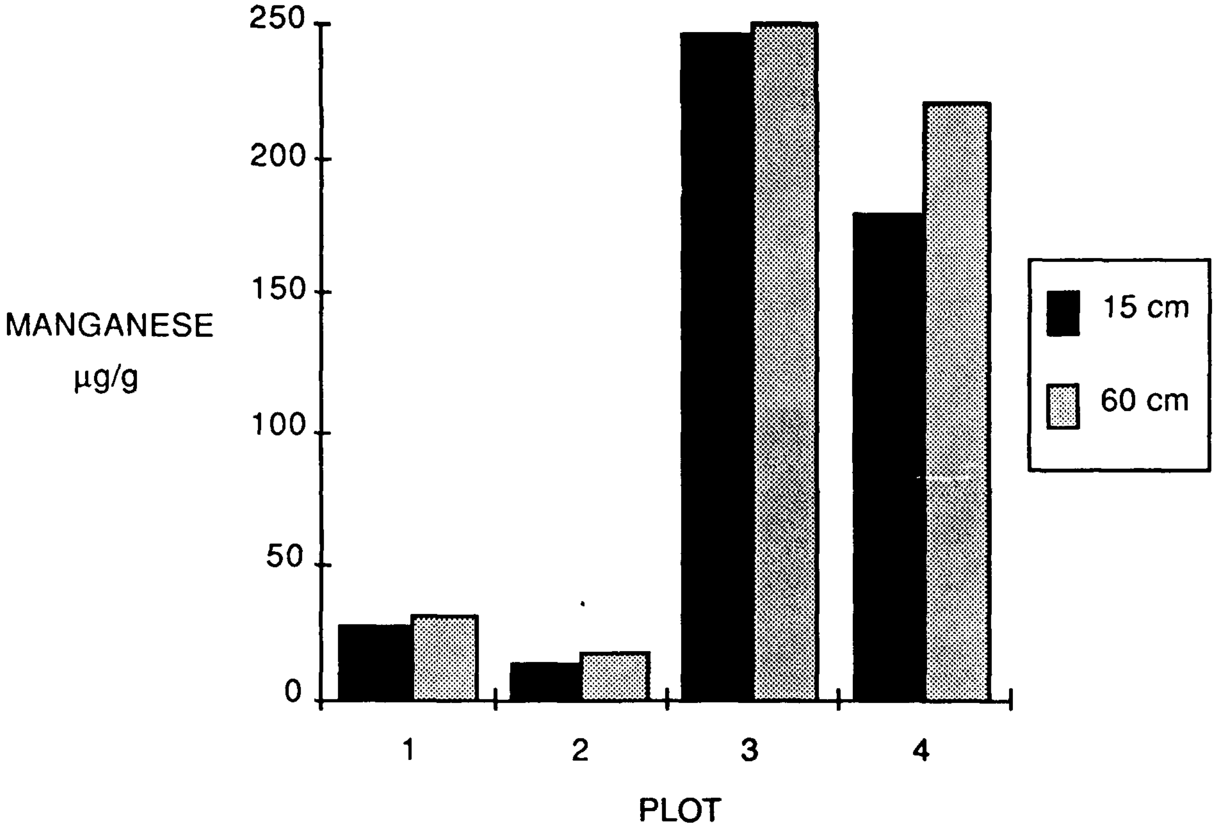

Figure 44. Exchangeable manganese from Red River plots, November 1984

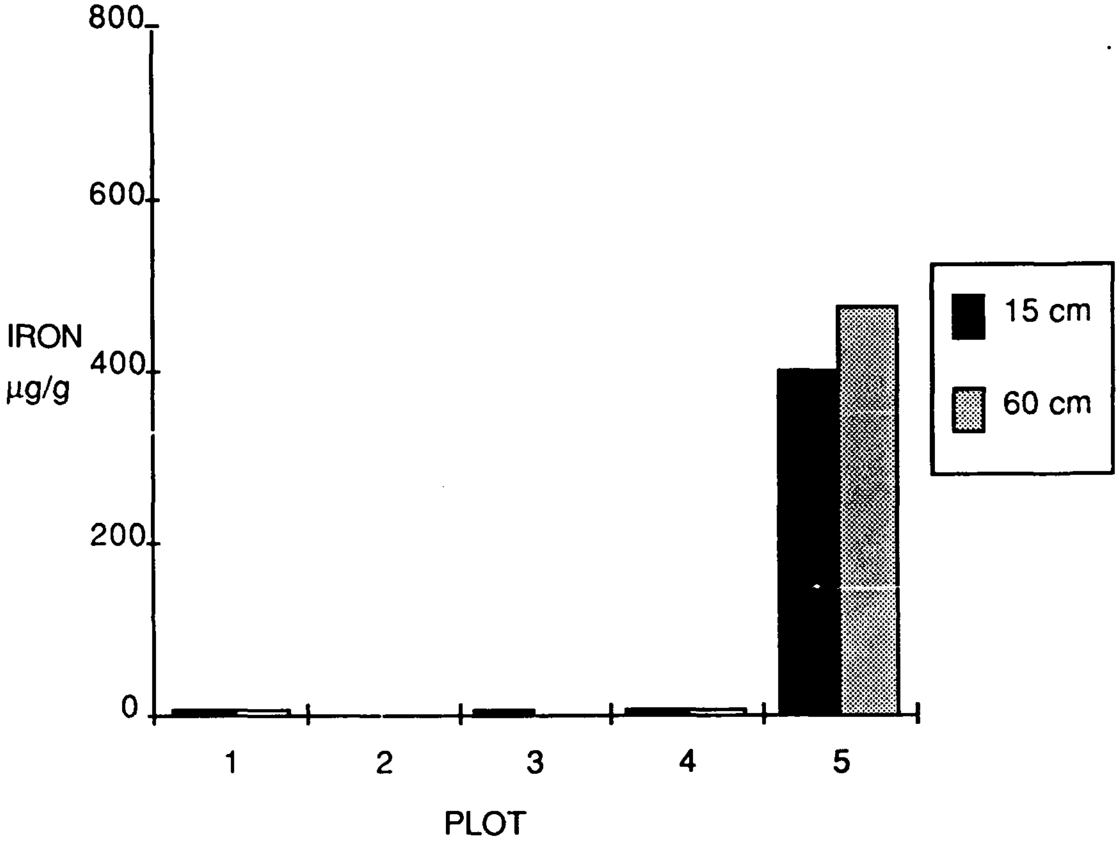

Figure 45. Exchangeable iron from Quimby plots, July 1985

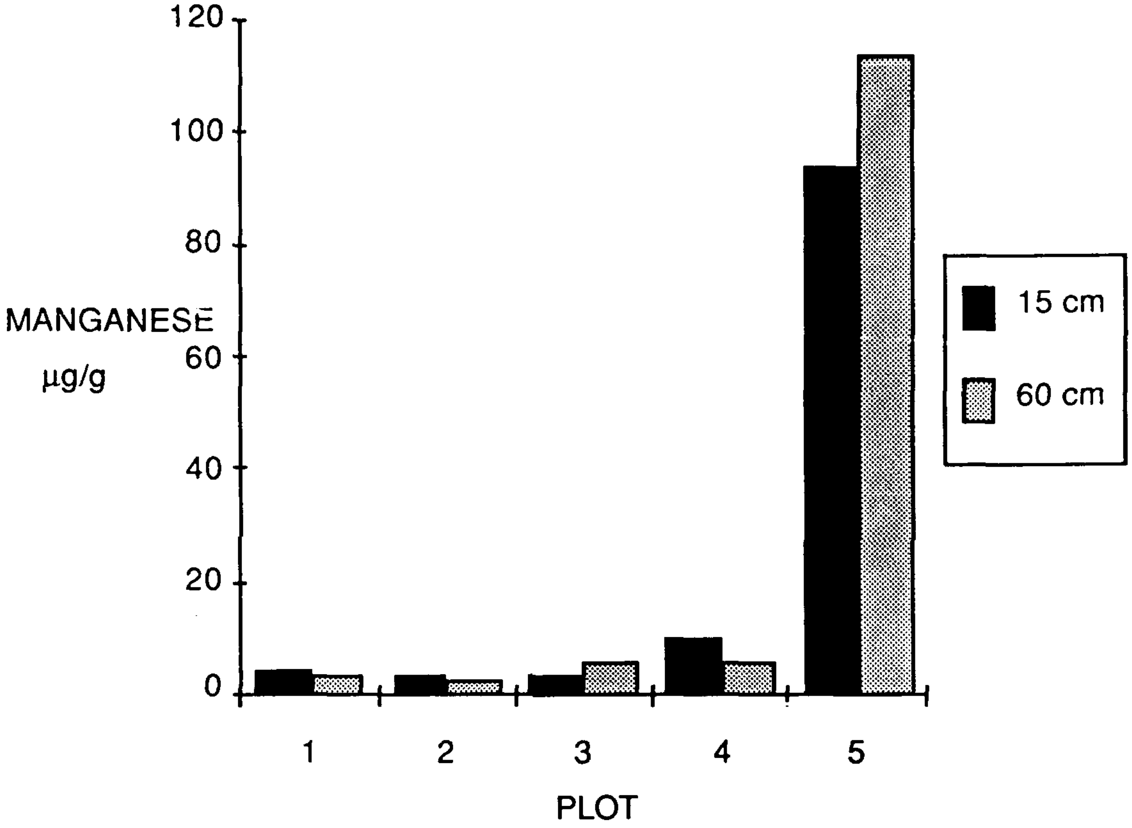

Figure 46. Exchangeable manganese from Quimby plots, July 1985

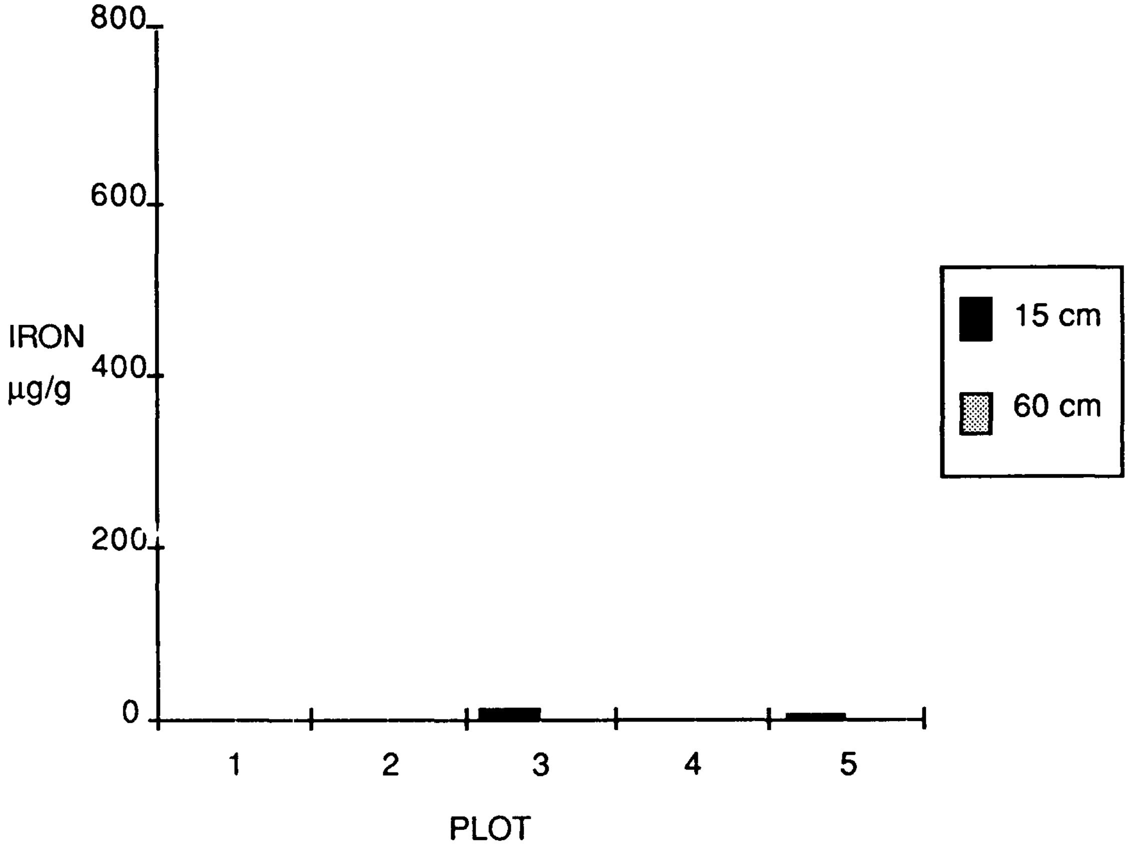

Figure 47. Exchangeable iron from Rolling Fork plots, August 1984

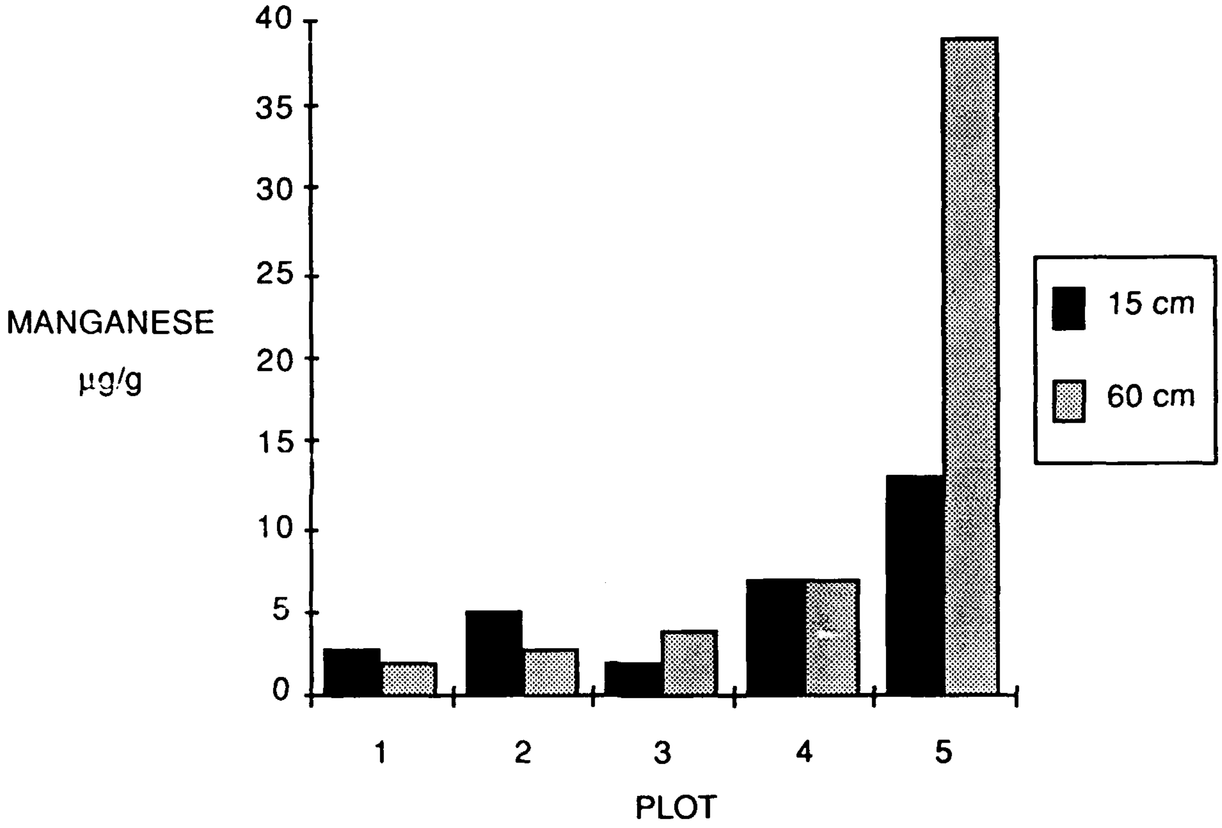

Figure 48. Exchangeable manganese from Rolling Fork plots, August 1984

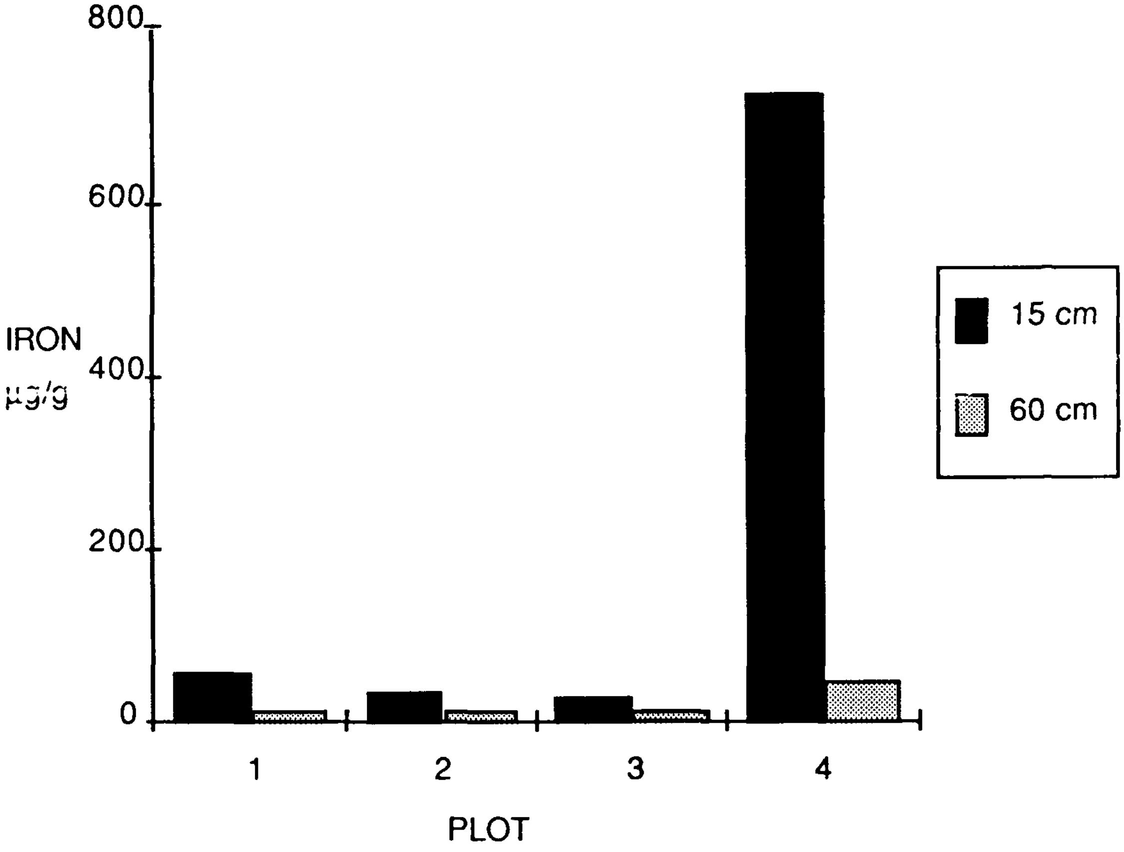

Figure 49. Exchangeable iron from Spring Bayou plots, June 1985

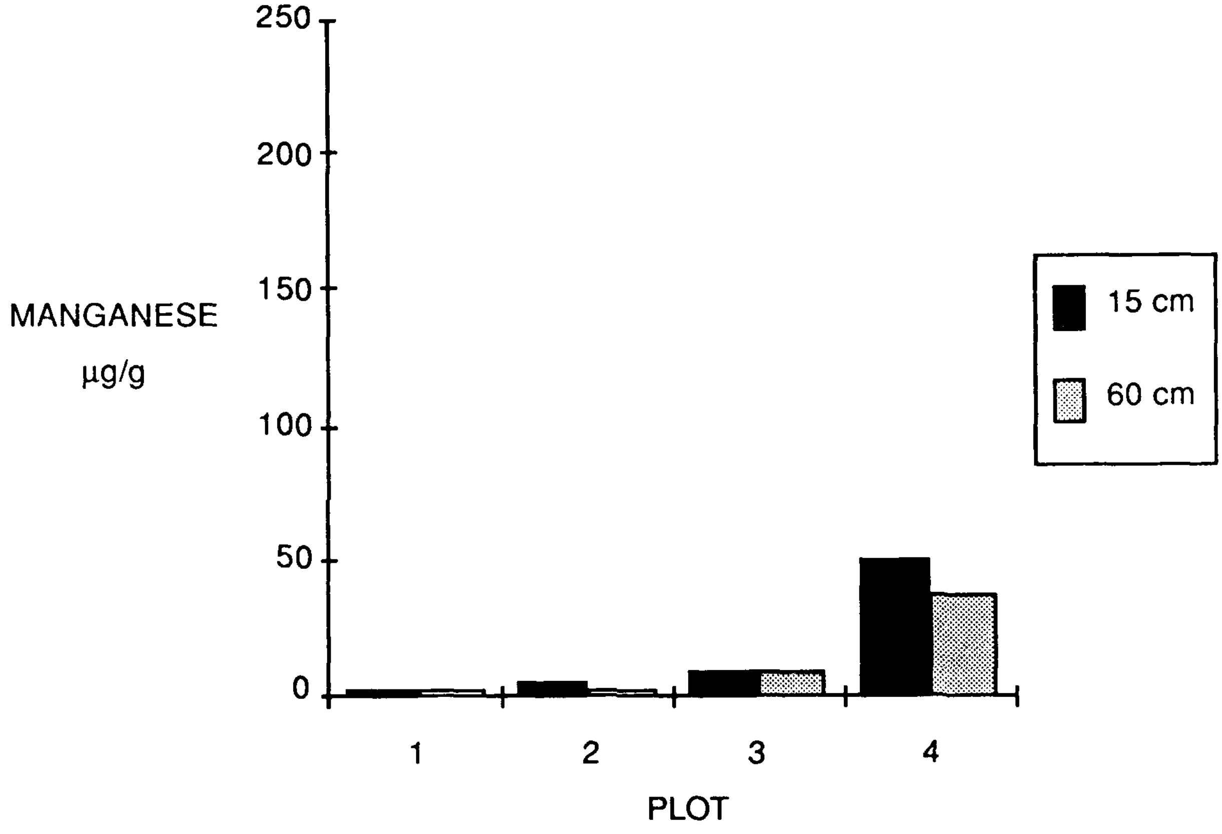

Figure 50. Exchangeable manganese from Spring Bayou plots, June 1985

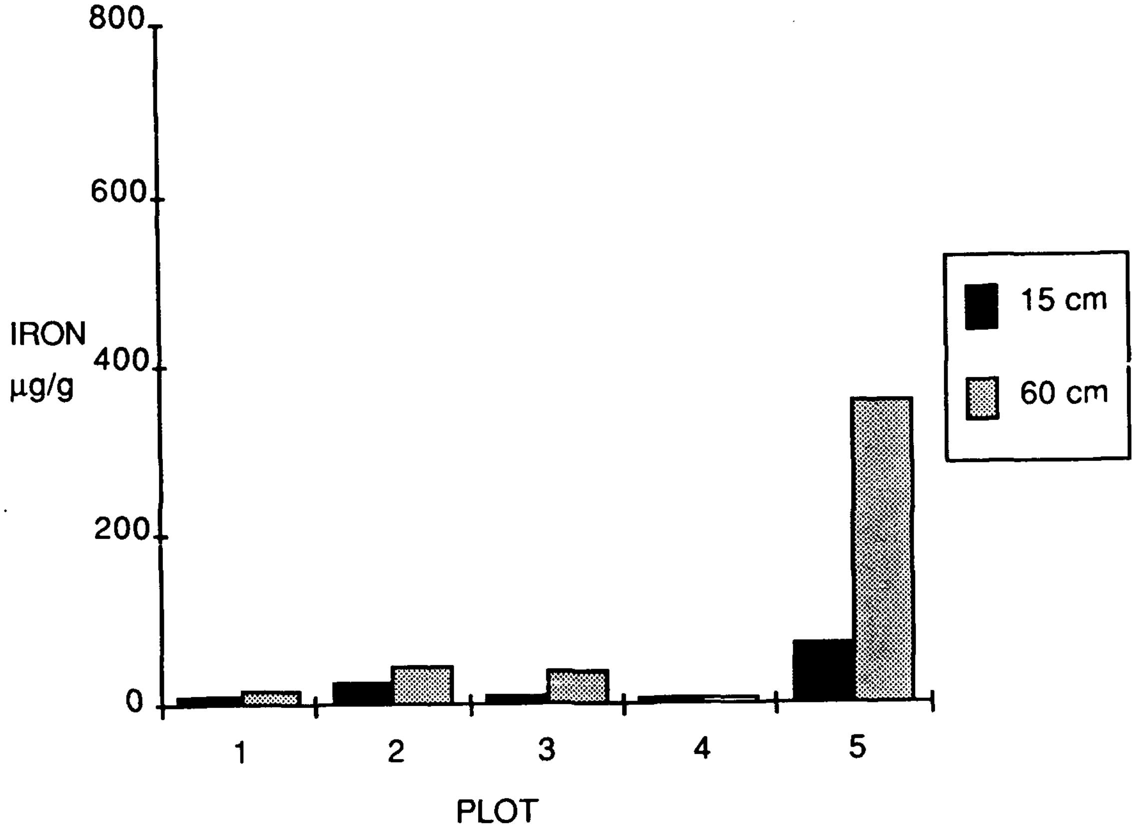

Figure 51. Exchangeable iron from Pearl River plots, September 1984

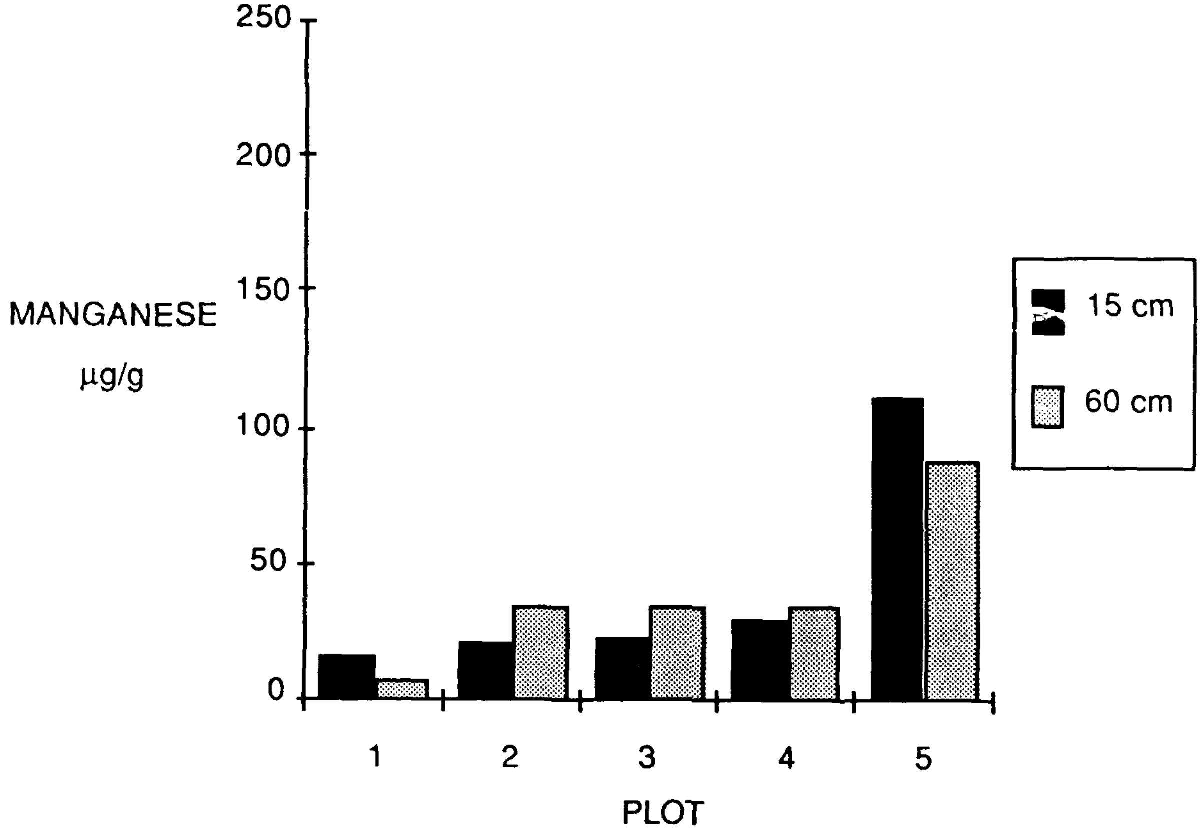

Figure 52. Exchangeable manganese from Pearl River plots, September 1984

Soil pH

406. Three pH trends were observed for the five research locations, though the groupings were not the same as those reported for exchangeable iron and manganese. *All* of the p*H* data are included in Appendix R, but only representative data were selected for illustration with figures.

