# 4 Geomorphic Chronology

## Introduction

The third objective of this study was to define the geomorphic chronology of the project area to the extent possible with the known data. The chronology is based on the available soils and geological data, results of the geomorphic mapping, boring and laboratory data produced during this study, and finally, the radiocarbon data from abandoned channels. The geomorphic history of the area is defined by the distribution and extent of the underlying geologic units, the floodplain sediments which overlie these formations, and the soils that have formed and modified these different landscape elements.

## Pleistocene

### Geomorphic setting and terrace levels

The Red River and Big Cypress Bayou were formed during the Pleistocene, a period of active continental glaciation in North America. The Red River and Big Cypress Bayou were not directly affected by continental glaciation during the Pleistocene. Neither of these fluvial systems directly received glacial meltwater or related sediments. Instead, geomorphic processes operating in the study area were controlled by climatic variations associated with Pleistocene glaciation. Climatic changes influenced the base level on the Red River and its tributaries. Since the outlet for the Red River during the latter part of the Pleistocene was by way of the Mississippi River Valley, direct effects of glaciation (i.e. glacial melt water, glacial sediment, and sea level changes) would have influenced the Red River's discharge to the Mississippi River and its link to the Gulf of Mexico.

The end result of this complex interchange between Pleistocene climate changes and associated base level response has been the creation and incision of a well defined drainage basin into the underlying Tertiary sediments. At the beginning of the Holocene, the Red River alluvial valley and its larger tributaries had developed a series of descending stepped terraces, formed as a result of aggrading and degrading fluvial cycles, and a well defined flood plain with associated environments of deposition.

Within the boundaries of the study area, the highest and oldest mapped terrace (Plates 10 through 13) is the Prairie Terrace (QTP), deposited approximately 115,000 to 130,000 years before the present (BP) during the Sangamon Interglacial Period (Harrelson 1990, and Harrelson and Smith 1988 (Pigure 5)). The next oldest terrace mapped in the study area is the Deweyville (QTD), a lower Red River terrace (Plates 10 through 13) that is situated stratigraphically below the Prairie (Smith and Russ 1974). This terrace is estimated to have been deposited between 14,000 and 30,000 years BP. Oversized abandoned channels are characteristic of the Deweyville. These oversized channels are indicative of a much wetter climate and a higher stream discharge.

Upstream from the head waters of Caddo Lake (Plates 5 and 6), several oversized abandoned channels were mapped. These channels are associated with the older point bar surface (PB2), possibly a lower terrace surface, adjacent to the floodplain. Because of limited topographic and flood frequency data, this surface was included as part of the floodplain. Abandoned channels contained on this surface are much larger in comparison to abandoned channel segments closer to and associated with the main channel. These larger abandoned channel segments may represent a Deweyville equivalent in the Big Cypress Bayou drainage basin. Unfortunately, vibracoring of sediments from one of these channels (Plate 6, borings V2 and V3) was unsuccessful in recovering sufficient organic materials to radiocarbon date the filling history.

In another abandoned channel (i.e. vibracore V4, Plate 7) associated with the PB2 surface, radiocarbon dates from this channel indicate a Late Pleistocene age approximately 15,000 to 16,000 years BP when filling began. Dates from vibracore V4 should be interpreted with caution as these dates were obtained near the basal portion of the channel fill sequence. Dates from this fill sequence may possibly represent older eroded organic sediments, rather than in situ, contemporaneous fill sequences. Ideally, dates from channel fill sequences should record the fine-grained filling history as opposed to the lateral migration component which may include older eroded materials. In addition to the limited radiocarbon data, two other kinds of evidence, soils and pollen data, suggest that these channels may be older than Holocene.

## Soils data

The first kind of evidence occurs in the soils which form the PB2 surface. A series of soil borings were drilled by the SCS (unpublished data) between Highway 43 and the abandoned channel in which vibracores V2 and V3 were drilled (Plate 6 for location). SCS borings define characteristics which are common for older mature soils. Soils at this location contain both argillic and fragipan horizons.

Argillic horizons are a diagnostic soil horizon representing a certain thickness (i.e. 7.5 to 15 cm) and an increased accumulation of clay (i.e. 3 to 8 percent) as compared to the overlying soils or the underlying parent material (Birkeland 1984). Clay content and thickness in argillic horizons are variable because of geographic differences in the soil forming variables (i.e. time, climate, slope, and composition of the underlying parent materials and overlying soils, etc.). Evidence for translocated clay particles from the overlying horizon must be present for a soil to contain an argillic horizon.

Fragipan horizons are soil horizons of high bulk density relative to the overlying soil horizons (Birkeland 1984). More detailed information and primary characteristics of fragipan soils are presented by Birkeland (1984). In summary, fiagipan soil horizons are brittle, range in thickness from 15 to 200 cm, and are common in loamy material in climates characterized by water moving through the soil at some time during the year. Fragipan horizons are low in organic matter and generally noncalcareous. The cementing or binding agent is believed to be silicate clay minerals. There are no other chemical or mineralogical associations related to fiagipan soils. The exact mechanism and conditions by which these soils form are unknown.

The geomorphic importance associated with argillic and fragipan soil horizons in the PB2 surface is that these soil horizons represent a stable surface and require a certain amount of time to develop. Exactly how much time is needed to develop either of these characteristics is unknown as it relates to the complex interchange between the different soil forming variables. Fragipan soils are often associated with the Pleistocene. Climatic changes are cited as possible mechanisms involved in their formation. However, Birkeland (1984) cautions that fiagipan horizons have been documented in the literature as forming entirely during the Holocene. The geomorphic significance of fragipan horizons in terms of this study is that the PB2 surface has been stable enough for pedogenic processes to imprint and alter the underlying fluvial deposits.

### Pollen data

The second kind of evidence which may help date the PB2 surface is derived from vibracore borings and results of the pollen analysis (Appendix C). A composite pollen diagram of selected pollen types as a function of their percent and depth is presented in Figure 6. All the cores except V7 in Figure 6 are derived from the PB2 surface. Because of the limited organics obtained during this study, cores with pollen suites from individual abandoned channels representative of different Holocene time intervals isn't possible. Rather, a combined or composite pollen diagram of selected species is presented in Figure 6 to develop relationships which may help define floodplain chronology. The pollen diagram includes pollen from three cores (V3, V4, and V7) ranging from the late Pleistocene to the present as defined by limited radiocarbon data and boring stratigraphy.

