# **Geoarchaeology and the Cross Timbers**

Compiled and edited by David J. Cranford, Elsbeth L. Dowd, and Don G. Wyckoff

with contributions by Nicholas H. Beale, Leland C. Bement, Abbie L. Bollans, James W. Clanahan, David J. Cranford, Linda S. Cummings, Elsbeth L. Dowd, Jason Eads, Stance Hurst, Thomas A. Jennings, Mike McKay, R.A. Varney, and Don G. Wyckoff





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#### Dedicated to

### Brian J. Carter

This memoir recognizes Dr. Brian J. Carter, soils scientist and geomorphologist at Oklahoma State University, Stillwater, Oklahoma. For over 25 years Brian has spent much of his research time studying how Oklahoma landscapes have changed through the millennia. His initial research involved locating and dating volcanic ash deposits throughout Oklahoma and adjacent states. His findings allowed him and his colleagues to develop reasonable estimates on erosion, and thus landscape change, over the Southern Plains during several million years.

His first involvement with Oklahoma archaeologists was in 1986 when he assisted Don Wyckoff in studying the geology and overlying soils at the Hajny mammoth site in Dewey County. Then in 1989, he was one of the principal investigators at the Burnham site in Woods County, and he participated in all the major field work undertaken there in 1991 and 1992. During this period, he also helped with Oklahoma Anthropological Society field schools in Sequoyah County directed by Lois Albert of the Oklahoma Archaeological Survey. By the early 1990s, Brian was assisting Lee Bement and Society field work at the Certain site in Beckham County and the Cooper site in Harper County. Most recently he has been a valued colleague during Lee's investigations at Jake's Bluff in Harper County and the Bull Creek studies in Beaver County as well as Don Wyckoff and Nick Czaplewski's study at Powell Farm in Canadian County. The above photo shows Brian recording the complex sediment and soil profiles in one of the backhoe pits dug at Powell Farm in June of 2007.

Less well known is Brian's work with Dr. Jim Theler (University of Wisconsin-La Crosse) and Don Wyckoff in documenting the distributions of modern land snail species. Brian's work with Jim and Don at Hajny and Burnham revealed the need for more comprehensive information about where species of land snails live today, in particular the kinds of vegetation niches, soils, and climate where particular species occur. Consequently, with a 1995 grant from the National Geographic Society, Brian, Jim and Don collected live land snails from upland settings from the Flint Hills of Oklahoma to the Sangre de Cristo Mountains in northern New Mexico. Between 1997 and 2005, Brian, Jim, and Don completed collecting surveys from Oklahoma to the Canadian border, from northern Oklahoma into the Ozark Plateau of northeastern Oklahoma, and from northern Oklahoma into the Hill Country of north-central Texas. Through all of this field work, most of which was done with private funds, Brian was responsible for recording information on the plants and soils where snails were collected. His correlation of this information with modern climatic records and species distributions will be a major





Brian Carter visiting with Lawrence LeVick at the Winters site in Jackson County.

Two views of Brian Carter at the Howard Gulley site in Greer County. Top, looking at cut-and-fill profile near an early Holocene bison kill. Bottom, with Stance Hurst inspecting dune deposits upslope from the bison kill.

contribution to the book being prepared on all the findings.

Throughout his work with the Oklahoma Archaeological Survey and with Oklahoma Anthropological Society field schools Brian has maintained rigorous standards of recording, a great willingness to share the information he was gathering, and a wonderful sense of humor. Over the years he has organized Friends of the Pleistocene field trips in Oklahoma and has always striven to get individuals interested in what soils have to tell us about the past. The students contributing chapters to this volume greatly benefited



Alluvial geologist Bob Brakenridge and Brian Carter at one of the complex sediment profiles exposed during 1989 excavations at the Burnham site in Woods County.

from Brian's allowing them to visit and record diverse soil profiles on his acreage north of Perkins. In 2005, these OU students hosted Brian's soils students to a lunch in Norman where both groups shared presentations of their research. The OSU-OU rivalry that is so prevalent in sports has never hindered Brian's interest and concern that students, no matter what school, profession, or avocation, learn to ask questions of soils and find answers by studying them properly. Knowing that all who have worked with Brian have benefitted from his curiosity and interest in the past, we believe it most appropriate that this volume be dedicated to him.

### Chapter 1 Geoarchaeology along the Cross Timbers

#### David J. Cranford and Don G. Wyckoff

"A procession of Buffaloes, moving along up the profile of one of those distant hills, formed a characteristic object in the savage scene. To the left, the eye stretched beyond this rugged wilderness of hills, and ravines, and ragged forests, to a prairie about ten miles off...Unluckily, our route did not lie in that direction; we still had to traverse many a weary mile of the Cross Timbers." Washington Irving, 1832 (as quoted by Foreman 1947:25).

#### Introduction

Numerous early explorers and travelers fashioned poetic passages describing the hardships they faced while negotiating the rugged patches of scrub oak forests between the eastern woodlands and the Great Plains. The Cross Timbers, as they became known (Foreman 1947), served as a natural obstacle for people making their way to the West. The lasting impression that many expressed about this stretch of wilderness was its hostile and uninhabitable nature. This sentiment persisted until roads and highways of the 19th and 20th centuries eventually conquered the unyielding woods.

We now know that people in the past indeed inhabited the vast stretches of post and blackjack oak. Archaeological studies have shown that there is a long history of human occupation within and around the Cross Timbers (Brooks 1987; Brooks et al. 1985; Drass 1997; Kawecki and Wyckoff 1984; Wyckoff and Shockey 1994; Wyckoff and Taylor 1971). These densely forested, upland settings supported a wide variety of wild game, plants, springs, and some knappable stone that attracted Native American groups. This monograph serves to increase our knowledge of Cross Timbers prehistory through geoarchaeological investigations at several locations along the Cross Timbers in Oklahoma. Geoarchaeology, the application of concepts and methods of the geosciences to archaeological research (Waters 1992:3), provides important insights into site formation, visibility, and context as well as environmental and climatic data.

#### **Defining the Cross Timbers**

Spreading from southeastern Kansas through central Oklahoma and deep down into Texas occurs a biotic region known as the Osage Savannah (Blair and Hubbell 1938). Actually it is an ecotone, a biotic transition zone, between the eastern woodlands found in the uplands of the Ozark Plateau and Ouachita Mountains to the varied grasslands of the Southern Plains. Before historic farming the Osage Savannah was characterized by tall grass prairies surrounded by scrubby oak dominant woodlands (Figure 1.1). Where grasslands or woodlands occur is mainly controlled by differences in soil texture and chemistry (those derived from shale bedrock and those from sandstone), slope, aspect, and the consequent precipitation/evaporation effects of these interrelated physiographic factors (Blair and Hubbell 1938). The region historically known as the Cross Timbers is a segment of the Osage Savannah. With two north-south lobes (Figure 1.2), the historic Cross Timbers consisted of dense scrub oak, primarily blackjack (*Quercus marilandica*) and post oak (*Q. stellata*), stands that thrived on sandy uplands along the southwestern margin of the Osage Savannah. Because of the dense, interlaced growth of blackjack and post oak along this margin, the Cross Timbers were the bane of horse-riding Plains tribes and 19th century Anglo-American adventurers, soldiers, and traders (Gregg 1844:178-205; Irving in McDermott 1944; Latrobe in Spaulding 1968; Marcy in Hollon 1955; Marcy and Mc-Millan in G. Foreman 1937).

The exact geographic extent of the Cross Timbers has not been undertaken by modern ecologists, largely because historic settlement, farming, and oil field development between the 1880s and the 1950s disturbed, destroyed, or greatly modified substantial parts of the woodlands margin. Historian Carolyn Thomas Foreman (1947) has compiled a classic perspective of the Cross Timbers as viewed by 19th century military officers and civilians. She provides one of the best reconstructions (Figure 1.2) of the Cross Timbers distribution.

Generally speaking, the Cross Timbers originally comprised some 5,000,000 acres and extended over four hundred miles though eastern and central Texas as well as central Oklahoma (Foreman 1947:6). Beginning in central Texas, two large lobes that make up the majority of the Cross Timbers merge near the border of Oklahoma and Texas. Dense forests continue north into central Oklahoma. The last vestiges of the Cross Timbers terminate just south of the Cimarron River. Wyckoff (1984) previously provided a detailed discussion of the environmental conditions and climate that helped generate and maintain the Cross Timbers. However, it should be emphasized that this distinct region most likely formed sometime in the past 3000 years. Based on the pollen records from Ferndale Bog, Atoka County, Oklahoma, at the west edge of the Ouachita Mountains, it is clear that grasslands prevailed over those rugged uplands and the rolling landscape of what is now



Figure 1.1. Biotic regions of Oklahoma originally derived from Blair and Hubbell (1938:Fig.1) and Duck and Fletcher's (1943) game map of Oklahoma. The Osage Savannah biotic region is the pink and purple region that dominates the central part of Oklahoma. The Cross Timbers portion is composed of the southwest purple distributions. Based on a map made available by the Oklahoma Biological Survey of the University of Oklahoma.

the Osage Savannah during early and middle Holocene times (Albert 1981; Holloway 1994).

#### Previous Archaeological Studies in the Cross Timbers

As Brooks and Drass (1984:21) note, archaeological research in the Cross Timbers has a relatively long history, beginning as early as the 1930's, but it has been equally irregular and often narrow in scope. Much of the work documenting archaeological resources was conducted in the Washita River valley where it cuts across the Cross Timbers. Other surveys, namely those of Lake Arcadia (Hartley 1976), Lake of the Arbuckles (Barr 1965, 1966), and Lake Thunderbird (Williams 1955), identified numerous sites but few had much material or contexts deemed worthy of study. This observation led Hartley (1976) to question whether there was actually a significant prehistory represented in the region.

In 1984, Kawecki and Wyckoff produced a volume that identified the importance of the Cross Timbers both historically and prehistorically. Besides defining the geographic and ecological character of this prominent ecotone, that study set out to emphasize its archaeological significance. The seven sites reported in that monograph represented different kinds of prehistoric occupations in several diverse settings (Figure 1.3). Most of the sites were located in major river valleys or along their important tributaries. The lack of archaeological deposits at or near the surface had been interpreted by some as an indication that the Cross Timbers were generally avoided during prehistoric times. One outcome of the *Contributions to Cross Timbers Prehistory* volume (Kawecki and Wyckoff 1984) was the recognition that diverse taphonomic processes contributed to the burial of archaeological sites and that a long record of human presence is likely but deeply buried.

#### The Current Study

This monograph primarily results from a University of Oklahoma graduate course in geoarchaeology. Offered in the fall of 2005, the class was designed to teach students the fundamentals of geoarchaeological research and expose them to various settings where different soils and erosional processes might affect the ability to study prehistory. One of the major emphases of this class was the examination of settings for clues to where buried archaeological deposits might be found. Many of the locations described in this study suggest that throughout the northern extent of the Cross Timbers the archaeological record may be deeply buried and out of reach of conventional surveying techniques. Such a conclusion can also be drawn from the contribution of Stance Hurst and Lee Bement and their colleagues. This contribution is found in Chapter 7, and, while presenting pedological and palynological results of trenching at archaeological site 34GR4 in southwestern Oklahoma, these findings are also relevant to our knowl-



Figure 1.2. The Cross Timbers as drawn by Albert H. Hanson for Carolyn Thomas Foreman (1947). The distribution is based on the accounts of Anglo-American explorers, soldiers, adventurers, and traders compiled and discussed by Foreman.

edge about past environments near the Cross Timbers. In fact, a noticeable part of the vegetation found among this westernmost reaches of the Wichita Mountains are diminutive growths of the scrub oak woodlands common to the Cross Timbers.

Kawecki and Wyckoff (1984) established the need for continued research in the Cross Timbers region. As a response to their call, this study presents geoarchaeological investigations from six localities. The locations visited as part of the class had a more north-south distribution than the sites reported in 1984 (Figure 1.4), which were mostly in central Oklahoma . This wider distribution of study localities allows for a broader regional perspective of the Cross Timbers.

The monograph is generally organized chronologically, beginning with the location containing the oldest soil profiles. The exception to this theme is Chapters 5 and 6, the latter yielding evidence of an ice-age pond deposit. These two chapters are significant in that they describe soils not located in modern alluvial settings. Instead the chapters deal with upland hillside settings. As a result, they provide an interesting parting caveat to diversity within and near the Cross Timbers.

Chapter 2 provides a discussion of two buried soils located along Mustang Creek, just west of Oklahoma City. These soils suggest that climatic conditions sometimes were favorable for soil formation during the Altithermal, a time (7500 to 4000 years ago) usually believed to be too hot and dry to sustain substantial plant growth and thus extended human occupation of the Southern and Central Plains. Archaeological evidence of the Calf Creek culture identified not far from Mustang Creek supports the idea that the climate in the Cross Timbers during the Middle Holocene was less severe than other locations (Morgan 1994). Soil descriptions made in 1986 and recent core samples provide an important window into this dynamic period.

Pumpkin Creek, located in Love County, Oklahoma, is better known as the namesake for a nearby early Archaic site (Wyckoff and Taylor 1971), but Chapter 3 investigates the complex alluvial history revealed in the nearby creek's exposed cut-banks. With multiple buried soils, the dominant and most obvious feature at the Pumpkin Creek locale

3



Figure 1.3. Locations of the archaeological sites presented in Kawecki and Wyckoff (1984): 1. Manwell (34OK105); 2. Bethel (34PT56); 3. Austin Sandpit (34GV139); 4. Ayers (34MA126); 5. Barkhiemer (34SM29); 6. Hunsaker ((34PT72); and 7. Rose (34PT34).

is a dark, over-thickened paleosol. Two dates from one of the profiles indicate that the organic rich soil was formed sometime between 3100 B.P. to 1200 B.P. In a separate profile, a large cut-and-fill episode is evident and testifies to the active pedogenic and alluvial processes at work in this drainage.

A similar location to the north in Cleveland County, Oklahoma, is the focus of Chapter 4. The Pond Creek locality offers a glimpse at four buried soils, the oldest of which is a dark over-thickened paleosol somewhat analogous to the one at Pumpkin Creek. Radiocarbon dates and particle-size analysis of Pond Creek's soil profile suggests several climatic fluctuations affected soil formation in the area over the past 3000 years. In fact, a gleyed deposit underlying the soil horizons testifies to a much wetter environment than is evident today. Pond Creek makes an significant contribution to the ongoing dialogue concerning environmental reconstruction of the Cross Timbers region and that region's potential importance to prehistoric peoples.

As mentioned above, Chapters 5 and 6 do not follow the



Figure 1.4. The locations of soil profile exposures studied in this volume: 1. Carter Farm, Payne County; 2. Powell Farm, Canadian County; 3. Mustang Creek, Canadian County; 4. Menzie Farm, Cleveland County; 5. Pond Creek, Cleveland County; 6. Pumpkin Creek, Love County; and 7, archaeological site 34GR4, Greer County.

same chronological flow of the other sections. Rather, both chapters focus on non-alluvial, upland settings. Chapter 5 is meant to serve as an introduction for the subsequent contribution on Powell Farm and discusses the differences and significance of soils that form in these upland settings. Cranford (Chapter 5) briefly mentions several of the study locations visited as part of the geoarchaeology course but which are not formally addressed in the other studies.

The case study presented in Chapter 6 is unique and has some interesting archaeological implications. A Pleistocene pond deposit discovered beside a man-made farm pond in 1949 revealed the remains of numerous species of now extinct mega-fauna. As these remains were being removed by then University of Oklahoma paleontologist Dr. J. Willis Stovall, a small flint biface was discovered near the fossils. The geoarchaeological study at Powell Farm documents this ice-age deposit and an immediately overlying paleosol. Carbon 14 dates from the pond deposit confirm its antiquity (21,000 BP) and establish the age of the buried soil at around 4,300 years BP. In 2007, Oklahoma Anthropological Society volunteers assisted Don Wyckoff, Brian Carter, and Nick Czaplewski in a month-long excavation at Powell Farm to see if any cultural material in fact originates in this or the underlying Pleistocene soils or sediments. A future publication will detail these field findings.