407. The pH of the 15- and 60-cm depths at Red River showed a very small range in the near-neutral to weakly alkaline region. Apparently, the soil at this transect is well buffered (Figure 53).

408. The pH of the Quimby site was moderately acid (around 5) at the 15-cm depth of Plot 1 and tended to increase almost sequentially down the transect to the wetter plots. The same increasing pH trend (from driest to wettest plots) was noted at the 60-cm depth, and the pH was usually higher at the deeper (wetter) depths (Figure 54). This is a classic example of redox effects on pH in noncalcareous soils where the soil pH often approaches neutrality as the soil becomes more reducing (Gambrell and Patrick 1978).

409. The pH of the Pearl River soils was moderately to strongly acid and showed only a slight increase in the lower, wetter horizons (Figure 55). This low pH and small increase in the reduced, wet plots may be due in part to the sandy nature of the soil at this site.

410. The pH levels reported for the Rolling Fork and Quimby sites, taken 5 and 8 February 1985, appear too low (Table R1). Though the meter and electrodes were calibrated in pH 7.0 and then in pH 4.0 buffers prior to measurements being made, we still suspect these results. The measurements were repeated after obtaining new buffers and using a new electrode with similar results. However, without further sampling and work to confirm these low values, we wish to call attention to the probability of a problem with the data on these dates.

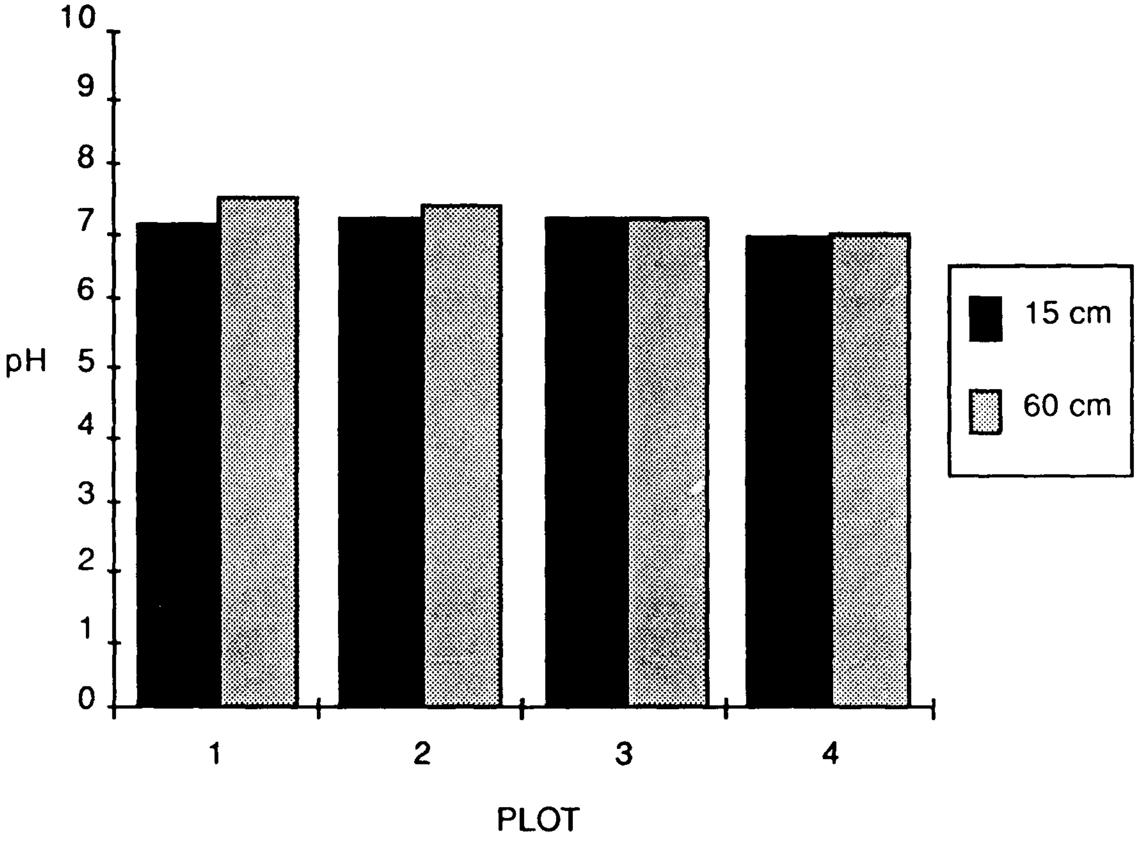

Figure 53. Soil pH of Red River plots, November 1984

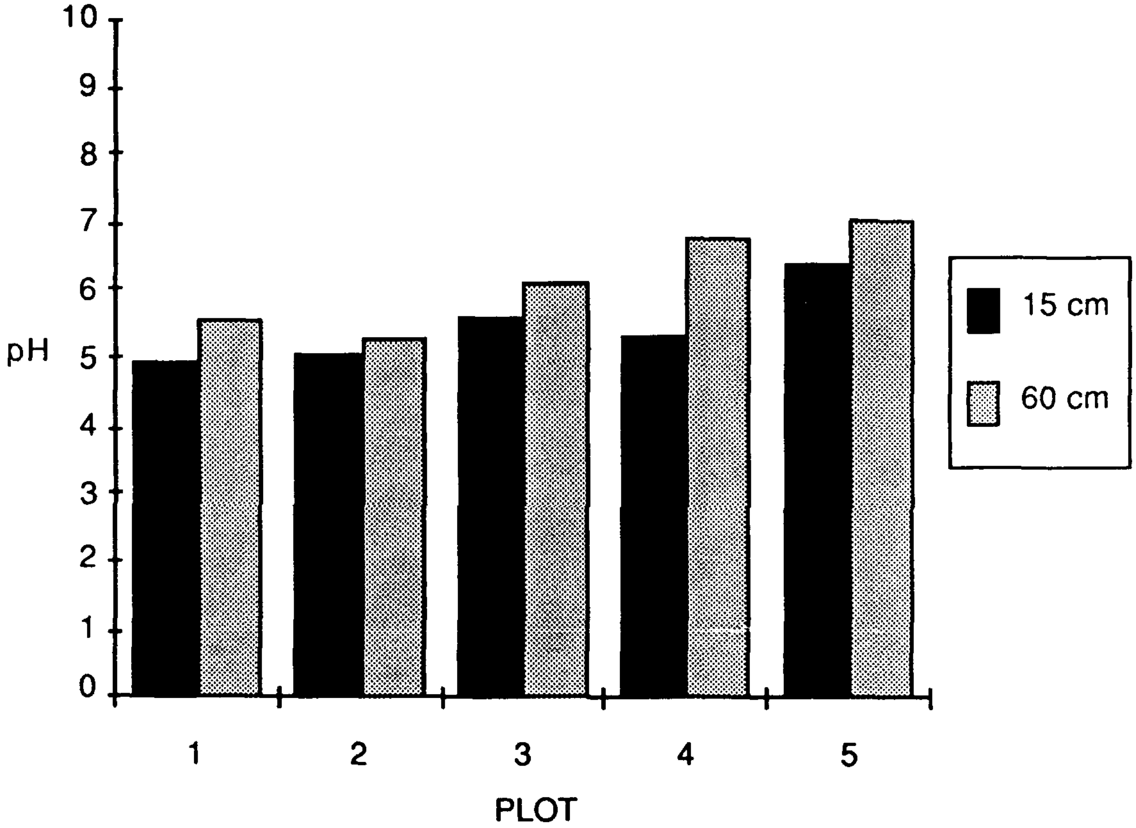

Figure 54. Soil pH of Quimby plots, August 1984

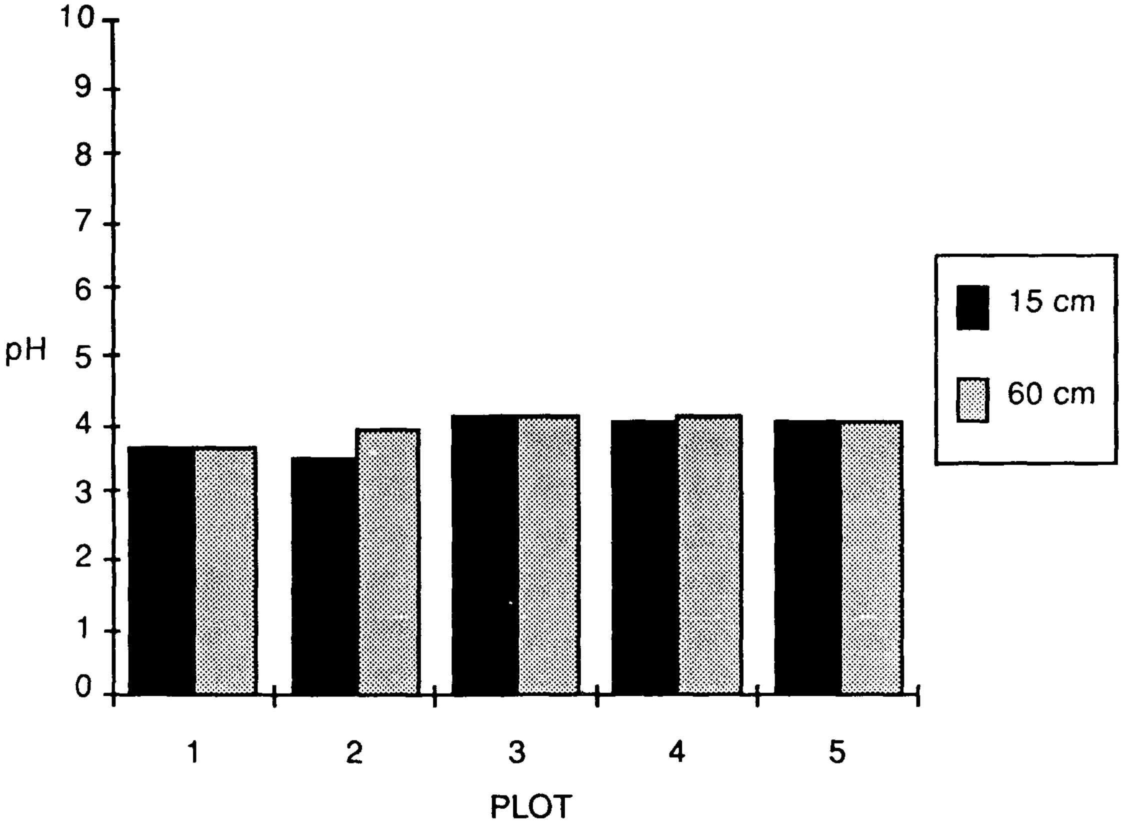

Figure 55. Soil pH of Pearl River plots, September 1984

CONCLUSIONS

411. Both pH and exchangeable iron and manganese levels reflected differences among wetland and upland plots at some of the five wetland research locations. However, by themselves, these measurements would not have identified all of the wet, reducing soil horizons included in this study. The reasons for this are related to the interaction of the factors affecting exchangeable iron and manganese levels that were discussed earlier in this section where elevated levels of extractable, reduced iron and manganese are sometimes not present even in wet, anaerobic soils. Additional work correlating the levels obtained with other soil properties may reveal more quantitative explanations for the observations reported; however, no relationships with measured soil chemical parameters (Appendix S) were observed. Analyzing the same soil materials for iron and manganese levels associated with colloidal hydrous oxides might reveal limitations in the potential levels available. For example, potentially available levels may be so low that little is present to be mobilized or extracted in strongly reducing soils.

412. At present, the absence of appreciable reduced iron and manganese cannot be used to determine if a soil horizon is oxidized. However, additional work along the lines indicated above may improve the utility of this type of measurement in characterizing wetland soils.

PART IV: SYNTHESIS

413. The three-parameter approach to delineating wetlands assumes an interactive and correlative response of vegetation and soils to the hydrologic regime. While not rigorously quantifying the vegetative component, Part I does provide the best scientific data available concerning the use of diagnostic soil indicators in wetland identification and delineation.

414. Part II provides an alternative approach for using vegetation as wetland indicators by investigating individual plant adaptations to flooding, specifically root coatings and ADH activity. The nature of Part II, as part of Dr. Good's Ph.D. dissertation (Good 1985), required that it be finished before the study described in Part I. Therefore, Part II is based on a subset (1983) of the total soils database. The wet and mesic cluster analysis designations based on this subset do create some problems in integrating the results from Part II. As discussed in Part I, 1983 was a much wetter year in terms of precipitation and flooding duration. In addition, the plots were classified as wet or mesic using the means of the first and second principal components. These principal components represent linear combinations of four variables (moisture content, redox potential, oxygen content, and water table depth) integrated across all depths. The criteria used in Part I were the oxygen and redox profiles at 30 cm and the soil diagnostic indicators. Finally, several of the wettest plots (PR5, RR4, SB4) and the Rolling Fork transect were not included in the Part II study.

415. Despite the different approaches, there was good agreement between Parts I and II in delineating the sites as wetland or nonwetland based on the soil variables (Table 11). Plots PR1 and QU3 were the only sites classified differently by the two approaches. In the case of PR1, the greater flooding in 1983 may have influenced the principal components analysis. The same reasoning is not valid for QU3, however, since it was classified as nonwetland by the cluster analysis. Both classifications may have been different if the wettest plots had been included. This would have provided more data from the wetland end of the scale that may have changed the relationship of PR1 and QU3 relative to actual wetlands. Both sites were considered transitional on the basis of the oxygen and redox profiles (Part I), so it is not surprising that different approaches classify them differently. Transitional sites are characterized by both wetland and nonwetland indicators.

416. The dual nature of transitional sites is exemplified by QU4. This site was treated as two subplots (QU4.A and QU4.B) in Part I because of the *a posteriori* observation of significant differences between the subplots. This plot was not separated into subplots in Part II, and the poorest accuracy of the discriminant function analysis was observed on QU4 (see Table 9). Accepting the Part I site classification, however, would decrease the accuracy of the discriminant function at Pearl River since the status of PR1 would change from wetland to nonwetland.

Table 11

Comparison of Soil Diagnostic (Part I) and Plant Adaptation (Part II) Delineation Approaches

	Wetland Status	
Plot	Part I Redox Profiles	Part II Cluster Analysis
	Pearl River	
PR1	Nonwetland	Wetland
PR2	Wetland	Wetland
PR3	Wetland	Wetland
PR4	Wetland	Wetland
	Red River	
RR1	Nonwetland	Nonwetland
RR2	Nonwetland	Nonwetland
RR3	Wetland	Wetland
	Spring Bayou	
SB1	Wetland	Wetland
SB2	Wetland	Wetland
SB3	Wetland	Wetland
	Quimby	
QU1	Nonwetland	Nonwetland
QU3	Wetland	Nonwetland
QU4	Wetland*	Wetland
QU5	Wetland	Wetland

417. The use of extractable iron and manganese to delineate wetland sites was not very successful (Part III). Even though the iron and manganese levels were elevated at most of the wettest plots, the technique did not reliably identify wetland or nonwetland sites. The interactive effects of soil pH, clay minerology, and soil pedogenesis were thought to have obscured any identifiable trends based on a soil wetness gradient. The depositional nature of bottomland hardwood soils results in a mosaic of soil characteristics that may also obscure distinct chemical differences among the sites. This variability was also seen in the Part II data where iron was much higher among wetland root coating samples and was highly correlated with principal component 1 (Table 7), but was not among the predictor variables selected because of its high standard deviation.

418. The common denominator in these approaches to wetland delineation is iron chemistry and its differential response to oxidizing and reducing soil conditions. Inundation and saturation change the soil redox environment in a generally predictable manner, and these changes result in iron-related diagnostic indicators. These indicators can provide indirect evidence that a site has functioned as a wetland. The critical question is a temporal one: is the site currently functioning as a wetland? It is necessary to use the vegetation and, in particular, the hydrology parameters to accurately answer this question.

419. The most problematic and critical area in bottomland hardwood forests is the boundary between wetland and nonwetland, which is often more gradual than abrupt. The results of these studies indicate that the soil diagnostic indicators, in conjunction with vegetative and hydrologic data, are better predictors of the wetland status of transitional sites than root-coating data or extractable iron.

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APPENDIX A: NEUTRON PROBE CALIBRATION

Table A1

Percent Adjustment Needed when Correction Factors Were Derived from Averaging Neutron Probe Data for each Depth within a Transect Compared to the Same Grouping of Gravimetric Data

Grouping	Average % Correction Required	Standard Deviation	Range
Red River, 15 cm	9.4	4.1	5.4-14.8
Red River, 45 cm	7.9	2.2	5.0-10.3
Pearl River, 15 cm	7.4	0.5	6.8- 8.0
Pearl River, 45 cm	10.6	0.3	10.6-10.9
Spring Bayou, 15 cm	8.5	0.5	8.0- 9.0
Spring Bayou, 45 cm	10.6	0.2	10.4-10.8

Table A2

Percent Adjustment Needed when Correction Factor was Derived from Averaging Neutron Probe Data from all Transects, Plots, Reps, and Depths

Grouping	Averge % Correction Required	Standard Deviation	Range
All data averaged, one factor	9.1	4.2	1.8-20.1

Table A3

Percent Adjustment Needed when Correction Factor was Derived from Averaging Neutron Probe Data from all Transects, Plots, Reps, and Depths, and Comparing this Single Correction Factor with the Gravimetric Data at the 15- and 45-cm Depths Separately

Grouping	Average % Correction Required	Standard Deviation	Range
15-cm depth	8.8	5.6	1.8-20.1
45-cm depth	9.4	2.4	5.8-13.7

Table A4

Percent Adjustment Needed when Correction Factors were Derived from Averaging Neutron Probe Data from all Transects, Plots, and Reps, but Considering Each Depth Separately, and Comparing these Two Correction Factors with the Gravimetric Data at the Two Depths

Grouping	Average % Correction Required	Standard Deviation	Range
15-cm depth	7.4	2.9	5.6-15.3
45-cm depth	10.3	2.6	7.8-16.0

APPENDIX B: PEARL RIVER CORRELATION COEFFICIENTS BY DEPTH

Table B1

Plot One

	EH15	OX15	NP15	WDEP
EH15	1.0	0.43*	-0.42	-0.53
OX15		1.0	-0.62	-0.68
NP15			1.0	0.78
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.64	-0.46	-0.57
OX30		1.0	-0.72	-0.72
NP30			1.0	0.82
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.42	-0.44	-0.47
OX60		1.0	-0.65	-0.68
NP60			1.0	0.71
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.61	-0.48	-0.41
OX120		1.0	-0.63	-0.70
NP120			1.0	0.63
WDEP				1.0

---

* All correlations are significant at the 0.01 level of probability unless otherwise indicated.

Table B2

Plot Two

	EH15	OX15	NP15	WDEP
EH15	1.0	0.79	-0.62	-0.76
OX15		1.0	-0.72	-0.79
NP15			1.0	0.78
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.85	-0.66	-0.75
OX30		1.0	-0.81	-0.81
NP30			1.0	0.85
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.90	-0.72	-0.80
OX60		1.0	-0.77	-0.78
NP60			1.0	0.80
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.82	-0.73	-0.55
OX120		1.0	-0.82	-0.74
NP120			1.0	0.70
WDEP				1.0

Table B3

Plot Three

	EH15	OX15	NP15	WDEP
EH15	1.0	0.79	-0.70	-0.72
OX15		1.0	-0.79	-0.79
NP15			1.0	0.86
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.80	-0.53	-0.66
OX30		1.0	-0.70	-0.81
NP30			1.0	0.83
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.67	-0.49	-0.58
OX60		1.0	-0.53	-0.69
NP60			1.0	0.76
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.73	-0.68	-0.70
OX120		1.0	-0.79	-0.70
NP120			1.0	0.63
WDEP				1.0

Table B4

Plot Four

	EH15	OX15	NP15	WDEP
EH15	1.0	0.64	-0.72	-0.69
OX15		1.0	-0.83	-0.85
NP15			1.0	0.86
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.81	-0.64	-0.79
OX30		1.0	-0.81	-0.85
NP30			1.0	0.90
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.79	-0.58	-0.78
OX60		1.0	-0.73	-0.92
NP60			1.0	0.71
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.64	-0.50	-0.63
OX120		1.0	-0.21ns*	-0.67
NP120			1.0	0.35
WDEP				1.0

*Nonsignificant.

Table B5

Plot Five

	EH15	OX15	NP15	WDEP
EH15	1.0	0.78	-0.79	-0.89
OX15		1.0	-0.84	-0.90
NP15			1.0	0.89
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.92	-0.81	-0.78
OX30		1.0	-0.78	-0.84
NP30			1.0	0.87
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.83	-0.78	-0.72
OX60		1.0	-0.72	-0.79
NP60			1.0	0.84
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	-0.32ns	0.58*	-0.03ns
OX120		1.0	-0.29ns	-0.69
NP120			1.0	0.11
WDEP				1.0

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*Significant at the 0.05 level of probability.

APPENDIX C: OXYGEN CONTENT AND REDOX POTENTIAL AT 15, 30, 60, AND 120 CM WITH WATER DEPTH FOR THE PEARL RIVER TRANSECT

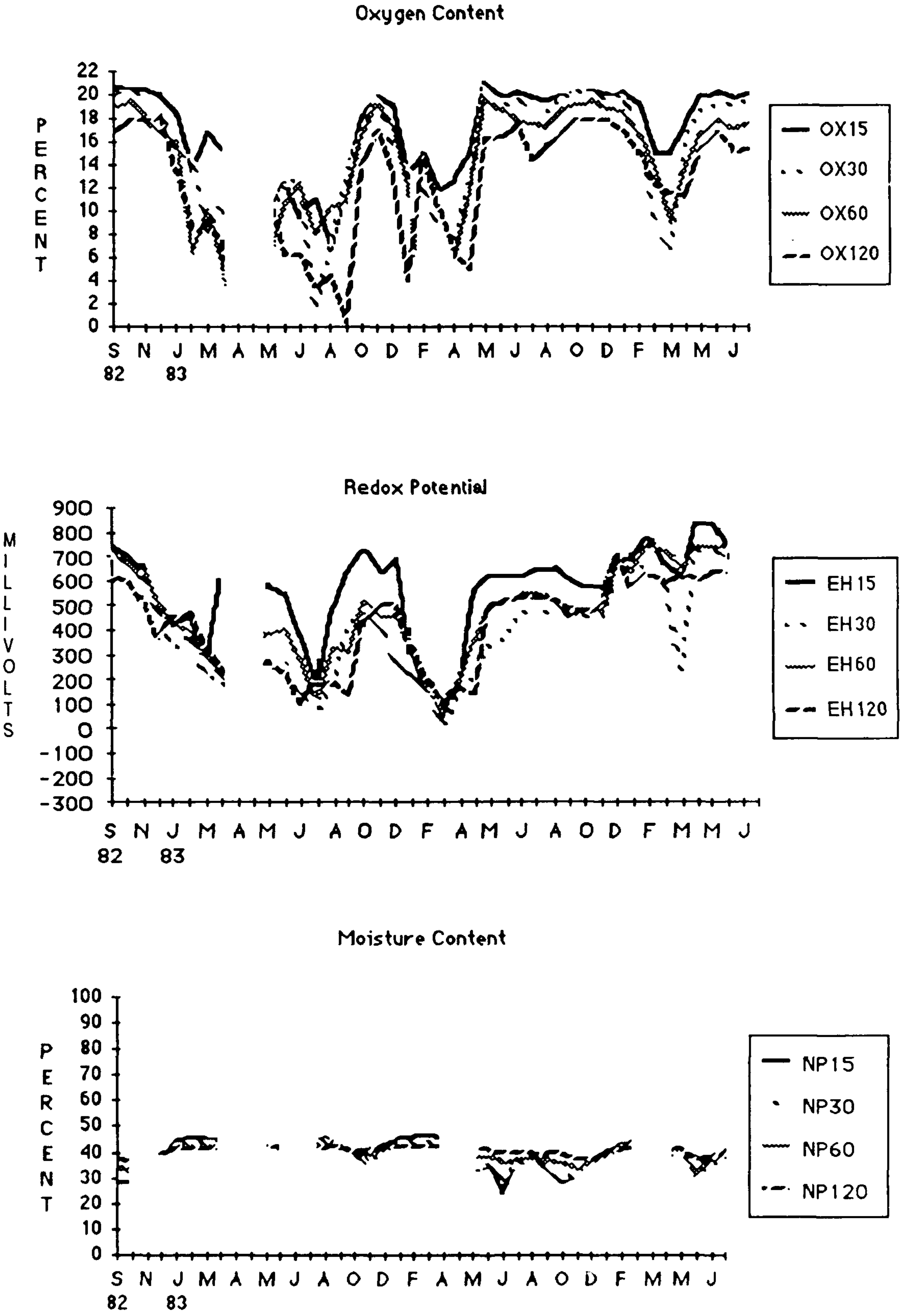
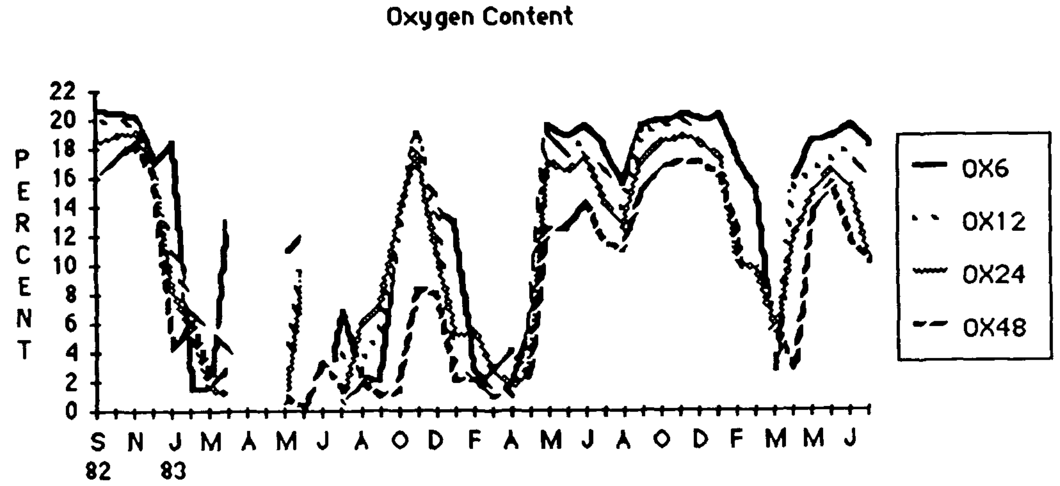
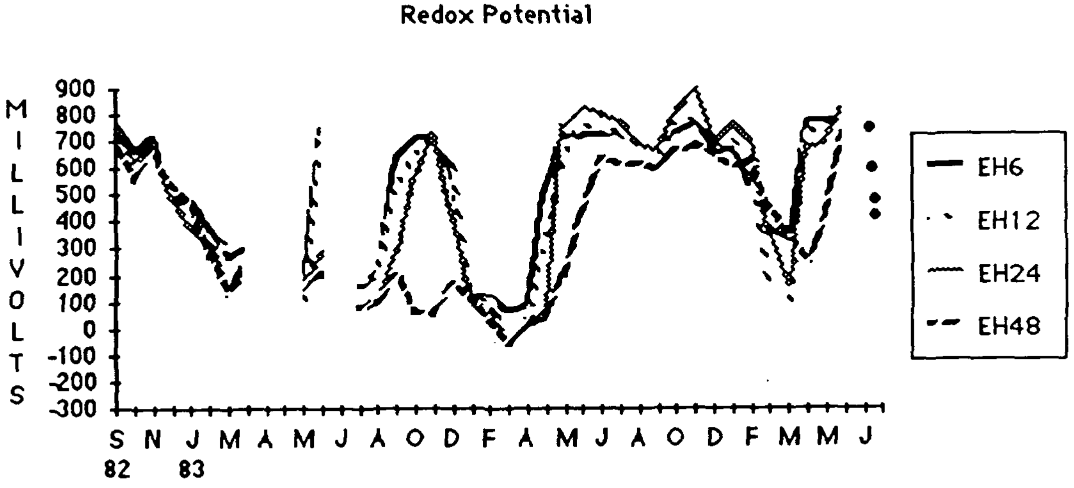