Four general categories of pollen types are summarized by Figure 6. These categories include grasslands, hardwoods (mainly oak and hickory), pine (excludes cool weather northern pine species), and total trees (includes all tree types). The time range represented by the pollen diagram is approximately 16,000 years. Radiocarbon dates are available from samples near

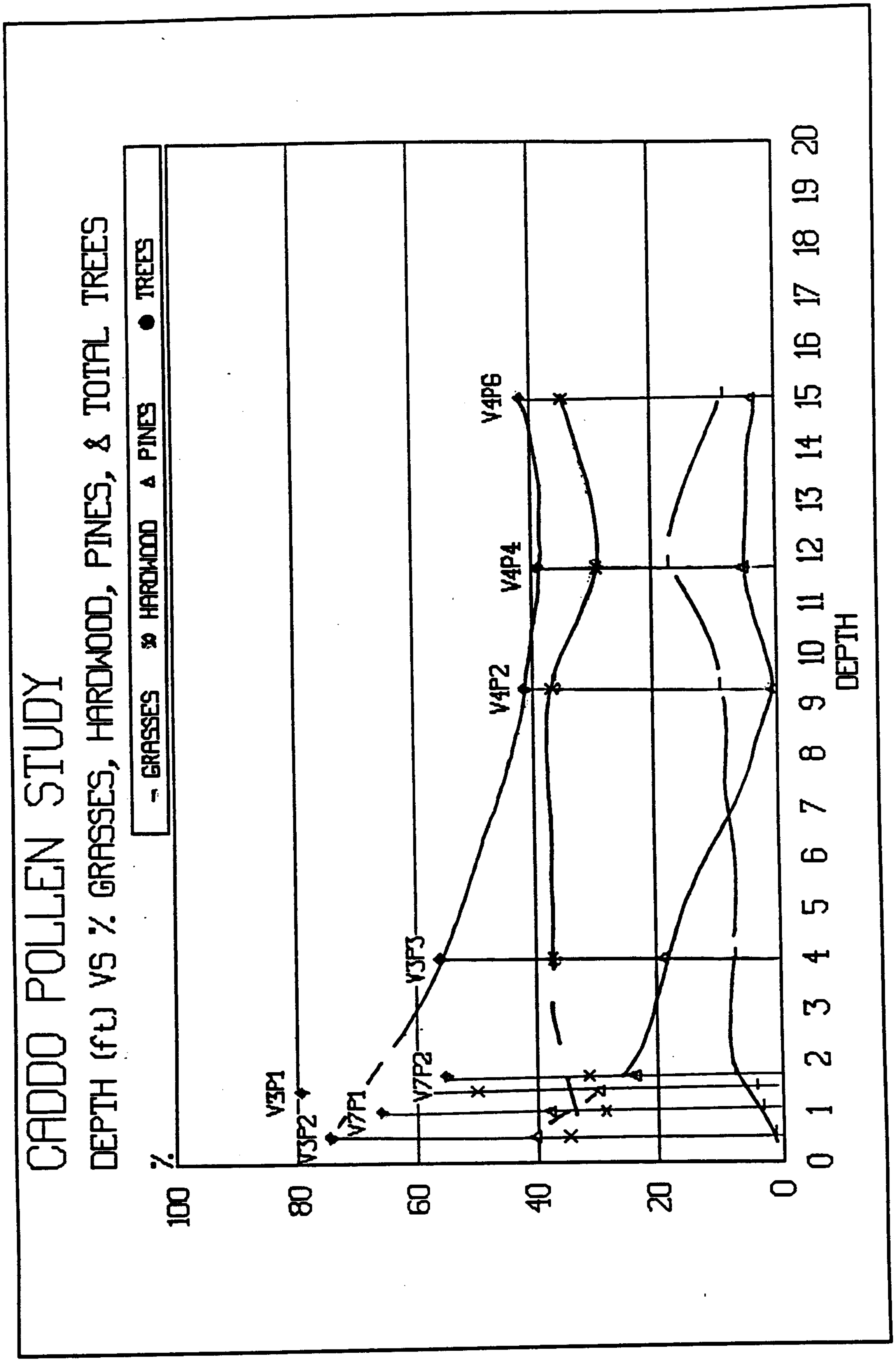



Figure 6. Pollen diagram from vibracores in headwaters of Caddo Lake

the base of V4 (16,810 to 15,180 years BP) and near the surface in V3 (105 years BP) and V7 (900 BP). The relationship among the various pollen categories indicates that total trees have increased overall, while grasslands have declined. Hardwoods have remained relatively stable, while pine is steadily increasing near surface.

The general significance of these categories is best summarized by Collins and Bousman (unpublished paper 1991) as follows:

> "The modern distribution of plant communities in Northeastern Texas is conditioned most clearly by the distribution of rainfall and temperature, but other factors, such as soil, have a significant affect as well. In general the modem plant communities consist of pine forests in far East Texas. As one travels from east to west oaks and hickory begin to replace pine, then hickory declines in frequency, and finally oak is displaced by more and more grass until in the west grasslands dominate the landscape. While these plant communities are seen as climax communities for the area in which they are mapped, it is generally believed that the distributions are controlled by climatic patterns and that significant changes in regional climatic patterns influence the distributions of these plant communities in a predictable fashion."

If the pollen data obtained from the headwaters of Caddo Lake is sufficiently "continuous and representative" of the last 15,000 years, then climate changes have not produced sharp vegetation shifts in the study area. The percentage of hardwoods has remained relatively stable. The overall increase in pine and total trees suggests that the study area is currently receiving higher temperature and rainfall rates than compared to the late Pleistocene. The data in Figure 6 suggest that extreme changes in vegetation, where one climax community was replaced by another representing a several-order magnitude shift along the vegetation gradient, did not occur as a result of changing climate. Instead, vegetation changes were less severe with movement occurring as gradual shifts along the east to west pine-hickory-oak-grasses gradient described by Collins and Bousman (unpublished paper 1991). Pollen data obtained during this study indicates the shift was primarily confined to the pine and hickory-oak communities. Pollen data from vibracore V4 (14.7 to 15 ft) indicates some boreal tree species (i.e. birch and spruce) were present in the study area during the late Pleistocene (Appendix C, sample V4-P6). Pine dominance in the southeastern United States occurred by the middle Holocene as determined from a regional pollen database as shown by Figures 7a through 7e (from Delcourt and Delcourt 1983).

It must be stressed that the pollen data obtained during this study do not completely represent Holocene climate change. Rather, the pollen data (Figure 6 and Appendix C) may only represent the present and the late Pleistocene, with no intermediate data points from early to middle Holocene. It is highly likely that the data do not completely reflect events associated with the early and middle Holocene periods. Bryant and Holloway (1985) have noted that for east Texas in general there is a limited fossil pollen record from the Holocene for reasons previously cited. Where pollen data do exist for eastern