The geoarchaeological research undertaken at archaeological site 34GR4 is presented in Chapter 7. This work entailed both field profiles of backhoe trenches and pollen recovery from soil horizons exposed in these trenches. The location is part of the alluvial terrace system found along the west side of the North Fork of Red River. This terrace has been extensively eroded for more than 40 years by wave action on Lake Altus. This erosion has exposed many prehistoric artifacts and habitation features once buried in the terrace deposits. So the findings presented herein provide our first insight into the ages of the sediments and soils containing nearly 10,000 years of human occupation.

The final chapter summarizes all of the field reports presented herein and incorporates the findings with those from earlier geoarchaeological and pedological studies scattered along and near the Cross Timbers. From these findings we are able to discern at least nine intervals since the last ice age when climatic conditions were favorable enough to support considerable vegetation and to stabilize parts of central and southwestern Oklahoma. Some of these intervals correlate with notable archaeological finds made in this region.

#### Notes about this Study

Readers should be reminded that the following case studies are the products of a graduate course in geoarchaeology. The contributors are not trained soil scientists or geologists and should not be expected to be such. Most are in fact archaeologists. The projects for which this monograph is focused were intended to exercise practical field recording techniques of soils and apply the data to anthropological questions about Cross Timbers prehistory.

Another note is worth mentioning. It came to the attention of the editors that the soil taxonomy used in this study may not be comparable to the system employed by many geologists. This discrepancy is potentially confusing to those who are more familiar with the latter. The main difference is in the way the pedostratigraphic layers are numbered. Many geologists recognize numbers found to the left of the horizon designation as an indication of a change in parent material. This distinction is not used in the following case studies. Rather, since identifying changes in parent material sometimes requires more precise procedures than field observations allow, all soil descriptions were numbered on the left hand side for simplicity.

It should also be noted that the radiocarbon assays cited herein are as they were reported from their respective radiocarbon laboratories. It is a conscience decision on our part to present the data unmodified, without the use of the various calibrations and corrections now available. These corrections are important tools in the interpretation of radiocarbon data, but in the interest of researchers who may choose to use our data in the future when today's calibrations are no longer accurate, we have decided to report the original measured radiocarbon ages.

#### Acknowledgments

We wish to thank the University of Arizona Radiocarbon Lab, the Institute of Geological and Nuclear Sciences Limited in New Zealand, and Beta Analytic Inc. for their timely processing and interest in the samples we submitted. Also, this work could not have happened without the gracious cooperation of the many landowners. We are indebted to each of you.

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## Chapter 2 Windows to Central Oklahoma's Mid-Holocene: Geoarchaeological Investigations at Mustang Creek, Canadian County

Nicholas H. Beale and Mike McKay

#### Introduction

Archaeological research on the Southern Plains is a continuous effort to understand the dynamics of bioclimatic changes and human adaptation to those changes. In 1986, studies of the Mustang Creek drainage in central Oklahoma (Figure 2.1) revealed that our understanding of the environmental conditions of the Early and Middle Holocene, approximately 8000-3000 B.P., was insufficient, perhaps even incorrect. Currently, Early and Middle Holocene climate is regarded as having been too hot and dry to support a verdant landscape (Baugh 1986; Dillehay 1974; Flynn 1982), and, because of this, human activity is thought to have been extremely limited across much of the Southern Plains (Antevs 1955; Meltzer and Collins 1987).



Figure 2.1. Location of the Mustang Creek study locality relative to the historic Cross Timbers. Adapted from A. H. Hanson's map for C.T. Foreman (1947).

In contrast, samples of the buried soils along Mustang Creek that were subjected to radiocarbon dating during the 1986 survey indicate that the hot, dry Middle Holocene consisted of mesic intervals with long enough climatic stability and effective moisture to sustain abundant plant growth, producing conditions that would have supported human occupants in the region. Because of these unique results, we decided that Mustang Creek should be revisited for further sampling and geoarchaeological analysis. Core samples acquired during the 2005-2006 study again found two buried soils. However, radiometric analysis on the deepest of these soils returned a date from the Early Holocene, a period sometimes regarded as extremely xeric and inhospitable. Our 2005-2006 study is an attempt to refine understanding of Early and Middle Holocene prehistoric environments where today's Southern Plains meet the Cross Timbers.

#### **Area Description**

Mustang Creek is situated in the southeastern corner of Canadian County in central Oklahoma. It is a fifth order stream system contributing to the eastward flowing North Canadian River. The study area (Figure 2.2) is located



Figure 2.2. Location of the Mustang Creek study location and the cores taken in 2005, Canadian County, Oklahoma.

three miles west of the creek's confluence with the North Canadian River. Analysis was performed on the northern terrace of a north to eastward bend of the creek. At this point, Mustang Creek is presently confined within a deeply incised (2-3 m) channel.

#### **Previous Research**

Previous archaeology in the study area was undertaken in 1986 by the Oklahoma Archaeological Survey under the direction of Charles "Pat" Neel. At that time, Neel was conducting a pedestrian cultural resource survey of the Mustang Creek watershed funded through a sub-grant agreement with the State Historic Preservation Office, Oklahoma Historical Society, using matching funds from the Department of the Interior, National Park Service's Historic Preservation fund. During Neel's survey, two stacked paleosols were discovered in profiles along the northern terrace of Mustang Creek (Figure 2.3). The deeper of the two dark soils yielded a radiocarbon date of 5520 B.P. + 250 uncalibrated years (Beta-16986), suggesting that a mild, moist climate existed on the Southern Plains during the Middle Holocene (ca. 5,000-4,000 B.P.), part of the period referred to archaeologically as the Archaic. In fact, climatic studies conducted across much of the southern and central Plains indicate that the stable conditions of the Middle Holocene followed more xeric Early Holocene (ca. 10,000-7,500 B.P.) conditions known as the Altithermal. These xeric conditions are thought to have resulted in an eroded landscape that supported few plants and animals (Dillehay 1974; Flynn 1982) and, in all likeliness, few humans (Antevs 1955). Yet there are indications that some people were able to adapt to the hot, dry Early Holocene period and continued to survive on the Southern Plains until the climatic amelioration of the Middle Holocene and into the Late Holocene (ca. 4,000-2,000 B.P.).

It is likely that zonal climate changes of the Early Holocene reduced vegetative cover, which in turn reduced soil anchorage and porosity, predisposing the landscape to heavy erosion, particularly in upland settings. Sediments and the cultural material they possessed were then flushed from the smaller, higher gradient streams to be deposited downstream within alluvial fans and along the broader valley floors in the lower portions of watersheds during the Early Holocene and immediately following the Middle Holocene. Net sediment transport during the Altithermal resulted in the destruction of intact cultural features and any evidence of prehistoric human occupation along lower order stream settings. Additionally, Mid-Holocene (7,500-4,000 B.P.) sedimentation reduced the visibility of cultural materials in higher order drainages due to downstream deposition of alluvial sediments.

Cultural material has yet to be noted in association with the buried soils along Mustang Creek. However, a review of site records for the Mustang Creek basin indicates that the watershed was occupied from the Late Archaic (3,5002000 B.P.) into the Historic period. Nineteen sites are located within the drainage basin. By site character, 13 sites were historic farmsteads (2 being multi-component sites possessing both historic and prehistoric material), 1 site is a historic bridge, and the final 4 are prehistoric sites that are unassigned as to cultural tradition. Few of the prehistoric sites yielded artifacts with any temporally diagnostic characteristics. However, 34CN13 included a cache of 38 flake knives, 30 of which were manufactured from Boone chert which has its bedrock sources in northeastern Oklahoma.

Another of the unassigned prehistoric sites (34CN43) included two dart points, the first described as a "Castroville" point knapped from locally obtainable Ogallala quartzite. The second point was a "Gary" style point made from Neva chert, a knappable stone found in north-central Oklahoma (Everett 1977). The Gary point style is broadly distributed across the eastern United States and is particularly common in Oklahoma. Gary points suggest a Late Archaic (3,500-2000 B.P.) temporal affiliation for the site, though this style is known to appear into the Historic, as late as A.D. 1600 (Bell 1958:28-29). Likewise, the Castroville point style is diagnostic of Late Archaic traditions (4,000-1,000 B.P.). Although noted in Oklahoma, the slightly expanding stemmed, corner-notched Castroville points are more commonly found throughout central Texas, appearing less frequently north of the Edwards Plateau. They have also been associated with bison kills in the Texas Panhandle (Bell 1960; Turner and Hester 1985).

#### **Geomorphology and Environment**

The study locality is located on the Southern Plains in an area known as the Central Red Beds or Red Rolling Plains, a geographic region underlain by the southwestward dipping Flowerpot Shale (Fenneman 1931, 1938; Miser 1954; Mogg et al. 1960; Morris et al. 1976). The Flowerpot Shale is a 150-200 feet thick Middle Permian age (290-248 MYA) sedimentary rock of the El Reno Group that includes the Chickasha Formation, an erosion-resistant conglomerate of siltstone, sandstone, and shale, as well as the Duncan Sandstone which is composed of two layers of cross-bedded sandstone sandwiching within it a layer of shale (Armstrong 1958).

Mustang Creek is a North Canadian River tributary and is part of a river system that began forming during the Tertiary period (66-2.2 MYA). Mustang Creek is presently down-cutting into the underlying Permian bedrock (Fay 1959). The creek is a product of a large, dendritic system. This system drains 19,300 acres (30.16 square miles or 23,081 hectares) into a narrowly confined main trunk that maintains an annual discharge flowing eastward into the North Canadian River (United States Geological Survey 1966, 1986). By straight line measurement, Mustang Creek is 6.5 miles long from headwater to river confluence, crossing flat terrain that drops an average of 170 feet (52 meters) to produce a flow gradient of 0.5%. The flat primary stream terrace of Mustang Creek is composed of Quaternary alluvium deposited as inter-fingering lentils of silt, sand, clay, and gravels, all of which overlies the Flowerpot Shale. The terrace alluvium contains a significant aquifer and the volume of discharge, though flowing on a nominal gradient, has presently managed to incise the modern floodplain an average of three meters (Mogg et al. 1960). This down-cutting erosion of the Quaternary alluvium may be caused by a dropping water table as subsoil water reserves are increasingly tapped for use by the associated metropolitan area. As water is receding from immediately below surface, surface soils become less consolidated and more prone to downstream erosion.

Floodplain alluvium of Mustang Creek supports mollisol and entisol associations of the Port-Dale-Yahola-Gaddy-Gracemore-McClain-Reinach series (Carter 1996; Mogg et al. 1960). In the study area, the frequently flooded zone directly adjacent to the Mustang Creek channel is composed of sediments that have pedogenically transformed into a melanized Port silt loam soil under the cover of native grass pastures. The soil away from the terrace edge, where coring was undertaken, is Reinach very fine sandy loam. Like Port soil, Reinach soil is a nearly-level, dark soil that formed under grass pastures. Unlike Port soil, however, Reinach soils are not prone to flooding (Fisher and Swafford 1976).

The study area experiences a moist, subhumid climate (humidity levels ranging between 40% and 90%) with average summer temperatures of 80° F (26.7° C), average winter lows of 38° F (3.3° C), and prevailing southwesterly winds, all combining to produce an average growing season of 209 days. Temperature varies between extremes of 115° F (46.1° C) in the summer to -15° F (-26.1° C) in the winter. Average soil temperature beneath sod (10 cm or 4" thick) equals 59° F (15° C). When soils are bare, temperatures average 62° F (16.7°C). Yearly precipitation for southeastern Canadian County averages 39 inches with much of the rainfall delivered during the early spring in the form of severe thunderstorms. Every winter produces at least one inch of snowfall; however, one out of every five years produces as much as 10 inches of frozen precipitation (Morris et al. 1976; Oklahoma Climatalogical Survey 2002).

The effective moisture and loamy soils support a mosaic of low density riparian corridors along with mixed grass settings on the surrounding uplands (Morris et al. 1976). The mixed grass setting combines both the warm-season grasses of the western plains with the warm- and cool-season grasses of the eastern prairies. These bunch and sodforming grasses, along with numerous forbs, produce root masses that can, at times, extend more than five feet into supporting soils (Bruner 1931; United States Geological Survey 2000). Living within this mix of grassland and forest are numerous invertebrates, amphibians, reptiles, birds, rodents and mammals of all sizes. Important fauna accessible to early human occupants of the region were the large fur bearers such as the beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*) raccoon (*Procyon lotor*), black and grizzly bears (*Ursus americanus* and *U. arctos*), coyote (*Canis latrans*), fox (*Urocyon* sp.), bobcat (*Lynx rufus*), and badger (*Taxadea taxus*), as well as artiodactyls like white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), antelope (*Antelopcapra americana*), and most importantly both prehistorically and historically, bison (*Bison bison*; Jones et al. 1985; Risser 1974).

#### Methodology

The methodology used by Pat Neel and Don Wyckoff in 1986 differs from the methods used to obtain information at Mustang Creek during the fall of 2005. The investigation in 1986 used an exposed cutbank of a gulley to Mustang Creek to view three profiles. Each of these profiles were recorded using standard techniques and the classification system similar to those found in the Field Book for Describing and Sampling Soils Version 2.0 (Schoeneberger et al. 2002). Once the profiles were cleaned and fresh soil faces were observable, the profile was picked so that the natural structure of the soils would be apparent.

In contrast, the 2005 investigation of Mustang Creek used a Bull probe attached to a pickup truck rather than the natural cut-bank that was used in 1986 (Figures 2.4 and 2.5). Coring was necessary due to the modern construction trash that had been dumped into the previously studied draw. The rubbish caused a safety hazard for the crew and was too bulky and heavy to move, so core samples were taken in lieu of profile views. Both core samples penetrated to the modern water table. After the cores were retrieved, several different variables were used to ascertain the composition of the soils: color, texture, structure, consistence, bioturbation, boundary, thickness, and effervescence. These variables were identified based on standard field judging techniques defined by the Munsell Soils Color Chart and the Field Book for Describing and Sampling Soils Version 2.0 (Schoeneberger et al. 2002).

**Radiometric Dating.** The 1986 investigations documented two buried soils which were sampled in order to get radiometric dates. Three samples were taken: one from Profile 2 and two from Profile 3. Each of the samples was taken from the top ten centimeters of the buried horizons. Further investigation at Mustang Creek performed in 2005 also revealed two buried soils. These, too, were sampled by taking the top 10 centimeters of the soil except for Core 2, Horizon V, where both the top and bottom 10 cm were sampled. All of the samples were placed in 2 mil plastic bags and sent to Beta Analytic Incorporated. The 1986 samples were subjected to standard radiocarbon techniques,



Figure 2.3. View east of gully cutbank profile on north side of Mustang Creek and south of Mustang North Middle School (Figure 2.2). This profile (#2) was recorded in 1986 by Pat Neel and Don Wyckoff. Photo by Don Wyckoff.



Figure 2.4. Profile 2 recorded in 1986 by Pat Neel and Don Wyckoff. View east.

Figure 2.5. The abrupt upper boundary of the buried soil (VII) visible at base of profile in Figure 2.4. View east.