Figure C1. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Pearl River Plot 1





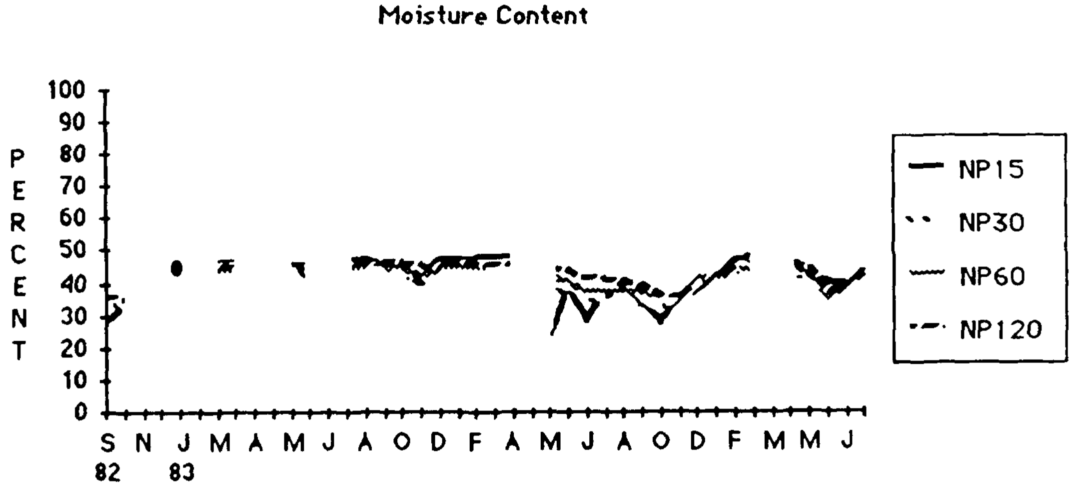


Figure C2. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Pearl River Plot 2

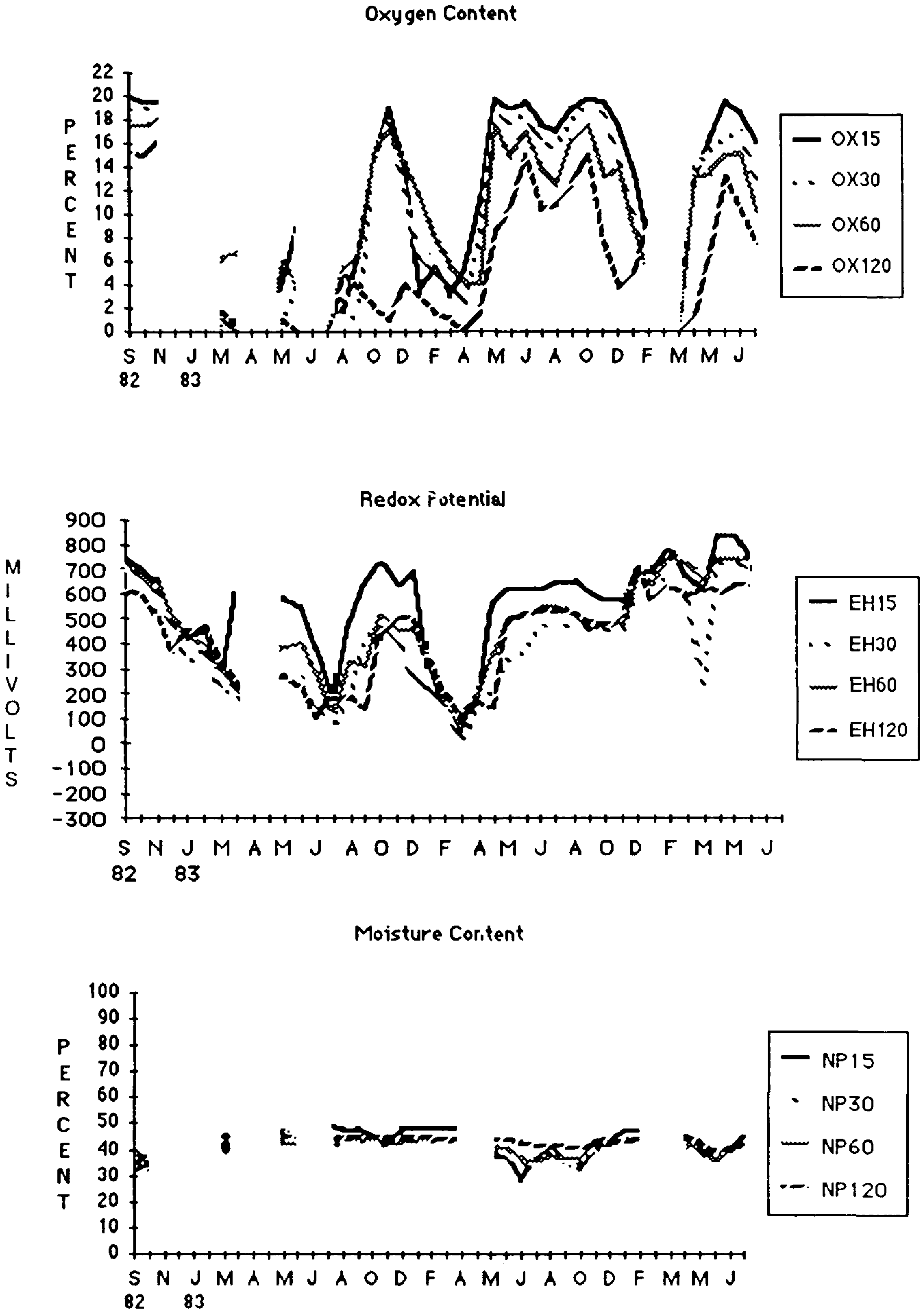
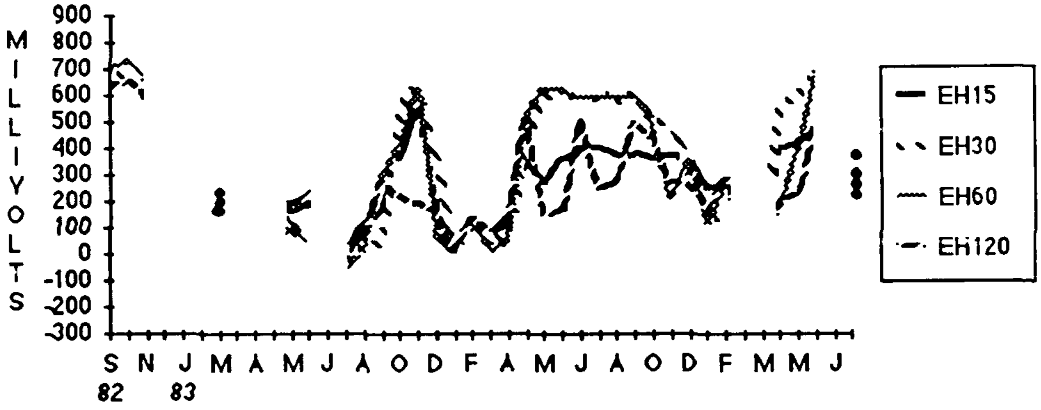


Figure C3. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Pearl River Plot 3

Oxygen Content

Redox Potential



Moisture Content

Figure C4. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Pearl River Plot 4

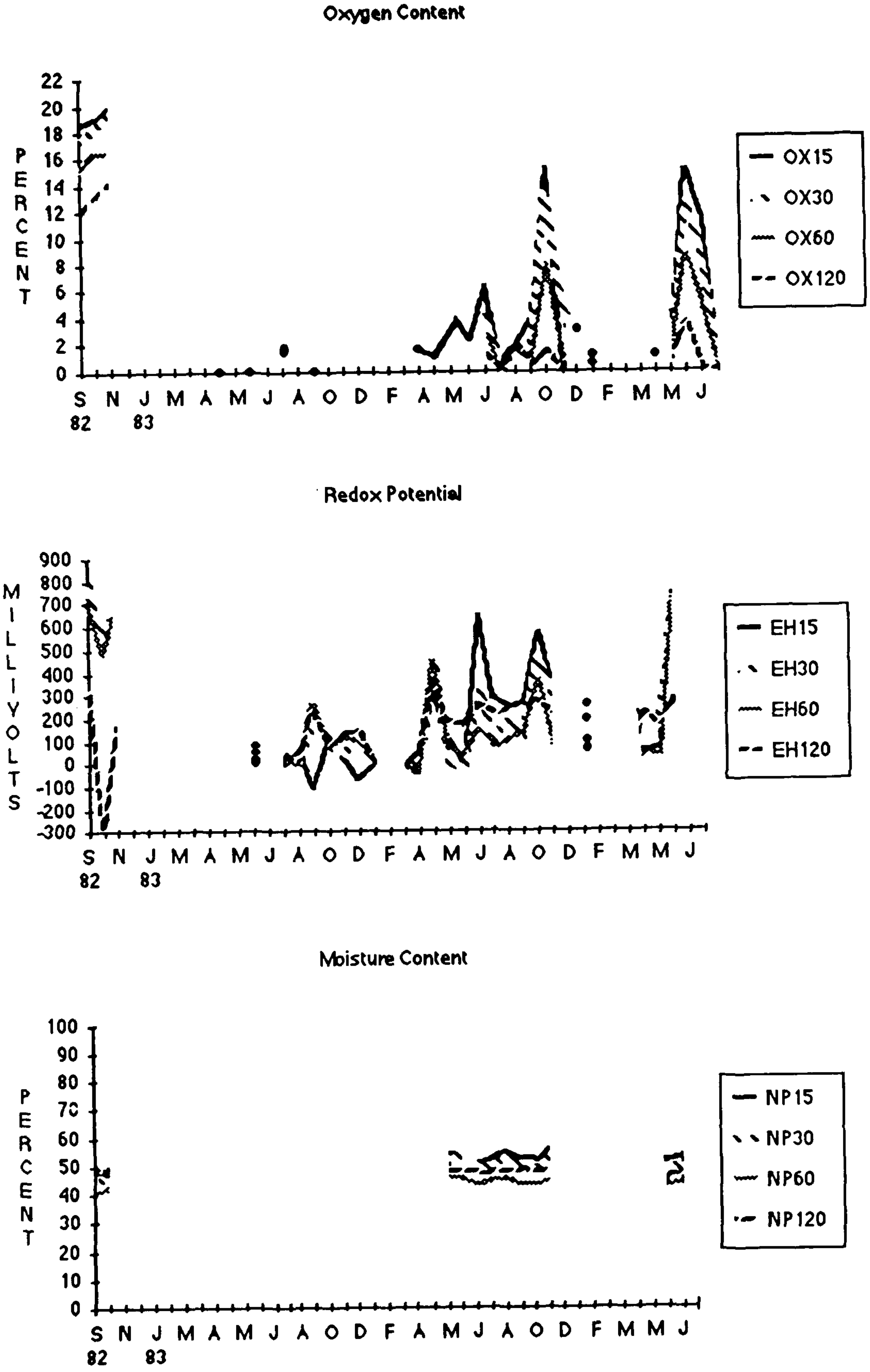


Figure C5. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Pearl River Plot 5

APPENDIX D: RESULTS OF LABORATORY SOIL ANALYSES: PARTICLE SIZE, BULK DENSITY, ORGANIC MATTER, AND pH

Table D1

Physical and Chemical Soil Data for the Pearl River Transect

Plot	Horizon	Sand	Silt	Clay	Texture	Bulk Density	Organic Matter	pH
		--------	%	---------		g/cc	%	
1	A1	36	56	8	Loam	1.29	2.1	3.9
	BW	25	51	24	Silt Loam	1.55	0.5	4.0
	Bg21	19	59	22	Silt Loam	1.61	0.3	3.9
	Bg22	25	57	18	Silt Loam	1.69	—	4.0
	Bg3	13	55	32	Silty Clay Loam	1.76	—	4.2
2	A1	32	60	8	Silt Loam	1.12	2.7	4.1
	Bg1	12	54	24	Silt Loam	1.67	0.4	4.0
	Bg2	12	62	26	Silt Loam	1.62	—	4.1
	Bg3	11	62	27	Silty Clay Loam	1.66	—	4.4
	Bg4	14	62	24	Silt Loam	1.72	—	4.2
3	A1	40	48	12	Silt Loam	1.66	1.6	4.2
	Bg1	23	47	30	Clay Loam	1.71	—	4.1
	Bg2	16	56	28	Silty Clay Loam	1.73	—	4.1
	Bg3	11	57	32	Silty Clay Loam	1.69	—	4.1
4	A1	34	42	24	Loam	1.54	1.0	4.2
	Bg1	19	49	32	Silty Clay Loam	1.66	0.5	4.1
	Bg2	18	52	30	Silty Clay Loam	1.71	—	4.3
	Bg3	13	53	34	Silty Clay Loam	1.60	—	4.3
	Bg4	23	49	28	Clay Loam	1.72	—	4.4
5	A1	—	—	—	—	1.48	—	4.5
	Bg1	20	48	32	Clay Loam	1.61	—	4.5
	Bg2	16	52	32	Silty Clay Loam	1.67	—	5.0
	Bg3	19	55	26	Silt Loam	1.71	—	4.4

Table D2

Physical and Chemical Soil Data for the Quimby Transect

Plot	Horizon	Sand	Silt	Clay	Texture	Bulk Density	Organic Matter	pH
		--------	%	---------		g/cc	%	
1	A1	32	40	28	Loam	1.43	2.4	4.8
	Bt1	34	42	24	Loam	1.44	1.4	5.0
	Bt2	44	36	20	Loam	1.51	—	5.1
	Bt3	59	27	14	Sandy Loam	1.56	—	5.2
	C	81	10	9	Sandy Loam	1.42	—	5.5
2	A1	16	20	64	Clay	1.39	5.2	5.5
	Btg1	7	44	49	Silty Clay	1.59	3.4	4.8
	Btg2	2	39	59	Clay	1.70	—	5.1
	2Bc1	7	56	37	Silty Clay Loam	1.63	—	5.6
3	A1	8	24	68	Clay	1.46	4.4	4.5
	Bg1	16	48	36	Silty Clay Loam	1.69	2.2	4.7
	Bg2	16	44	40	Silty Clay Loam	1.73	—	5.5
	Bg3	—	—	—	—	1.68	—	6.4
	2Cg	15	57	28	Silty Clay Loam	1.67	—	6.4
4	A1	12	16	72	Clay	1.56	4.2	5.6
	Bg1	22	18	60	Clay	1.65	2.5	7.2
	Bg2	9	40	51	Silty Clay	1.78	—	7.6
	BCg	6	50	44	Silty Clay	1.67	—	7.5
5	A1	20	24	56	Clay	1.02	<1.0	5.6
	Bg1	10	20	70	Clay	1.54	3.0	6.5
	Bg2	8	16	76	Clay	1.28	—	7.0
	Bg3	10	30	60	Clay	1.47	—	7.1

Table D3

Physical and Chemical Soil Data for the Red River Transect

Plot	Horizon	Sand	Silt	Clay	Texture	Bulk Density	Organic Matter	pH
		--------	%	---------		g/cc	%	
1	A	7	60	33	Silty Clay Loam	1.41	3.1	7.2
	C1-A	4	74	22	Silt Loam	1.59	0.5	7.2
	C1-B	1	54	45	Silty Clay	—	—	—
	C2-A	5	71	24	Silt Loam	1.64	0.9	7.3
	C2-B	4	43	53	Silty Clay	—	—	—
	C3	7	69	24	Silt Loam	1.49	—	7.5
2	A	3	54	43	Silty Clay	1.53	<1.0	7.6
	B	<1	53	47	Silty Clay	1.83	1.3	7.4
	C-A	12	65	23	Silt Loam	1.66	—	7.5
	C-B	1	61	38	Silty Clay Loam	—	—	7.5
3	A11	5	42	53	Silty Clay	1.72	<1.0	7.2
	A12	1	50	49	Silty Clay	—	2.3	7.3
	A1B	5	35	60	Silty Clay Loam	—	<1.0	7.2
	Bb	1	49	50	Silty Clay	1.64	1.1	7.3
	C	<1	53	47	Silty Clay	1.66	—	7.2
4	A	3	41	56	Silty Clay	1.74	2.7	7.1
	C	1	59	40	Silty Clay	1.62	—	7.2

Table D4

Physical and Chemical Soil Data for the Rolling Fork Transect

Plot	Horizon	Sand	Silt	Clay	Texture	Bulk Density	Organic Matter	pH
			%			g/cc	%	
1	A1	—	—	—	—	1.27	1.7	6.6
	Btg1	12	56	32	Silty Clay Loam	1.78	2.4	6.4
	Btg2	24	52	24	Silty Loam	1.51	—	5.5
	BC	32	48	20	Loam	1.49	—	6.0
	2C	36	48	16	Loam	1.43	—	6.1
2	A1	32	16	52	Clay	1.25	5.2	7.1
	Bg1	29	21	50	Clay	1.75	3.0	6.9
	Bg2	28	24	48	Clay	1.76	—	6.9
	Bg3	28	16	56	Clay	1.76	—	7.4
	Bg4	28	28	44	Clay	1.77	—	7.6
	2C	16	56	28	Silt Loam	1.66	—	7.4
3	A1	20	20	60	Clay	1.32	5.2	7.0
	Bg1	16	20	64	Clay	1.86	2.5	6.6
	Bg2	16	14	70	Clay	1.69	—	6.7
	2C	24	36	40	Clay Loam	1.66	—	7.4
4	A	16	10	74	Clay	1.37	5.8	5.7
	Bg1	16	8	76	Clay	1.73	1.7	6.4
	Bg2	16	16	68	Clay	1.79	—	7.6
	Bg3	16	32	52	Clay	1.82	—	7.6
	C1	12	40	48	Silty Clay	1.74	—	7.1
	C2	8	44	48	Silty Clay	1.71	—	7.4
5	A	16	20	64	Clay	1.58	5.6	5.9
	Bg1	16	12	72	Clay	1.70	3.3	6.4
	Bg2	16	12	72	Clay	1.69	—	6.5
	Bg3	16	12	72	Clay	1.77	—	7.0
	Bg4	<1	17	83	Clay	1.82	—	6.9
	C	<1	22	78	Clay	1.77	—	—

Table D5

Physical and Chemical Soil Data for the Spring Bayou Transect

Plot	Horizon	Sand	Silt	Clay	Texture	Bulk Density	Organic Matter	pH
			%			g/cc	%	
1	A	16	20	64	Clay	1.86	2.8	4.5
	Btg1	16	43	41	Silty Clay	1.85	1.0	4.7
	Btg2	33	30	37	Clay Loam	1.87	—	5.1
	Btg3	14	42	44	Silty Clay	1.87	—	5.5
	BCg	32	41	27	Loam	1.81	—	5.8
2	A1	8	12	80	Clay	1.85	3.2	5.5
	Btg1	15	28	57	Clay	1.78	2.0	5.2
	Btg2	31	32	37	Clay Loam	1.86	—	5.7
	Btg3	17	32	51	Clay	1.88	—	6.0
	2CG	41	26	33	Loam	1.70	—	6.0
3	A1	16	8	76	Clay	1.81	3.0	5.0
	Bg1	16	46	38	Silty Clay Loam	1.84	0.6	6.2
	Bg2	14	39	47	Clay	1.89	—	6.3
	2Cg	19	43	38	Silty Clay Loam	1.69	—	6.5
4	A1	5	17	78	Clay	1.86	5.4	6.6
	Cg1	1	6	93	Clay	1.73	—	6.3
	Cg2	8	32	60	Clay	1.85	—	7.0
	Cg3	21	37	42	Clay	1.67	—	7.3

APPENDIX E: SOIL PROFILE DESCRIPTIONS FOR THE PEARL RIVER TRANSECT

Plot 1 - Arkabutla Series

Described and sampled by W. Blake Parker, Steve Forsythe, Steve Faulkner, Bob Owens, Richard Nolde and Pan Sceeling.

Soil classification. fine-silty, mixed, acid, thermic Aeric Fluvaquents

A--0 to 10 cm, dark brown (10 YR 3/3) silt loam; weak fine granular structure; common fine roots; extremely acid.

BW--10 to 25 cm; pale brown (10 YR 6/3) silt loam; weak fine granular structure; few iron and manganese conditions; common fine roots; extremely acid.

Bg21--25 to 74 cm; light brownish gray (2.5 Y 6/2) silt loam; common medium distinct brownish yellow (10 YR 6/6) and few fine prominent strong brown (7.5 YR 5/6) mottles; weak medium subangular blocky structure; few fine iron and manganese concretions; common fine and few medium roots; extremely acid.

Bg22--74 to 124 cm; light brownish gray (2.5 Y 6/2) silt loam; common coarse distinct brownish yellow (10 YR 6/6) mottles; weak medium subangular blocky structure; few fine roots; very strongly acid.

Bg3--117 to 152 cm; light brownish gray (2.5 Y 6/2) silt loam; common fine distinct yellowish brown (10 YR 5/6) mottles; weak medium subangular blocky structure; common medium iron and manganese concretions; very strongly acid.

Plot 2 - Rosebloom Series

Soil classification. fine-silty, mixed, acid, thermic Typic Fluvaquents

A1--0 to 10 cm, brown (10 YR 5/3) silt loam; weak fine granular structure; common fine roots; very strongly acid.

Bg1--10 to 38 cm; light brownish gray (10 YR 6/2) silt loam; weak fine subangular blocky structure; few iron and manganese concretions; common fine roots; extremely acid.

Bg2--38 to 56 cm; light brownish gray (10 YR 6/2) silt loam; common medium prominent yellowish brown (10 YR 5/6) and few medium prominent brown (10 YR 4/3) mottles; weak medium subangular blocky structure; few iron and manganese concretions; common fine roots; very strongly acid.

Bg3--56 to 79 cm; light brownish gray (2.5 Y 6/2) silty clay loam common fine distinct yellowish brown (10 YR 5/4) and few fine prominent strong brown (7.5 YR 5/6) mottles; moderate medium subangular blocky structure; common medium iron and manganese concretions; very strongly acid.

Bg4--79 to 130 cm, brownish yellow (10 YR 6/6) silty clay loam; common medium distinct yellowish brown (10 YR 5/6) and few faint strong brown (7.5 YR 5/6) mottles; weak medium subangular blocky structure; few medium iron and manganese concretions; very strongly acid.

Plot 3 - Rosebloom Series

Soil classification. fine-silty, mixed, acid, thermic Typic Fluvaquents

A1--0 to 20 cm, pale brown (10 YR 6/3) silt loam; common medium faint light brownish gray (10 YR 6/2) mottles; weak fine granular structure; few common iron and manganese concretions; common fine roots; very strongly acid.

Bg1--20 to 50 cm, light brownish gray (2.5 Y 6/2) silty clay loam; common medium distinct brownish yellow (10 YR 6/8) and strong brown (7.5 YR 5/8) mottles; moderate medium subangular blocky structure; few common iron and manganese concretions; common fine and common medium roots; very strongly acid.

Bg2--50 to 99 cm, light brownish gray (2.5 Y 6/2) silty clay loam; common medium distinct brownish yellow (10 YR 6/8) and common coarse distinct strong brown (7.5 YR 5/8) mottles; massive structure; common medium iron and manganese concretions; common fine roots; very strongly acid.

Bg3--99 to 147 cm, light brownish gray (2.5 Y 6/2) silty clay loam; many coarse prominent brownish yellow (10 YR 6/8), and strong brown (7.5 YR 5/8) mottles; weak medium subangular blocky structure; very strongly acid.

Plot 4 - Rosebloom Series

Soil classification. fine-silty, mixed, acid, thermic Typic Fluvaquents

A1--0 to 15 cm, light brownish gray (2.5 Y 6/2) silt loam; yellowish brown (10 YR 5/4) strong brown (7.5 R 5/6) mottles; weak fine granular structure; common fine roots; very strongly acid.

Bg1--15 to 41 cm, light brownish gray (2.5 Y 6/2) silt loam; common medium distinct brownish yellow (10 YR 6/8) and few fine faint brown (10 YR 5/3) mottles; weak fine subangular blocky structure; many medium iron and manganese concretions; oxidized root channels; very strongly acid.