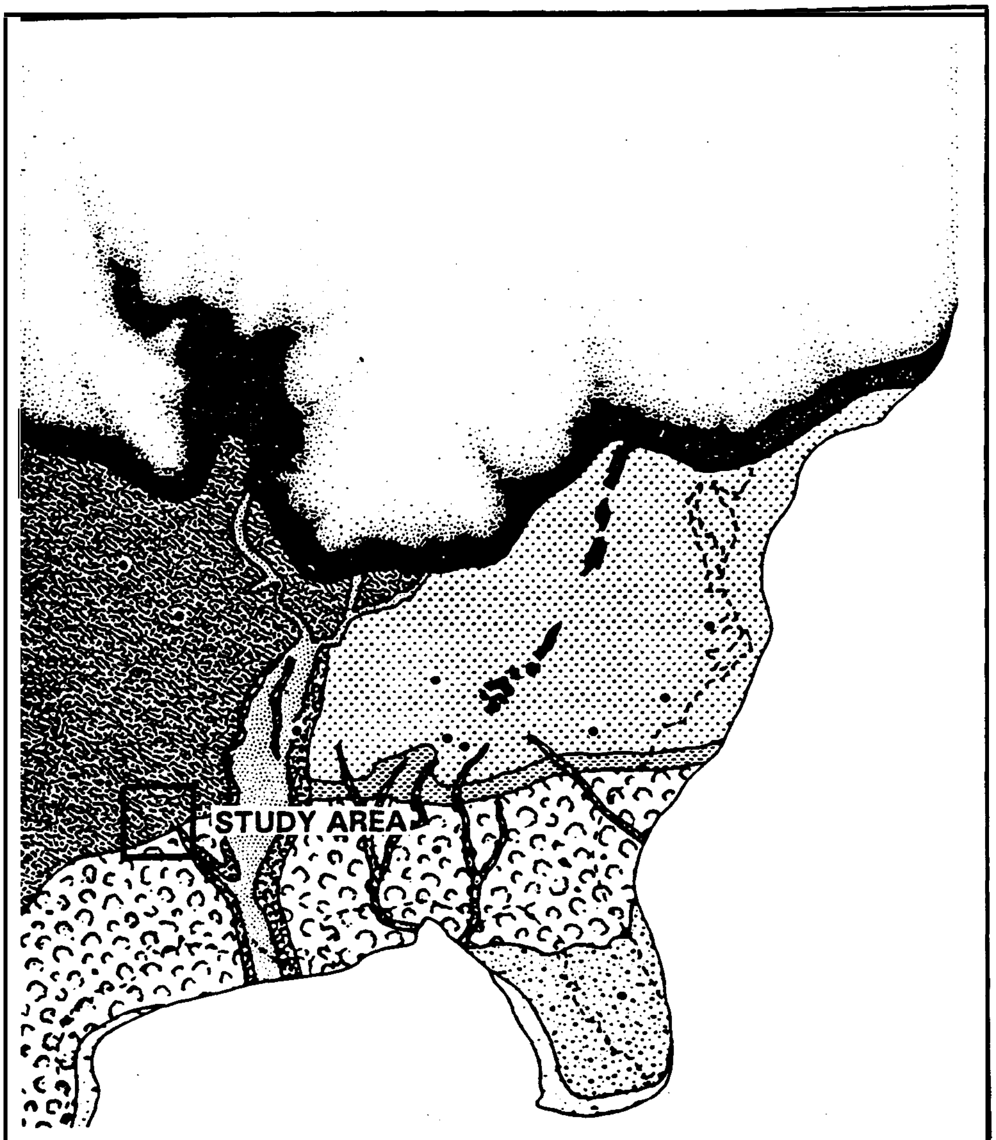



Figure 7. Paleovegetation maps; see Figure 7e for legend (from Delcourt and Delcourt 1983) (Sheet 1 of 5)

and central Texas, some characteristics are known about the early Holocene. Collins and Bousman (unpublished paper 1991) have compiled radiocarbon and pollen data from two Texas sites, Weakly Bog (near Dallas) and Boriack Bog (near Austin), which are shown in Figure 8. Their diagram shows the general distribution of grasses and arboreal (trees) pollens for the past 16,000 years. Their diagram illustrates the complex relationship between grasslands and trees during the late Pleistocene and Holocene periods. As grasslands increased in dominance, trees declined accordingly, and vice versa. The authors note that the data from these two Texas sites indicate that grasslands were dominant during the middle Holocene when drought conditions were documented for other parts of Texas. It is highly possible that the

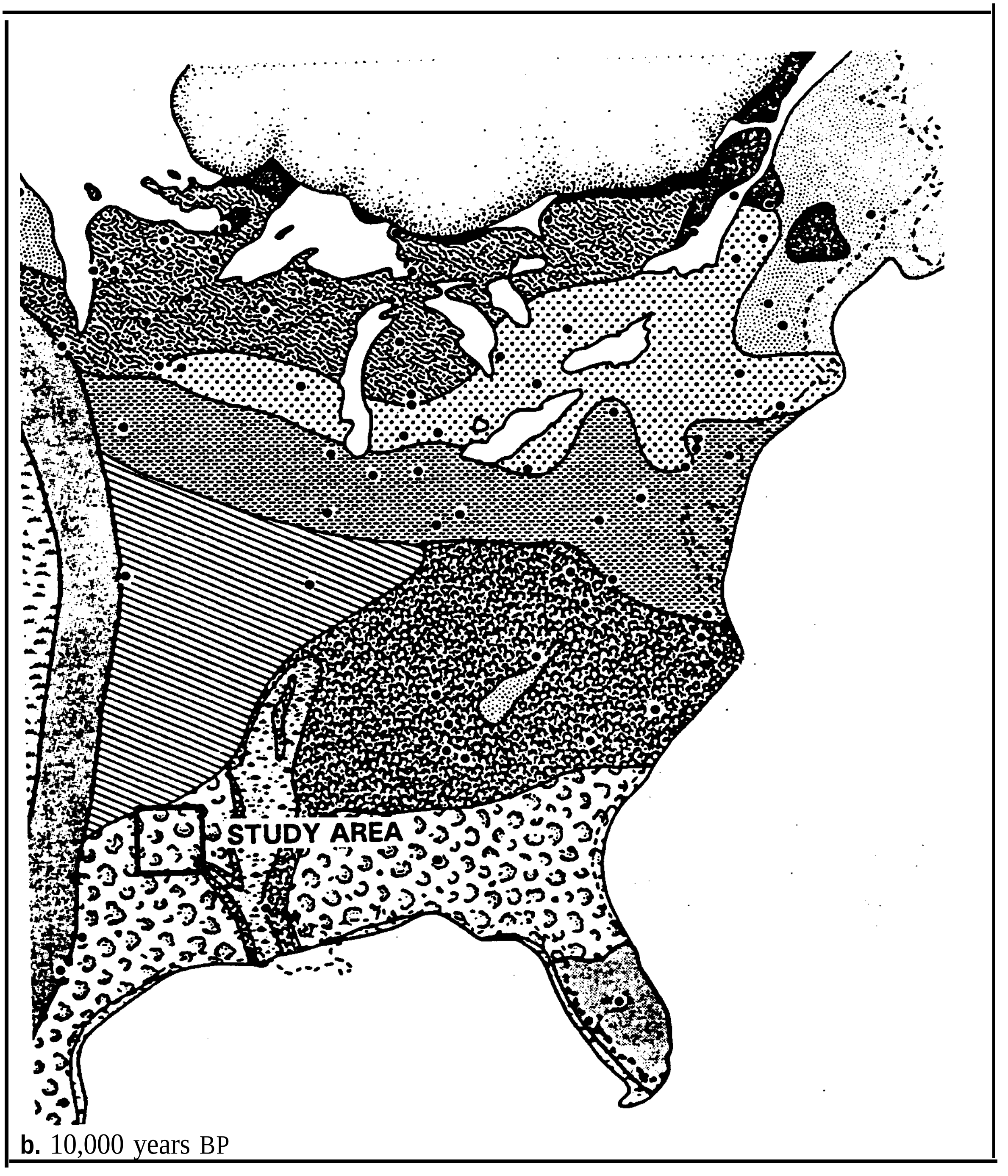



**Figure 7. (Sheet 2 of 5)**

middle Holocene pollen record is absent in the Caddo area partly because of the middle Holocene drought or "Hypsotherm."