Table 2.1.	Mustang Creek	Profile #2 1	recorded in <sup>•</sup>	1986 bv	Pat Neel and	l Don W	vckoff.
	Tradening Creek		ceoraca m.	1,00 0	A MC I YOUR WING		y 0110111

Horizon Designations	Depth and Horizon Descriptions
A- I	0 to 56.0cm, 5YR3/3 (dark reddish brown) silt; moderate medium to fine granular structure; very friable; slightly sticky, slightly plastic; many very fine and fine roots; gradual wavy boundary; 56cm thick.
B <sub>1k</sub> - 11	56.0 to 136.0cm, 2.5YR3/6 (dark red) silt; moderate medium prismatic structure; very friable; slightly sticky, slightly plastic; common fine roots; gradual smooth boundary; 80cm thick.
2B <sub>tk</sub> - III	136.0 to 191.0cm, 2.5YR4/6 (red) silt; weak medium prismatic structure; very friable; slightly sticky, non-plastic; many fine roots; abrupt smooth boundary; 55cm thick.
IV	191.0cm to 194.0cm, 3cm thick.
3B-V	194.0 to 200.0cm, 7.5YR4/4 (brown) silt; weak thin platy structure; very friable; non- sticky, non-plastic; few very fine roots; abrupt smooth boundary; 6 cm thick.
C- VI	200.0 to 265.0cm, 7.5YR4/6 (strong brown) loamy fine sand; massive structure; very friable; non-sticky, non-plastic; few very fine roots; abrupt smooth boundary; 65 cm thick.
A <sub>b</sub> -VII*	<ul> <li>265.0 to 350.0cm, 7.5YR3/2 (dark brown) silt; weak fine granular structure; very friable; slightly sticky, slightly plastic; gradual wavy boundary; 85cm thick.</li> <li>*A sample of this horizon was radiocarbon dated at 5520 ± 230 B.P. (Beta-16986)</li> </ul>
2A <sub>b</sub> - VIII	350.0 to 426.0cm, 7.5YR3/4 (dark brown) silt; weak fine granular structure; very friable; slightly sticky, slightly plastic; 76cm thick.



Figure 2.7. View southeast of buried soil on south bank of Mustang Creek one and one-half miles upstream from Mustang North Middle School as visible in 1986. The stadia rod is at the location of Profile 3 recorded by Pat Neel and Don Wyckoff. Photo by Don Wyckoff.



Figure 2.8. View south of Profile 3 as exposed and recorded by Pat Neel and Don Wyckoff in 1986. Note that three buried soils are represented at this location. Photo by Don Wyckoff.

but the 2005 samples underwent AMS dating. (Note: All radiocarbon ages presented in this study are reported as uncalibrated ages.)

#### Results

The following results are from Don Wyckoff's field notes from the 1986 studies and the 2005 geoarchaeology class's field notes for the later investigations at Mustang Creek. The results include the information gathered from two profiles (Profile 2 and Profile 3) exposed in 1986 and two cores (Core 1 and Core 2) recovered in 2005.

**Profile 2.** Soil Profile 2 consists of eight observed horizons (Figures 2.3 to 2.6). The characteristics of the profile are idealized in Figure 2.6 and summarized in Table 2.1. Horizon I is an A horizon and represents a mollic epipedon. This A horizon overlies two argillic horizons (Horizons II and III). Following the argillic horizons is a well cemented calcic lens (Horizon IV). This lens contains both carbonate concretions and hematite grains. The calcic lens overlies Horizon V, a B horizon. The B horizon is followed by a C horizon (Horizon VI). Horizon VIII is a melanized Ab horizon that suggests a period of stability. The first 10 cm (265.0 cm to 275.0cm) of this Ab were collected and sub-



Figure 2.9. Drawing of Mustang Creek Profile #3 as recorded by Pat Neel and Don Wyckoff in 1986.

mitted for radiocarbon dating. The date from this sample is  $5520 \pm 230$  B.P. (Beta-16986). The sample contained 0.1% organic carbon in the soil.

**Profile 3.** Profile 3 is comprised of 16 observed horizons (Figures 2.7 and 2.8). The horizons are shown in Figure 2.9 and is summarized in Table 2.2. The first horizon (Horizon I) is an Ap horizon. The Ap suggests that in the past, the area was plowed. Underlying the Ap horizon is Horizon II. This horizon is an A1 and represents a mollic epipedon. The epipedon is immediately followed by a C horizon (Horizon III). Horizon IV is a melanized argillic Bt horizon. The top 10 cm (74.0 cm to 84.0 cm) were taken for radiocarbon dating. The date of this horizon is 570 ± 80 B.P. (Beta-16987) and the sample contained 0.4% organic carbon. Underlying the melanized horizon, eleven C horizons (Horizon V through Horizon XV) were identified.

The last horizon recognized in Profile 3 is a melanized Ab horizon (Horizon XVI). Furthermore, this horizon is approximately 1 m above the surface of Mustang Creek. Because this is a buried A horizon, the top 10 cm (240.0 cm to 250.0 cm) were collected for radiometric dating. The submitted sample dates to  $5400 \pm 120$  B.P. (Beta- 16988) and contained 0.2% organic carbon.

#### Findings from 2005 Coring at Mustang Creek

Figures 2.10 through 2.13 show the 2005 field work that resulted in the dated cores discussed below.

**Core 1.** Core 1 consists of eight observed horizons (Figure 2.14) and the findings are summarized in Table 3. Horizon I is a melanized A horizon, which is a mollic epipedon. This mollic epipedon overlies an argillic B horizon (Horizon II). Following the Bt horizon is a C horizon (Horizon III). Underlying Horizon III is a buried A horizon. This melanized Ab horizon represents a period of stability. Hence, a 10 cm soil sample (91.0 cm to 101.0 cm) was collected for dating purposes. The result from the AMS dating is  $5680 \pm 50$  B.P. (Beta-210182) with a 13C/12C ratio of -19.8 o/oo. The Ab overlies four argillic B horizons (Horizon II).

<b>Table 2.2.</b>	Mustang Creek Pi	ofile #3 Description as	s recorded by <b>I</b>	Pat Neel and Don
	Wyckoff in 1986.			

Horizon Designation	Depth and Horizon Description
A <sub>p</sub> -I	0.0 to 18.0cm, 5YR3/4 (dark reddish brown) loamy fine sand; weak fine granular structure; very friable; slightly sticky, non-plastic; many fine and medium roots; clear wavy boundary; 18cm thick.
A <sub>1</sub> - II	18.0 to 44.0cm, 5YR2.5/2 (dark reddish brown) loamy fine sand; weak medium granular structure; very friable; slightly sticky, non-plastic; many fine and medium roots; clear wavy boundary; 26cm thick.
C- III	44.0 to 74.0cm, 5YR4/4 (reddish brown) loamy fine sand; massive structure; very friable; non-sticky, non-plastic; few very fine and medium roots; clear wavy boundary; 30cm thick.
B <sub>tn</sub> – IV*	<ul> <li>74.0 to 105.0cm, 5YR2.5/2 (dark reddish brown) silt; weak fine columnar structure; very friable; slightly sticky, non-plastic; common very fine roots; clear smooth boundary; 31cm thick.</li> <li>*A sample of this horizon was radiocarbon dated at 570 ± 80 B.P. (Beta-16987).</li> </ul>
2C-V	105.0 to 125.0cm, 2.5YR4/6 (red) loamy fine sand; massive structure; very friable; slightly sticky, non-plastic; abrupt smooth boundary; 20cm thick.
2C <sub>2</sub> - VI	125.0 to 131.0cm, 2.5 YR4/6 (red) coarse sand; massive structure; very friable; non- sticky, non-plastic; abrupt wavy boundary; 6cm thick.
2C <sub>3</sub> - VII	131.0 to 140.0cm, 2.5 YR4/8 (red) fine sand; massive structure; very friable; non-sticky, non-plastic; abrupt wavy boundary; 9cm thick.
2C₄- VIII	140.0 to 144.0cm, 2.5 YR4/6 (red) coarse sand; massive structure; very friable; non- sticky, non-plastic; few very fine roots; abrupt wavy boundary; 4cm thick.
2C₅- IX	144.0 to 182.0cm, 2.5 YR4/6 (red) very fine sand; massive structure; very friable; non- sticky, non-plastic; abrupt wavy boundary; 38cm thick.
2C <sub>6</sub> - X	182.0 to 188.0cm, 2.5 YR3/6 (dark red) coarse sand; massive structure; very friable; slightly sticky, non-plastic; abrupt wavy boundary; 6cm thick.
2C7- XI	188.0 to 217.0cm, 2.5 YR3/6 (dark red) fine sand; massive structure; very friable; non- sticky, non-plastic; abrupt wavy boundary; 29cm thick.
2C <sub>8</sub> - XII	217.0 to 221.0cm, 2.5 YR3/6 (dark red) coarse sand; massive structure; very friable; non-sticky, non-plastic; abrupt smooth boundary; 4cm thick.
2C9- XIII	221.0 to 226.0cm, 2.5 YR4/6 (red) very fine sand; massive structure; very friable; non- sticky, non-plastic; abrupt wavy boundary; 5cm thick.
2C <sub>10</sub> - XIV	226.0 to 230.0cm, 2.5 YR3/2 (dusky red) coarse sand; massive structure; very friable; non-sticky, non-plastic; abrupt smooth boundary; 4cm thick.
2C <sub>11</sub> - XV	230.0 to 240.0cm, 2.5 YR4/6 (red) fine sand with silty clay loam; massive structure; very friable; non-sticky, non-plastic; abrupt smooth boundary; 10cm thick.
2A <sub>b</sub> -XVI*	<ul> <li>240.0 to 268.0+cm, 7.5YR3/2 (dark brown) silty clay loam; weak fine granular structure; very friable; slightly sticky, slightly plastic; very few very fine roots.</li> <li>* A sample of this horizon was radiocarbon dated at 5400 + 120 B.P. (Beta-16988).</li> </ul>



Figure 2.10. View west of 2005 Core #1 location on terrace directly north of Mustang Creek. Photo taken October 8, 2005, by Mike McKay.



Figure 2.11. View east of 2005 Core #2 location. Mustang Creek is to the right. The gully profiled in 1986 is just beyond the core location. Photo taken October 8, 2005, by Mike McKay.



Figure 2.12. Setting up the Bull probe coring rig at 2005 Core #1 location. View is to the southwest and Mustang Creek is just beyond the tree line. Photo by Don Wyckoff.



Figure 2.13. Tom Jennings and Abbie Bollans field testing texture of one of the segments of 2005 Core #1 taken beside Mustang Creek. Photo taken by Don Wyckoff.

Horizon Designation	Depth and Horizon Description
A- I	0.0 to 66.0cm, 7.5YR3/3 (dark brown) loamy sand; very friable; non-sticky, non- plastic; non-effervescent; gradual boundary; 66cm thick.
B <sub>t</sub> - II	66.0 to 96.5cm, 5YR4/4 (reddish brown) loamy sand; friable; slightly sticky, slightly plastic; non-effervescent; abrupt boundary; 30.5cm thick.
C - III	96.5 to 185.5cm, 7.5YR5/6 (strong brown) sand; very friable; non-sticky, non-plastic; non-effervescent; abrupt boundary; 89cm thick.
A <sub>b</sub> - IV*	<ul> <li>185.5 to 212.5cm, 5YR3/3 (dark reddish brown) sandy clay loam; friable; slightly sticky, slightly plastic; non-effervescent; abrupt boundary; 89cm thick.</li> <li>*A sample from this horizon was AMS dated at 5680 ± 50 B.P. (Beta-210182).</li> </ul>
2B <sub>tb1</sub> -V	212.5 to 233.5cm, 5YR4/4 (reddish brown) sandy clay loam; friable; slightly sticky, plastic; non-effervescent; abrupt boundary; 21cm thick.
2B <sub>tckb2</sub> - VI	233.5 to 257.5cm, 5YR4/6 (yellowish red) sandy clay loam; friable; slightly sticky, plastic; very slightly effervescent; clear boundary; 24cm thick.
2B <sub>tkb3</sub> -VII*	257.5 to 300.5cm, 2.5YR3/6 (dark red) sandy clay loam; friable; slightly sticky, plastic; slightly effervescent; abrupt boundary; 43cm thick.
2B <sub>tcb4</sub> - VIII	300.5 to 341.5cm, 5YR4/6 (yellowish red) loamy sand; very friable; slightly sticky, slightly plastic; non-effervescent; 41cm thick.

Table 2.3. Description of Mustang Creek Core #1 recorded October 8, 2005.

Table 2.4.	Description a	f Mustang	Creek	Core #2	recorded	October 8	, 2005.
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Horizon	Depth and Horizon Description
Designation	
A- I	0.0 to 70.0cm, 5YR3/3 (dark reddish brown) sandy loam; loose; non-sticky, non-plastic; non-effervescent; clear boundary; 70cm thick.
B <sub>tc</sub> - II	70.0 to 168.0cm, 2.5YR4/8 (red) loamy sand; very friable; slightly stick, slightly plastic; non-effervescent; clear boundary; 98cm thick.
2B <sub>tk</sub> - III	168.0 to 180.0cm, 5YR4/6 (yellowish red) sandy clay loam; very friable; sticky, plastic; slightly effervescent; abrupt boundary; 12cm thick.
C- IV	180.0 to 280.0cm, 5YR4/4 (reddish brown) loamy sand; loose; non-sticky, non-plastic; non-effervescent; gradual boundary; 100cm thick.
A <sub>b</sub> -V*	<ul> <li>280.0 to 400.0cm, 7.5YR3/2 (dark brown) silty clay; very friable; slightly stick, slightly plastic; non-effervescent; clear boundary; 120cm thick.</li> <li>*The upper 10 cm of this horizon was AMS dated at 6200 ± 50 B.P. (Beta-215951), whereas the lower 10 cm yielded an AMS date of 7380 ± 40 B.P. (Beta-210183).</li> </ul>
3B <sub>tcb</sub> - VI	400.0 to 440.0cm, 5YR4/4 (reddish brown) sandy clay; very friable; sticky, very plastic; non-effervescent; clear boundary; 40cm thick.
2A <sub>b</sub> -VII*	440.0 to 456.0+cm, 5YR4/3 (reddish brown) sandy clay loam; very friable; non-sticky, slightly plastic; non-effervescent.

zons V through VIII). Horizon VI also contains carbonate, hematite, and manganese nodules. Horizon VII contains carbonate nodules, and Horizon VIII includes hematite and manganese nodules.

**Core 2.** The location of core 2 is within 30 ft of Profiles 1 and 2 studied in 1986 (Figure 2.11). Core 2 contains seven observed horizons (Figure 2.14) and the results are summarized in Table 2.4. Horizon I is an A horizon which is a mollic epipedon. The mollic epipedon is followed by

two argillic B horizons (Horizons II and III). Horizon II contains hematite nodules, and Horizon III contained carbonate inclusions. These argillic horizons overlie a C horizon (Horizon IV). Following the C horizon is a melanized Ab soil horizon (Horizon V). The top 10 cm (280.0 cm to 290.0 cm) and the bottom 10 cm (390.0 cm to 400.0 cm) were collected for AMS dating. These samples date to  $6200 \pm 50$  B.P. (Beta-215951) with a 13C/12C ratio of -18.3 o/oo and 7380  $\pm$  40 B.P. (Beta-210183) with a 13C/12C ratio of -19.8 o/oo respectively. Underlying the buried A



Figure 2.14. Idealized stratigraphy and depth correlations of soil horizons identified in 2005 Cores #1 and #2 adjacent Mustang Creek in Canadian County, Oklahoma.

is another argillic B horizon (Horizon VI) which contains manganese inclusions. Following Horizon VI is a second buried A soil. The top 10 cm (440.0 cm to 450.0 cm) of this horizon was also collected for radiometric dating. The AMS result dates this buried A horizon to  $8030 \pm 50$  B.P. (Beta-215952) with a 13C/12C ration of -19.5 o/oo.