Bg2--41 to 74 cm, light brownish gray (2.5 Y 6/2) silty clay loam; common medium distinct strong brown (7.5 ÁÂ 5/6) and few fine prominent brownish yellow (10 YR 6/8) mottles; moderate medium subangular blocky structure; very strongly brown.

Bg3--74 to 117 cm, light brownish gray (2.5 Y 6/2) silty clay loam; common medium distinct gray (5 Y 6/1) common medium distinct strong brown (7.5 YR 5/6) and few fine prominent brownish yellow (10 YR 6/8) mottles; common medium iron and manganese concretions; very strongly acid.

Bg4--117 to 150 cm, strong brown (7.5 YR 5/6) light brownish gray (10 YR 6/2) and gray (5 Y 6/1) silty clay loam; weak medium subangular blocky structure; very strongly acid.

Plot 5 - Rosebloom Series

Soil classification. fine-silty, mixed, acid, thermic Typic Fluvaquents

Oi--+5 to 0 cm, raw hardwood litter composed of leaves and twigs.

A1--0 to 13 cm, grayish brown (2.5 Y 5/2) silt loam; common fine prominent dark brown (7.5 YR 4/4) mottles; very strongly acid; common fine roots.

Bg1--13 to 41 cm, grayish brown (2.5 Y 5/2) silt loam or silty clay loam; common medium prominent dark brown (7.5 YR 4/4) mottles; weak medium subangular blocky structure; numerous iron stains in root channels; few fine roots; moderately acid.

Bg2--41 to 71 cm, grayish brown (2.5 Y 5/2) silt loam; few fine prominent dark brown (7.5 YR 4/4) mottles; weak medium subangular blocky structure; few iron stains in root channels; moderately acid.

Bg3--71 to 122+ cm, gray (5 Y 6/1) silt loam; many coarse prominent brownish yellow (10 YR 6/8) and common fine prominent yellowish red (5 YR 5/6) mottles; weak medium subangular blocky structure.

APPENDIX F: QUIMBY CORRELATION COEFFICIENTS BY DEPTH

Table F1

Plot One

	EH15	OX15	NP15	WDEP
EH15	1.0	0.64*	-0.36	-0.38
OX15		1.0	-0.47	-0.09ns[†]
NP15			1.0	0.14ns
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.37	-0.28**	-0.29
OX30		1.0	-0.33	-0.21ns
NP30			1.0	0.04ns
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.25**	-0.41	-0.03ns
OX60		1.0	-0.35	-0.11ns
NP60			1.0	0.01ns
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.32	-0.09ns	-0.14ns
OX120		1.0	-0.24**	-0.14ns
NP120			1.0	0.06ns
WDEP				1.0

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* All correlations are significant at the 0.01 level of probability unless otherwise indicated.
** Significant at the 0.05 level of probability.
[†] Nonsignificant.

Table F2

Plot Two

	EH15	OX15	NP15	WDEP
EH15	1.0	0.50	-0.37	-0.13ns
OX15		1.0	-0.59	-0.44
NP15			1.0	0.44
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	-0.17ns	-0.04ns	0.19ns
OX30		1.0	-0.40	-0.43
NP30			1.0	0.33
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.44	-0.21ns	-0.12ns
OX60		1.0	-0.26*	-0.39
NP60			1.0	0.17ns
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.63	-0.14ns	-0.49
OX120		1.0	-0.38	-0.40
NP120			1.0	0.28*
WDEP				1.0

*Significant at the 0.05 level of probability.

Table F3

Plot Three

	EH15	OX15	NP15	WDEP
EH15	1.0	0.62	-0.22ns	-0.70
OX15		1.0	-0.43	-0.72
NP15			1.0	0.40
WDEP				1.0
	EH30	**OX30**	**NP30**	**WDEP**
EH30	1.0	0.85	-0.18ns	-0.73
OX30		1.0	-0.35*	-0.83
NP30			1.0	0.34*
WDEP				1.0
	EH60	**OX60**	**NP60**	**WDEP**
EH60	1.0	0.80	-0.19ns	-0.74
OX60		1.0	-0.26ns	-0.80
NP60			1.0	0.16ns
WDEP				1.0
	EH120	**OX120**	**NP120**	**WDEP**
EH120	1.0	0.78	-0.37	-0.51
OX120		1.0	-0.50	-0.71
NP120			1.0	0.37*
WDEP				1.0

*Significant at the 0.05 level of probability.

Table F4

Plot Four

	EH15	OX15	NP15	WDEP
EH15	1.0	0.71	-0.48	-0.62
OX15		1.0	-0.52	-0.65
NP15			1.0	0.74
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.66	-0.54	-0.77
OX30		1.0	-0.47	-0.74
NP30			1.0	0.54
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.44	-0.42	-0.62
OX60		1.0	-0.24ns	-0.63
NP60			1.0	0.39
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.49	-0.29*	-0.46
OX120		1.0	-0.33*	-0.43
NP120			1.0	0.29*
WDEP				1.0

*Significant at the 0.05 level of probability.

Table F5

Plot Five

	EH15	OX15	NP15	WDEP
EH15	1.0	0.31ns	0.80*	-0.28ns
OX15		1.0	-0.89ns	-0.82
NP15			1.0	0.76*
WDEP				1.0

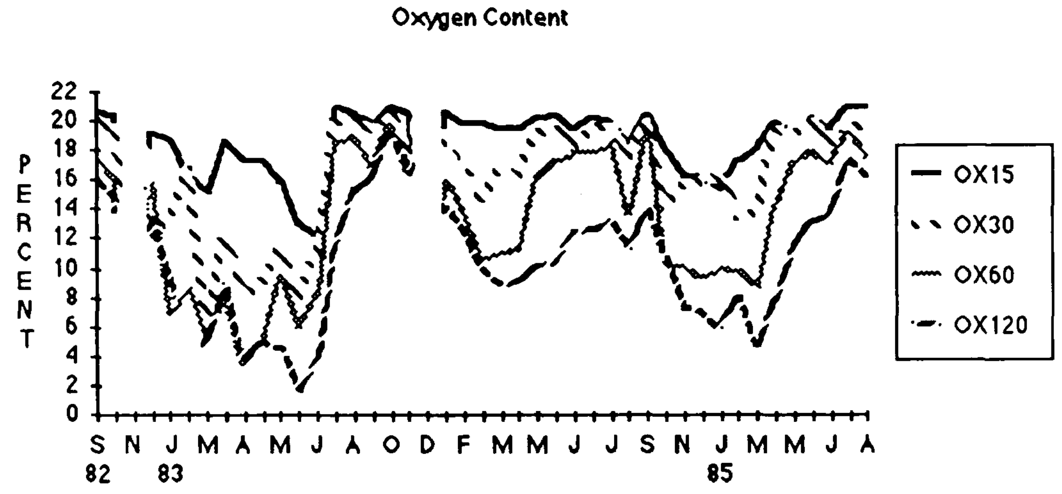
	EH30	OX30	NP30	WDEP
EH30	1.0	0.17ns	0.84*	-0.18ns
OX30		1.0	0.00ns	-0.34ns
NP30			1.0	-0.01ns
WDEP				1.0

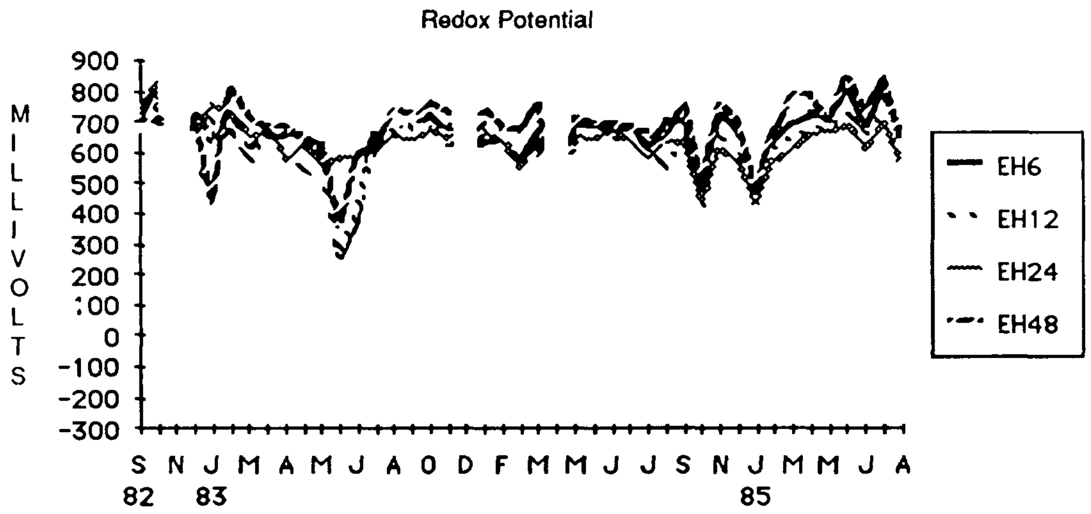
	EH60	OX60	NP60	WDEP
EH60	1.0	0.35ns	-0.11ns	-0.09ns
OX60		1.0	-1.00ns	-0.30ns
NP60			1.0	0.32ns
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	-0.10ns	0.34ns	-0.40ns
OX120		1.0	0.00ns	-0.64
NP120			1.0	0.34ns
WDEP				1.0

*Significant at the 0.05 level of probability.

APPENDIX G: OXYGEN CONTENT AND REDOX POTENTIAL AT 15, 30, 60, AND 120 CM WITH WATER DEPTH FOR THE QUIMBY TRANSECT





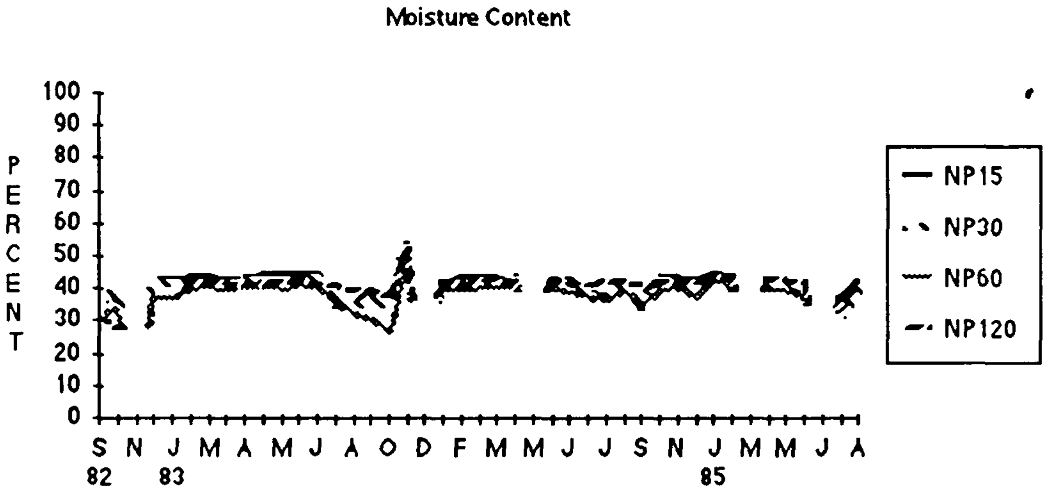
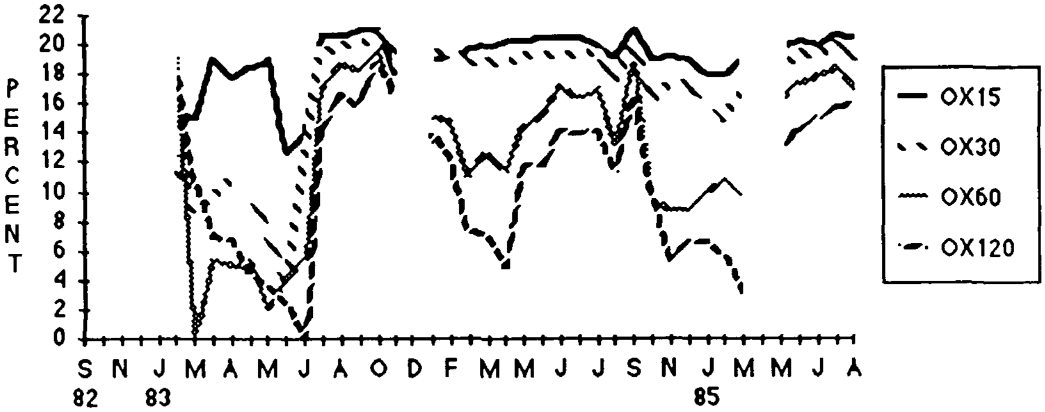


Figure G1. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Quimby Plot 1

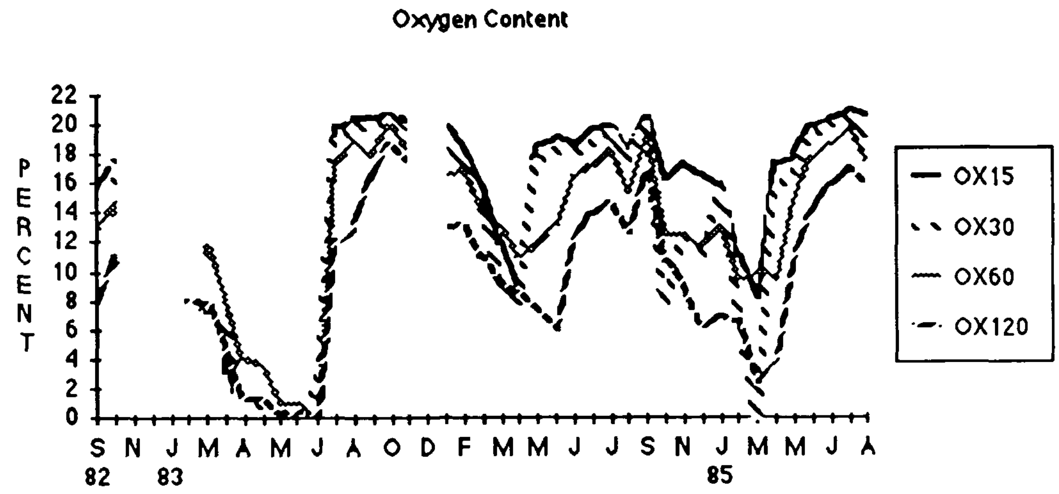
Oxygen Content



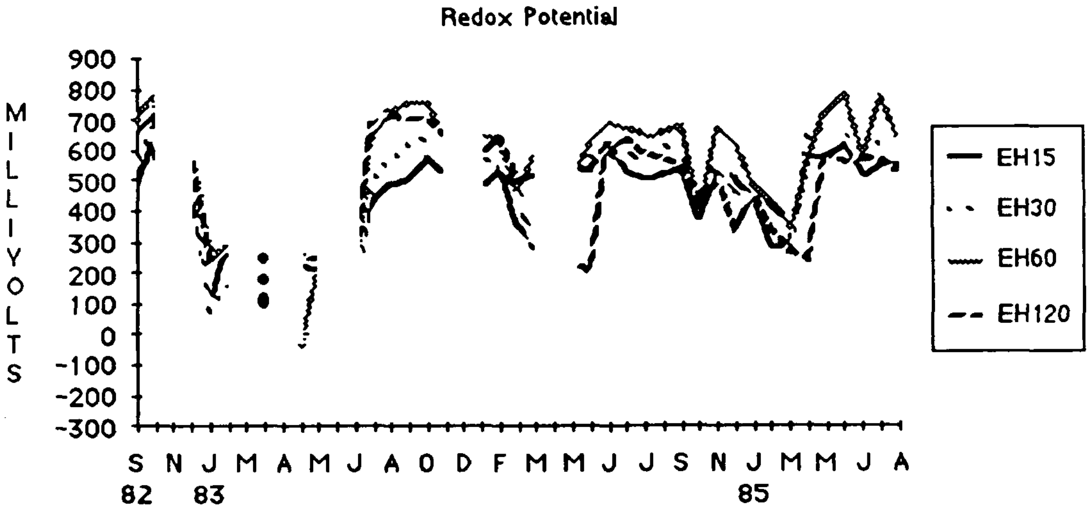
Redox Potential

Moisture Content

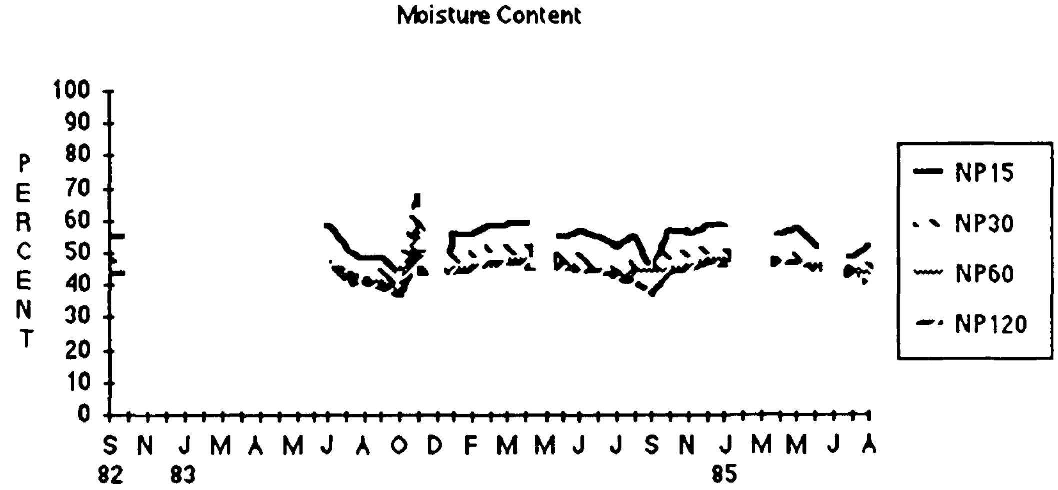
Figure G2. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Quimby Plot 2



Oxygen Content



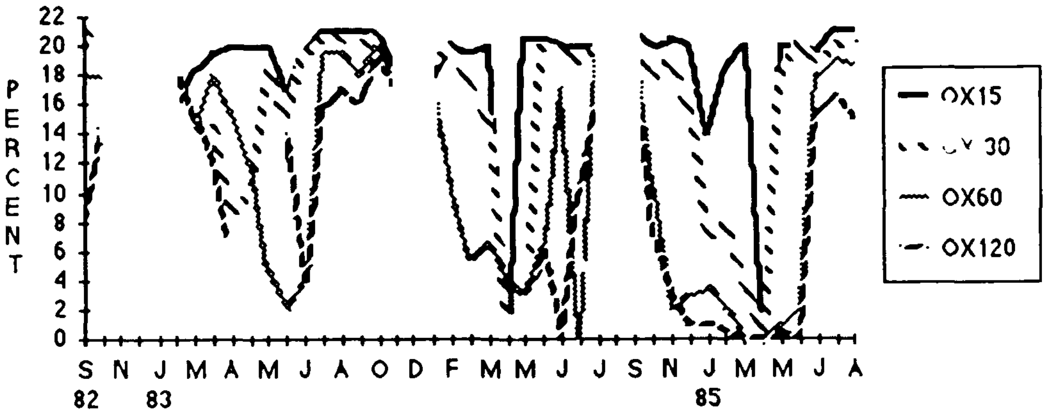
Redox Potential



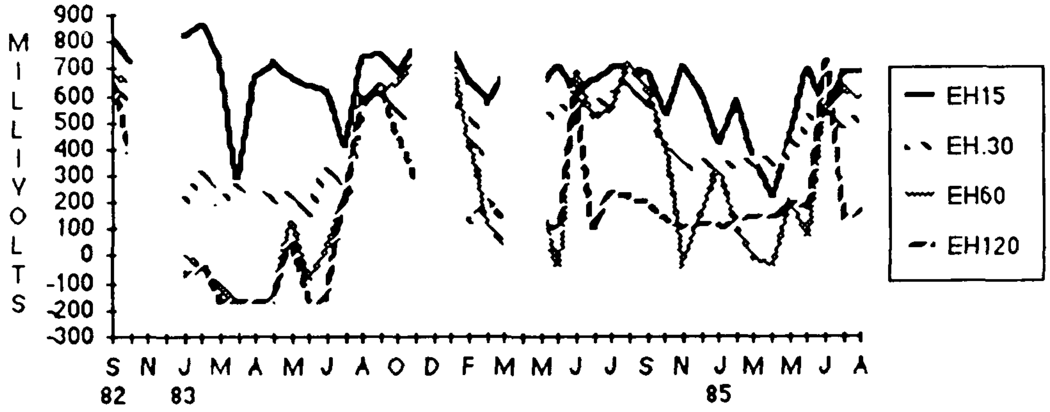
Moisture Content

Figure G3. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Quimby Plot 3

Oxygen Content



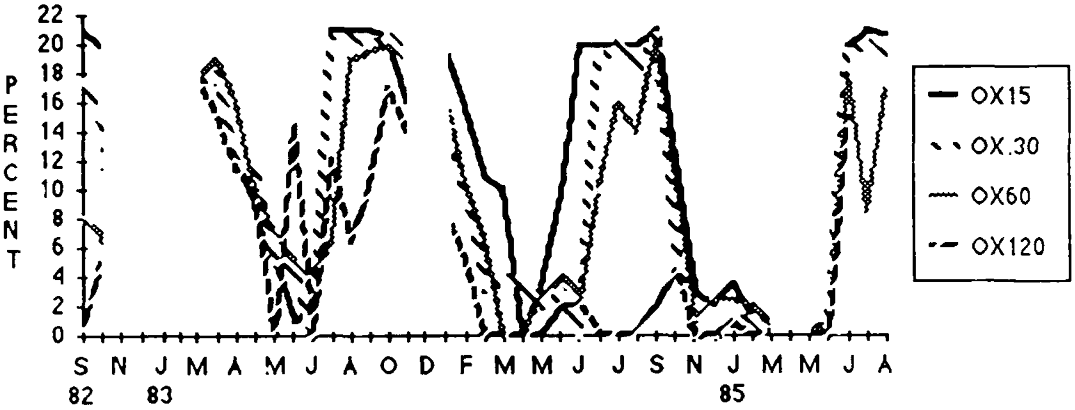
Redox Potential



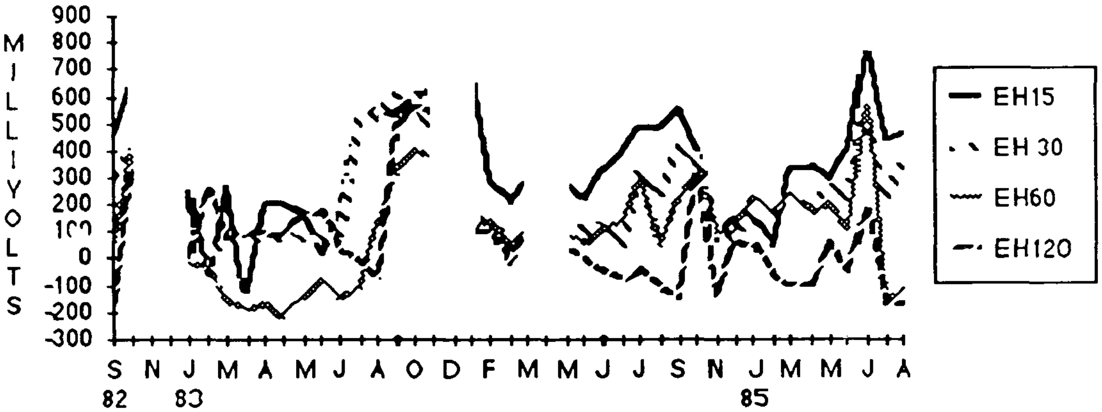
Moisture Content

Figure G4. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Quimby Plot 4.A

Oxygen Content



Redox Potential



Moisture Content

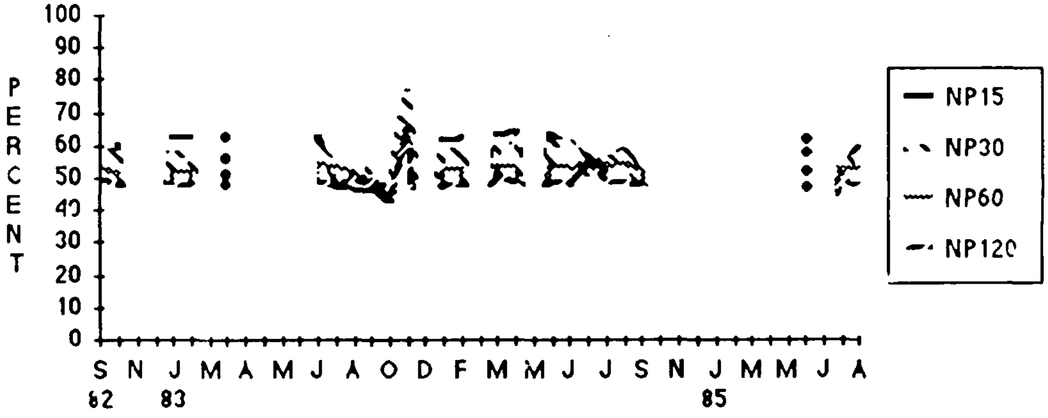


Figure G5. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Quimby Plot 4.B

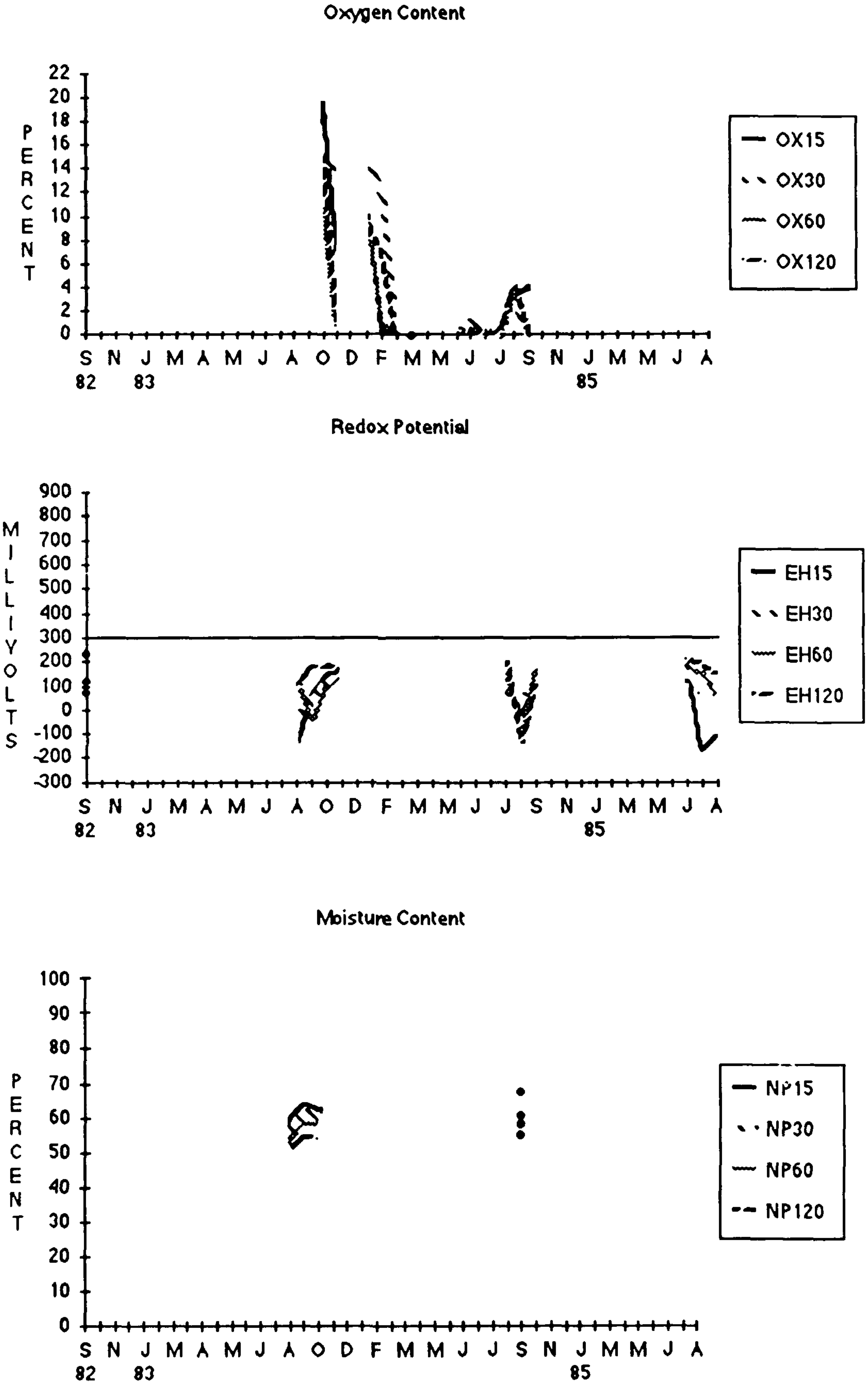


Figure G6. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Quimby Plot 5

APPENDIX H: SOIL PROFILE DESCRIPTION FOR THE QUIMBY TRANSECT

Plot 1 - Goldman Series

Described and sampled by W. Blake Parker, Steve Shetron, Thurman Allen, and Steve Faulkner.