## Summary

Pollen data are available from two cores from the PB2 surface which represent extreme ends in a 15,000-year time interval. If the Pleistocene age at

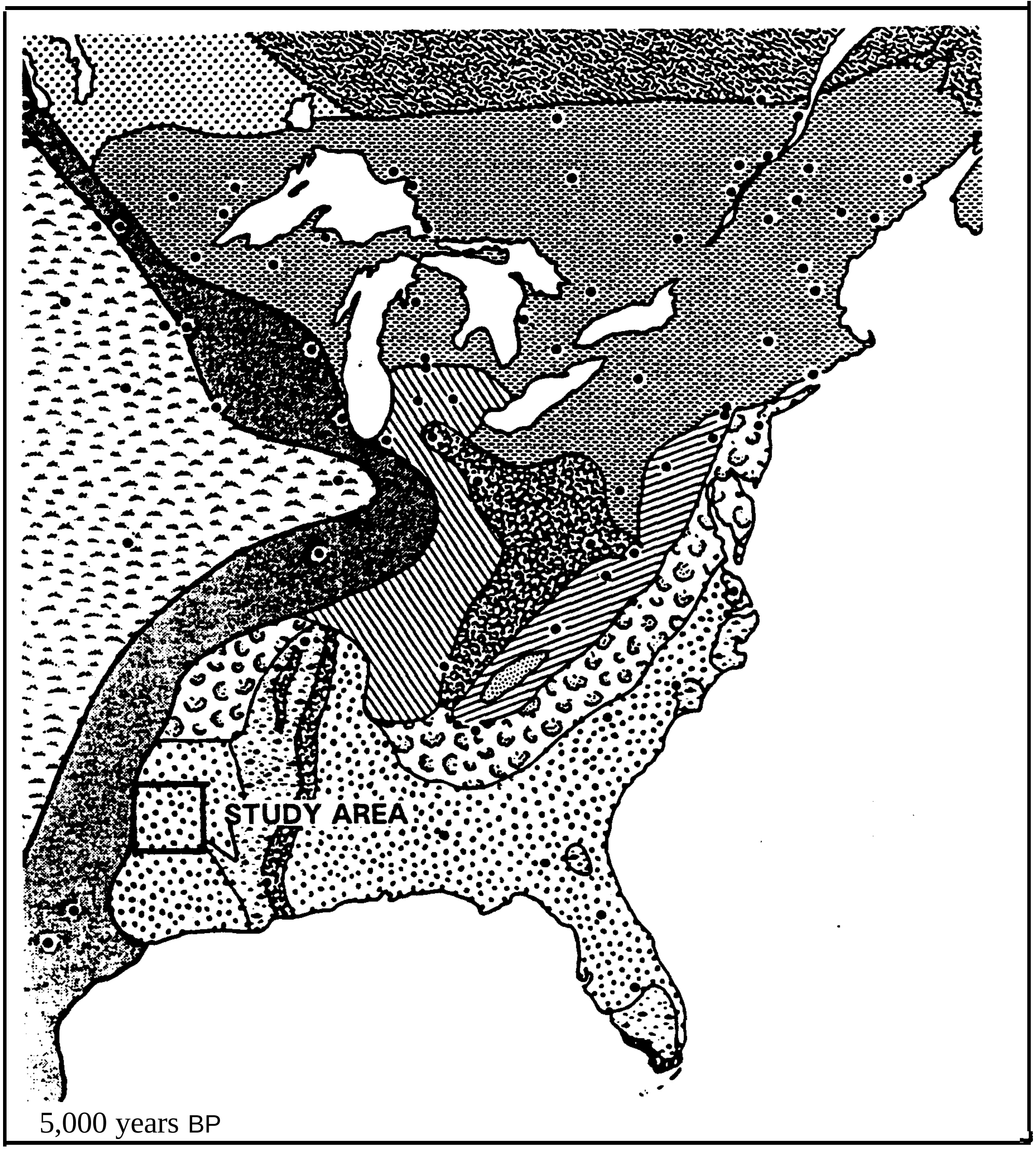



Figure 7. (Sheet 3 of 5)

one end of this time interval is correct (i.e. based on in situ abandoned channel sediments and not older, eroded, and transported organic deposits), then the PB2 surface may contain Pleistocene floodplain remnants. Pollen data from Texas and other locations in the southeastern United States show that climate changes have caused major shifts in vegetation patterns during the past 16,000 years. Exactly what changes have occurred during the early and late Holocene are unknown as organic sediments are not abundant in the subsurface from the headwaters of Caddo Lake. Absence of organic sediments may relate in part to middle Holocene drought conditions that were present in