#### Discussion

The purpose of this study is to reaffirm and better document the pedogenic processes of Mustang Creek, how these relate to reconstructing the past in Oklahoma, and how these might correspond to the archaeological record. The results from this study impact our knowledge of past bioclimatic change and archaeological processes both at the regional and macro-regional levels. Understanding regional change illuminates macro-regional differences (or similarities) providing broader knowledge of prehistoric variation and processes.

**Regional.** The profiles and core samples taken from Mustang Creek provide small windows into the past. These glimpses suggest that Mustang Creek has undergone many different types of geologic processes. First, Mustang Creek soils are mollisols characteristic of soil formation within a prairie or steppe grassland environment. Furthermore, the Mustang Creek epipedon shows heavy melanization, suggesting that the landscape underwent an extensive period of environmental stability.

Second, the different C horizons separating buried melanized horizons suggest that the Mustang Creek environment was constantly in flux between mesic conditions where sediments were altered by pedogenesis and xeric conditions when sediments were deposited along the drainage basin. Between the two buried A horizons that have been dated in Profile 3, there are major depositional episodes probably due to flooding. These flooding episodes took place between 570  $\pm$  80 B.P. and 5400  $\pm$  120 B.P. These periods of environmental instability are represented by soil horizons that overlay each other and are very similar. For example, most of the properties of Horizons VIII and IX in Profile 3 are similar except for their texture. Because coarse sand is overlying very fine sand, this can be interpreted as one flooding event with later settling of the sediments, the smaller grain sizes working downwards to create these two distinct horizons. This pattern of grain settling is also evident between Horizons VI and VII, Horizons X and XI, Horizons XII and XIII, and Horizons XIV and XV. Therefore all of these horizons are a product of alluviation and may attest to five different flooding episodes.

Due to the 1986 and 2005 investigations at Mustang Creek, at least three different buried A horizons have been identified. Each of these suggests a period of environmental stability wherein sediments remained intact while undergoing pedogenic change. The earliest period of stability represented in the study locality is Core 2's Horizon VII that has an AMS date of  $8030 \pm 50$  B.P. (Beta-215952). The next period of stability is evident in Profile 2's Horizon VIII (synonymous with Profile 3's Horizon XVI, and Core 1's Horizon IV). The horizons probably are the same soil though they possess different but similar dates of  $5520 \pm$ 230 B.P. (Beta-16986), 5400 ± 120 B.P. (Beta-16988), and 5680 ± 50 B.P. (Beta-210182) respectively. Furthermore, the two dates yielded from Core 2 Horizon V indicates that this soil horizon took over 1,000 years to form. The youngest buried A horizon is Profile 3's Horizon IV. This horizon is dated to  $570 \pm 80$  B.P. (Beta-16987). The archaeological implications of these dates will be discussed in the next section.

As previously mentioned, the study area is associated with the Reinach series of soils (Carter 1996; Mogg et al. 1960). Field judging of Mustang Creek soils, however, does not corroborate the presence of Reinach soils. First, scholars have suggested that the Reinach series is not prone to flooding (Fisher and Swafford 1976). The amount of alluvial sediments found during the study suggests that flooding has been common at this location of Mustang Creek. Furthermore, except for the C horizons, the soils found at Mustang Creek do not have attributes that correspond to the Reinach series.

*Macro-Regional.* In order for a study to be pertinent beyond the scope of its own microcosm, it is necessary to view the larger picture and how the study can advance our knowledge on a broader scale. This section takes the results from Mustang Creek and extends them into this larger arena. As previously mentioned, the middle Holocene is characterized by the xeric Altithermal. The Altithermal limited plant growth which in turn reduced subsistence for larger fauna (Antevs 1955). Hence, humans depending upon larger fauna for their own subsistence may have been forced from the region during the Altithermal. For years archaeologists have used this theory to support the lack of archaeological material relative to the middle Holocene. The one exception is the Calf Creek complex.

The Calf Creek complex has been interpreted to have existed ca. 5000 to 6500 B.P., during the peak of the Altithermal (Duncan 1995). Presently, there is little evidence of this cultural tradition occupying Canadian County, although archaeologists have found such materials (Figure 2.15) in nearby Oklahoma and Cleveland counties (Brooks 1983). The general consensus has been that the Altithermal caused such dramatic climate changes that the present study region would have been uninhabitable for humans.

The 1986 and 2005 investigations at Mustang Creek suggest otherwise. Because buried A horizons provide evidence of melanization which requires long periods of stability in order to form, the presence of these horizons indicate that there were some intervals of ameliorated stability in the region. For instance, the previously mentioned Core 2 Horizon V indicates that there was a period of stability for over a thousand years. The radiocarbon and AMS dates of Profile 2, Horizon VII (5520 ± 230, Beta-16986), Profile 3, Horizon XVI (5400 ± 120, Beta-16988), and Core 1, Horizon IV (5680 ± 50, Beta-210182) correlate with both the Altithermal and the Calf Creek culture. Hence, the region around Mustang Creek would have been a prime location for Calf Creek peoples to exploit resources during what is commonly referred to as the xeric Altithermal. Furthermore, the climatic stresses of the Altithermal are usually considered to have peaked between 8,000 and 6,000 B.P. At Mustang Creek, the lowest of the paleosols as seen in Core 2, Horizon VII dates to 8030 ± 50 B.P. (Beta-210185)



Figure 2.15. Both faces of Calf Creek projectiles found in Cleveland and Oklahoma counties within 20 miles of the Mustang Creek drainage. The three examples on the upper left of the top row are from Oklahoma County, whereas the rest are from sites eroding into Lake Draper in Cleveland County. Specimens are made from Edwards chert, Alibates chert, Ogallala quartzite, and heat-treated Frisco chert. Photos courtesy of Jim Cox, Norman, Oklahoma.

providing additional evidence for stability when the environment is considered to have been inhospitable for human habitation. Unfortunately, no cultural material has been detected with the lowest and oldest Mustang Creek paleosol, and so this notion that Mustang Creek was inhabitable during the early Holocene is based solely upon the pedogenic record.

These results beg the question, why have archaeologists not found any archaeological evidence that corresponds to these time periods if Mustang Creek was a pocket of stability during the Altithermal? The answer lies within the methods. The shallowest depth for the buried A horizons is almost 2 meters from the ground surface. Conventional archaeological methods (i.e. shovel testing) are unable to reach these depths. In a time when cultural resource management projects provide much of the archaeological data, the research is driven by the client and not the archaeologist. Hence, businesses are not willing to pay for the extra cost to reach such depths. In order to fully understand the archaeological record during the Altithermal, it is necessary for archaeologists to either convince their clients to spend more money or to introduce new survey methods and techniques that allow full exposure of Early and Middle Archaic materials hidden by the bioclimatic changes of the Altithermal.

#### Conclusion

The study of Mustang Creek has shed some light on the alluvial deposition and the pedogenic processes transforming the region. Mustang Creek provides evidence that its dynamic past includes episodic flooding interspersed with periods of stability. It is these periods of environmental stability that may open a new chapter in central Oklahoma's prehistory. With the discovery of several buried A horizons dating to the Early and Middle Holocene, it is possible to revise accepted concepts pertaining to the Altithermal and to better determine where previously undiscovered Archaic sites, such as those of the Calf Creek complex, will be found in the future. The one concern is that conventional archaeological techniques will not uncover remnants of Archaic cultures due to their depth. Thus, the results from this study at Mustang Creek may not only add to the archaeological discussion, but also dictate the need for new techniques for locating pockets of stability that may have evidence of early prehistoric cultures.

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## Chapter 3 Pedogenic Investigations along Pumpkin Creek, Love County, Oklahoma

#### Abbie L. Bollans and Thomas A. Jennings

#### Introduction

Geomorphological research was conducted on a stream bank along Pumpkin Creek, located on the Southern Plains in Love County, Oklahoma (Figure 3.1). Our goal was to determine some of the paleoenvironmental factors that influenced the settlement and subsistence strategies of prehistoric people in the area through time. Two buried soils were documented and radiocarbon dated, and they indicate a period of significant floodplain stability from 3100 to 1200 B.P.

Accounting for the variability of geological processes that occur in different stream drainages throughout a region is critical for adequately assessing: 1) where archaeological sites are likely to be preserved; and 2) when, where and how prehistoric people moved across the landscape in order to exploit available resources. This chapter reviews past geomorphologic studies conducted in the Southern Plains, presents new information about the geomorphology



Figure 3.1. Location of the Pumpkin Creek exposure relative to the historic Cross Timbers. Adapted from A.H. Hanson's map for C.T. Foreman (1947).

of the Pumpkin Creek fluvial system, and compares and contrasts these results as means to help reconstruct past environments and their impact on hunters and gatherers living in the region.

The nearby Pumpkin Creek site (34LV49) was predominantly occupied during the Early Archaic period (9500-7000 B.P.; Wyckoff and Taylor 1971). However, the presence of two Late Archaic projectile point styles indicates the area was also visited by prehistoric people at approximately 3000–1000 B.P., coinciding with the period of landscape stability. Moreover, while similar geomorphic changes have been documented along other fluvial systems over the Southern Plains, our data reveals that the environmental conditions necessary for soil development occurred 1000 years earlier along Pumpkin Creek.

#### Pumpkin Creek (34LV49) Site Description

The Pumpkin Creek site was occupied during the early Holocene, when the region transitioned from a mesic forest into savannah grassland. This site was a temporary lithic workshop camp that was reoccupied throughout the early Archaic period (9,500 - 7,000 B.P). The material remains from the Pumpkin Creek site were found in an eroding hillside, within a reddish-brown soil horizon that was approximately 8-13 cm thick (Wyckoff and Taylor 1971). To make a variety of stone tools implements, prehistoric people utilized waterworn cobbles of Cretaceous cherty gravels of the Antlers Formation in addition to quartzite, sandstone, hematite, and petrified wood resources that were located in the area (Wyckoff and Taylor 1971:40). The majority of the lithic tools are cryptocrystalline, and they include projectile points, drills, and a variety of scrapers and flakes (ibid.). The presence of these implements in addition to cores and preforms suggest that the camp was used not only for working stone, but also for activities related to subsistence. In particular, 49 finished tools, the majority being projectile points and cutting tools, indicate that the site was used for meat and hide processing activities (Neustadt 2000; Wyckoff and Taylor 1971).

Dalton, Plainview, and a few Scottsbluff projectile points (Figure 3.2) comprise the majority of the diagnostic lithics from Pumpkin Creek, revealing Paleoindian and early Archaic occupations of the site (Neustadt 2000:36; Wyckoff and Taylor 1971). In addition, Ellis and Darl points were also recovered (Wyckoff and Taylor 1971). These points **Chapter 3: Pedogenic Investigations along Pumpkin Creek** 



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Figure 3.2. Examples of early Holocene projectile points recovered at the Pumpkin Creek site (34Lv49). Adapted from Wyckoff and Taylor 1971: Figure 4.

date to 3000-1000 B.P. and 2000-1000 B.P., respectively (Bell 1960), indicating the site was frequented throughout the Archaic period.

The tools at Pumpkin Creek are similar to artifacts from other sites identified throughout the Southern and Central Plains and the Eastern Woodlands (Johnson 1989). Thus, understanding the geological attributes and paleo-environmental conditions along Pumpkin Creek (Figure 3.3) is critical for developing a regional model for discovering and uncovering associated sites. These sites could provide additional information about changes in human subsistence and settlement patterns in the area through time.

#### **Geographic and Physiographic Location**

Pumpkin Creek drains into the Red River, which creates the southern border of Oklahoma. The Red River is the second largest river basin in the Great Plains. It drains four physiographic provinces including the Great Plains and the Coastal Plains and four terrestrial ecotones, including the Central and Southern Mixed Grasslands and the Central Forest Grassland Transition Zone (Matthews et al. 2005:300).

Pumpkin Creek is located in Love County, which represents the northern limit of the Gulf Coastal Plain (Bullard 1925). In particular, Pumpkin Creek is situated on the border of the Osage Plains and the Gulf Coastal Plain (Figure 3.4), also known as the Osage Savannah district (Madole et al. 1991). The landscape of the Osage Savannah district is composed of alternate layers of weathered shale and sandstone, in addition to rolling hills and alluvial flats in floodplains and streams (Blair and Hubble 1938:433). The streams in the area have narrow channels and expansive floodplains. The southernmost part of the Cross Timbers, where Pumpkin Creek is situated, developed sandy soils as a result of the coastal plains. Thus, Pumpkin Creek over-



Figure 3.3. View of the south half of the Pumpkin Creek exposure, Love County, Oklahoma. Photo taken September 24, 2005, by Don Wyckoff.



Figure 3.4. Location of the Pumpkin Creek exposure withing the Osage Plains physiographic region. Adapted from Madole et al. 1991: Figure 2.

lies sandy soils derived from Cretaceous parent material that includes alluvial and colluvial deposits.

Local relief is approximately 70 ft. and consists of rolling, hilly uplands (Wyckoff and Taylor 1971). Today, the area is on the border of the Plains-Eastern Woodland ecotone (Figures 3.1 and 3.4), specifically the border of the Grand Prairie and the Cross Timbers regions of Oklahoma (Wyckoff and Taylor 1971). The Cross Timbers region consists of upland sandstone hills that support scrubby, woody vegetation (Gray and Galloway 1959). It is a transitional zone comprised mostly of short deciduous oak forest (Matthews et al. 2005:300). Currently, the average annual rate of precipitation at Pumpkin Creek is approximately 36 cm a year, and the evapotranspiration rate is also about 36 cm a year (Gray and Galloway 1959:Fig. IV). The average temperature is about 65 degrees Fahrenheit. Vegetation consists of cottonwood, oak, sumac, and bluestem grass. Historic farming of cotton and peanuts took place in the area throughout the 1930s; however, since 1946 the area has been used for grazing livestock (Wyckoff and Taylor 1971).

Significant environmental changes have occurred since the last ice age. Due to decreasing effective moisture and increasing seasonality, the Southern Plains region became dominated by grassland through the early Holocene. Pollen and vertebrate data reveal that escalating regional aeration culminated in a severe middle Holocene drying period termed the Altithermal (Albert 1981; Antevs 1955; Bryant and Holloway 1985; Ferring 1990a:255; Graham 1987; Meltzer 1995). The pollen record at Ferndale Bog (Figure 3.5), located east of the study area in Atoka County, Oklahoma, presents one of the clearest pictures to date of these changes (Bryant and Holloway 1985; Holloway 1994). Holloway (1994) interprets the Ferndale Bog record as showing a gradual shift from woodlands to tall grass prairie between 11,800 and 5,400 B.P., implicating a decrease in effective moisture throughout the region. With the end of the Altithermal around 4000 B.P., the trend reverses and effective moisture gradually increases allowing trees to repopulate the Ferndale Bog locality. Other researchers have documented a similar increase in effective moisture during the late Holocene throughout the Southern Plains region (Ferring 1990a:255; Hall 1988; Reid and Artz 1984; Waters and Nordt 1995).



Figure 3.5. The relative pollen record from Ferndale Bog, Atoka County, Oklahoma, some 100 miles east of Pumpkin Creek. Adapted from Bryant and Holloway 1995: Figure 6.

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Figure 3.6. Location of the Pumpkin Creek exposure in relation to the distribution of the Antlers/Trinity Formation. Adapted from U.S. Geological Survey Groundwater Atlas 1996.



Figure 3.7. Location of the Pumpkin Creek exposure in relation to the Pumpkin Creek archaeological site (34Lv49). Adapted from U.S. Geological Survey, Lake Murray 7.5' topographic map, 1964.



Figure 3.8. Sketch of the Pumpkin Creek exposure, the locations of the studied profiles, and the extent of the recorded horizons. Note the cut-and-fill at the left (south) end of the exposure.