Soil classification. coarse - silty, mixed, thermic, Aquic Hapludalfs

A1--0 to 10 cm, dark grayish brown (10 YR 4/2) silt loam; moderate medium subangular blocky structure; friable; few coarse and medium fine roots; very strongly acid; gradual wavy boundary.

Bt1--10 to 23 cm, dark grayish brown (10 YR 4/2) silt loam; few fine faint yellowish brown (10 YR 5/4) mottles; moderate medium subangular blocky structure; few coarse and common fine roots; very strongly acid; gradual smooth boundary.

Bt2--23 to 41 cm, brown (10 YR 5/3) clay loam; common medium distinct yellowish brown (10 YR 5/6) mottles; moderate medium subangular blocky structure; friable; ped faces coated; crotovina present; few fine and medium roots; very strongly acid; gradual smooth boundary.

Bt3--41 to 66 cm, yellowish brown (10 YR 5/4) very fine sandy loam; common medium distinct yellowish brown (10 YR 5/6) and few fine distinct grayish brown (10 YR 5/2) mottles; weak medium subangular blocky structure; very friable; few fine mica flakes; few fine roots; strongly acid; gradual smooth boundary.

C--66 to 178+ cm, dark brown (10 YR 4/3) sandy loam; common medium faint brown (10 YR 5/3) mottles; structureless, single grain; loose, few fine roots; strongly acid.

Plot 2 - Tensas Series

Soil classification. fine, montmorillonitic, thermic Vertic Ochraqualfs

A1--0 to 13 cm, dark gray (10 YR 4/1) clay; moderate medium subangular blocky structure; firm; many fine and medium roots; slightly acid; clear smooth boundary.

Btg1--13 to 28 cm, very dark gray (10 YR 3/1) clay; moderate medium subangular blocky structure; firm; common fine and medium roots; moderately acid; clear wavy boundary.

Btg2--28 to 56 cm, dark grayish brown (10 YR 4/2) silty clay; few fine distinct strong brown (7.5 YR 5/6) and common medium distinct dark yellowish brown (10 YR 4/6) mottles; moderate medium subangular blocky structure; firm; common fine and medium roots; moderately acid; clear wavy boundary.

2BC1--56 to 107 cm, grayish brown (10 YR 5/2) silty clay loam; common medium distinct dark yellowish brown (10 YR 4/4) and few medium distinct yellowish brown (10 YR 5/6) mottles; many iron and manganese stains; weak medium subangular blocky structure; firm; few fine roots; moderately acid.

Plot 3 - Kobel Series

Soil classification. fine, montmorillonitic, nonacid, thermic Vertic Haplaquepts

A1--0 to 13 cm, dark gray (10 YR 4/1) clay; common fine distinct yellowish brown (10 YR 5/4) mottles; moderate medium subangular blocky structure; friable; few coarse and many fine roots; very strongly acid; abrupt smooth boundary.

Bg1--13 to 51 cm, very dark gray (10 YR 3/1) clay; common medium distinct dark yellowish brown (10 YR 3/4) mottles; strong medium subangular blocky structure; friable; few coarse roots; very strongly acid; clear wavy boundary.

Bg2--51 to 66 cm, gray (10 YR 5/1) silty clay loam; common medium distinct dark yellowish brown (10 YR 4/4) and yellowish brown (10 YR 5/6) mottles; strong medium subangular blocky structure; friable; few medium roots; slightly acid; clear wavy boundary.

Bg3--66 to 152 cm, gray (10 YR 5/1) silty clay loam; common medium distinct strong brown (7.5 YR 5/6), dark yellowish brown (10 YR 4/4) and yellowish brown (10 YR 5/6) mottles; iron and manganese stains; moderate medium subangular blocky structure; friable; few fine roots; slightly acid; clear wavy boundary.

2Cg--152 to 183 cm, gray (10 YR 5/1) silty clay loam and brown (10 YR 5/3) silt loam, stratified; common medium distinct dark yellowish brown (10 YR 4/4) mottles; weak fine subangular blocky structure; friable; slightly acid.

Plot 4 - Kobel Series

Soil classification. fine, montmorillonitic, nonacid, thermic Vertic Haplaquepts

A1--0 to 13 cm, dark gray (10 YR 4/1) clay; many fine distinct yellowish brown (10 YR 5/6) and strong brown (7.5 YR 5/6) mottles; moderate medium subangular blocky structure; firm; many fine and medium roots; moderately acid; clear wavy boundary.

Bg1--13 to 48 cm, dark gray (10 YR 4/1) clay; few fine prominent reddish brown (5 YR 4/4) and few fine distinct yellowish brown (10 YR 5/4) mottles in upper part of horizon; common medium faint dark brown (10 YR 4/3) and few medium distinct strong brown (7.5 YR 5/6) mottles in lower part of horizon; few iron and manganese concretions; moderate medium subangular blocky structure; firm; common fine and medium roots; neutral; clear smooth boundary.

Bg2--48 to 91 cm, gray (10 YR 5/1) clay; common medium distinct yellowish brown (10 YR 5/6) and dark brown (7.5 YR 4/4) mottles; moderate medium subangular blocky structure; firm; few fine and medium roots; mildly acid; clear smooth boundary.

BCg--91 to 112+ cm, grayish brown (10 YR 5/2) silty clay loam; common medium distinct yellowish brown (10 YR 5/6) mottles; common iron and manganese stains and concretions; weak medium subangular blocky structure; friable; few fine roots; mildly acid.

Plot 5 - Fausse Series

Soil classification. very-fine, montmorillonitic, nonacid, thermic Typic Fluvaquents

A1--0 to 10 cm, dark grayish brown (10 YR 4/2) clay; common medium prominent dark gray (5 YR 4/1) mottles; common fine and medium roots; moderately acid; clear smooth boundary.

Bg1--10 to 23 cm, dark gray (2.5 Y N 4/0) clay; common medium prominent dark gray (5 YR 4/1) mottles or ped surfaces; common fine and medium roots; neutral; gradual smooth boundary.

Bg2--23 to 51 cm, dark gray (2.5 Y N 4/0) clay; common medium distinct dark yellowish brown (10 YR 4/4) and few medium prominent dark brown (7.5 YR 3/4) mottles; common medium and coarse roots; mildly acid; gradual smooth boundary.

Bg3--51 to 86 cm, dark gray (2.5 Y N 4/0) clay; common fine distinct dark yellowish brown (10 YR 4/4) and light olive brown (2.5 Y 5/4) mottles; common fine and medium roots; mildly acid.

APPENDIX I: RED RIVER CORRELATION COEFFICIENTS BY DEPTH

Table I1

Plot One

	EH15	OX15	NP15	WDEP
EH15	1.0*	0.50	-0.19ns†	0.26**
OX15		1.0	-0.42	0.01ns
NP15			1.0	0.20ns
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.17ns	0.05ns	0.17ns
OX30		1.0	-0.46	0.20ns
NP30			1.0	0.20ns
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.40	-0.27**	0.07ns
OX60		1.0	-0.45	-0.03ns
NP60			1.0	0.21ns
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.57	-0.18ns	-0.33ns
OX120		1.0	-0.47	-0.42
NP120			1.0	0.27**
WDEP				1.0

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* All correlations are significant at the 0.01 level of probability unless otherwise indicated.

** Significant at the 0.05 level of probability.

† Nonsignificant.

Table I2

Plot Two

	EH15	OX15	NP15	WDEP
EH15	1.0	0.50	-0.00ns	-0.02ns
OX15		1.0	-0.44	-0.29
NP15			1.0	0.30
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.74	-0.05ns	-0.22*
OX30		1.0	-0.38	-0.27*
NP30			1.0	0.36
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.41	-0.30	-0.18ns
OX60		1.0	-0.39	-0.30
NP60			1.0	0.49
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.51	-0.35	-0.64
OX120		1.0	-0.44	-0.40
NP120			1.0	0.39
WDEP				1.0

*Significant at the 0.05 level of probability.

Table I3

Plot Three

	EH15	OX15	NP15	WDEP
EH15	1.0	0.57	-0.65	-0.42
OX15		1.0	-0.80	-0.75
NP15			1.0	0.85
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.55	-0.43	-0.41
OX30		1.0	-0.66	-0.63
NP30			1.0	0.73
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.16ns	-0.04ns	-0.06ns
OX60		1.0	-0.22ns	-0.07ns
NP60			1.0	0.44
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.04ns	-0.21ns	-0.23ns
OX120		1.0	-0.06ns	-0.16ns
NP120			1.0	0.02ns
WDEP				1.0

Table I4

Plot Four

	EH15	OX15	NP15	WDEP
EH15	1.0	0.23ns	-0.38ns	-0.13ns
OX15		1.0	-0.72	-0.43*
NP15			1.0	0.67
WDEP				1.0

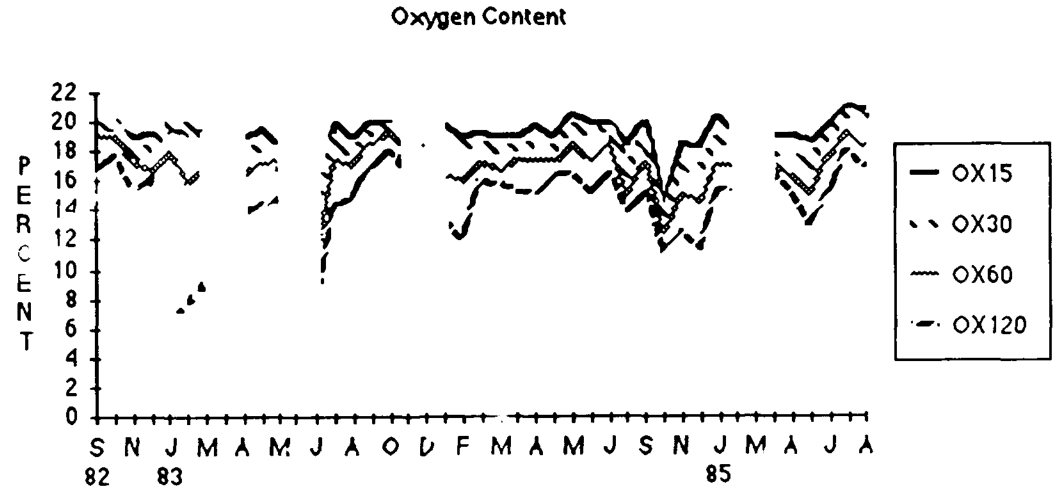
	EH30	OX30	NP30	WDEP
EH30	1.0	-0.19ns	-0.51*	-0.27ns
OX30		1.0	-0.30ns	-0.23ns
NP30			1.0	0.07ns
WDEP				1.0

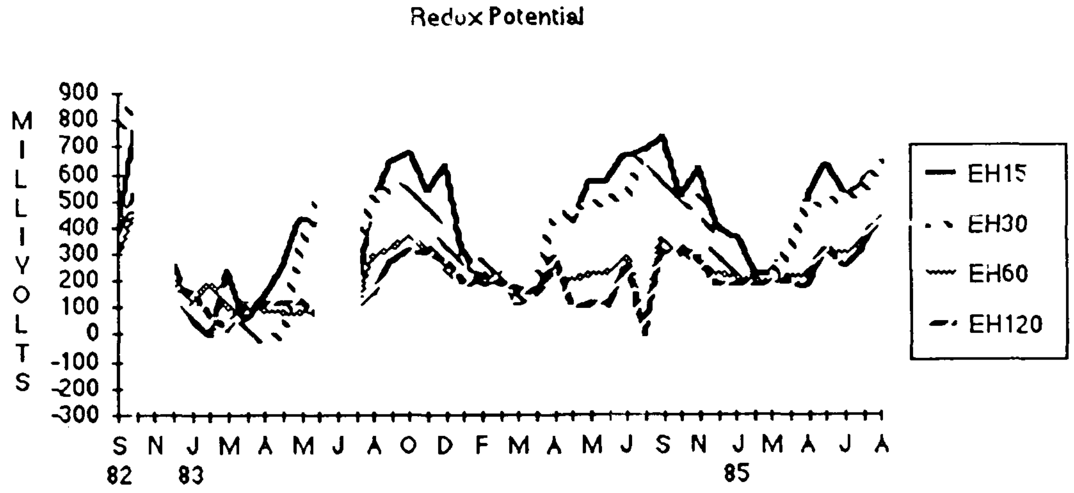
	EH60	OX60	NP60	WDEP
EH60	1.0	-0.33ns	-0.05ns	-0.48*
OX60		1.0	-0.22ns	-0.28ns
NP60			1.0	0.12ns
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	-0.12ns	-0.01ns	-0.37ns
OX120		1.0	-0.02ns	-0.00ns
NP120			1.0	0.00ns
WDEP				1.0

*Significant at the 0.05 level of probability.

APPENDIX J: OXYGEN CONTENT AND REDOX POTENTIAL AT 15, 30, 60, AND 120 CM WITH WATER DEPTH FOR THE RED RIVER TRANSECT





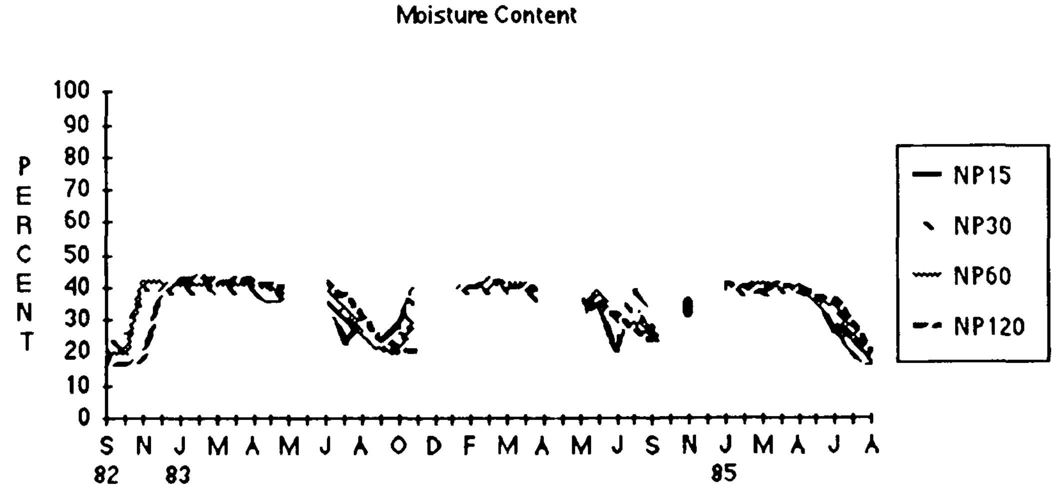


Figure J1. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Red River Plot 1


Oxygen Content


Redox Potential


Moisture Content

Figure J2. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Red River Plot 2

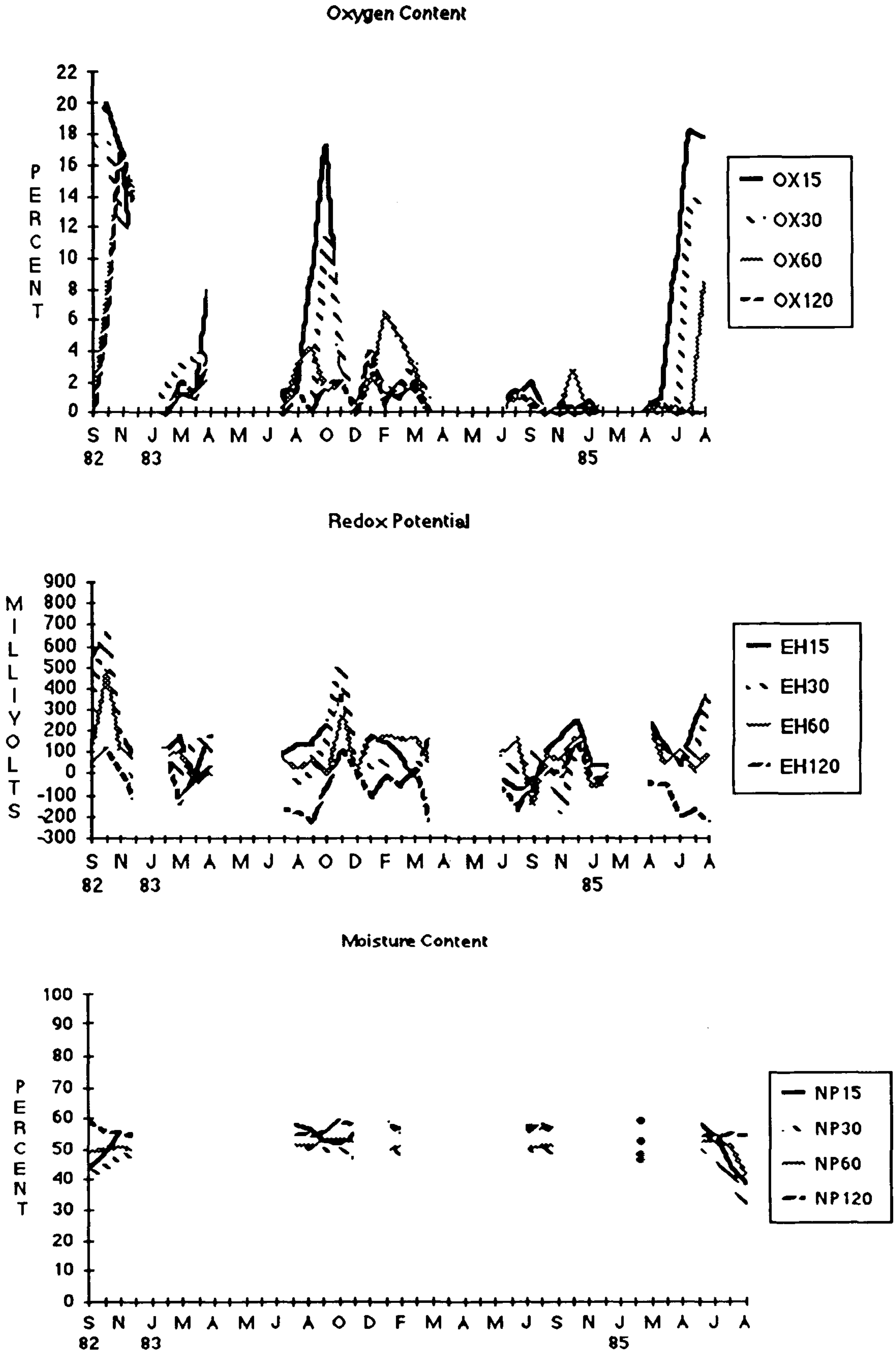
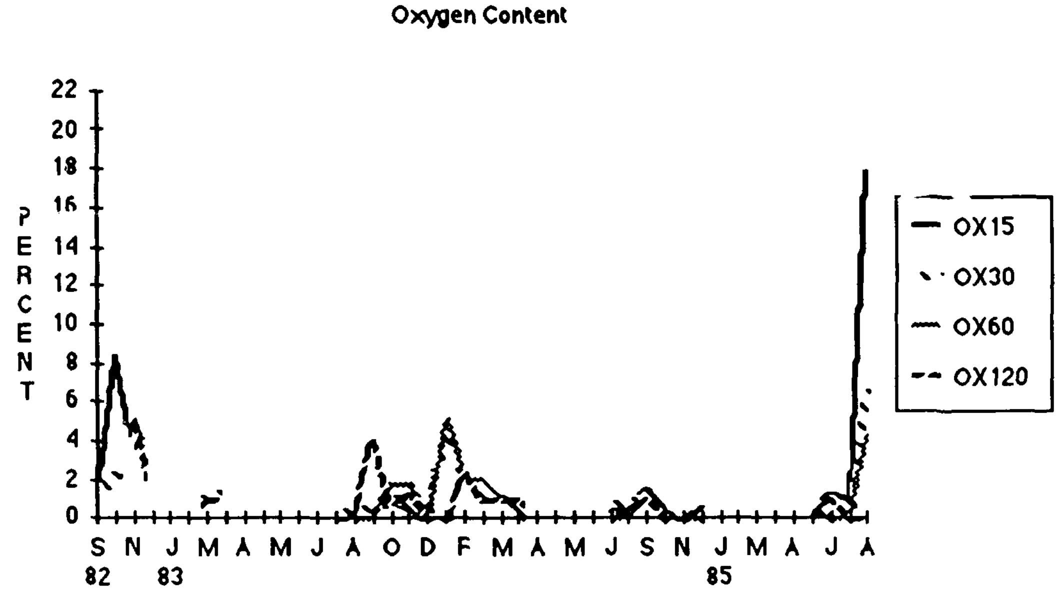
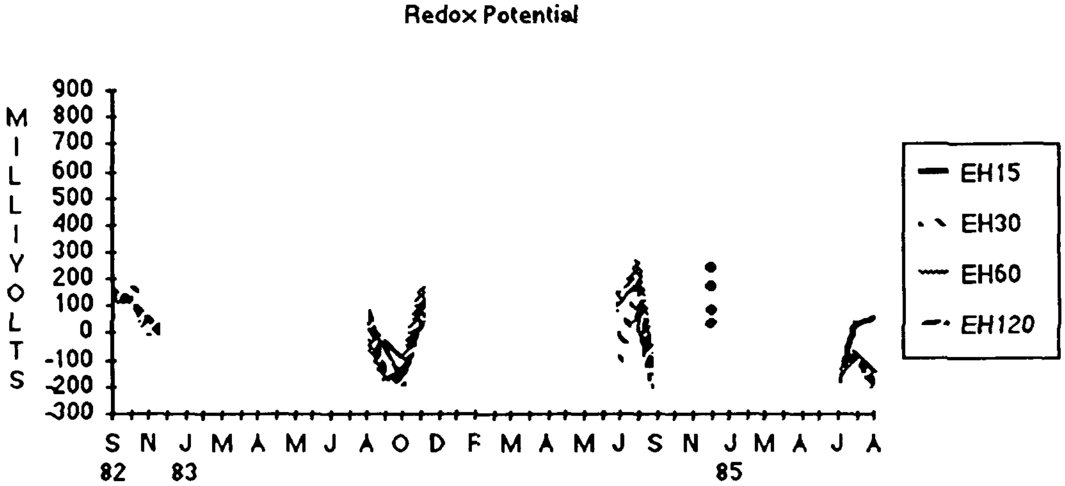


Figure J3. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Red River Plot 3





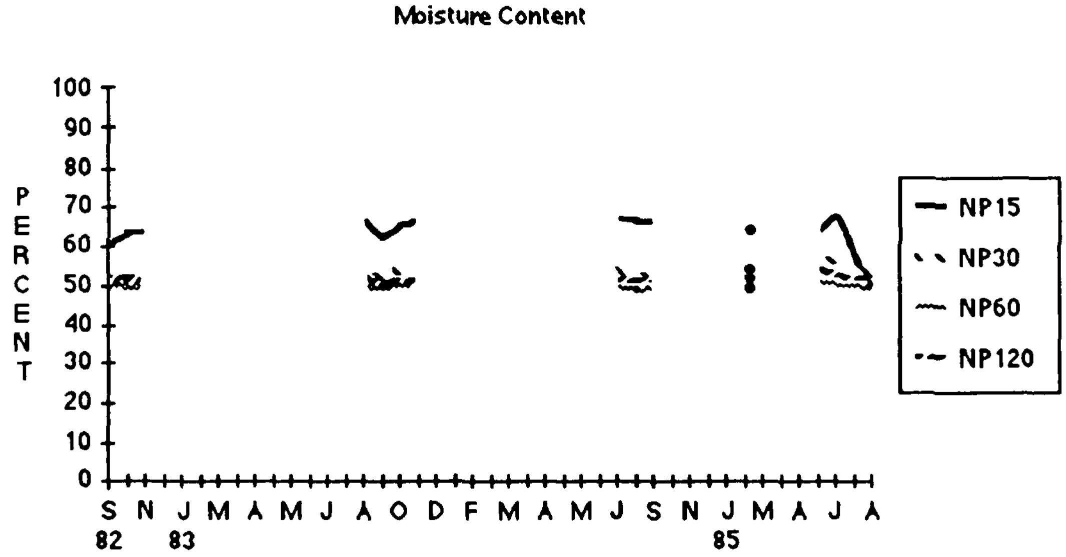


Figure J4. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Red River Plot 4

APPENDIX K: SOIL PROFILE DESCRIPTIONS FOR THE RED RIVER TRANSECT

Plot 1 - Norwood Series

Described and sampled by W. Blake Parker, Steve Forsythe, Steve Faulkner, Buddy Clairain, Bob Owens, and George Martin.

Soil classification. fine-silty, mixed (calcareous), thermic Typic Udifluvents

A--0 to 10 cm, very dark gray (10 YR 3/1) silt loam; weak fine granular structure; common fine roots; moderately alkaline.