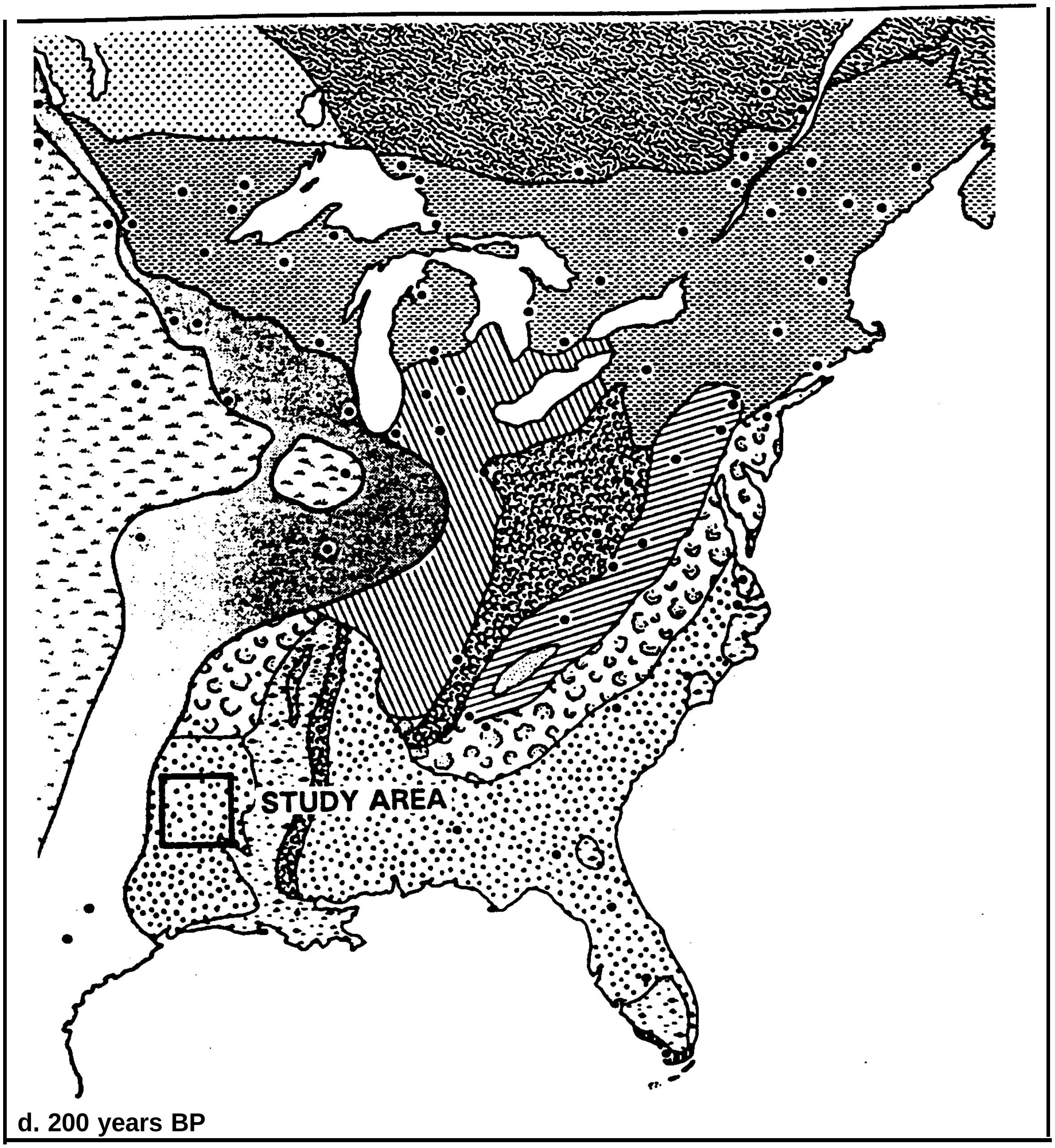
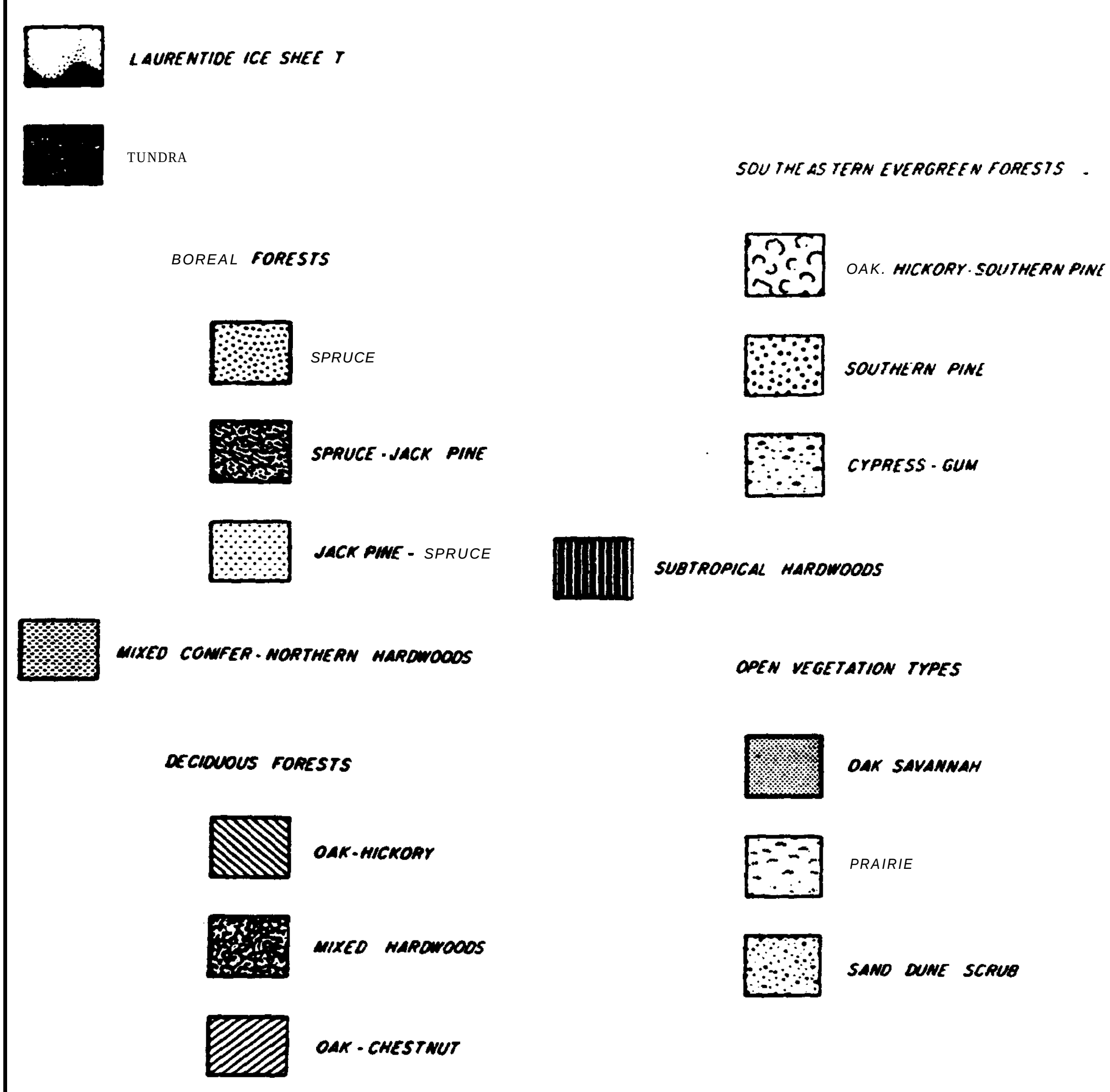



**Figure 7.** **(Sheet 4 of 5)**

central and eastern Texas during this time. Soils data and size, shape, and meander amplitude of certain meander loops-near the headwaters of Caddo Lake indicate that this surface has the potential to be much older than Holocene.

The exact age range for the PB2 surface in the headwaters area of Caddo lake is unknown. Geomorphic evidence indicates that this surface has been stable and possibly may extend at some locations well into the late Pleistocene In terms of its archaeological significance, the PB2 surface has been stable enough that it may contain paleoindian sites. In the final analysis,




**). Legend for Paleovegetation map**

**Figure 7. (Sheet 5 of 5)**

archaeological evidence may represent the best means to further define the age of this geomorphic surface.