#### Parent Material and Soils of Pumpkin Creek

Soils and sediments at Pumpkin Creek overlie Cretaceous shoreline deposits known as the Antlers Formation, which is part of the Trinity group (Figure 3.6). Located north of the Red River, the Antlers Formation is the youngest deposit of the Comanchean Sea (Hart and Davis 1981). The Trinity Group consists of beach or shore sand deposits accumulated by the Comanchean Sea as it weathered Paleozoic rocks from the Cretaceous period (Bullard 1925). The Trinity group is represented by sand particles, coarse conglomerates, lentils of clay and shale, and sometimes calcareous limestone (Bullard 1925:17).

Soils overlying the Antlers Formation are of the Stephenville and Windthorst series. Both series consist of "deep, well-drained light-colored soils" (Maxwell and Reasoner 1966:88-90). In addition, both series have a moderately coarse textured surface layer, and fine textured subsoil (Maxwell and Reasoner 1966:88). Soils from the Windthorst series are more strongly consolidated than the Stephenville series because they contain a higher clay component in the 2Btb horizon. Furthermore, Windthorst series typically develop over the Antlers Formation, and the Stephenville series typically develop over the Trinity Formation (Maxwell and Resoner 1966:88-90).

#### **Current Study**

Three soil profiles (Figures 3.7 and 3.8) were studied at Pumpkin Creek in order to document geomorphic processes of valley fill and to reconstruct local paleoenvironmental





Figure 3.9. Photo and correlated horizons of Pumpkin Creek exposure Profile C, which was over 3.0 m in depth. Lines in the photo show where soil samples were collected for AMS dating. Photo taken September 4, 2005, by Don Wyckoff.

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#### **Chapter 3: Pedogenic Investigations along Pumpkin Creek** Table 3.1. Soil Profile A (Black) Description.

Depth (cm)	Horizon	Moist Color	Structure	Consistence (Wet/Moist/Dry)	Texture	Effervescence	Boundary
0-15	Ар	10YR4/3	sg	sopo/vfr/sh	LS	NE	cs
15-88	С	10YR5/4	sg	sopo/vfr/so	S	NE	as
88-118	3Ab	10YR3/1	2vfsbk	ssp/fr/h	SCL	NE	as
118-260+	2Bknb	10YR3/1	2fpr	ssps/fr/h	SCL	SL	

#### Table 3.2. Soil Profile A (White) Description.

Depth (cm)	Horizon	Moist Color	Structure	Consistence (Wet/Moist/Dry)	Texture	Effervescence	Boundary
0-15	Ар	10YR4/3	sg	sopo/vfr/sh	LS	NE	cs
15-93	C	10YR4/3	sg	sopo/vfr/so	S	NE	as
93-124	4Ab	10YR3/2	2vfsbk	ssps/fr/h	SCL	NE	aw
124-260+	Sediments	10YR5/3	sg	sopo/vfr/so	S	VS	

#### Table 3.3. Soil Profile B Description.

Depth (cm)	Horizon	Moist Color	Structure	Consistence (Wet/Moist/Dry)	Texture	Effervescence	Boundary
0-11	Ар	10YR4/3	sg	sopo/vfr/sh	LS	NE	cs
11-27	Bt	10YR4/6	l v fsbk	sspo/fr/h	LS	NE	cs
27-49	С	10YR5/4	sg	sopo/vfr/so	S	NE	cs
49-65	СЗАЬ	10YR3/1 10YR5/4	sg/1fsbk	sopo/vfr/sh	LS	NE	cs
65-94	3Ab	10YR3/1	2vfsbk	ssp/fr/h	SCL	NE	cs
94-138	2Bknb	10YR3/1	2fpr	ssps/fr/h	SCL	SL	cs
138-200+	2Bknb2	10YR3/1	2fpr	ssps/fr/h	SCL	SL	

#### Table 3.4. Soil Profile C Description.

Depth (cm)	Horizon	Moist Color	Structure	Consistence (Wet/ Moist/Dry)	Texture	Effervescence	Boundary
0-17	Ар	10YR4/3	sg	sopo/vfr/sh	LS	NE	cs
17-23	Bt	7.5YR4/6	lvfsbk	sspo/fr/h	LS	NE	cs
23-51	C	7.5YR5/4	sg	sopo/vfr/so	S	NE	as
51-58	2Ab	10YR4/4	2vfsbk	ssps/fr/h	LS	NE	as
58-88	2Cb	10YR6/4	sg	sopo/vfr/sh	LS	NE	as
88-133	3Ab	10YR3/1	2vfsbk	ssp/fr/h	SCL	NE	cs
133-180	2Bknb	10YR3/1	2fpr	ssps/fr/h	SCL	SL	cs
180-287	2Bknb2	10YR3/1	2fpr	ssps/fr/h	SCL	SL	cs
287-314	2Btb	10YR4/1	2fsbk	ssp/vfr/sh	SCL	VS	cs
314-389+	3Cb	10YR6/1	sg	sopo/vfr/so	S/LS	NE	cs

#### Key to Profile Descriptions:

Texture

Structure		
	Grade:	I-weak; 2-moderate
	Size:	vf-very fine; f-fine;
	Type:	sg-single grain; sbk-subangular blocky; pr-prismatic
Consistence		
	Stickiness:	so-non sticky; ss-slightly sticky
	Plasticity:	po-non plastic; ps-slightly plastic; p-plastic
	Resistance	

Moist: vfr-very friable; fr-friable Dry:

so-soft; sh-slightly hard; h-hard

Effervescence: NE-noneffervescent; VS-very slightly effervescent; SL-slightly effervescent Boundary

SCL

LS S

Distinctness: a-abrupt; c-clear Topography: s-smooth; w-wavy

Sandy clay loam

Loamy sand Sand



Figure 3.10. Pumpkin Creek exposure Profile B with correlated drawing of recognized horizons. Photo taken September 24, 2005, by Don Wyckoff.

conditions. The three soil profiles were positioned west of the archaeological site, along the western 1st terrace of Pumpkin Creek (Figure 3.8). The banks of the stream where the profiles were studied vary from 8 to 10 meters high, and nearly 4 meters of soils and sediments were exposed in each profile.

#### Results

Profile descriptions begin with Profile C, the northern-

most profile (Figure 3.9), followed by Profiles B and A. Because C is the deepest profile excavated, it contains all soil horizons present in the other two profiles (except one horizon associated with the cut-and-fill) as well as some additional, unique horizons. As such, designations for horizons identified in profile C will be used for corresponding horizons in Profiles B and A.

Profile C. This is the deepest profile investigated, ex-

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# **Chapter 3: Pedogenic Investigations along Pumpkin Creek**

tending 3.89 m below the surface (Figure 3.9; Table 3.4). The surface soil consists of an 8 cm thick A horizon followed by a slightly argillic Bt horizon. These overlie a C horizon consisting of sand mixed with 10% gravels of pebble size and smaller. The presence of sand and gravels indicates this horizon is the result of floodplain deposition and aggradation.

Two buried soils were identified within Profile C. The first occurs 51 cm below the surface. Horizon 2Ab is a weakly developed, lightly melanized A horizon lying directly over horizon 2Cb, laminated deposits of sand and loam. A bulk soil sample from the 2Ab horizon yielded a radiocarbon date of  $118 \pm 53$  B.P. (Arizona - AA68186) and a stable carbon ratio of 19.9 %o. The lamination combined with the presence of sands within the 2Cb horizon again indicates this horizon represents alluvial deposition.

The second buried soil begins 88 cm below the surface. Horizon 3Ab is a thick (45 cm), deeply melanized horizon. Below lies 181 cm of B horizons. Two calcic and cambic horizons were identified based on the presence of calcium carbonate filaments (3Bknb) and nodules (3Bknb2), and these overlie the argillic horizon 3Btb. Comprising over two meters of sediments, the thickness of this second soil suggests it results from cumulic soil development.

Two bulk soil samples were recovered for radiocarbon dating from the second buried soil. One sample was removed from horizon 3Ab at a depth of 98 cm below the surface and yielded a date of  $1230 \pm 40$  yr B.P. (Beta - 210184) with a stable carbon isotope ratio of -17.9 o/oo. The second date came from horizon 3Bknb2 at a depth of 277 cm and yielded a date of  $3130 \pm 40$  yr B.P. (Beta - 210185) with a stable carbon isotope ratio of -18.6 o/oo. Together, these dates provide a bracket for the period of time in which this second buried soil developed.

The stable carbon isotope ratios from Pumpkin Creek indicate a mixed C3 and C4 vegetation was present (Nordt et al. 1994). They compare to ratios from the Trinity River during mesic periods (Humphrey and Ferring 1994), suggesting the climate along Pumpkin Creek may have been relatively moist during this period of cumulic soil development. Moreover, the three stable carbon isotope ratios obtained from Profile C document a steadily increasing percentage of C3 vegetation along Pumpkin Creek during the last 3000 years.

The final stratigraphic unit identified (3Cb) consists of laminated layers of sand and loam. Gleying indicates these sediments were saturated with water for extended periods of time. Although they resemble spring deposits described by Haynes (1995), determining their precise origin will require further investigation.

Profile B. Profile B (10.9 m south of C) was cleaned

to a depth of 200 cm (Figure 3.10; Table 3.3). As in profile C, the surface soil consists of three horizons (Ap, Bt, and C) extending approximately 50 cm below the surface. Directly below 50 cm, however, Profile B differs significantly. Horizons 2Ab and 2Cb are absent. Instead, horizon C3Ab constitutes a 22 cm thick mixture of the C horizon and the 3Ab horizon beneath. The exact cause of this mixing remains unknown; however, it may be the result of a localized event such as a tree fall. Extending the profile north and south as well as trenching into the bank might help resolve this question. The final two horizons identified in Profile B are the 44 cm thick 2Bknb and the 62+ cm thick 2Bknb2 horizons.

**Profile A.** Profile A (Figure 3.11), the cut and fill sequence located 14.9 m south of B, was divided into two separate profile descriptions labeled Black (non-cut-and-fill sediments; Tables 3.1 and 3.5) and White (cut-and-fill sediments; Tables 3.2 and 3.6). Both halves were cleaned to a depth of 260 cm. No differences exist in the top portions of the Black and White profiles. In contrast to profiles B and C, no Bt horizon was identified within the surface soil of Profile A. The A horizon transitions directly to C. In this location, the soil is also deeper than further north, extending to a depth of 88-93 cm.

Differences between the Black and White profiles begin at approximately 90 cm below the surface (Tables 3.5 and 3.6), the depth at which the cut-and-fill sequence is first encountered. In the Black portion (Table 3.5), the 3Ab horizon is again present, however it is less thick (only 30 cm) than in profile C. Beneath lies the calcic and cambic 2Bknb horizon.

As noted, the White profile (Table 3.6) at this depth consists of the cut-and-fill sediments. Horizon 4Ab consists of approximately 30 cm of cumulic soil development. This horizon is analogous to the 3Ab horizon documented in the other profiles. However, when compared to horizon 3Ab, the lighter color and absence of an associated B horizon indicates this soil began developing towards the end of the 1900 year period of cumulic horizonization revealed by Profiles B and C.

A bulk soil sample from the top of the 4Ab horizon (Figure 3.11 and Table 3.6) yielded a radiocarbon date of  $333 \pm 38$  B.P. (Arizona – AA68187) with a stable carbon isotope ratio of 18.5 %o. While evidence of bioturbation was rare in Profiles B, C, and the Black portion of Profile A, the White portion of Profile A exhibited heavy bioturbation. Numerous krotovinas were visible. More recent carbon was transported downward in the profile, and we therefore consider the 333 B.P. date to be skewed in favor of a more recent age.

Horizon 4Ab (Table 3.6) rests directly on the laminated sand and gravel deposits of the stream cut. The cut is a

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Figure 3.11. Photo and profile drawings of Pumpkin Creek exposure Profile A. Arrows show the location of the "White" and "Black" profile descriptions. Dashed lines show the border of the cut-and-fill. The line in the 4Ab horizon indicates where the soil sample was collected for AMS dating. Photo taken September 24, 2005, by Don Wyckoff.

Table 3.5.	Soil Horizon Descriptions for Pumpkin Creek Profile A "Black", recorded by Nicholas
	Beale and Mike McKay on September 24, 2005.

A <sub>p</sub>	0.0 to 15.0cm, 10YR4/3 (brown) loamy sand; granular structure; slightly hard, very friable; non-sticky, non-plastic; non-effervescent; clear smooth boundary.
С	15.0 to 88.0cm, 10YR5/4 (yellowish brown) sand; granular structure; soft, very friable; non-sticky, non-plastic; non-effervescent; abrupt smooth boundary.
3A <sub>b</sub>	88.0 to 118.0cm, 10YR3/1 (very dark gray) sandy clay loam; moderate very fine subanglular blocky structure; hard, friable; slightly sticky, plastic; non-effervescent; abrupt smooth boundary.
3B <sub>knb1</sub>	118.0 to 260.0+cm, 10YR3/1 (very dark gray) sandy clay loam; moderate fine prismatic structure; hard, friable; slightly sticky, slightly plastic; slightly effervescent.

# Table 3.6. Soil Horizon Descriptions for Pumpkin Creek Profile A "White", recorded by Nicholas Beale and Mike McKay on September 24, 2005.

A <sub>p</sub>	0.0 to 15.0cm, 10YR4/3 (brown) loamy sand; granular structure; slightly hard, very friable; non-sticky, non-plastic; non-effervescent; clear smooth boundary.
С	15.0 to 93.0cm, 10YR4/3 (brown) sand; granular structure; soft, very friable; non-sticky, non-plastic; non-effervescent; abrupt smooth boundary.
4A <sub>b</sub>	93.0 to 124.0cm, 10YR3/2 (very dark grayish brown) sandy clay loam; moderate very fine subanglular blocky structure; hard, friable; slightly sticky, plastic; non-effervescent; abrupt wavy boundary.

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paleochannel of Pumpkin Creek. The channel was abandoned some time after 3000 years ago. Subsequent vertical accretion produced horizon 4Ab. Determining the exact direction of stream flow when this channel was active would require additional investigation into the creek bank deposits.

# Summary: Pumpkin Creek Floodplain History

Investigations along Pumpkin Creek revealed a 3100 year geomorphic history. For a period of approximately 1900 years (3100-1200 B.P.), overbank flooding along Pumpkin Creek was frequent and nonviolent, depositing primarily clay and little sand. Pedogenesis kept pace with sediment deposition resulting in the formation of a thick, deeply melanized cumulic soil. Stable carbon isotope ratios suggest the climate was relatively mesic during this time. After 1200 B.P., the depositional environment changed to higher velocity flood events which deposited sands and gravels and covered the cumulic soil. A brief period of landscape stability allowed a weakly developed soil to form; however, this soil was quickly buried. Abrupt changes at the top of the profile undoubtedly result from erosion after historic farming was begun in the watershed.

# Discussion

Late Holocene cumulic soils analogous to the one defined in this paper have been identified over the Southern Plains (Madole et al. 1991). Although these soils bear striking similarities, significant differences exist. The chronological period over which cumulic horizonization occurred differs locally. In addition, some debate remains over what climatic conditions facilitated soil development.

The Asa soil along the Brazos River in east-central Texas developed from 1250 to 500 yr B.P. (Waters and Nordt 1995). Along the Trinity River in North-Central Texas, the West Fork paleosol formed 2000 to 1000 yr B.P., and the Caddo soil developed in southwestern Oklahoma during this same time (Ferring 1990b; Hall 1988). In northeastern Oklahoma, the Copan paleosol formed from 2000 to 1300 yr B.P. (Reid and Artz 1984). As this paper has shown, soil formation along Pumpkin Creek occurred from 3100 to 1200 B.P. Although this period overlaps periods of soil formation in these other Southern Plains locations, horizonization began significantly earlier and continued for nearly 2000 years.