C1--10 to 46 cm, dark brown (7.5 YR 4/4) silt loam; massive structure; common fine and medium roots; moderately alkaline.

C2--46 to 81 cm, brown (7.5 YR 5/4) silt loam and reddish brown (5 YR 4/4) silty clay, stratified; few fine faint strong brown (7.5 YR 5/8) mottles; massive structure; few fine roots; moderately alkaline.

C3--81 to 122 cm, dark brown (7.5 YR 4/4) silt loam; massive structure; few fine roots; moderately alkaline.

Remarks. Profile is stratified throughout. The A horizon has a reddish brown (5 YR 4/4) silt loam layer 2 cm thick. C1 has strata of very fine sandy loam, with obvious bedding planes. C2 has silty clay loam strate, with the lower part slightly effervescent. C3 has thin strata of very fine sandy loam.

Plot 2 - Norwood Series

Soil classification. fine-silty, mixed (calcareous), thermic Typic Udifluvents

A--0 to 10 cm, brown (7.5 YR 5/2) silt loam; weak fine granular structure; many fine roots; moderately alkaline.

B--10 to 56 cm, reddish brown (5 YR 4/4) silty clay; weak fine subangular blocky structure; common fine roots; neutral.

C--56 to 122 cm, dark brown (7.5 YR 4/4) silty clay loam and strong brown (7.5 YR 5/6) silt loam to very fine sandy loam, stratified; massive structure; few fine roots; moderately alkaline.

Plot 3 - Moreland Series

Soil classification. fine, mixed, thermic, Vertic Hapludolls

A11--0 to 5 cm, very dark grayish brown (10 YR 3/2) silt loam; weak fine granular structure; common fine and medium roots; mildly acid.

A12--5 to 13 cm, dark brown (7.5 YR 4/4) silt loam; weak medium subangular blocky structure; common fine and medium roots; mildly acid.

A1b--13 to 18 cm, very dark grayish brown (10 YR 3/2) silt loam; weak fine granular structure; common fine and medium roots; mildly acid.

Bb--18 to 43 cm, reddish brown (5 YR 4/4) silty clay loam; few fine faint gray (5 YR 5/1) mottles; iron and manganese stains in root channels; weak medium subangular blocky structure; common fine and medium roots; mildly acid.

C--43 to 122 cm, dark brown (7.5 YR 4/2) silty clay loam; common fine faint gray (5 YR 5/1) and few fine faint olive (5 Y 4/4) mottles; massive structure; common fine and medium roots; mildly acid.

Remarks. Soft iron masses present, olive (5 Y 4/4) on a few ped faces. Thin strata of silt loam present.

Plot 4 - Yorktown Series

Soil classification. very-fine, montmorillonitic, nonacid, thermic Typic Fluvaquents

0e--+8 cm to 0, very dark grayish brown (10 YR 3/2) organic; massive structure.

A1--0 to 8 cm, dark grayish brown (10 YR 4/2) silt loam; massive structure; many fine roots.

0eb--8 to 13 cm, very dark grayish brown (10 YR 3/2) organic; massive structure.

C1--13 to 76 cm, dark brown (7.5 YR 4/2) silt loam; massive structure; common fine roots to 16 cm, and few fine roots below 16 cm.

C2--76 to 122 cm, dark reddish gray (5 YR 4/2) clay; massive structure.

Remarks. Thin organic layer less than 3 cm thick occurs at 23 cm, and at 48 cm.

APPENDIX L: ROLLING FORK CORRELATION COEFFICIENTS BY DEPTH

Table L1

Plot One

	EH15	OX15	NP15	WDEP
EH15	1.0*	0.17ns†	-0.28**	-0.06ns
OX15		1.0	-0.62	-0.03ns
NP15			1.0	0.21ns
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.27**	-0.30	-0.26*
OX30		1.0	-0.44	-0.01ns
NP30			1.0	0.18ns
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.07ns	-0.18ns	-0.08ns
OX60		1.0	-0.65	-0.06ns
NP60			1.0	0.23**
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.28**	-0.04ns	-0.06ns
OX120		1.0	-0.52	-0.03ns
NP120			1.0	0.28**
WDEP				1.0

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* All correlations are significant at the 0.01 level of probability unless otherwise indicated.
** Significant at the 0.05 level of probability.
† Nonsignificant.

Table L2

Plot Two

	EH15	OX15	NP15	WDEP
EH15	1.0	0.60	-0.63	-0.64
OX15		1.0	-0.66	-0.81
NP15			1.0	0.76
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	-0.67	-0.52	-0.73
OX30		1.0	-0.71	-0.73
NP30			1.0	0.63
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.42	-0.65	-0.46
OX60		1.0	-0.57	-0.55
NP60			1.0	0.66
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.49	-0.55	-0.38
OX120		1.0	-0.76	-0.61
NP120			1.0	0.78
WDEP				1.0

Table L3

Plot Three

	EH15	OX15	NP15	WDEP
EH15	1.0	0.57	-0.54	-0.66
OX15		1.0	-0.56	-0.60
NP15			1.0	0.65
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.66	-0.65	-0.79
OX30		1.0	-0.74	-0.61
NP30			1.0	0.62
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.69	-0.67	-0.64
OX60		1.0	-0.73	-0.64
NP60			1.0	0.66
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.43	-0.66	-0.57
OX120		1.0	-0.59	-0.45
NP120			1.0	0.55
WDEP				1.0

Table L4

Plot Four

	EH15	OX15	NP15	WDEP
EH15	1.0	0.72	-0.62	-0.69
OX15		1.0	-0.77	-0.82
NP15			1.0	0.83
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.65	-0.45	-0.70
OX30		1.0	-0.82	-0.86
NP30			1.0	0.76
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.40	-0.50	-0.74
OX60		1.0	-0.87	-0.65
NP60			1.0	0.63
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.73	-0.64	-0.41
OX120		1.0	-0.87	-0.52
NP120			1.0	0.56
WDEP				1.0

Table L5

Plot Five

	EH15	OX15	NP15	WDEP
EH15	1.0	0.53	-0.32ns	-0.57
OX15		1.0	-0.70	-0.79
NP15			1.0	0.90
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.70	0.59	-0.76
OX30		1.0	-0.84	-0.84
NP30			1.0	0.89
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.68	-0.61	-0.68
OX60		1.0	-0.83	-0.90
NP60			1.0	0.69
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	-0.23ns	-0.11ns	-0.02ns
OX120		1.0	-0.42*	-0.63
NP120			1.0	0.63
WDEP				1.0

*Significant at the 0.05 level of probability.

APPENDIX M: OXYGEN CONTENT AND REDOX POTENTIAL AT 15, 30, 60, AND 120 CM WITH WATER DEPTH FOR THE ROLLING FORK TRANSECT

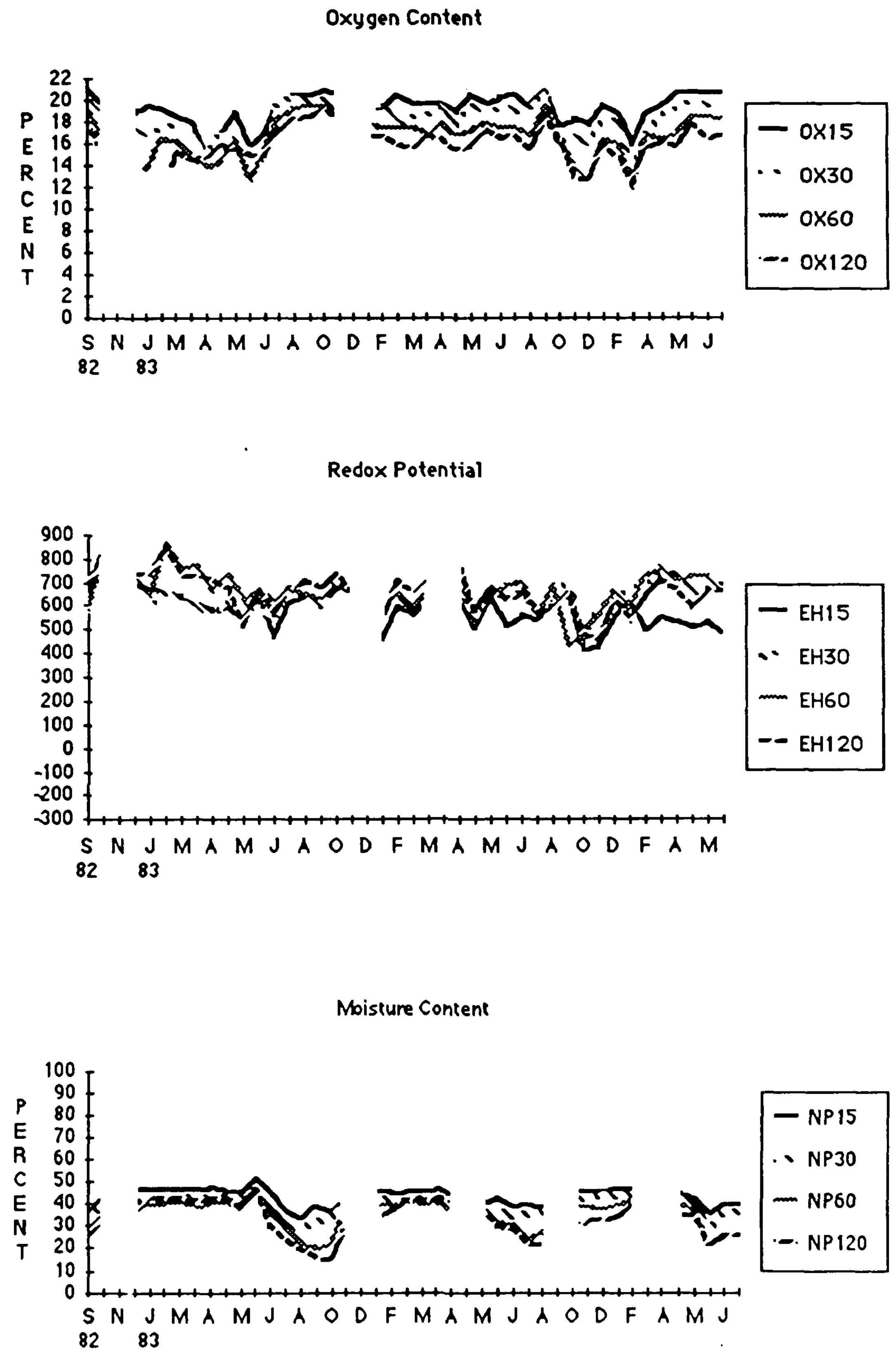


Figure M1. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Rolling Fork Plot 1

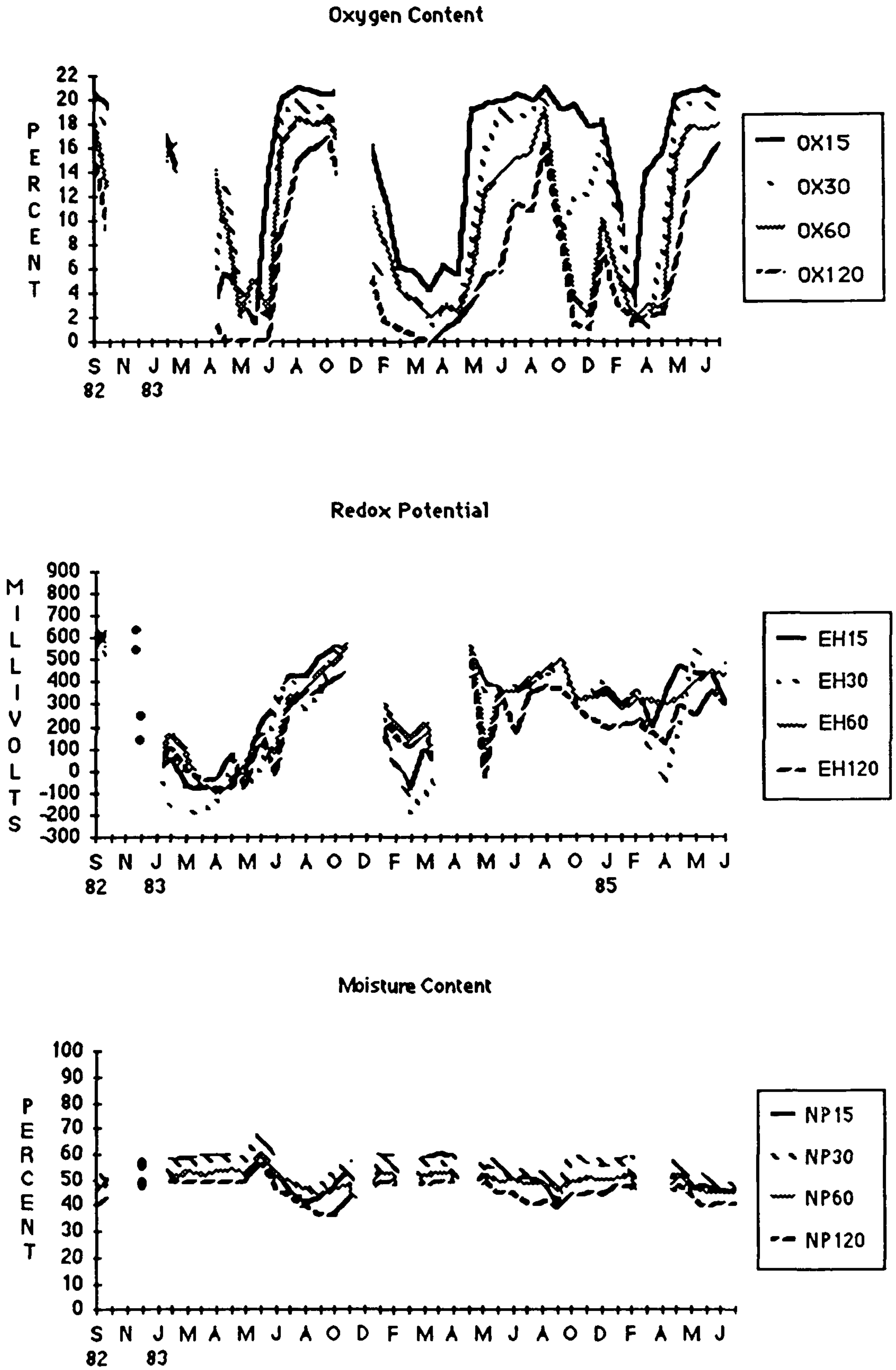
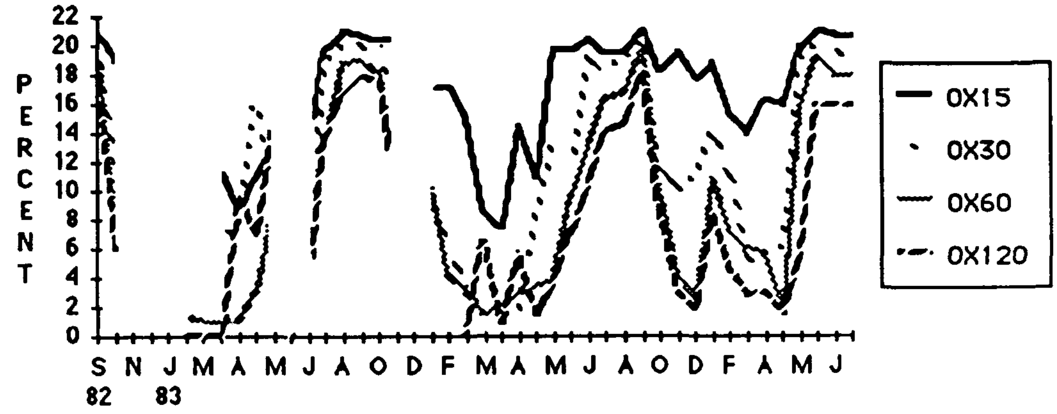
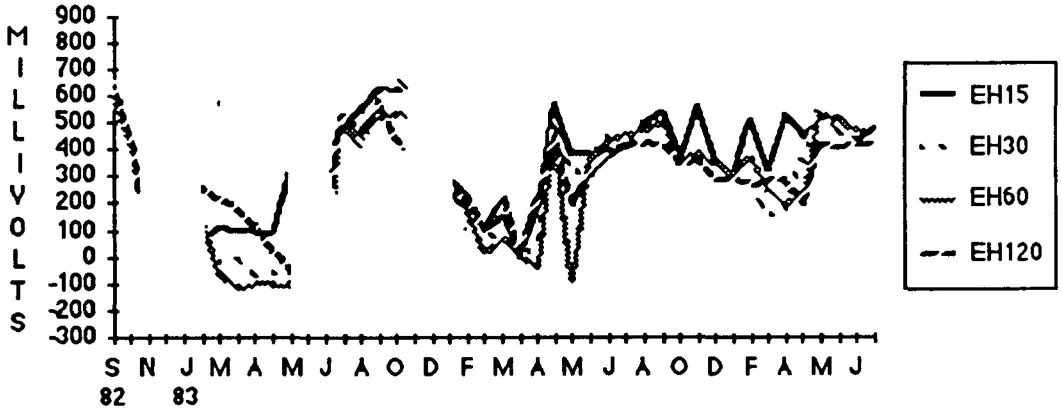


Figure M2. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Rolling Fork Plot 2

Oxygen Content



Redox Potential



Moisture Content

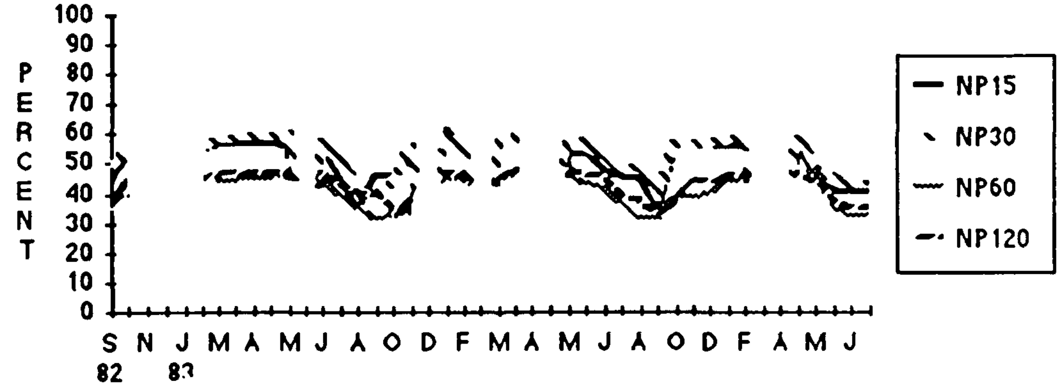
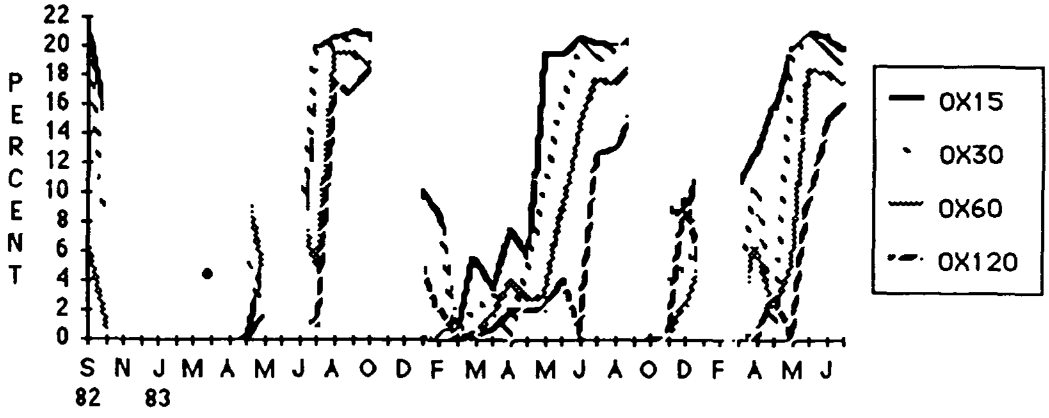


Figure M3. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Rolling Fork Plot 3

Oxygen Content



Redox Potential

Moisture Content

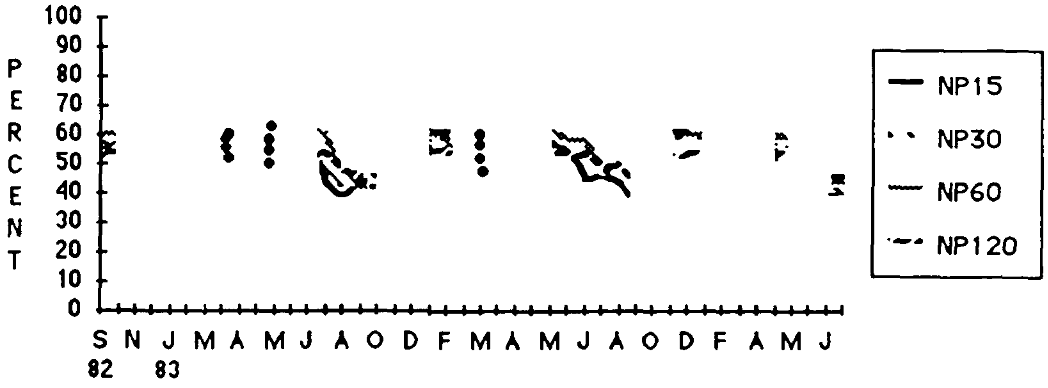


Figure M4. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Rolling Fork Plot 4

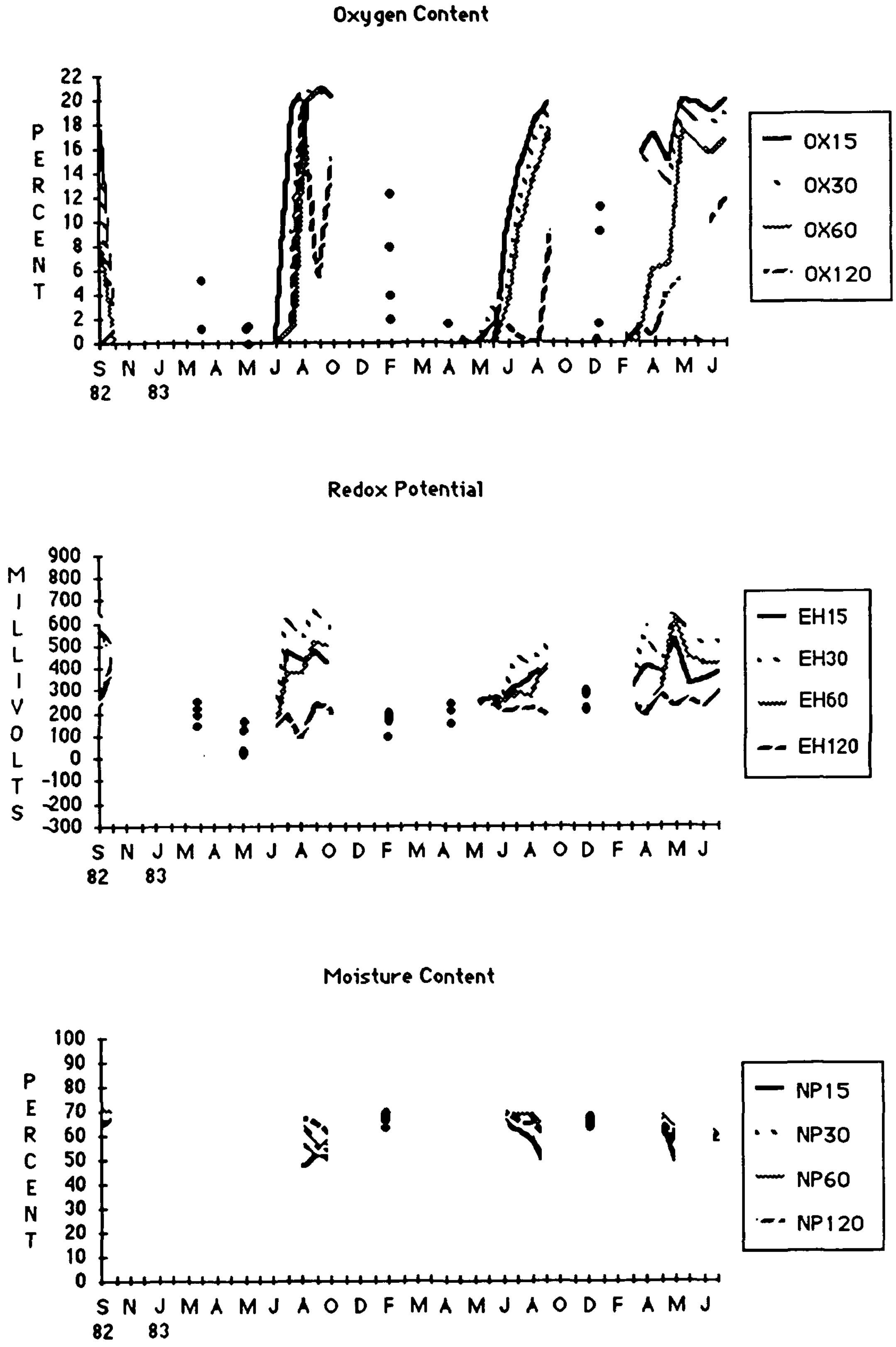


Figure M5. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Rolling Fork Plot 5

APPENDIX N: SOIL PROFILE DESCRIPTIONS FOR THE ROLLING FORK TRANSECT

Plot 1 - Dundee Series

Described and sampled by W. Blake Parker, Steve Shetron, Don Holzer, Bill Koos, H. L. Neal, and Steve Faulkner.

Soil classification. fine - silty, mixed, thermic, Aeric Ochraqualfs

Al-- 0 to 5 cm, very dark gray (10 YR 3/1) silt loam; weak fine granular structure; friable; common medium roots; slightly acid; abrupt, smooth boundary.

Btg1--5 to 43 cm, dark grayish brown (10 YR 4/2) silty clay loam; few fine faint dark yellowish brown (10 YR 4/6) mottles; patchy clay films on ped faces; weak medium subangular blocky structure; friable; fine medium and common roots; slightly acid; gradual wavy boundary.

Btg2--43 to 76 cm, dark grayish brown (10 YR 4/2), silty clay loam; common medium distinct brown (10 YR 5/3) and dark yellowish brown (10 YR 4/6) mottles; patchy clay films on ped faces; weak medium subangular blocky structure; friable; fine roots; moderately acid; gradual, wavy boundary.

BC--76 to 102 cm, grayish brown (10 YR 5/2) very fine sandy loam; common medium distinct brown (10 YR 5/3) and dark yellowish brown (10 YR 4/6) mottles; patchy clay films on ped faces; weak medium subangular blocky structure; friable; few fine roots; moderately acid; abrupt smooth boundary.

2C--102 to 203 cm, brown (10 YR 5/3) very fine sandy loam; few fine faint dark yellowish brown (10 YR 4/6) mottles; massive structure; friable; moderately acid.

Remarks. Lower 2C stratified at 127 cm with bedding planes of very fine sand, silts, and organic matter.