## Holocene

At the beginning of the Holocene, the Mississippi River changed from a braided to a meandering system (Saucier 1974). Braided stream conditions were the result of the large influx of sediment from the melting glaciers that

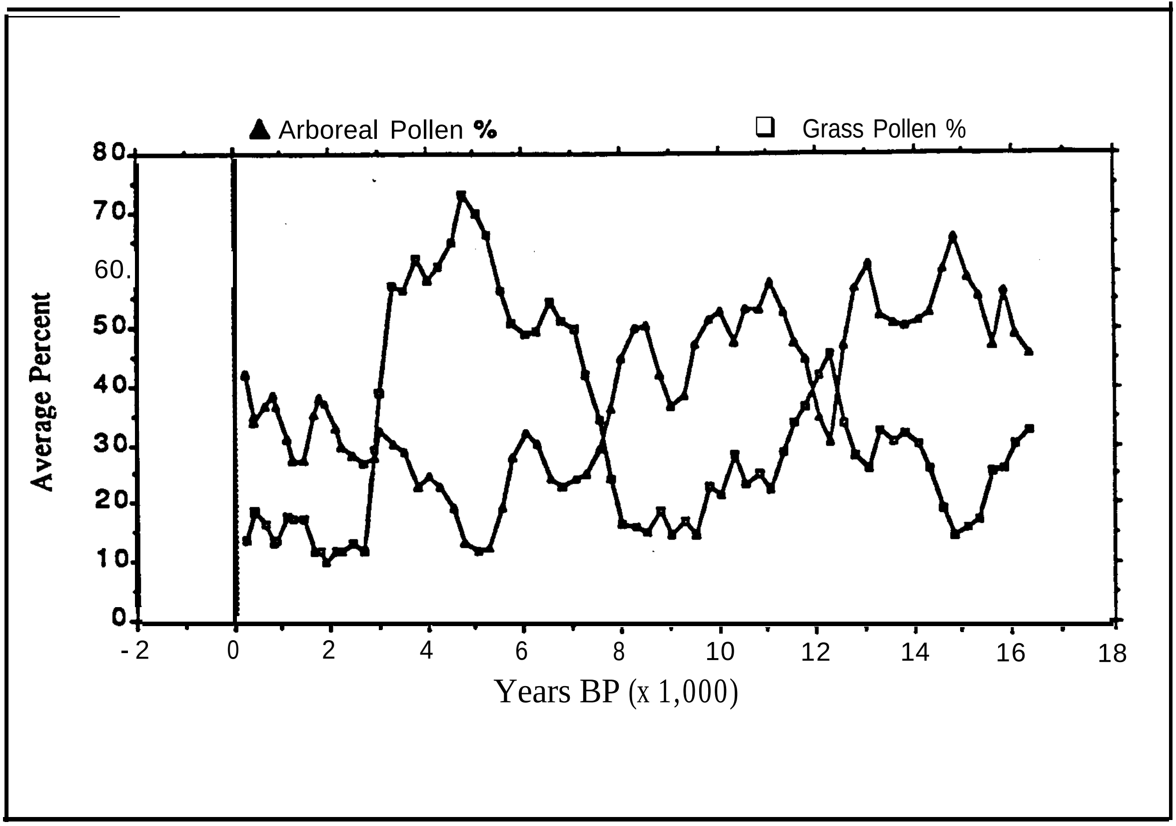



**Figure 8.** **Summary pollen analysis from two eastern Texas sites: Weakly Bog, near Dallas, and Boriack Bog, near Austin (from Collins and Bousman, unpublished paper 1991)**

had covered much of North America. Numerous, interconnected, or anastomosing stream courses in the Mississippi River Valley carried the glacial melt water and sediment gulfward. With the beginning of a meandering system, the Mississippi River began building a series of meander belt courses across its alluvial valley. As sea level reached its present level approximately 5,000 years ago, the Mississippi River began building a series of delta complexes seaward across coastal Louisiana (Figure 5).

The Red River was not directly affected by continental glaciation, since it did not directly transport glacial sediment and meltwater. Because glacial outwash and sediment were not transported by the Red River or its tributaries, the Red River was probably a meandering system during the Pleistocene. Climate changes were the primary geomorphic forces that affected the Red River valley and its tributaries.

Course shifts by the Mississippi River would have affected the Red River and its tributaries. Major course shifts would have influenced the location of the mouth of the Red River and its discharge to the Mississippi River. Major changes in the discharge location would have affected overall river distance and gradient and ultimately base levels. These changes would cause either stream aggradation or incision along the length of the Red River floodplain and its tributaries.

During the Holocene, the Mississippi River built five meander belt courses in its alluvial valley (Figure 5, modified from Saucier 1974, and Saucier and Snead 1989). In the Red River valley, six remanent meander belts are preserved (Smith and Russ 1974, Russ 1975, Saucier 1974, Saucier and Snead 1989). The most recent Red River course to the Mississippi River may have formed some time between 500 and 1,000 years ago through Moncla Gap (Russ 1975). Pearson (1986) suggests this change may have occurred even earlier, perhaps as early as 1,800 years ago based on archaeological data. This last course shift may have been partly responsible for the formation of the Red River Raft. The raft was a series of log jams approximately 100 miles in length which were present in the lower Red River valley during historic time.

The natural damming of the Red River by a series of log jams along portions of its lower valley may have been triggered by the migration of the Red River's mouth to Moncla Gap, a new position on the floodplain of the Mississippi River, and also by changing climate. Hall (1990) indicates that approximately 1,000 years ago a regional climate change occurred from moist to dry in the southern Great Plains. The response by the Red River to this climate change may have led to channel incision which helped to promote increased bank erosion. Similar changes have been noted for the central Great Plains (Martin 1992). Floodplain incision, bank erosion, and valley-wide lateral migration may have introduced a large influx of sediment and trees into the lower Red River Valley to form the Red River Raft.

## Historic

By the early 1800's, the lower Red River was blocked by a series of logjams known as the "Great Raft." The Red River Raft was a nearly 100-mile-long series of log jams which had accumulated on the point bars of the river and formed numerous interconnected river channels in the upper Red River valley (Guardia 1933). An account of rafting is described by Timothy Flint (1833) as follows (Smith 1982):

> "About thirty leagues (i.e., 70 miles) above Natchitoches, commences the great raft, which is. . . a broad, swampy expansion of alluvion of the river to the width of twenty or thirty miles. The river, spreading here into vast number of channels, frequently shallow courses, has been for ages clogging with a compact mass of timber and fallen trees, wafted from the upper region. Between these masses, the river has a channel, sometimes lost in a lake, and found by following the outlet of that lake back to the parent channel. The river is blocked up by this immense mass of timber for a length on its meanders, of between sixty and seventy miles. There are places where the water can be seen in motion under the logs. In other places the whole width of the river may be crossed on horseback, and boats only make their way, in passing these places, by following the inlet of a lake and coasting it to its outlet, and thus finding the channel again. Weeds, flowering shrubs, and small