Asa and Caddo soil formation has been attributed to a shift to more mesic conditions (Hall and Lintz 1984; Hall 1988; Waters and Nordt 1995:317). Reid and Artz (1984:174) postulate that the Copan soil formed in northeastern Oklahoma during a period of less variable precipitation and fewer large floods. Finally, Humphrey and Ferring (1994) argue that the West Fork paleosol formed along the Trinity River during a period of decreased moisture (but see Brown 1998). The stable carbon isotope ratios from Pumpkin Creek indicate soil formation occurred during a relatively mesic period which supported abundant C3 vegetation. However, the percentage of C3 plants continued to increase after cumulic soil development ceased.

This brief summary of Late Holocene pedological research in the Southern Plains illustrates two key aspects of floodplain geomorphology. First, the chronology of cumulic soil development is highly variable for each locality and each fluvial system. Second, a wide variety of climatic factors, including increased moisture, increased aridity, or changes in the frequency and severity of precipitation events, influence stream volume and sediment load which directly affects floodplain horizonization.

#### Conclusions

Based on the chronology of previously established typological sequences, two projectile point styles recovered from the Pumpkin Creek archaeological site place people at the location from 3000 to 1000 B.P. Given their presence, several questions remain to be answered. What was the environment like when people were exploiting local tool-stone resources? What plant and animal resources may have drawn them to the area? Further, how have subsistence and settlement patterns changed through time as the local climate changed?

To begin answering these questions, geomorphological investigations were undertaken along a portion of Pumpkin Creek. Excavations at one spot revealed a 3100 year fluvial history and the presence of two buried soils. Radiocarbon dates on soil samples recovered from the lowest soil bracketed a period of cumulic soil development and floodplain stability between 3100 and 1200 B.P., the same time people were utilizing nearby lithic resources.

This research further highlights the necessity of studying each fluvial system independently. Critically, the climatic changes documented in other portions of the Southern Plains appear to have occurred nearly 1000 years earlier along Pumpkin Creek. Stable carbon isotope ratios suggest this 1900 year period may have been relatively mesic; however, more research is needed to determine what specific environmental factors contributed to soil development.

The geomorphological data presented in this paper merely represent one piece of the puzzle. Combining this data with other climatological indicators will facilitate reconstruction of the past environment of south-central Oklahoma. Once we have a clearer picture of the Late Holocene climate, we can begin to discuss how people visiting the Pumpkin Creek Site exploited available resources and adapted to environmental changes in the region.

#### Acknowledgments

We express our gratitude to the landowner who generously allowed us to conduct our investigations on his property and to Mike Waller for his assistance and helping to gain

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# Chapter 4 Geoarchaeological Investigations at Pond Creek, Central Oklahoma

# David J. Cranford and Elsbeth Dowd

#### Introduction

Central Oklahoma's Pond Creek (Figure 4.1) offers an intriguing opportunity to study past environments and archaeology along the Cross Timbers. The alluvial sequence at the study location contains at least four buried soils of varying thicknesses in as many meters of sediment. Each of the four soils indicates a period of landscape stability, during which horizonization occurred. By investigating the physical attributes and radiocarbon ages of the alternating zones of stability and sedimentation within the documented profiles, our study will contribute to the ongoing discussion of the environmental history of the Cross Timbers region.

The lowest of the four soils is an over-thickened paleosol, which was identified as the Pond Creek Paleosol by David Morgan (1994:46) in previous investigations. This study will compare the Pond Creek Paleosol to similar late Holocene paleosols on the Southern Plains. It is our hope that together these soils will increase our knowledge of past climates and the prehistoric populations they affected. An analysis of the Pond Creek Paleosol can also help us to understand the particular processes involved in the formation of this over-thickened paleosol, and the ways in which those processes potentially affected archaeological site formation. Our study will consider the implications of the Pond Creek soils on buried site potential and archaeological visibility and recovery. The number and variety of paleosols at Pond Creek provide evidence for the complex

dynamics of landscape formation in central Oklahoma. Sediment may cover more than thirteen hundred years of cultural occupation along Pond Creek and other local streams. Based on this study, we believe that traditional survey techniques are inadequate in these settings and must be modified to take into account buried deposits along these and other streams. Recognition of the buried site potential in the Cross Timbers

Figure 4.2. View downstream (south) at the Pond Creek locality. Photo taken October 22, 2005, by David Cranford.



Figure 4.1. Location of the Pond Creek Exposure relative to the historic Cross Timbers. Adapted from A.H. Hanson's map for C.T. Foreman (1947).





region will help correct biases in the interpretation of local and regional prehistory

# **Description of Study Locality**

The Pond Creek locality is found in southeastern Cleveland County, Oklahoma. Specifically, the site is just north of the confluence of Helsel Creek and Pond Creek, at an elevation of approximately 1040 feet above mean sea level (Figures 4.2 and 4.3). Pond Creek drains the eastern part of the Lexington Wildlife Management Area, which is bounded by the Indian Meridian on the west, Slaughterville road on the north, Pottawatomie County on the east, and State Highway 39 on the south (Morgan 1994: 28).

Pond Creek is a third-order perennial stream that is part of the Canadian River Basin. The study site is in the upper part of the Pond Creek drainage system. The creek has a straight channel (Figure 4.2), which is unusual compared to the meandering or braided streams channels commonly found in this part of Oklahoma (Figure 4.3). The stream appears to have been mechanically channelized and straightened in the early- to mid-twentieth century based on early aerial photographs and maps. The banks of the stream are relatively steep, which allowed access to the eastern exposure. Figure 4.3. Topographic map showing location of Pond Creek Exposure, southeastern Cleveland County, Oklahoma. Adpated from Eason 7.5' quadrangle map, U. S. Geological Survey, 1958.

Pond Creek is in the rolling dissected uplands of the Osage Plains geomorphic province and in the Cross Timbers biotic zone. The area is geologically composed of Quaternary alluvial deposits that overlie the Garber Sandstone and Wellington Formations, two important aquifers that cover the eastern two-thirds of Cleveland County. These formations consist of cross-bedded sandstone layers that are fine- to very fine-grained and loosely cemented, irregularly interbedded with layers of sandy to silty shale (Morgan 1994:30; Wood and Burton 1968:19). Differential weathering between the layers of shale and resistant sandstone accounts for the rough, hilly nature of most of this terrain (Blair and Hubbell 1938:433). The Garber Formation overlies or grades into the Wellington Formation, which is the oldest of the area's Permian rocks (Morgan 1994:30-1; Anderson 1927:9; Travis 1930:11). According to Morgan (1994:31), the Quaternary alluvium in the stream valleys yields Ogallala gravel, including Ogallala quartzite and an

opaque whitish-tan to shiny whitish opaline chert.

Soils near the Pond Creek site belong to either the Pulaski Series or the Weswood Series. Soils of the Pulaski Series are entisols, specifically coarse-loamy, nonacid Typic Ustifluvents that form in loamy and sandy alluvium on low flood plains (Bourlier et. al. 1983:154-5). They are deep, well drained, and moderately permeable, with slopes ranging from 0 to 2 percent. Weswood Series soils are inceptisols, specifically fine-silty Fluventic Ustochrepts (Bourlier et. al. 1983:163-4). Like the Pulaski soils, they also form on floodplains and are deep, well drained, moderately permeable, and are either level or very gently sloping. Both the Pulaski and Weswood soil series are described as containing a buried A horizon located at a depth of 76 centimeters below the surface.

In central Oklahoma today, the climate is characterized by long, hot summers and short winters (Blair and Hubbell 1938:433-4). Extremely cold weather is rare. The average temperature in Cleveland County is about 60 degrees Fahrenheit. Average precipitation over a 67-year period in Norman was 33.36 inches, but this varies seasonally, as the region receives more rainfall during the spring and summer months (Morgan 1994:33). An important climatic factor for biotic growth and soil formation in this area is that the average annual rates of precipitation and evapotranspiration are approximately the same (Wyckoff 1984:3).

According to Hall (1988:206-9), a relatively moist climate persisted in the Osage Plains from about 2000 to 1000 years ago. He based this interpretation on an analysis of vertebrate faunal materials, mollusks, pollen, alluvial geomorphology, and soils from rockshelters and alluvial sites across Oklahoma. About 1000 years ago, conditions apparently became much drier, resulting in a climate similar to that of today.

Pond Creek is in the Osage Savanna biotic district, the western edge of which constitutes the Cross Timbers (Blair and Hubbell 1938:433). The extent of the district is closely related to the climate, for as Wyckoff (1984:3) has noted, its location correlates with the area of Oklahoma that has approximately equal rates of precipitation and evapotranspiration, or slightly more precipitation. The region contains both scrub forests and grasslands. According to Blair and Hubbell (1938:434), primary plants include blackjack oak (Quercus marilandica), post oak (Quercus stellata), and black hickory (Carya buckleyi), along with various grasses including broadleaf uniola (Uniola latifolia), Virginia wild rye (Elymus virginicus), and Japanese chess (Bromus japonicus). Streams contain aquatic mosses, and streambeds have red birch (Betula nigra), black willow (Salix nigra), and buttonbush (Cephalanthus occidentalis). Mammals are represented by both eastern deciduous forest and western grassland species. For a more extensive discussion of the environment, prehistory, and history of the Cross Timbers see Wyckoff (1984).

#### **Previous Investigations at Pond Creek**

Archaeologists have been aware of the Pond Creek location and its buried soils since at least 1993, and it continues to be a fruitful area for study. At that time, an archaeological survey of the Lexington Wildlife Management Area was undertaken in cooperation with the Oklahoma Wildlife Conservation Department, the Oklahoma Archeological Survey and the Oklahoma Anthropological Society. As a result of the survey, 20 new sites were found, 2 isolated artifacts were documented, and a thick, organic-rich soil buried under more than a meter of sediment was identified, referred to as the Pond Creek Paleosol (Morgan 1994).

David Morgan's (1994:39) report on the survey included a profile description that indicated the presence of three buried soils, the bottom one of which was roughly a meter thick. Morgan was curious about the geographic extent of the paleosol and followed this dark horizon upstream approximately 500 meters from the profile location until it terminated at an outcropping of the Permian bedrock. The over-thickened soil continued down stream for another 2 km. The report also mentions that many of the surrounding tributaries also contained the Pond Creek Paleosol for upwards of 400 meters above their confluences with the main channel (Morgan 1994).

Morgan collected several soil samples from his Pond Creek profile. From these samples he submitted three for radiocarbon dating; one from the second buried soil (2Ab) and two from the dark thickened horizon (4Ab). Other samples were sent to Jim Theler at the University of Wisconsin- La Crosse for gastropod analysis and the results were reported in Morgan's study (Morgan 1994:46). The dates from the top and bottom of the Pond Creek Paleosol yielded age determinations of 870± 70 B.P. and 1330± 70 B.P., respectively (Table 1). Based on the horizon's age, size and relative stratigraphic position, Morgan recognized a similarity between it and other paleosols mentioned in the literature such as the Copan, Caddo, and Piedmont. Theler reported that 95% of the snail species represented in the Pond Creek Paleosol were terrestrial and therefore indicated that little to no pond or marsh action contributed to the formation of the soil (Morgan 1994:46).

There was little discussion in Morgan's report about the significance of the date from the second buried soil;  $120\pm$  70 B.P. This age was no doubt problematic and not easily explained since there is yet another buried soil above it, and only 120 years or so to account for its formation and the subsequent sedimentation. New dates, discussed later, have clarified the chronology of sedimentation at Pond Creek. If indeed the second buried soil dates to 120 years ago, we can begin to understand the time required to form a recognizable surface horizon.

Since Morgan's study, Pond Creek has been visited several times by geoarchaeology classes from the University of Oklahoma. The last time Pond Creek was profiled prior to the current study was in 2004, and three field recordings took place at that time. Copies of the 2004 descriptions were retained by Wyckoff and were used as references for this study but are not included here.

#### **Current Study**

On October 22, 2005, the Pond Creek locality was revisited in order to relocate and record new descriptions of the paleosol. Four new profiles were placed along fortythree meters of the east bank, north of the confluence of Helsel Creek with Pond Creek. All profiles were excavated in the same vicinity as previous profiles but due to a lack of provenience, earlier work could not be accurately identified or integrated, though the 1993 profile most likely was closest to profile C. The eastern bank was selected because it provided a vertical profile that was more accessible for study. The profiles were given a designation of 'A' through 'D' from north to south. Profile A was approximately ten meters north of B; B was thirteen meters from C and profile D was twenty meters south of C.

Two persons were assigned to clean and record each pro-

# **Chapter 4: Geoarchaeological Investigations at Pond Creek**

file. The field recording methods consisted of first cleaning roughly a meter of the bank with shovels, picks, and trowels until fresh soil was exposed and the desired depth was reached. In some cases, the profile was stepped to allow access to the uppermost horizons. Before recording, each group picked the surface of the profile to tease out the structure of the pedogenic units. Depth, structure, percent gravel, consistency, texture, presence of clay films, and type of boundary were recorded for each profile (Schoeneberger, et. al 2002). Moist and dry soil colors were determined with a Munsell Color Chart and a 10% HCL solution was used to measure the soil's effervescent response. Finally, each group drew a scaled sketch of their profile and collected soil samples as needed.

#### Results

Further laboratory testing is required to substantiate the accuracy of field observations, including particle size analysis, pH, and percent total and organic carbon. Lab methods could answer many of the lingering questions from this study and should be conducted at some point in the future. To help with these answers, particle size analysis was conducted on close interval samples collect from one column (Profile A). The results of this analysis are presented below.

While Morgan observed three buried surface horizons, we identified four distinct soils beneath the modern ground surface (Figure 4.3). The first zone of melanization occurred at 20 centimeters below the surface (cmbs) in profile D and progressively got deeper, to 38 cm, as it approached profile A (Figure 4.4). The sediment overlying this horizon most likely represents relatively recent historic erosion due to agricultural plowing. There appeared to be a slight color change within this soil that could represent a weak B horizon. Approximately 80 cmbs, another weakly developed soil was visible. Like the first soil, slight color changes occurred within this zone to suggest early stages of B horizon formation. About a meter of alluvial sediment separated the second buried soil from the third.

Until this study, the third buried soil (3Ab), a dark brown horizon immediately overlying the over-thickened Pond Creek Paleosol (4Ab), was never separated from its lower counterpart. One possible reason this observation was never made might be because the boundary is not as easily visible in every profile. The 3Ab soil is most clearly defined in Profile A where it is separated from the 4Ab by a violently effervescent carbonate layer (Table 4.1). The Pond Creek Paleosol was subdivided into 4Ab1 and 4Ab2 on the basis of carbonate levels. Carbonate inclusions become more pronounced in the 4Ab2 giving this zone a whitish tint. Another striking difference between the profiles was the overall thickness of the 4Ab soil. This soil in Profiles B and C measured at, or slightly less than a meter whereas the soil in Profiles A and D was at least a meter and a half, despite being only a short distance away (Figure



Figure 4.4. Recording Profile A (the northernmost studied) on the east bank of Pond Creek, southeastern Cleveland County. Note 3 buried soils, the lowest appearing to be cumulic in nature. Photo taken October 22, 2005, by Don Wyckoff.

# 4.5).

The absence of gleyed material in the Pond Creek Paleosol, as well as the geographic extent of the deposit, supports Theler's interpretation that ponding was not a significant factor in the soil's formation. The most likely cause was landform stability and intense biotic development brought on by an ameliorated climate and increased affective moisture.