Plot 2 - Kobel Series

Soil classification. fine, montmorillonitic, nonacid, thermic Vertic Haplaquepts

A1-- 0 to 10 cm, very dark gray (10 YR 3/1) silty clay loam; weak fine subangular, blocky structure; firm; fine common and medium roots; neutral; clear wavy boundary.

Bg1--10 to 25 cm, dark grayish brown (10 YR 4/2) to dark gray (10 YR 4/1) clay; common fine distinct dark yellowish brown (10 YR 4/6) mottles; moderate medium angular blocky structure; very firm; fine common and medium roots; neutral; clear wavy boundary.

Bg2--25 to 43 cm, dark gray (10 YR 4/1) clay; common, medium, distinct dark yellowish brown (10 YR 4/6) mottles; moderate medium angular blocky structure; very firm; few fine roots; mildly acid; clear wavy boundary.

Bg3--43 to 86 cm, gray (10 YR 5/1) clay; few fine faint dark yellowish brown (10 YR 4/6) mottles; few nonintersecting slicken sides; moderate medium angular blocky structure; very firm; few fine roots; mildly acid; clear wavy boundary.

Bg4--86 to 107 cm, dark grayish brown (10 YR 4/2) clay; common medium distinct yellowish brown (10 YR 5/8) mottles; few nonintersecting slicken sides; moderate medium angular blocky structure; very firm; mildly acid; clear wavy boundary.

2C--107 to 203 cm, grayish brown (10 YR 5/2) silt loam; common medium distinct yellowish brown (10 YR 5/8) mottles and common medium distinct strong brown (7.5 YR 5/6) mottles at 152 cm and brown (10 YR 5/3) fine sand or silt bands; massive structure breaking to weak fine angular blocky structure in silt loam lenses; firm.

Remarks. At 102 cm, lenses of fine sand and silt loam (5 and 10 cm thick) occurred, respectively. Manganese stains occurred at 152 cm in silt loam. Very fine roots at 152 cm.

Plot 3 - Tunica Series

Soil classification. clayey over loamy, montmorillonitic, nonacid, thermic Vertic Haplaquepts

A1--0 to 13 cm, very dark gray (10 YR 3/1) silty clay; weak fine subangular, blocky structure; firm; few fine medium and coarse roots; neutral; abrupt, wavy boundary.

Bg1--13 to 25 cm, dark gray (10 YR 4/1) to dark grayish brown (10 YR 4/2) clay; few medium faint dark yellowish brown (10 YR 4/6) mottles, moderate medium angular blocky structure; very firm; few fine medium and coarse roots; neutral; gradual, wavy boundary.

Bg2--25 to 53 cm, dark gray (10 YR 4/1) to dark grayish brown (10 YR 4/2) clay; common medium distinct reddish brown (5 YR 4/4) mottles; moderate medium angular blocky structure; very firm; few fine medium and coarse roots; neutral; abrupt smooth boundary.

2C-53 to 203 cm, dark gray (10 YR 4/1) silty clay loam and grayish brown (10 YR 5/2) very fine sandy loam; common medium distinct reddish brown (5 YR 4/4) mottles; massive structure; firm; few fine roots; neutral.

Remarks. The Bg1 and Bg2 horizons are speckled with white (10 YR 8/2) clusters of a carbonate like material. 2C has thin stratas of very fine sand, silts, silt loam, and silty clay loam. Fine sandy loam is 2.5 cm thick at 53 to 203 cm. Silty clay loam is 8 cm thick. Weakly expressed slicken sides are present below 97 cm with no intersection evident. In 2C, clay loam breaks to weak, fine, subangular blocky structure.

Plot 4 - Sharkey Series

Soil classification. very-fine, montmorillonitic, nonacid, thermic Vertic Haplaquepts

A--0 to 10 cm, very dark grayish brown (10 YR 3/2) silty clay; weak fine subangular blocky structure; very firm; few fine medium and coarse roots; moderately acid; abrupt wavy boundary.

Bg1--10 to 46 cm, dark gray (10 YR 4/1) clay; common medium distinct yellowish red (5 YR 4/6) mottles; moderate medium angular blocky structure; very firm; few fine medium and coarse roots; neutral; clear wavy boundary.

Bg2--46 to 97 cm, dark gray (10 YR 4/1) and dark grayish brown (10 YR 4/2) clay; few fine distinct yellowish red (5 YR 4/6) mottles; moderate medium angular blocky structure; very firm; few fine roots; mildly acid; clear wavy boundary.

Bg3--97 to 122 cm, dark gray (10 YR 4/1) clay; many medium distinct reddish brown (5 YR 4/4) mottles; moderate medium angular blocky structure; very firm; few fine roots; mildly acid; cleary wavy boundary.

Cl--122 to 140 cm, dark gray (10 YR 4/1) clay; few fine distinct brown (10 YR 5/3) mottles; massive structure; firm; mildly acid; abrupt smooth boundary.

C2--140 to 203 cm, dark gray (10 YR 4/1) clay; many medium distinct dusky red (2.5 YR 3/2) mottles; massive structure; firm; mildly acid.

Remarks. Horizons Bg2, Bg3, and C1 are speckled with very pale brown (10 YR 8/3) carbonate-like grains to 152 cm. Nonintersecting slicken sides at 46 to 51 cm and evident to 122 cm. C1 and C2 structure breaks to weak, fine, subangular, blocky structure. C1 has thin lenses of dark grayish brown (10 YR 4/2) silty clay loam.

Plot 5 - Fausse Series

Soil classification. very-fine, montmorillonitic, nonacid, thermic, Typic Fluvaquents

A--0 to 10 cm, dark grayish brown (10 YR 4/2) silty clay; few fine faint dark brown (10 YR 4/3) to dark yellowish brown (10 YR 4/4) mottles; weak fine subangular blocky structure; very firm; slightly plastic; common fine roots; neutral; clear wavy boundary.

Bg1--10 to 20 cm, dark grayish brown (10 YR 4/2) clay; reddish brown (5 YR 4/4) mottles; moderate medium subangular blocky structure; very firm; slightly plastic; common fine roots; neutral; clear wavy boundary.

Bg2--20 to 46 cm, dark gray (10 YR 4/1) to dark grayish brown (10 YR 4/2) clay; many coarse distinct yellowish red (5 YR 5/6) and dark yellowish brown (10 YR 4/6) mottles; moderate medium angular blocky structure; very firm; slightly plastic few fine roots; mildly acid; clear wavy boundary.

Bg3--46 to 86 cm, dark grayish brown (10 YR 4/2) clay; many coarse distinct yellowish red (5 YR 5/6) mottles; weak medium angular blocky structure; very firm; slightly plastic; few fine roots; mildly acid; clear wavy boundary.

Bg4--86 to 122 cm, dark gray (10 YR 4/1) clay; many coarse distinct yellowish red (5 YR 5/6) and dark yellowish brown (10 YR 4/6) mottles; weak medium angular blocky structure; firm; slightly plastic; mildly acid.

C--122 to 203 cm, gray (2.5 Y N5/0) to dark gray (2.5 Y N4/0) clay; common medium distinct red (2.5 YR 4/6) and yellowish red (5 YR 4/6) mottles; massive structure; firm; slightly sticky and plastic; moderately alkaline.

Remarks. All Bg horizons show strong development of slicken sides that intersect. Bg2 has accumulation of gray (10 YR 5/1) clay flows in cracks and root channels. Cracking is evident to 122+ cm.

APPENDIX O: SPRING BAYOU CORRELATION COEFFICIENTS BY DEPTH

Table O1

Plot One

	EH15	OX15	NP15	WDEP
EH15	1.0*	0.64	-0.60	-0.70
OX15		1.0	-0.59	-0.67
NP15			1.0	0.83
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.68	-0.50	-0.68
OX30		1.0	-0.52	-0.75
NP30			1.0	0.71
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.65	-0.66	-0.64
OX60		1.0	-0.68	-0.62
NP60			1.0	0.67
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.55	-0.65	-0.57
OX120		1.0	-0.68	-0.57
NP120			1.0	0.66
WDEP				1.0

---

* All correlations are significant at the 0.01 level of probability unless otherwise indicated.

Table O2

Plot Two

	EH15	OX15	NP15	WDEP
EH15	1.0	0.61	-0.63	-0.70
OX15		1.0	-0.62	-0.76
NP15			1.0	0.82
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.76	-0.62	-0.72
OX30		1.0	-0.71	-0.88
NP30			1.0	0.72
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.70	-0.34	-0.63
OX60		1.0	-0.37	-0.76
NP60			1.0	0.54
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.72	-0.58	-0.59
OX120		1.0	-0.81	-0.68
NP120			1.0	0.72
WDEP				1.0

Table O3

Plot Three

	EH15	OX15	NP15	WDEP
EH15	1.0	0.63	-0.51	-0.66
OX15		1.0	-0.59	-0.80
NP15			1.0	0.74
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.70	-0.59	-0.81
OX30		1.0	-0.58	-0.81
NP30			1.0	0.68
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.74	-0.59	-0.67
OX60		1.0	-0.74	-0.74
NP60			1.0	0.63
WDEP				1.0

	EH120	OX120	NP120	WDEP
EH120	1.0	0.39	-0.38*	-0.30*
OX120		1.0	-0.34*	-0.47
NP120			1.0	0.40
WDEP				1.0

---

* Significant at the 0.05 level of probability unless otherwise indicated.

Table O4

Plot Four

	EH15	OX15	NP15	WDEP
EH15	1.0	0.46	-0.51	-0.37
OX15		1.0	-0.64	-0.78
NP15			1.0	0.69
WDEP				1.0

	EH30	OX30	NP30	WDEP
EH30	1.0	0.64	-0.61	-0.49
OX30		1.0	-0.66	-0.66
NP30			1.0	0.65
WDEP				1.0

	EH60	OX60	NP60	WDEP
EH60	1.0	0.53	-0.48*	-0.51
OX60		1.0	-0.66	-0.52
NP60			1.0	0.43*
WDEP				1.0

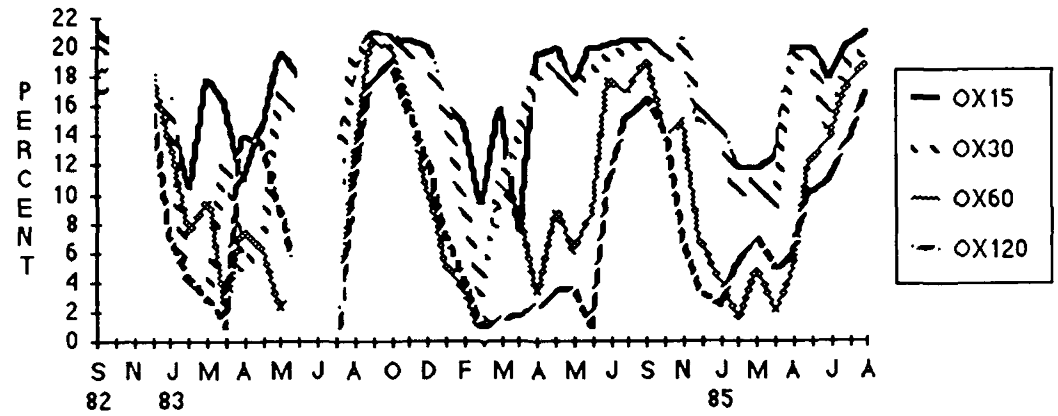
	EH120	OX120	NP120	WDEP
EH120	1.0	0.23ns	-0.33ns	-0.18ns
OX120		1.0	-0.31ns	-0.37ns
NP120			1.0	0.18ns
WDEP				1.0

---

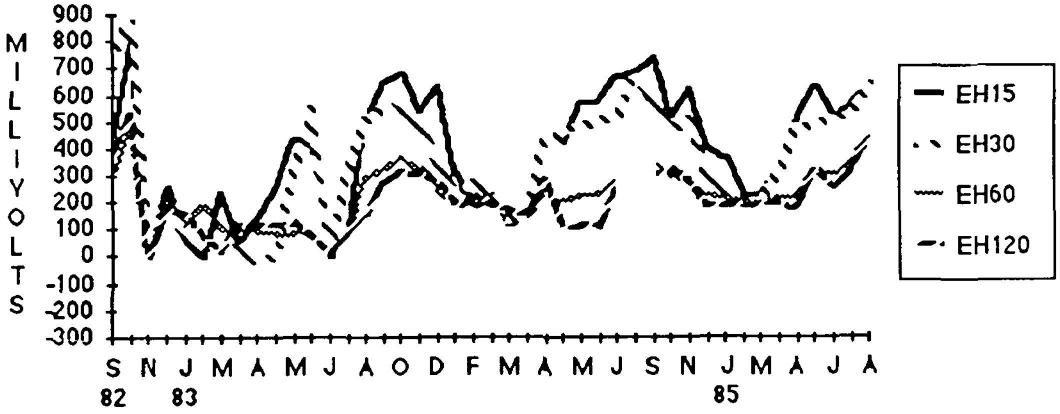
* Significant at the 0.05 level of probability unless otherwise indicated.

APPENDIX P: OXYGEN CONTENT AND REDOX POTENTIAL AT 15, 30, 60, AND 120 CM WITH WATER DEPTH FOR THE SPRING BAYOU TRANSECT

Oxygen Content



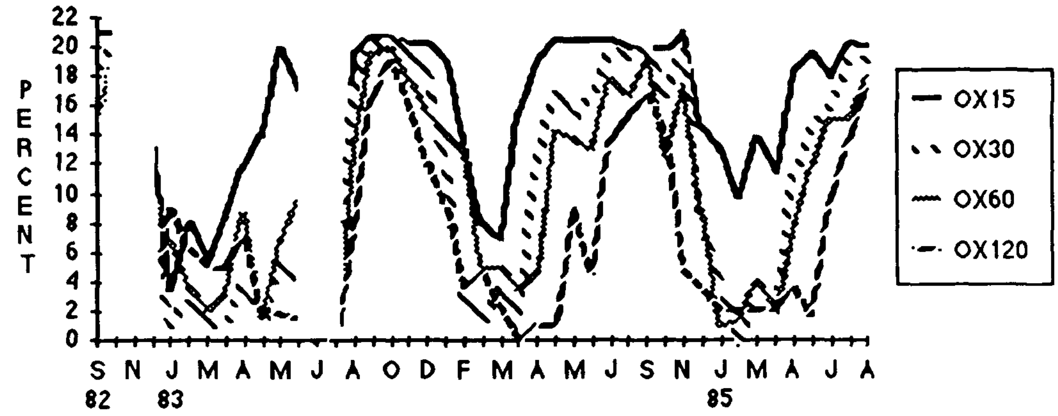
Redox Potential



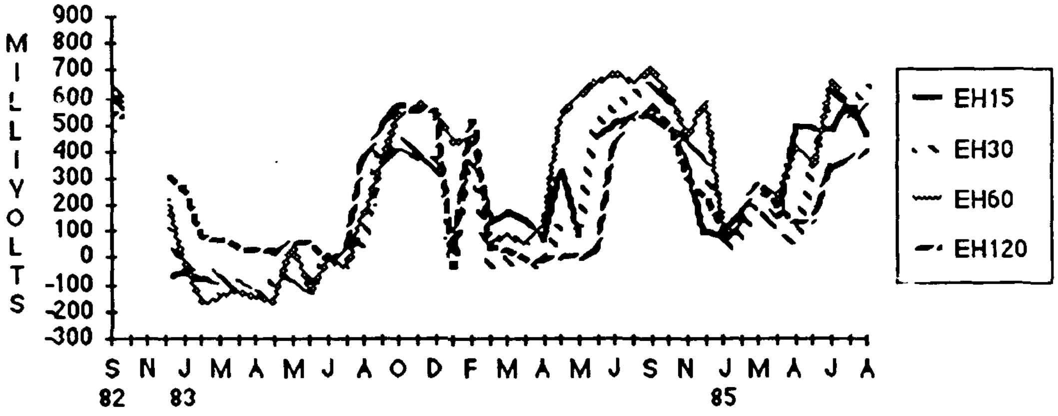
Moisture Content

Figure P1. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Spring Bayou Plot 1

Oxygen Content



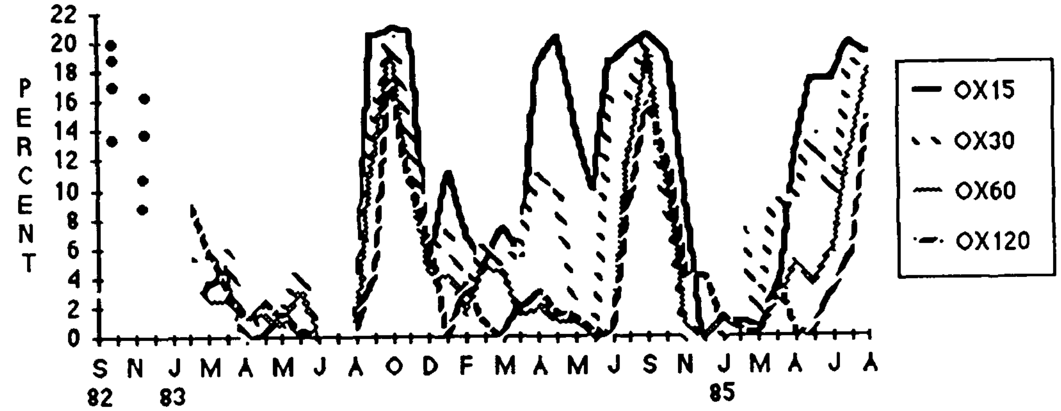
Redox Potential



Moisture Content

Figure P2. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Spring Bayou Plot 2

Oxygen Content



Redox Potential

Moisture Content

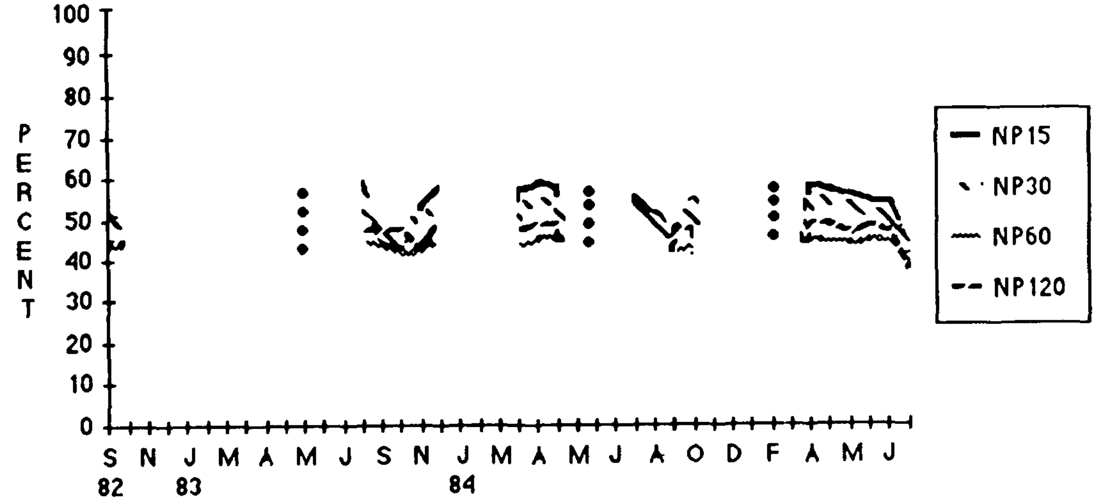
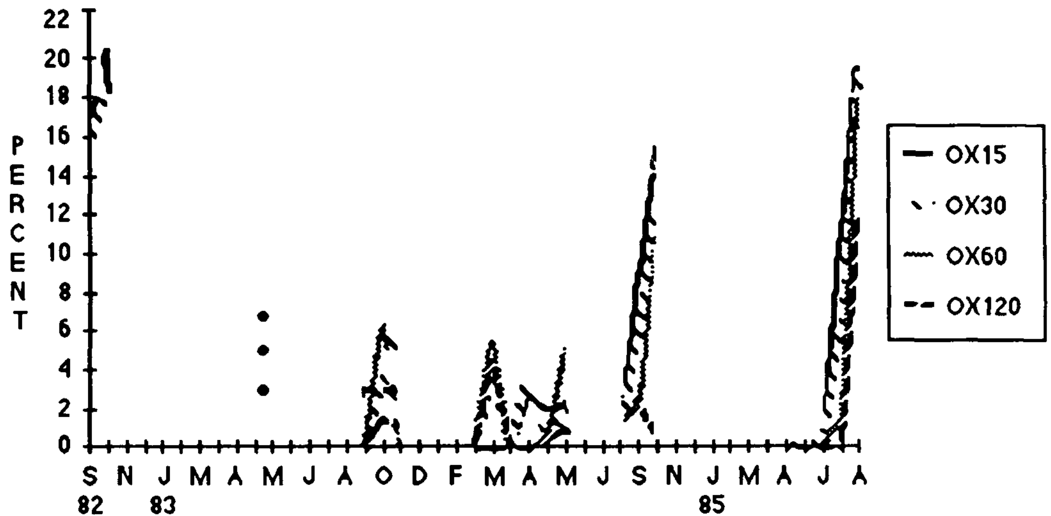


Figure P3. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Spring Bayou Plot 3

Oxygen Content



Redox Potential

Moisture Content

Figure P4. Oxygen content, redox potential, and soil moisture content at 15, 30, 60, and 120 cm for Spring Bayou Plot 4

APPENDIX Q: SOIL PROFILE DESCRIPTIONS FOR THE SPRING BAYOU TRANSECT

Plot 1 - Tensas Series

Described and sampled by W. Blake Parker, Steve Forsythe, Buddy Clairain, Steve Faulkner, Bob Owens, and George Martin.

Soil classification. fine-montmorillonitic, thermic Vertic Ochraqualfs

A1--0 to 13 cm, dark grayish brown (10 YÂ 4/2) silty clay; few fine distinct yellowish brown (10 YR 5/6) and strong brown (7.5 YR 5/6) mottles; weak medium subangular blocky structure; common fine roots; strongly acid.

Btg1--13 to 38 cm, grayish brown (10 YR 5/2) silty clay loam; many medium distinct yellowish brown (10 YR 5/6) and few fine faint strong brown (7.5 YR 5/6) mottles; moderate medium subangular blocky structure; common fine and medium roots; moderately acid.

Btg2--38 to 66 cm, grayish brown (2.5 Y 5/2) silty clay loam; common medium distinct yellowish brown (10 YR 5/6) mottles; moderate medium subangular blocky structure; few fine and medium roots; moderately acid.

Btg3--66 to 94 cm; grayish brown (2.5 Y 5/2) silty clay loam; few, fine distinct yellowish brown (10 YR 5/4) mottles; moderate medium subangular blocky structure; common iron and manganese concretions; few fine and medium roots; moderately acid.

BCg--94 to 122 cm, grayish brown (2.5 Y 5/2) silt loam; few fine distinct yellowish brown (10 YR 5/4) mottles; weak medium subangular blocky structure; common iron and manganese concretions; few fine roots; slightly acid.

Remarks. Horizons Btg2 and Btg3 have gray (10 YR 5/1) clay flows on the ped faces.

Plot 2 - Tensas Series

Soil classification. fine, montmorillonitic, thermic Vertic Ochraqualfs

A1--0 to 13 cm, dark grayish brown (10 YR 4/2) clay; few fine distinct yellowish brown (10 YR 5/6) mottles; modeate medium subangular block structure; common fine roots; strongly acid.

Btg1--13 to 33 cm, dark grayish brown (10 YR 4/2) silty clay; common medium distinct yellowish brown (10 YR 5/6) mottles; moderate medium subangular blocky structure; common fine roots; strongly acid.

Btg2--33 to 66 cm, grayish brown (2.5 Y 5/2) silty clay; yellowish brown (10 YR 5/6) gray (10 YR 5/1) mottles; moderate medium subangular blocky structure; common fine roots; moderately acid.

Btg3--66 to 86 cm, grayish brown (2.5 Y 5/2) silty clay loam; common fine distinct light olive brown (2.5 Y 5/6) mottles; moderate medium subangular blocky structure; few fine iron and manganese concretions; common fine roots; slightly acid.

2Cg--86 to 122 cm, grayish brown (2.5 Y 5/2) silty clay loam; common fine distinct yellowish brown (10 YR 5/6) mottles; massive structure; few fine iron and manganese concretions; common fine roots; slightly acid.

Remarks. Horizons Btg1, Btg2, and Btg3 have gray (10 YR 5/1) and dark gray (10 YR 4/1) clay flows on ped faces.

Plot 3 - Kobel Series

Soil classification. fine, montmorillonitic, nonacid, thermic Vertic Haplaquepts

A1--0 to 15 cm, dark gray (10 YR 4/1) clay; many fine prominent strong brown (7.5 YR 4/6) mottles; moderate medium subangular blocky structure; firm; sticky; common fine roots; moderately acid; clear smooth boundary.

Bg1--15 to 51 cm, dark gray (5Y 4/1) clay; common medium prominent dark yellowish brown (10 YR 4/4) mottles; moderate medium subangular blocky structure; firm; sticky; few fine and medium roots; slightly acid; gradual wavy boundary.

Bg2--51 to 94 cm, gray (5Y 5/1) clay; common medium prominent dark yellowish brown (10 YR 4/4) mottles; moderate medium subangular blocky structure; common fine and medium iron and manganese concretions; firm; sticky; few fine roots; neutral; gradual wavy boundary.

2Cg--94 to 145 cm, gray (5Y 5/1) silty clay loam; common medium prominent yellowish brown (10 YR 5/4) mottles; massive structure; few fine roots; neutral.

Remarks. Horizon 2Cg has a thin strata of lighter texture material. This profile's texture gets lighter with depth.

Plot 4 - Fausse Series

Soil classification. very-fine, montmorillonitic, nonacid, thermic Typic Fluvaquents

0a--+8 cm to 0, very dark gray (10 YR 3/1) organic; massive structure.

A1--0 to 5 cm, dark gray (5 Y 4/1) clay; massive structure; common fine roots; neutral (meter).

Cg1--5 to 33 cm, dark gray (5 Y 4/1) clay; many fine prominent yellowish brown (10 YR 5/6), strong brown (7.5 YR 5/6) and few fine prominent reddish brown (5 YR 4/4) mottles; massive structure; common fine roots; slightly acid (meter).

Cg2--33 to 61 cm, gray (5 Y 5/1) clay; few fine distinct light olive brown (2.5 Y 5/4), (2.5 Y 5/6) mottles; massive structure; few fine roots; neutral (meter).

Cg3--61 to 71 cm, gray (5 Y 5/1) clay; common medium prominent yellowish brown (10 YR 5/6) and common coarse prominent strong brown (7.5 YR 5/6) mottles; massive structure; few iron and manganese concretions; few fine roots; neutral (meter).

Cg4--71 to 122 cm, clay; few fine prominent yellowish brown (10 YR 5/6) mottles; massive structure; few iron and manganese concretions; neutral.