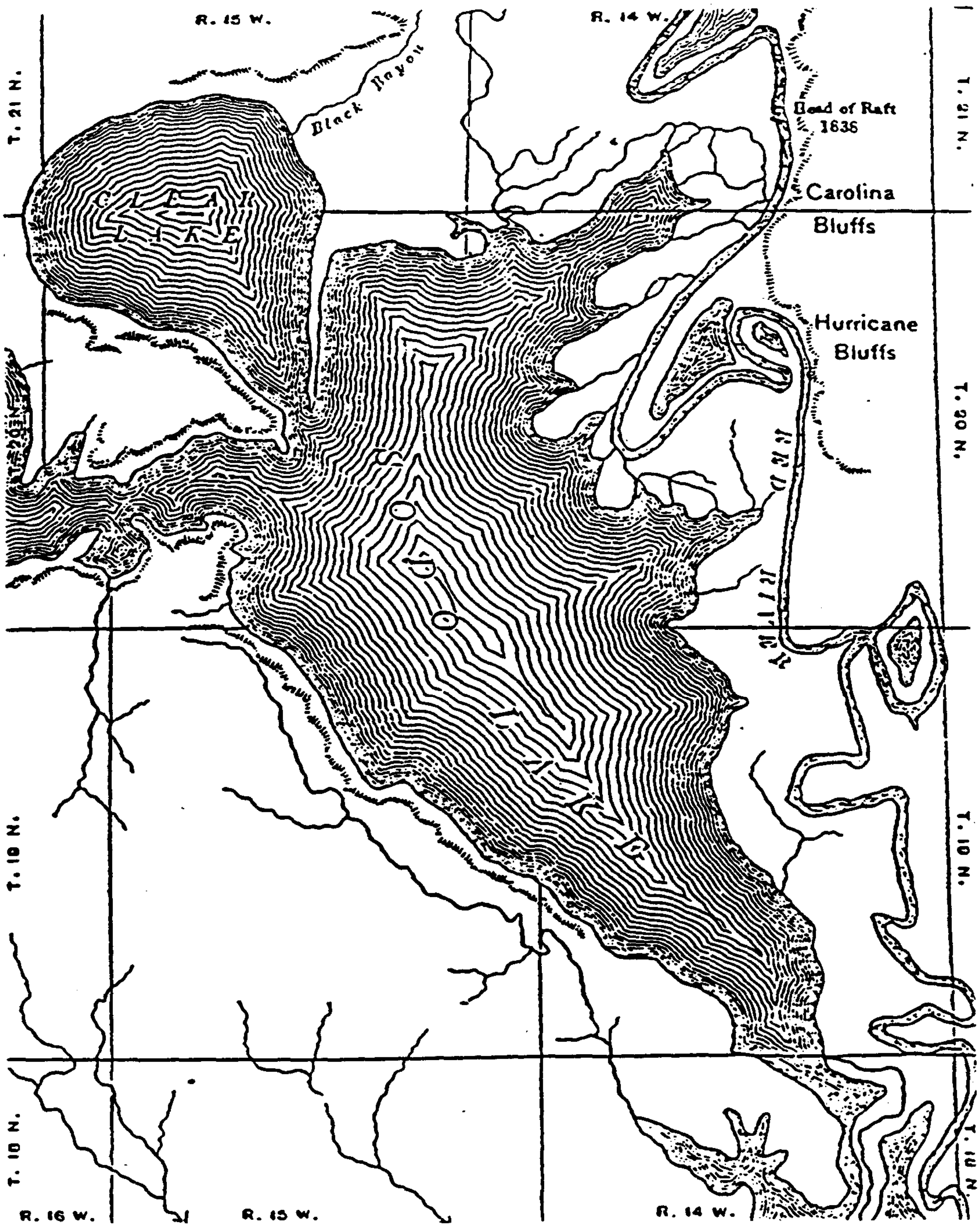
willows have taken root upon the surface of this timber, and flourish above the waters. But in all these places the course of the river, its outlines and its bends, are distinctly marked by a margin of forest trees which grow here on the banks in the same manner as they do where the channel is open."

As described in the previous summary by Flint (1833), the Red River Raft led to the formation of numerous valley margin lakes within the Red River valley and alluvial valleys of its tributaries. The raft was an important mechanism for the formation of the large lakes that covered much of the study area during historic time. This study will not examine in detail the history of the raft other than its significance to lake formation as it is beyond the scope of this investigation. Further information about the raft is available from numerous historic accounts and papers (Darby 1816, Flint 1833, Veatch 1906, Caldwell 1941, and Mills 1978).

Soda Lake covered much of the lower study area by the early 1800's as shown by Figure 9a (from Veatch 1906). Soda Lake was connected to Caddo Lake by way of Willow Pass (See Figure 9b for location of Willow Pass.). It is judged that the maximum lake limits for Soda Lake were established during historic time, near the levels indicated by Figure 9a. Beneath the limits of Soda Lake, lacustrine deposits buried the former floodplain of the Red River. The thickness of these lacustrine sediments was identified at one location (Plates 12 and 13, boring ST-12) and was about 3.2 ft (0.98 m). Lacustrine deposits may be even thicker, depending on distance from sediment source areas.

Lake limits for Caddo Lake, or Ferry Lake as it was known in the early part of this century, were determined by Leverett (1913). He examined geomorphic evidence for ancient shorelines in the bluffs surrounding the lake. His study concluded that the mean high water stage for Caddo Lake was approximately 4 ft (1.22 m) higher than the present level (i.e. 169 ft (51.51 m) MSL) which is regulated by Caddo dam. Relict shoreline evidence indicated that lake levels may have reached a maximum of approximately 180 ft (54.86 m). These fluctuations are due perhaps to seasonal variations.