What is not clear, however, is whether the Pond Creek paleosol represents a single cumulic or pachic soil, or a series of welded soils. A cumulic soil refers to an over-thickened soil where sediments are deposited at the same rate as pedogenesis while pachic denotes an over-thickened horizon formed with surface sedimentation (Ferring 1992:4). A welded soil denotes one or more distinct episodes of soil development are connected by a more strongly developed overlying soil. This distinction becomes important when trying to understand the relationship between cultural deposits located in these contexts. Further laboratory testing is required to substantiate the accuracy of field observa-

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Figure 4.5. Pond Creek profile sketches correlated from north (left) to south (right) as recorded in 2005. Four buried former surfaces (A horizons) are manifest in these profiles.

tions, including pH, and percent total and organic carbon. Lab methods could answer many of the lingering questions from this study and should be conducted at some point in the future. To help with these answers, particle size analysis was conducted on close interval samples collect from one column (Profile A). The results of this analysis are presented below.

Bulk soil samples were taken from the top ten centimeters of each buried soil in Profile A. From those samples, three were submitted to the National Science Foundation (NSF) Arizona AMS Facility at The University of Arizona for radiocarbon analysis. Despite the likelihood of being very recent, we decided to date the first buried soil. In doing so, we hoped to test Morgan's seemingly early date of  $120 \pm 70$  B.P. from the second buried soil (2Ab). The concern was whether 120 years would be long enough to allow the development of two distinct surface horizons and their subsequent burial. Though each of the two soils in question were weakly developed and lacked a clearly defined B horizon, their presence in the profile indicates two periods of landscape stability long enough to incorporate organic material into an identifiable zone.

Unfortunately, it appears that the sample collected from the first buried soil became contaminated and yielded a surprising radiocarbon age of  $621 \pm 38$  B.P. Further testing may shed more light on this question, but for now it seems reasonable that the increased sedimentation due to historic plowing and agricultural activities contributed to the creation and burial of the first two soils observed at Pond Creek.

A sample from the newly identified 3Ab, as well as the

Pond Creek Paleosol (4Ab), was submitted in an attempt to clarify the chronology of that sequence. As mentioned above, until the 2005 investigations, the third buried soil had gone unrecognized. This is likely due to the striking nature of the immediately underlying Pond Creek Paleosol, making the more subdued third buried soil difficult to discern. Generally, the results of the radiocarbon assays seem to agree with the dates described by Morgan (1994). The third buried soil yielded a date of  $783 \pm 47$  B.P. while the top of the Pond Creek Paleosol resulted in a date of 910  $\pm 38$  B.P.

In addition to the samples taken for radiocarbon dating, a close-interval column was collected from Profile A for the purposes of particle-size analysis. A continuous column was carefully removed 10cm at a time begining at the base of the profile to avoid contamination from overlying sediments. Each sample was subjected to a simplified particle-size analysis (Figure 4.7) by hydrometer method after Gee and Bauder (1979).

In general, the particle-size analysis seems to agree with our observations made in the field. Two major spikes at 47.5cm and 77.5cm in the percentage of silt and clay at the top of the profile correspond to the first two buried soils (1Ab and 2Ab). The relatively similar amounts of silt and clay between 227.5cm and 367.5cm indicate a period of stability and increased pedogenisis and fits nicely with our observation of the Pond Creek Paleosol (4A). The third buried soil, described earlier, is not as easily decernable with these data. A slight rise in the percentage of clay is evident between 187.5cm and 212.5cm despite the dramatic increase in the percent sand. What seems to be clear from the particle-size analysis is that the alluvial regime

	by David Cranford and Elsbeth Dowd.
С	0 to 38 cm, 2.5YR5/8 (red) sandy loam, 2.5YR4/6 (red) when moist; massive structure; loose, slightly hard; not sticky, not plastic; very fine to fine roots common throughout; non-effervescent; gradual smooth boundary; between 5 and 15 cm thick.
lΑ <sub>b</sub>	38 to 59 cm, 2.5YR3/1 (dark reddish gray) silt loam, 2.5YR2.5/1 (reddish black) when moist; weak fine granular structure; friable, slightly hard; moderately sticky, very plastic; very fine to fine roots common throughout; non-effervescent; abrupt smooth boundary; between 0.5 and 2 cm thick.
С	59 to 82.5 cm, 2.5YR4/6 (red) silty clay, 2.5YR4/4 (reddish brown) when moist; massive structure; very friable, hard; very sticky, moderately plastic; very fine to fine roots common throughout; non-effervescent; gradual smooth boundary; between 5 and 15 cm thick.
2A <sub>b</sub>	82.5 to 99 cm, 2.5YR3/3 (dark reddish brown) silt loam, 2.5YR2.5/2 (very dusky red) when moist; weak fine granular structure; friable, slightly hard; moderately sticky, very plastic; few very fine to fine roots throughout; non-effervescent; gradual smooth boundary; between 5 and 15 cm thick.
2B <sub>bw</sub> 1	99 to 118 cm, 2.5YR3/4 (dark reddish brown) sandy clay loam, 2.5YR2.5/3 (dark reddish brown) when moist; weak fine granular structure; firm, very hard; moderately sticky, moderately plastic; few very fine roots throughout; non-effervescent; gradual smooth boundary; between 5 and 15 cm thick.
2B <sub>bw</sub> 2	118 to 138 cm, 2.5YR4/6 (red) sandy clay loam, 2.5YR3/6 (dark red) when moist; weak fine granular structure; firm, very hard; moderately sticky, moderately plastic; few very fine roots throughout; non-effervescent; gradual smooth boundary; between 5 and 15 cm thick.
2C	138 to 179 cm, 5YR4/6 (yellowish red) sandy loam, 2.5YR4/8 (red) when moist; massive structure; loose when moist, loose when dry; not sticky, not plastic; few very fine roots throughout; non-effervescent; gradual smooth boundary; between 5 and 15 cm thick.
3A <sub>b</sub>	179 to 214 cm, 7.5YR4/4 (brown) sandy loam, 7.5YR2.5/2 (very dark brown) when moist; weak fine granular structure; very friable, hard; slightly sticky, moderately plastic; non-effervescent; clear smooth boundary; between 2 and 5 cm thick; boundary demarcated by strong, violently effervescent carbonate layer.
4A <sub>bnk</sub> 1	214 to 264 cm, 10YR3/1 (very dark gray) clay loam, 10YR2/2 (very dark brown) when moist; moderate coarse prismatic structure; very friable, hard; very sticky, very plastic; strongly effervescent; clear smooth boundary; between 2 and 5 cm thick.
4A <sub>bnk</sub> 2	264 to 360 cm, 10YR4/1 (dark gray) clay loam, 10YR2/2 (very dark brown) when moist; moderate coarse prismatic structure; very friable, hard; very sticky, very plastic; strongly effervescent; many carbonate inclusions; diffuse smooth boundary; between 15 and 20 cm thick.
4C	360 to 410+ cm, 5YR6/6 (reddish yellow) sandy loam with many 5YR5/6 (yellowish red) very coarse mottles; 5YR4/6 (yellowish red) with 5YR4/4 (reddish brown) mottles when moist; massive structure; very friable, slightly hard; moderately sticky, slightly plastic; non-effervescent; numerous crotovena.

Table 4.1. Soil Horizon Descriptions from Pond Creek Profile A as Recorded October 22, 2005,



Figure 4.6. Thickness variation in the Pond Creek paleosol (4Ab) between 2005 Profile A (left) and a 2004 profile (right) some 25 meters south.

Lab no.	Uncorrected Ages	Age Ranges	Depth in cm	Stratigraphic location
AA68190	621 ± 38 B.P.	A.D. 1291-1367	45.0-55.0 cm	First buried soil
Beta-71753	120 ± 70 B.P.	A.D. 1760-1900	≈ 74.0-95.0cm	Second buried soil
AA68189	783 ± 47 B.P.	A.D. 1120-1214	190.0-200.0cm	Top of third buried soil
Beta-71754	870 ± 70 B.P.	A.D. 1010-1150	≈182.0-273.0cm	Top of Pond Creek Paleosol
AA68188	910 ± 38 B.P.	A.D. 1002-1078	220.0-230.0cm	Top of Pond Creek Paleosol
Beta-71755	1330 ± 70 B.P.	A.D. 550-690	≈182.0-273.0cm	Bottom of Pond Creek Paleosol
Beta- 218658	3080 ± 40 B.P.	1170-1090 B.C.	≈400+	Gleyed deposit below Pond Creek Paleosol

Table 4.2.	Radiocarbon	<b>Dates from</b>	<b>Buried Soil</b>	Horizons at Pon	d Creek Exposure.

42 **Chapter 4: Geoarchaeological Investigations at Pond Creek** Particle Size Analysis- Profile A % 0 10 20 30 40 50 60 70 80 90 100 0 1Ab 50 2Ab 100 150 E 200 3Ab Depth 250 4Ab % Sand % Clay % Silt 300 350 400 450

Figure 4.7. Particle size analysis results for horizons recognized in 2005 Profile A. Close interval samples were collected every 5.0 cm and subjected to a simplified hydrometer method of particle size analysis. The shaded areas indicate where buried melanized soils were observed in the field.

that supported the Pond Creek Paleosol changed abruptly and began depositing large amounts of sandy sediments. If the radiocarbon estimates are correct, this change took place sometime after AD 1040-1080. After an initial period of sedimentation, a brief period of stability (ca. AD 1170) returned to the Pond Creek area allowing a soil to form on the sandy loam directly on top of the Pond Creek Paleosol. Pedogenisis was significant enough to darken this soil, making it difficult to distinguish from the underlying paleosol, but it was not developed enough to change the structure and composition of the paleosol. The introduction of so much sand points to dramatic erosion occuring on the uplands. The actual cause of this erosion can be argued, but severe drought comes first to mind.

During the work at Pond Creek, a gleyed deposit was identified in a nearby, east-facing cut bank that was stratigraphically below the Pond Creek Paleosol. The deposit consisted of a thick zone of gray sediment with mussel shells preserved within and eroding out of the matrix. This stratigraphic unit did not appear in any of the profiles presented in this study, but it was considered interesting enough to collect samples of the sediments and fossils for dating and identification. A bulk sediment sample was sent to Beta Analytic Inc. for dating while photos (Figure 4.8) of the mussel shells were given to Jim Theler of the University of Wisconsin-La Cross to be identified. According to Theler, the bivalves recovered from Pond Creek were Fat Mucket (*Lampsilis siliquoidea*), a species common to the Missis-



Figure 4.8. Fat mucket (Lapsilis siliquoidea) mussell shell recovered from the gleyed deposit at Pond Creek.

sippi River drainage. This species is normally found in low energy sand/silt substrates in moderate to slow waters (personal communication). The gleyed sediments in which these specimens were collected, yielded a radiocabon assay of 3080 + 40 BP (Beta-218658). This date corresponds well with the oldest date from the Pumpkin Creek profile some 90 miles south (Bollans and Jennings, this volume).

**Paleoenvironmental Reconstruction**. Pond Creek provides us with an alluvial record covering roughly the last 3000 years. Regardless of the presence or absence of cultural material, the soils associated with the Pond Creek drainage reveal clues about the environment and climate experienced by people living on this landscape in the past. Soils indicate periods of landscape stability where plants and animals were active on the landscape, thereby incorporating organic material into the ground as they decayed. Increased biotic activity usually results from an increase in effective moisture while plant growth stabilizes underlying sediments reducing erosion and in turn sedimentation.

Based on the interpretation of the soil profile at Pond Creek, at least four periods of relative landscape stability are represented. Due to the soil's thickness and dark color, the Pond Creek Paleosol indicates a time of prolonged stability and considerable moisture. This is an important consideration when interpreting potential prehistoric settlement and subsistence strategies.

Like Morgan, we feel that the Pond Creek Paleosol is similar temporally and stratigraphically to other paleosols in the region, such as the Copan Paleosol from north-central Oklahoma and the Caddo Paleosol from the southwestern part of the state (Hall 1988; Artz 1985; Ferring 1990, 1992). Hofman and Drass (1990) describe a thick soil horizon they call the Piedmont Paleosol in northwestern Oklahoma County. Waters (1992:58,60) mentions the Asa paleosol along the Brazos River in Texas that formed around 1300 to 500 B.P.. The West Fork Paleosol is another soil in Texas dating to around this time (Ferring 1992:12-13). All told, the evidence suggests that there was a significant period of increased effective moisture leading to soil formation throughout the Cross Timbers and Southern Plains between 2000-1000 B.P.

## **Archaeological Implications**

According to Morgan (1994:37), known archaeological sites near Pond Creek include unidentified prehistoric quarry or workshop sites and a number of historic farmsteads. A file search at the Oklahoma Archeological Survey revealed a total of 107 sites in the 14.7 square miles of the Lexington Wildlife Management area, within the upper drainage basins of Pond Creek, Helsel Creek, and Little Buckhead Creek. These include 35 historic sites, 58 unidentified prehistoric lithic scatters, and 12 sites with mixed historic and unidentified prehistoric components. One late prehistoric site (no more specific date was identified), and a site with

historic and archaic components, based on an early archaic point were found approximately 60 cm beneath the surface. During the survey reported by Morgan, the prehistoric sites were located by pedestrian survey and shovel testing. They could not be dated or assigned to a cultural phase since no diagnostic artifacts were found among the recovered material.

Based on the environmental reconstruction at Pond Creek, we should expect significant use of this locality by prehistoric peoples. The Pond Creek Paleosol indicates a relatively moist climate that would have supported a healthy biomass. Radiocarbon dates for the Pond Creek Paleosol correlate to the Plains Woodland and early Plains Village periods in this region (Morgan 1984:46); however, the terraces created by Pond Creek and other local streams would have buried any sites on the original floodplains from these periods. As pointed out by Mandel and Bettis (2001:182-3), buried soils, especially those representing long periods of stability, should have a relatively high probability of human occupation. Because of the potential for buried deposits, we should expect to find archaeological material in drainages that cut through the Pond Creek Paleosol and other deeply buried soils.

Although the lack of diagnostic artifacts from archaeological periods corresponding to the Pond Creek Paleosol may indicate an absence of habitation from these periods, it may also demonstrate the drawbacks of current testing methods. Traditional pedestrian survey and shovel testing will not locate cultural horizons within deeply buried paleosols. Mandel and Bettis (2001:183-4) have recommended a survey strategy that would use techniques specifically designed to address this issue. First one must determine if there are buried soils present in the survey locality, in order to assess buried site potential. The presence or absence of buried soils and their extent can be determined by walking along stream cut banks and by using a hydraulic coring rig. If present, buried soils should be examined and dated by radiocarbon analysis to establish the potential temporal range for cultural deposits, and then subsurface exploration strategies can be developed. Unfortunately, the use of coring equipment and radiocarbon dating may be cost prohibitive for many archaeologists. At the very least, however, surveyors should attempt to pay closer attention to stream cut banks, and recognize buried site potential implicated by paleosols. The identification of paleosols along the Cross Timbers through new survey techniques has the potential to reveal buried deposits and to expand our understanding of archaeology in this region.

#### Conclusions

The purpose of this study is multifaceted. The 2005 investigations at Pond Creek were intended to help elucidate the local and regional paleoenvironments of the past two thousand years. Understanding what Pond Creek was like in the past will help us understand the people who may

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have lived there. The pedogenic processes that formed the thick paleosols found over such a wide area are still under debate. This study does not provide a resolution to the problem, but we hope to bring attention to the matter so scholars working with similar deposits will not automatically assume a cumulic or other situation. We also echo the caution that many geoscientists have expressed, that at least in the vicinity of Pond Creek, sites older than a couple hundred years are potentially buried under meters of sediment, thus out of reach and out of sight of archaeologists using traditional survey techniques. Without recognizing this bias, interpretations of the archaeological record will be flawed.

Three new dates from Pond Creek will bring the total number of radiocarbon dates for the site to six (Table 2). We imagine that this makes Pond Creek one of the best dated soil sequences in the area. This distinction, we hope, will encourage further study of the site and its soils. There are still significant questions to be answered.