APPENDIX R: SOIL pH, IRON, AND MANGANESE CHEMISTRY DATA

Table R1

Soil pH Data

Site	Sampling Date	Rep	Depth cm	pH Value by Plot				
				1	2	3	4	5
Rolling Fork	24 Aug 84	1	15	5.00	6.45	5.20	5.30	6.60
		2	15	6.40	5.80	5.00	5.50	6.60
		1	60	4.50	6.50	7.10	7.35	6.70
		2	60	6.65	6.85	7.20	7.30	6.10
Quimby	30 Aug 84	1	15	5.15	4.90	5.90	5.75	6.40
		2	15	4.85	5.30	5.40	5.05	6.45
		1	60	5.30	5.15	6.30	6.70	7.05
		2	60	5.85	5.40	5.90	6.90	7.10
Pearl River	11 Sept 84	1	15	3.65	3.65	4.45	3.65	4.05
		2	15	3.75	3.30	3.90	4.50	4.15
		1	60	3.95	3.90	3.80	4.60	3.55
		2	60	3.35	4.00	4.55	3.75	4.60
Red River	8 Nov 84	1	15	6.80	7.20	7.11	6.80	---*
		2	15	7.55	7.30	7.26	7.10	---
		1	60	7.65	7.52	7.10	7.10	---
		2	60	7.55	7.30	7.26	7.10	---
Spring Bayou	13 Nov 84	1	15	4.80	5.45	5.89	5.97	---
		2	15	4.78	5.45	5.73	6.11	---
		1	60	5.30	6.28	6.54	7.10	---
		2	60	5.60	6.00	6.58	7.17	---
Red River	28 Jan 85	1	15	7.00	6.85	6.60	---	---
		2	15	6.75	6.60	7.40	---	---
		1	60	7.10	6.70	6.80	---	---
		2	60	7.05	6.80	6.85	---	---
Spring Bayou	29 Jan 85	1	15	4.50	4.45	5.85	---	---
		2	15	4.40	4.60	5.20	---	---
		1	60	4.80	5.50	6.50	---	---
		2	60	4.90	5.70	5.85	---	---

(Continued)

*Missing data caused by either deep surface water or only four plots (Red River, Spring Bayou) on the transect.

Table R1 (Concluded)

Site	Sampling Date	Rep	Depth cm	pH Value by Plot				
				1	2	3	4	5
Rolling Fork	8 Feb 85	1	15	2.35	3.25	3.30	3.20	---
		2	15	2.75	3.30	3.15	3.45	---
		1	60	2.80	3.20	4.10	4.35	---
		2	60	2.90	4.40	3.50	4.10	---
Quimby	5 Feb 85	1	15	5.30	3.30	3.00	2.60	---
		2	15	3.40	2.95	3.10	2.30	---
		1	60	5.30	3.90	5.00	3.20	---
		2	60	5.00	3.00	3.30	3.85	---
Pearl River	27 May 85	1	15	4.10	4.20	4.40	4.30	4.40
		2	15	4.10	4.15	4.25	4.35	4.40
		1	60	4.05	4.50	4.40	4.35	4.30
		2	60	4.10	4.30	4.20	4.45	4.65
Red River	7 June 85	1	15	8.20	7.80	7.80	6.80	---
		2	15	8.00	7.70	7.70	7.00	---
		1	60	8.20	8.35	8.00	7.30	---
		2	60	8.10	8.10	7.70	7.20	---
Spring Bayou	11 June 85	1	15	5.65	5.90	6.00	5.70	---
		2	15	5.00	5.90	6.50	6.00	---
		1	60	5.70	6.50	7.00	7.70	---
		2	60	4.90	6.80	6.40	6.90	---
Rolling Fork	27 June 85	1	15	6.00	6.80	6.80	7.00	6.70
		2	15	6.40	6.60	6.80	7.00	7.00
		1	60	6.30	7.40	7.30	7.50	7.00
		2	60	6.20	7.10	7.20	7.50	7.00
Quimby	11 July 85	1	15	6.05	6.20	6.25	5.70	7.10
		2	15	6.00	6.00	5.80	5.50	6.80
		1	60	5.50	5.80	6.20	5.70	7.10
		2	60	6.50	6.00	6.00	6.90	7.70

Table R2

Iron Data

Site	Sampling Date	Rep	Depth cm	Fe (µg/g) by Plot 1	2	3	4	5
Red River	17 Aug 84	1	15	6.70	4.27	146	1010	
		2	15	5.40	4.14	958	2250	
		1	60	6.16	4.63	668	1920	
		2	60	6.16	4.07	587	1640	
	7 Sept 84	1	15	2.56	3.33	123	2490	
		2	15	1.84	2.90	272	259.0	
		1	60	1.89	2.70	664	1670	
		2	60	1.93	3.33	380	1797	
	8 Nov 84	1	15		4.36		947	
		2	15	5.51	5.04	940.5	2180	
		1	60	5.58	5.02	614	1880	
		2	60		4.54	565	1640	
	7 Feb 85	1	15	9.38	6.75	369		
		2	15	11.2		1100		
		1	60		7.20	1330		
		2	60	12.1	4.23	1590		
	7 June 85	1	15	13.0	8.57	405	1790	
		2	15	9.31	5.74	828	2180	
		1	60	5.96	8.28	1280	1660	
		2	60	8.62	6.77	875	2280	
Quimby	30 Aug 84	1	15	19.0	9.43	4.68	8.46	137
		2	15	10.5	8.62	13.5	70.00	981
		1	60	9.45		6.57	8.08	15.8
		2	60	8.08	7.22	10.9	3.40	58.3
	5 Feb 85	1	15	0.990	2.16	14.4	21.5	
		2	15	2.41	2.07	12.6	36.9	
		1	60	2.16	3.44	5.51	1.80	
		2	60	2.34	1.98	2.41	10.6	

(Continued)

(Sheet 1 of 3)

Table R2 (Continued)

Site	Sampling Date	Rep	Depth cm	Fe (µg/g) by Plot 1	2	3	4	5
Quimby	11 July 85	1	15	4.90	3.62	7.09	5.98	605
		2	15	9.16	2.38	13.4	8.30	1990
		1	60	8.86	7.29	6.30	16.1	182
		2	60	6.21	2.43	4.18	2.61	772
Rolling Fork	24 Aug 84	1	15	2.61	3.22	8.75	4.68	12.8
		2	15	2.97	4.32	15.1	4.59	4.75
		1	60	2.47	3.06	3.08	4.25	4.07
		2	60	2.34	3.51	5.89	3.76	3.82
	8 Feb 85	1	15	3.28	5.04	26.1	19.4	
		2	15	4.70	4.81	29.7	9.29	
		1	60	2.88	3.85	4.81	18.6	
		2	60	2.81	6.86	2.90	8.84	
	27 June 85	1	15	4.88	5.11	6.21	4.57	14.4
		2	15	3.33	8.93	10.3	8.08	11.0
		1	60	3.44	2.45	3.13	10.6	9.45
		2	60	3.64	3.87	5.15	7.15	8.12
Spring Bayou	13 Nov 84	1	15	32.4	34.6	45.9	200	
		2	15	157	11.7	38.0	50.6	
		1	60	3.01	1.33	4.32	2.45	
		2	60	4.54	1.37	5.85	17.3	
	29 Jan 85	1	15	16.4	76.0	66.1		
		2	15	25.9	25.2	128	47.9	
		1	60	3.08	2.47	12.4		
		2	60	4.50	2.81	11.7	15.7	
	11 June 85	1	15	70.2		25.9	313	
		2	15	48.6	35.3	34.6	1140	
		1	60	10.7		10.5	73.6	
		2	60	16.6	11.8	15.6	17.2	

(Continued)

(Sheet 2 of 3)

Table R2 (Concluded)

Site	Sampling Date	Rep	Depth cm	Fe (µg/g) by Plot				
				1	2	3	4	5
Pearl River	11 Sept 84	1	15	15.5	8.57	13.7	10.98	97.2
		2	15	13.9	53.1	14.3	9.22	44.32
		1	60	16.6	22.1			481
		2	60	19.2	71.1	41.4	11.0	234
	27 May 85	1	15	26.3	9.74	42.3	29.9	47.2
		2	15	12.0	24.7	51.7	7.24	27.0
		1	60	26.8	16.1	19.8	9.34	236
		2	60	10.98	29.0	22.5	8.55	10.3

(Sheet 3 of 3)

Table R3

Manganese Data

Site	Sampling Date	Rep	Depth cm	Mn (µg/g) by Plot				
				1	2	3	4	5
Red River	17 Aug 84	1	15	28.1	19.3	268	103	
		2	15	27.0	11.09	225	259	
		1	60	29.2	22.7	308	241	
		2	60	35.3	14.06	211	202	
	7 Sept 84	1	15	19.7	19.0	261	150.0	
		2	15	12.3	16.9	229	130.0	
		1	60	15.5	18.6	261	133	
		2	60	10.87	23.8	168	134	
	8 Nov 84	1	15		18.4		100.80	
		2	15	25.9	11.1	227	254	
		1	60	27.0	21.5	297	247	
		2	60		13.4	208	210.8	
	7 Feb 85	1	15	36.0	36.0	163		
		2	15	42.3		335		
		1	60		31.3	290.2		
		2	60	37.1	14.4	172		
	7 June 85	1	15	34.2	17.3	292	94.5	
		2	15	36.4	27.4	373	119	
		1	60	30.4	27.4	191	175	
		2	60	29.2	19.0	183	229	
Quimby	30 Aug 84	1	15	5.60	4.34	10.6	5.17	106
		2	15	4.81	6.52	10.3	19.5	100.35
		1	60	9.02		5.26	16.2	118
		2	60	3.01	5.13	6.01	7.29	224
	5 Feb 85	1	15	1.17	2.38	1.08	1.21	
		2	15	3.51	1.62	1.73	5.56	
		1	60	0.338	1.89	0.520	5.60	
		2	60	0.563	1.35	0.720	4.77	

(Continued)

(Sheet 1 of 3)

Table R3 (Continued)

Site	Sampling Date	Rep	Depth cm	Mn (µg/g) by Plot				
				1	2	3	4	5
Quimby	11 July 85	1	15	8.19	3.62	4.84	7.94	90.2
		2	15	1.35	3.89	3.15	12.2	97.9
		1	60	2.59	4.57	9.02	4.27	118
		2	60	5.35	1.87	2.14	7.56	109
Rolling Fork	24 Aug 84	1	15	2.38	2.56	3.91	7.60	14.5
		2	15	2.86	7.29	1.06	6.79	12.9
		1	60	1.44	2.16	5.58	6.46	39.4
		2	60	2.86	3.85	2.07	7.20	38.7
	8 Feb 85	1	15	4.14	4.75	0.765	17.2	
		2	15	5.20	4.99	0.788	24.5	
		1	60	1.93	3.31	4.86	17.0	
		2	60	1.62	11.0	3.24	11.4	
	27 June 85	1	15	3.51	10.91	8.37	11.6	33.1
		2	15	22.9	9.13	8.17	14.8	22.9
		1	60	4.70	3.51	3.15	15.3	21.7
		2	60	11.9	11.9	4.99	14.4	36.9
Spring Bayou	13 Nov 84	1	15	0.607	0.585	4.81	11.5	
		2	15	0.517	7.76	7.51	15.7	
		1	60	1.46	2.23	4.32	14.1	
		2	60	1.66	1.44	6.07	27.2	
	29 Jan 85	1	15	0.383	2.61	5.71		
		2	15	0.292	0.450	7.02	15.0	
		1	60	1.51	4.66	3.82		
		2	60	1.69	1.06	13.9	25.9	
	11 June 85	1	15	2.29		8.23	19.9	
		2	15	2.50	6.86	8.93	81.0	
		1	60	3.51		4.54	18.0	
		2	60	2.90	2.43	16.2	58.3	

(Continued)

(Sheet 2 of 3)

Table R3 (Concluded)

Site	Sampling Date	Rep	Depth cm	Mn (µg/g) by Plot 1	2	3	4	5
Pearl River	11 Sept 84	1	15	13.2	10.5	20.4	27.0	81.0
		2	15	19.5	33.7	26.5	34.9	144
		1	60	2.99	40.3			78.7
		2	60	13.9	32.6	34.6	36.0	99.0
	27 May 85	1	15	18.5	13.8	26.1	44.8	40.0
		2	15	25.6	37.8	22.3	30.1	28.3
		1	60	5.42	41.4	35.5	66.6	84.6
		2	60	12.7	49.3	52.0	48.1	98.1

(Sheet 3 of 3)

APPENDIX S: SOIL CHEMISTRY DATA FOR ALL TRANSECTS

Table S1

Pearl River Plot 1

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC* Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Pearl River	1	Arkabutla	A1	2.9	1.1	0.3	0.1	17.6	22.0	20.0	2.64
Pearl River	1	Arkabutla	Bw	1.4	0.4	0.2	0.1	10.0	12.1	17.4	3.50
Pearl River	1	Arkabutla	Bg21	0.9	0.3	0.2	0.1	10.1	11.6	12.9	3.00
Pearl River	1	Arkabutla	Bg22	0.9	0.5	0.5	0.1	8.8	10.8	18.5	1.80
Pearl River	1	Arkabutla	Bg3	1.4	1.9	0.1	0.5	14.5	18.4	21.2	0.74

* Cation exchange capacity.

Table S2

Chemical Analysis of Pearl River Plot 2 Rosebloom Series

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Pearl River	2	Rosebloom	A1	2.7	1.3	0.3	0.1	13.6	18.0	24.4	2.08
Pearl River	2	Rosebloom	Bg1	1.4	0.8	0.1	0.1	11.4	13.8	17.4	1.75
Pearl River	2	Rosebloom	Bg2	3.7	1.0	0.1	0.1	11.4	16.3	30.1	3.70
Pearl River	2	Rosebloom	Bg3	2.3	1.7	0.3	0.1	15.0	19.4	22.7	1.35
Pearl River	2	Rosebloom	Bg4	2.0	1.7	0.1	0.2	13.2	17.2	23.3	1.18

Table S3

Pearl River Plot 3

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				---------- meq/100 g ----------							
Pearl River	3	Rosebloom	A1	2.7	1.3	0.3	0.1	9.5	13.9	31.7	2.08
Pearl River	3	Rosebloom	Bg1	4.5	2.3	0.2	0.2	13.2	20.4	35.3	1.96
Pearl River	3	Rosebloom	Bg2	3.2	1.4	0.1	0.2	11.9	16.8	29.2	2.29
Pearl River	3	Rosebloom	Bg3	3.6	1.8	0.2	0.3	13.6	19.5	30.3	2.00

Table S4

Pearl River Plot 4

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				---------- meq/100 g ----------							
Pearl River	4	Rosebloom	A1	2.7	1.2	0.1	0.1	9.7	13.8	29.7	2.25
Pearl River	4	Rosebloom	Bg1	4.1	1.8	0.2	0.1	9.6	15.8	39.2	2.28
Pearl River	4	Rosebloom	Bg2	4.5	2.3	0.2	0.2	11.9	19.1	37.7	1.96
Pearl River	4	Rosebloom	Bg3	5.0	2.8	0.2	0.3	14.1	22.4	37.1	1.79
Pearl River	4	Rosebloom	Bg4	4.1	2.3	0.2	0.2	10.9	17.7	38.4	1.78

Table S5

Pearl River Plot 5

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Pearl River	5	Rosebloom	Oi	9.5	4.0	0.2	0.2	6.3	20.2	68.8	2.38
Pearl River	5	Rosebloom	A1	4.1	1.5	0.4	0.1	14.1	20.2	30.2	2.73
Pearl River	5	Rosebloom	Bg1	4.1	1.7	0.2	0.1	13.6	19.7	31.0	2.41
Pearl River	5	Rosebloom	Bg2	4.1	1.5	0.2	0.1	12.4	18.3	32.2	2.73
Pearl River	5	Rosebloom	Bg3	2.7	1.3	0.2	0.1	10.1	14.4	29.9	2.08

Table S6

Quimby Plot 1

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Quimby	1	Goldman	A1	9.0	4.0	0.2	0.2	14.3	27.7	48.4	2.25
Quimby	1	Goldman	Bt2	7.2	3.7	0.4	0.1	15.0	26.4	43.2	1.95
Quimby	1	Goldman	Bt3	8.1	3.0	0.2	0.1	6.6	18.0	63.3	2.70
Quimby	1	Goldman	C	5.4	1.8	0.2	0.1	5.3	12.8	58.6	3.00

Table S7

Quimby Plot 2

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Quimby	2	Tensas	A1	29.5	10.0	0.8	0.1	16.0	56.4	71.6	2.95
Quimby	2	Tensas	Btg1	21.6	8.9	0.8	0.2	16.3	47.8	65.9	2.43
Quimby	2	Tensas	Btg2	15.8	6.7	0.4	0.2	12.8	35.9	64.3	2.36
Quimby	2	Tensas	2Bc1	14.8	6.0	0.5	0.2	11.4	32.9	65.3	2.47

Table S8

Quimby Plot 3

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Quimby	3	Kobel	A1	24.8	12.5	0.9	0.4	17.6	56.2	68.7	1.98
Quimby	3	Kobel	Bg1	27.9	14.4	0.7	0.8	13.2	57.0	76.8	1.94
Quimby	3	Kobel	Bg2	25.7	13.4	0.6	0.8	10.1	50.6	80.0	1.92
Quimby	3	Kobel	Bcg	18.5	9.5	0.4	0.5	6.6	35.5	81.4	1.95

Table S9

Quimby Plot 4

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Quimby	4	Kobel	A1	29.5	8.9	0.8	0.1	20.7	60.0	65.5	3.31
Quimby	4	Kobel	Bg1	20.0	9.2	0.6	0.2	18.5	48.5	61.9	2.17
Quimby	4	Kobel	Bg2	16.2	7.9	0.5	0.2	11.4	36.2	68.5	2.05
Quimby	4	Kobel	Bg3	14.8	7.4	0.5	0.3	9.2	32.2	71.4	2.00
Quimby	4	Kobel	2Cg	14.2	7.2	0.4	0.2	7.6	29.6	74.3	1.97

Table S10

Quimby Plot 5

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Quimby	5	Fausse	A1	32.4	12.0	1.0	0.2	27.7	73.3	62.2	2.70
Quimby	5	Fausse	Bg1	30.2	14.9	1.2	0.3	16.3	62.9	74.1	2.03
Quimby	5	Fausse	Bg2	33.5	17.2	0.9	0.6	12.4	64.6	80.8	1.95
Quimby	5	Fausse	Bg3	33.8	16.7	0.8	0.8	11.0	63.1	82.6	2.02

Table S11

Red River Plot 1

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				----------	meq/100 g	----------					
Red River	1	Norwood	A	22.5	7.0	0.6	0.1	6.4	36.6	82.5	3.21
Red River	1	Norwood	C1-A	29.7	5.9	0.5	0.1	5.3	41.5	87.2	5.03
Red River	1	Norwood	C1-B	29.7	5.9	0.5	0.1	5.3	41.5	87.2	5.03
Red River	1	Norwood	C2-A	32.9	4.3	0.3	0.1	4.4	42.0	89.5	7.65
Red River	1	Norwood	C2-B	35.8	6.5	0.5	0.1	4.4	47.3	90.7	5.51
Red River	1	Norwood	C3	18.5	4.0	0.6	0.1	3.1	26.3	88.2	4.63

Table S12

Red River Plot 2

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				----------	meq/100 g	----------					
Red River	2	Norwood	A	18.7	6.9	0.6	0.1	6.2	32.5	80.9	2.71
Red River	2	Norwood	B	29.0	7.0	0.6	0.1	6.2	42.9	85.5	4.14
Red River	2	Norwood	C-A	25.5	5.0	0.2	0.1	0.3	31.1	99.0	5.10
Red River	2	Norwood	C-B	30.2	5.7	0.3	0.1	0.3	36.6	99.2	5.30

Table S13

Red River Plot 3

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				----------	----------	----------	meq/100 g	----------	----------		
Red River	3	Moreland	A11	30.2	9.7	0.6	0.3	9.2	50.0	81.6	3.11
Red River	3	Moreland	A12	22.1	11.2	0.4	0.4	6.2	40.3	84.6	1.97
Red River	3	Moreland	A1B	43.7	13.7	0.6	0.6	6.2	64.8	90.4	3.19
Red River	3	Moreland	Bb	27.9	10.0	0.4	0.4	6.4	45.1	85.8	2.79
Red River	3	Moreland	C	33.3	10.4	0.3	0.5	6.4	50.9	87.4	3.20

Table S14

Red River Plot 4

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				----------	----------	----------	meq/100 g	----------	----------		
Red River	4	Yorktown	A	22.7	10.4	0.5	0.9	9.7	44.2	78.1	2.18
Red River	4	Yorktown	C	23.9	8.9	0.4	0.5	5.9	39.6	85.1	2.69

Table S15

Rolling Fork Plot 1

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Rolling Fork	1	Dundee	A1	42.8	9.5	0.8	0.2	17.6	70.9	75.2	4.51
Rolling Fork	1	Dundee	Btg1	20.5	8.4	0.7	0.1	11.9	41.6	71.4	2.44
Rolling Fork	1	Dundee	Btg2	14.0	6.4	0.5	0.2	11.5	32.6	64.7	2.19
Rolling Fork	1	Dundee	BC	9.9	4.6	0.4	0.1	6.6	21.6	69.4	2.15
Rolling Fork	1	Dundee	2C	8.1	3.3	0.3	0.1	8.8	20.6	57.3	2.45

Table S16

Rolling Fork Plot 2

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Rolling Fork	2	Kobel	A1	30.6	12.9	1.0	0.3	13.2	58.0	77.2	2.37
Rolling Fork	2	Kobel	Bg1	30.2	12.7	0.6	0.4	13.2	57.1	76.9	2.38
Rolling Fork	2	Kobel	Bg2	26.6	12.4	0.6	0.4	6.3	46.3	86.4	2.15
Rolling Fork	2	Kobel	Eg3	15.8	13.9	0.8	0.5	7.6	38.6	80.3	1.14
Rolling Fork	2	Kobel	Eg4	26.6	11.2	0.5	0.5	9.2	48.0	80.8	2.37
Rolling Fork	2	Kobel	2C	21.6	9.3	0.3	0.4	5.3	36.9	85.6	2.32

Table S17

Rolling Fork Plot 3

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Rolling Fork	3	Tunica	A1	32.0	13.5	0.8	0.3	13.2	59.8	77.9	2.37
Rolling Fork	3	Tunica	Bg1	27.5	13.4	0.8	0.3	10.2	52.2	80.5	2.05
Rolling Fork	3	Tunica	Bg2	28.4	13.4	0.7	0.3	14.3	57.1	75.0	2.12
Rolling Fork	3	Tunica	2C	20.7	9.9	0.6	0.2	9.2	40.6	77.3	2.09

Table S18

Rolling Fork Plot 4

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Rolling Fork	4	Sharkey	A	28.4	13.0	1.1	0.3	22.4	65.2	65.6	2.18
Rolling Fork	4	Sharkey	Bg1	32.4	13.9	0.8	0.6	14.0	61.7	77.3	2.33
Rolling Fork	4	Sharkey	Bg2	41.0	17.2	0.8	1.4	12.3	72.7	83.1	2.38
Rolling Fork	4	Sharkey	Bg3	30.6	14.5	0.8	0.7	11.2	57.8	80.6	2.11
Rolling Fork	4	Sharkey	C1	27.0	12.7	0.6	0.6	9.9	50.8	80.5	2.13
Rolling Fork	4	Sharkey	C2	28.8	11.0	0.9	0.5	10.6	51.8	79.5	2.62

Table S19

Rolling Fork Plot 5

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Rolling Fork	5	Fausse	A	26.6	13.0	1.2	0.4	18.2	59.4	69.4	2.05
Rolling Fork	5	Fausse	Bg1	29.3	14.4	1.0	0.7	16.7	62.1	73.1	2.03
Rolling Fork	5	Fausse	Bg2	31.5	14.7	1.2	0.8	19.4	67.6	71.3	2.14
Rolling Fork	5	Fausse	Bg3	30.6	14.5	0.9	0.9	17.6	64.5	72.7	2.11
Rolling Fork	5	Fausse	Bg4	27.5	12.2	0.9	0.7	14.3	55.6	74.3	2.25
Rolling Fork	5	Fausse	C	27.5	11.2	1.0	0.5	8.4	48.6	82.7	2.46

Table S20

Spring Bayou Plot 1

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Spring Bayou	1	Tensas	A1	17.3	11.2	0.8	0.2	21.3	50.8	58.1	1.54
Spring Bayou	1	Tensas	Btg1	10.8	7.9	0.1	0.2	11.4	30.4	62.5	1.37
Spring Bayou	1	Tensas	Btg2	12.2	8.2	0.3	0.5	10.1	31.3	67.7	1.49
Spring Bayou	1	Tensas	Btg3	14.9	9.4	0.5	0.6	8.7	34.1	74.5	1.59
Spring Bayou	1	Tensas	BCg	10.4	6.9	0.3	0.8	6.6	25.0	73.6	1.51

Table S21

Spring Bayou Plot 2

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Spring Bayou	2	Tensas	A1	19.8	11.5	0.7	0.3	9.2	41.5	77.8	1.72
Spring Bayou	2	Tensas	Btg1	14.4	8.7	0.5	0.3	8.8	32.7	73.1	1.66
Spring Bayou	2	Tensas	Btg2	12.2	7.2	0.7	0.3	7.0	27.4	74.5	1.69
Spring Bayou	2	Tensas	Btg3	16.0	9.0	0.5	0.4	8.4	34.3	76.5	1.78
Spring Bayou	2	Tensas	2CG	11.7	6.5	0.3	0.2	5.9	24.6	76.0	1.80

Table S22

Spring Bayou Plot 3

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				meq/100 g							
Spring Bayou	3	Kobel	A1	22.5	14.4	0.8	0.4	18.2	56.3	67.7	1.56
Spring Bayou	3	Kobel	Bg1	18.7	11.4	0.4	0.5	9.2	40.7	76.2	1.64
Spring Bayou	3	Kobel	Bg2	16.2	9.5	0.4	0.4	8.7	35.2	75.3	1.71
Spring Bayou	3	Kobel	2Cg	15.8	8.4	0.4	0.6	8.4	33.6	75.0	1.88

Table S23

Spring Bayou Plot 4

Site	Plot	Soil Series	Horizon	Ca	Mg	K	Na	H	CEC Sum	Percent Base Saturation	Ca/Mg
				----------	----------	----------	meq/100 g	----------	----------		
Spring Bayou	4	Fausse	Ca	31.5	12.0	0.9	0.5	37.5	82.4	54.5	2.63
Spring Bayou	4	Fausse	A1	30.2	12.7	0.7	0.5	14.4	58.5	75.4	2.38
Spring Bayou	4	Fausse	Cg1	24.8	13.7	0.7	0.8	12.9	52.9	75.6	1.81
Spring Bayou	4	Fausse	Cg2	15.5	8.4	0.3	1.1	5.7	31.0	81.6	1.85
Spring Bayou	4	Fausse	Cg3	16.7	8.7	0.4	0.7	7.6	34.1	77.7	1.92