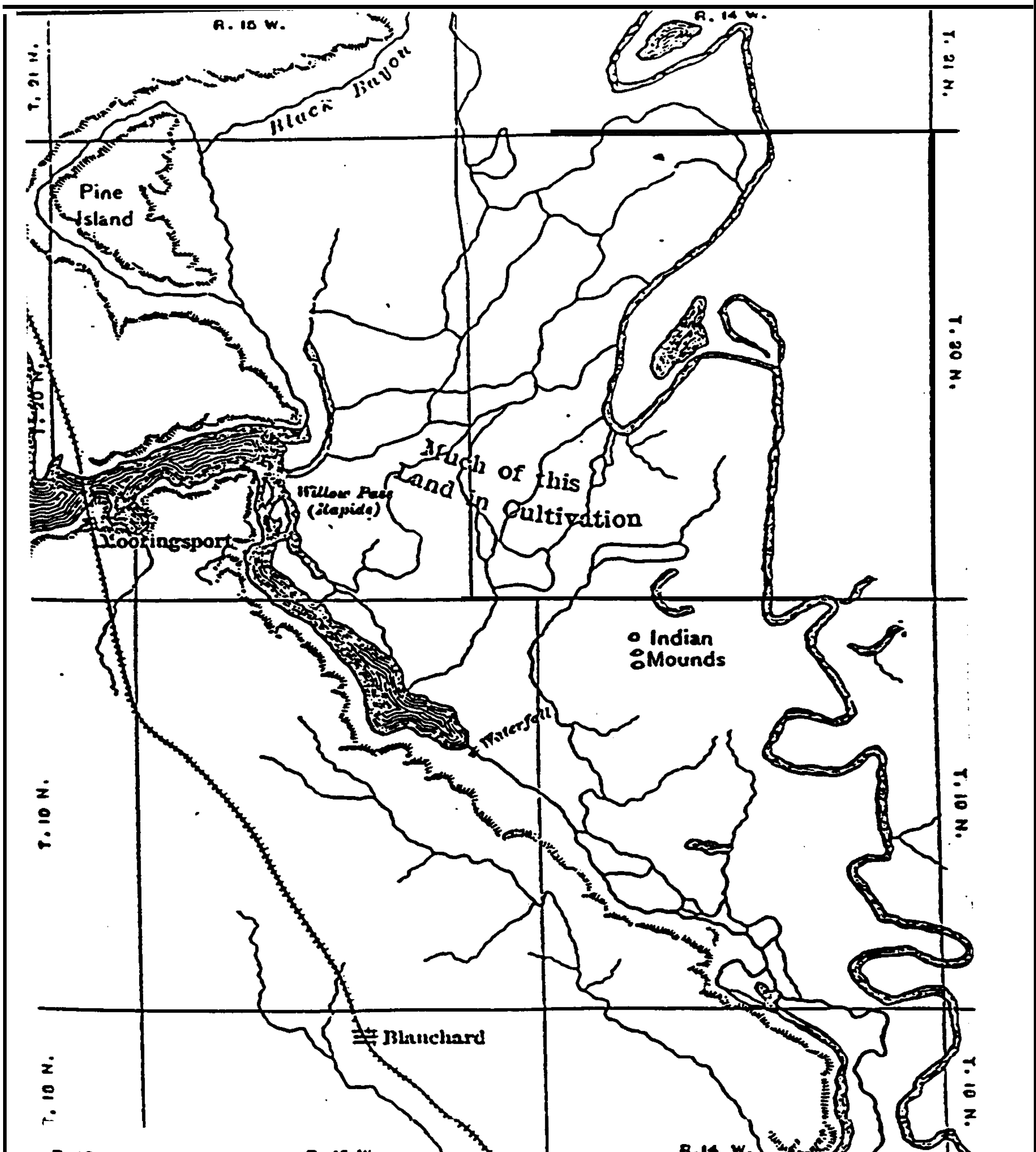
Complete removal of the Great Raft was accomplished by the USACE by 1873 for navigation purposes. Removal was conducted intermittently, depending on congressional funding and the national interest at the time, and took approximately 40 years to complete. Removal of the Great Raft caused the Red River to degrade its channel headward and drained the large lakes such as Soda Lake that had formed behind the raft. Fluvial downcutting of the present Red River floodplain did not reach Caddo Lake but completely drained Soda Lake (Figure 9b) After draining Soda Lake, the channel of Twelvemiie Bayou began degrading headward. Ridder (1914) reported approximately a 14-ft (4.27-m) maximum falls on Twelvemile Bayou. The rate of headward erosion along Twelvemile Bayou was estimated at approximately 1,400 to 2,000 ft (426.73 to 609.61 m) per year based on data reported by Oliver (1908), Ridder (1914), and Leverett (1913). Leverett (1913) estimated that by




Area covered in 1838 and 1839

**Figure 9. Location and limits of Soda Lake (Veatch 1906) (Continued)**

the middle 1930's the falls would have advanced to the present location of Caddo Dam. The Corps built Caddo Dam in 1914 to prevent complete draining of Caddo Lake. A control structure and weir were later added in 1974.




b. Area covered in 1901

**Figure 9. (Concluded)**

## Origin of Caddo and Soda Lakes

Origins for Caddo and Soda Lakes are important questions that need to be addressed by this study, particularly as they affect or impact the distribution of cultural components. Debate on the specific origins for these lakes has occurred since the early 1900's (Veatch 1906, Kidder 1914, Leverett 1913, Janes 1914, Fisk 1940, Russ 1975, and Bagur 1992a and 1992b).

A seismic origin has been attributed to the formation of these lakes by Indian legend. However, there is no geomorphic evidence in the form of active faults or recorded historic earthquake activity for this part of the United States. Borings drilled as part of the foundation for Caddo Dam reveals no stratigraphic or sedimentological evidence of earthquake induced sand boils (USACE 1893). If there were a seismic source associated with these lakes, then evidence in the historical seismicity, present day tectonism, or geomorphic record would be present. No such evidence exists.

The New Madrid area is the location for the hugest historic earthquakes that have occurred in North America. These earthquakes occurred during the winters of 1811 and 1812. Isoseissmal data (Stearns and Wilson 1972) interpreted for this earthquake indicate the source area is too far distant from the study area to cause damage of the type necessary to produce lakes by vertical crustal movements. Origins for these lakes can be explained by natural fluvial processes.

Fisk (1940) proposed that valley margin lakes may have formed from "natural levee damming" by the main course as it migrated against the valley wall and intersected the valley mouths of the tributary streams. The process of natural levee growth would then build a dam across the tributary course and block access to the drainage. For Caddo Lake to form by this mechanism, it would require the Red River to occupy the Black Bayou course along the western valley wall and then to build a sediment dam in Willow Pass. Black Bayou is considered to be one of the earliest meander belts of the Red River (Saucier and Snead 1989). Assuming Black Bayou did formCaddo Lake, then the lake would have formed 4 to 5 thousand years ago. Geomorphic evidence, historic accounts, and the available archaeological data do not support the present lake complex as being this old.

Veatch (1906) argues the origin for the lakes must include the raft as the mechanism which dams the river, rather than strictly by natural sedimentation and base level changes. Perhaps the best evidence of a raft origin for the lakes is demonstrated by the events following removal of the raft. Removal resulted in valley-wide degradation of the Red River's floodplain, draining of Soda Lake, and caused down cutting of a new channel along Twelvemile Bayou to a lower base level. Leverett (1913) estimated that if Caddo Dam had not been built, Caddo Lake would have been drained by the 1930's.

Ultimately, the origin for the lakes is due, in part, to changes in base level between the Mississippi and Red Rivers because of shifting meander belts and climatic changes. Geomorphic evidence (i.e. lacustrine delta development in the Caddo Lake headwaters) and historic data evaluated during this study suggest that the present lakes are relatively young (less than 500 years before the present).

A more accurate age date is not possible with the available data. A more precise determination of the lake age would require numerous borings from beneath Caddo Lake and the former lake floor of Soda Lake to obtain additional stratigraphic and radiocarbon data. Archaeological data in the next section of this report provide additional evidence for the age of the lake complex based on the distribution of cultural components.

Caddo Lake represents a shallow, 3- to 5-mile-wide (4.83- to 8.05-km), drainage basin lake with a narrow valley at its confluence to the Red River. The entrance into Caddo Lake from Twelvemile Bayou is a natural setting for the location of Caddo Dam, since the valley is so narrow at this location. Prehistoric formation of Caddo Lake would have flooded the existing floodplain of Big Cypress Bayou. This former floodplain would have contained a welldefined main channel, abandoned courses and channels, and associated environments of deposition. The available historic and prehistoric data examined during this study suggests that existing archaeological sites would have been impacted by the lake formation, if there were any present.