To better understand the geographic range of the Pond Creek Paleosol, and therefore its role in the local environment, it is necessary to document its lateral extent across the drainage. Coring in transects perpendicular to the stream would indicate how widespread the soil is and contribute to the overall knowledge of alluvial regimes at Pond Creek. As mentioned before, lab methods would yield significant insight into the depositional history and pedomorphic processes related to the formation of the paleosols.

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# Chapter 5 Geoarchaeology and Upland Settings Along and Adjacent the Cross Timbers

David J. Cranford

# Introduction

Soil studies can provide many valuable lines of evidence to archaeologists as they struggle to interpret the past. Of these, environmental reconstructions and assessing archaeological site preservation are two of the most important goals in studying soils by archaeologists. The ability to assess site integrity and location can be greatly enhanced when archaeological studies use interdisciplinary approaches. Geoarchaeological studies can enable us to identify the most likely parts of a soil profile to contain archaeological deposits and which geographical settings are more conducive for having preserved contexts. This type of information is particularly important when evaluating the effectiveness of survey techniques or when interpreting site significance with potentially mixed associations.

The reports in this monograph, thus far, have dealt primarily with the archaeological potential of alluvial settings found along lesser streams in the Cross Timbers. Due to the depositional characteristics of alluvial environments in major river valleys, they are usually prime candidates for geoarchaeological studies of this type, though as we know, prehistoric people did not limit their activities to riverine settings.

Upland settings, such as hilltops, were undoubtedly frequented by prehistoric (and historic) people. Campsites placed on these types of landscapes could command strategic views of lowlands, aiding in the tracking of game or communication. In addition, hilltops could provide sanctuary from periodic flooding as well as relief from certain pests, like biting flies and mosquitoes that breed in low-lying areas.

As is evident by the previous chapters, the Cross Timbers region does indeed contain secondary watersheds with significant, and sometimes deeply buried, soil horizons. This chapter and the next will instead deal with stable upland settings and their associated soils. In this section, the main focus will be on what archaeologists might expect to find on typical stable uplands in the Cross Timbers and how those findings affect site formation processes. In the following chapter, Clannahan and Eads report on an unusual hillside locality, Powell Farm, that contains a Pleistocene pond deposit (with Pleistocene vertebrate fossils) and a buried soil.

# **Upland Soil Formation Processes**

What is an upland setting? How are they formed and what do they look like? Although being able to identify this usually obvious landform is important, more essential is understanding the processes at work that form and maintain upland settings. By definition, an "upland" includes any land or area of land of high elevation; though this can be a relative term, it usually refers to landscapes that are not directly adjacent to streams or other bodies of water. Uplands come in all shapes and sizes depending upon multitude factors, including, but not limited to: underlying parent material/ bedrock source, regional geologic history, climatic conditions, topography and hydrology. Hills, terraces, ridges, and escarpments are all specific kinds of uplands, though there are many more landform types that could also be included here.



Figure 5.1. Locations mentioned in text and their positions relative to the historic Cross Timbers. Adapted from A.H. Hanson's map for C.T. Foreman (1947).

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Though it may be intuitive, it is important to mention that not all upland settings contain soils. Soil formation, or pedogenesis, requires specific conditions in order to occur. One of the main factors for the presence of pedogenic soils is landscape stability. Ultimately, soils are created when sediments are chemically and physically altered as a result of weathering (Jenny 1994; Waters 1992), but if sediments are not kept in place long enough to allow these changes, soils will not form. Stability also affects, and is affected by, the amount of plant growth occurring on the surface. Roots hold together sediments reducing erosion while introducing carbon in the form of organics into the soil, thus creating an A horizon (Waters 1992: 41).

As the definition of uplands implicates, elevation and topography are usually distinguishing characteristics of these types of landscapes, and erosion goes hand in hand with them. Erosion is a continual problem for uplands, especially soils and sediments located on hill slopes in the Cross Timbers (Gray and Bakhtar 1973). The processes that move and redeposit upland sediments can be extremely complex, especially when considering hill slopes, where soils are rarely found due to the inherent instability. As such, I will attempt to focus only on stable upland landscapes and the soils that have the potential to arise there. For a detailed discussion of hillslope processes, refer to Selby (1993).

Upland soils usually form from sediments that are derived from underlying bedrock sources that have broken down due to weathering. The main weathering processes that affect level uplands are moisture, frost fracturing, and biomechanical disturbance from plants and especially roots. Moisture, whether from rain, snow, or other means, is essential for soil development as well as also accelerating the decomposion of parent material. Any cracks or fissures that allow moisture to seep into rock faces has a potential for frost action to occur. Roots, over the course of many years, also have significant effects on breaking down bedrock into particles from which soils can form.

Upland settings that do retain soils tend to be uncomplicated and rarely contain paleosols (Figure 5.2), but an exception is Powell Farm described in the next chapter. Uplands vary considerably and statements concerning general characteristics of these types of settings should be kept to a minimum or limited to regional studies.

## Archaeology in Upland Settings

Archaeological remains deposited on upland settings



Figure 5.2. A Pleistocene calcic horizon dipping to the left as exposed in a hillside cutbank adjacent Pond Creek and upstream from the Holocene exposures discussed by Cranford and Dowd in this volvume.

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can be affected by a variety of taphonomic processes. Aeolian sedimentation, erosion and bioturbation seem to be the most common, if not most important, to consider (Frederick et al. 2002; Balek 2002, Johnson 2002). One of the biggest problems for archaeological preservation on upland settings is the general lack of sedimentation. It is common sense that the longer archaeological materials remain on the surface before it is buried, the greater the chances for disturbance. One study, however, has shown that sedimentation of uplands is possible and probable.

Eolian sedimentation has been noted as a significant process affecting some uplands in the Cross Timbers of eastern Texas (Frederick et al. 2002; Wyckoff 1984). Optically stimulated luminescence (OSL) dating was used to calculate the last time sediments were exposed to sunlight (Frederick et al. 2002:192). The results indicated that sediments were open to the elements during parts of the Holocene and periods of eolian deposition covered the uplands, potentially preserving archaeological deposits in their original context.

Bioturbation is a process that is mentioned frequently but rarely is seriously taken into account unless unexpected results require explanation. Numerous researchers have noted the potential effects of earthworms, ants, gophers, etc. on 'stable' uplands (Balek 2002; see Johnson 2002). Their ability to move vast amounts of earth is quite impressive. Plants are also capable of burying objects on the surface (Balek 2002). So even if sedimentation rates are not sufficient enough to bury archaeological remains, artifacts can still become incorporated into the soil by a number of biomechanical processes, distorting their context.

#### Typical Upland Soils in the Cross Timbers

The Cross Timbers were so named by early settlers as they struggled to traverse the vast scrub oak-hickory woodlands in eastern Oklahoma and Texas (Foreman 1947). As such, these oak-hickory forests are supported, for the most part, by well-drained sandy soils derived from the Permianage sandstone that forms the Rolling Red Bed Plains. The Cross Timbers also contain areas that include soils originating from other types of parent materials, such as Cretaceous beach sand of the Comanchean Formation (Figure 5.3). The sandy soils generally represent the in situ weathering and decomposition of these bedrock sources, though eolian accumulations have been shown to also contribute to upland sediments (Frederick et al. 2002).

## **Examples from the Cross Timbers**

Through the course of the investigations for the studies already presented in this manuscript, additional localities were visited to record profiles in a variety of settings, including uplands. Here I will describe three locations across Oklahoma (Figure 5.1) that contained soils in upland settings; Pumpkin Creek, Menzie Farm, and Carter Farm.



Figure 5.3. Geoarchaeology students recording profiles developed on Cretaceous beach sand (Antlers Formation) at archaeological site 34LV49, the Pumpkin Creek site, in Love County. September 24, 2005.

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Two of the locations, Pumpkin Creek and Carter Farm, have associated archaeological deposits but all three demonstrate examples of landscapes that have high potential for prehistoric human use.

**Pumpkin Creek Site (34LV49).** The Pumpkin Creek site profiles discussed in this chapter will refer to an exposure at the archaeological site (34LV49) mentioned earlier in Bollans and Jennings (Chapter 3). In the summer of 1968, two local collectors identified a small, heavily eroded site in Love County, Oklahoma on a north-facing hillside just south of Pumpkin Creek. (Wyckoff and Taylor 1971). The Pumpkin Creek site (34Lv49), as it became known, yielded a variety of bifacially worked stone tools that included many Early Archaic lanceolate and notched projectile points forms as well as scrapers, drills, and flakes.

As mentioned previously, the Pumpkin Creek site is atop the Antlers Formation, the youngest deposit from the Comanchean Sea present during the Cretaceous Period, and specifically the Trinity Group, made up of accumulated beach sand (Hart and Davis 1981; Bullard 1925). The soils associated with the Pumpkin Creek site are derived from these beach sands and are part of the Stephenville-Windthorst complex; a series known for its light-colored and heavily eroded sandy clay soils (Maxwell and Reasoner 1966:25). These types of soils are found predominantly in gently rolling uplands with 1-5% slope.

The Pumpkin Creek profile described in Table 5.1 was recorded in an erosional gully adjacent to the archaeological site (Figures 5.3 and 5.4). Several other profiles were documented at intervals around the lip of the gully and aside from slight variation in horizon thickness, probably correlating with their different locations on the hillside, all soil characteristics were very similar. The horizon sequence was relatively simple; A-B-BC-C. Due to the nature of the soil, the A horizon was predictably thin; only 6 cm thick (Figure 5.4). The B horizon was strongly developed and became increasingly hard as it approached the compacted beach sand (C horizon). The iron concretions identified in the B horizon (see Table 5.1) speaks to the ancient age of the soil. Thus it is highly unlikely that cultural materials would be found at this level. In this case, all archaeological material deposited on the surface since humans were in North America would then be confined to only six centimeters of soil, creating the possibility for significant mixing and post-depositional movement. Sites in such soils would be massively impacted by even shallow plowing. It is not surprising, given the noticeable erosion, that all the cultural material from the Pumpkin Creek site was surface collected (Wyckoff and Taylor 1971).

*Menzie Farm.* The Menzie farm, which is named for the landowners Don and Jane Menzie, is located in southeastern Cleveland County, Oklahoma, not far from the Pond Creek study area (Chapter 4). The geology of the Menzie Farm area is Permian-age sandstone, similar to much of the Cross Timbers region. The soils that formed in these sediments likely weathered in situ from the underlying redbed sandstone.

The soil associations at the Menzie Farm are primarily from the Stephenville-Darsil-Newalla complex, but also include soils defined as gullied Harrah fine sandy loam (Bourlier et al. 1987:19). These profiles are generally well-drained, occur on 3 to 8% slopes, and are deep to moderately deep, though the surface horizon is usually 4-6 inches or less. The Stephenville soil accounts for about 55% of the landscape and is found mostly on ridge tops and some slopes. The Harrah fine sandy loam is especially suseptible to erosion and as much as 10% of the landscape is made up of gullies that range from 2-20 feet in depth (Bourlier et al. 1987:24).

Large gullies at the Menzie Farm have created prominent exposures on the landscape, revealing a relatively simple, but well-developed upland soil (Figure 5.4). Here, like Pumpkin Creek, the soil horizons are straightforward and uncomplicated consisting of only an ochric A horizon and a heavily argillic subsurface (B) horizon (Table 5.2). Distinct clay films were observed on the coarse, angularblocky peds beginning around 28.0 cm below the surface suggesting the incredible time needed to form the horizon. Though the exact amount of time required to produce an argillic horizon such as the one at Menzie Farm is unknown, it is believed by geologists, pedologists and archaeologists that these zones are of Pleistocene age and therefore most likely lack subsurface archaeological deposits (Frederick et al. 2002:192). While no archaeological remains were documented at the Menzie Farm, if present, cultural material no doubt would be confined to the sandy surface horizon where slope erosion and biogenic disturbance would be rampant, thus greatly reducing a site's contextual integrity. This locality is important since it represents a soil profile likely to be found in uplands across much of the Cross Timbers region.

*Carter Farm.* The Carter Farm refers to property owned by Dr. Brian Carter of Oklahoma State University (OSU). Carter is a soil scientist at OSU and periodically takes his own students, and others, to the farm to practice field recording techniques. The farm, which is located in Payne County, Oklahoma, contains several diverse types of soils within a relatively small area, making it well suited to educational purposes.

The soil regimes found on the Carter Farm differ from the two previous localities. The first profile is near an old historic cabin and contains a dark, humic midden believed to be used as a garden at one time (Table 5.3). In fact, as one of the profiles was being cleaned and recorded, a white-ware sherd was identified at the base of the shallow



Figure 5.4. Pumpkin Creek site soil profile described in Table 5.1. Photo taken September 24, 2005, by Don Wyckoff.

# Table 5.1. Profile Description at the Pumpkin Creek Site (34LV49), An Upland Setting in Love County, Oklahoma. Recorded by David Cranford and Elsbeth Dowd on September 24, 1005.

A	0 to 6.0cm, 10YR6/6 Dark yellowish brown (dry), 10YR4/4 Brownish yellow (moist); sandy loam; moderate, medium, angular blocky structure; slightly hard, very friable, slightly sticky, moderately plastic; non-effervescent; clear, smooth boundary; common fine and few medium roots.
Btc	6.0 to 26.0cm, 5YR4/6 Yellowish red (dry/moist); sandy clay; strong, coarse, angular blocky structure; very hard, firm, sticky, very plastic; non-effervescent; distinct clay films; clear, smooth boundary; common fine and few medium roots; iron concretions present >0.5cm.
2Btc	26.0 to 62cm, 7.5YR5/6 Strong brown (dry), 7.5YR4/6 strong brown (moist); sandy clay; moderate, very coarse, angular blocky structure; very hard, firm, sticky, very plastic; non-effervescent; faint clay films; gradual, smooth boundary; few medium roots, common iron concretions 0.5 -1.5 cm.
BC	62.0 to 138.0cm, 5YR5/8 yellowish red mottled with 5YR8/3 pink (dry), 5YR5/6 yellowish red mottled with 5YR8/3 pink (moist); sandy clay; moderate, very coarse, angular blocky structure; extremely hard, firm, sticky, very plastic; non-effervescent; diffuse smooth boundary; few medium roots; few iron concretions.
С	138.0 +, 10YR8/6 brownish yellow (dry), 10YR6/6 yellow (moist); sand; massive structure; very hard, very friable, slightly sticky, not plastic; non-effervescent; few roots.

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Figure 5.5. Upland soil profile at the Menzie Farm in Cleveland County, Oklahoma. A sandy ochric epipedon overlies a well developed argillic subsurface horizon. Note scrub oak common to Cross Timbers in background. Photo taken September 11, 2005, by Don Wyckoff.

Table 5.2. Profile Description at the Menzie Farm Upland Setting, Cleveland County, Oklahoma.

A	0.0-28.0 cm, 7.5YR6/4 Light brown (dry), 7.5YR4/6 Strong brown (moist); sandy loam; weak, fine, granular structure; soft, very friable; non-sticky, non-plastic; non-effervescent; clear, smooth boundary, common fine roots.
Btn	28.0-105.0+cm, 2.5YR4/6 Red (dry), 2.5YR4/8 Red (moist); Sandy clay; strong, coarse, prismatic to angular blocky structure; very hard, friable; slightly sticky, very plastic; non-effervescent; distinct clay films; few coarse roots.

# plow zone (Figure 5.5).

50

leach iron and other elements from the soil.

# Conclusions

The other soil recorded at the Carter farm is unlike any of the other described here so far, yet is similar to those described by Frederick et al. (2002) for other parts of the Cross Timbers (Table 5.4). Like those soils illustrated in Frederick et al. (2002), eolian sedimentation plays a more significant role at this location than in situ weathering of bedrock sources. The organic debris on the surface and lighter colored E horizon testify that the soil is, and has been, directly associated with a wooded forest environment, which contributes leaf litter and tannic acids that

Several important insights should be taken from this brief discussion of soils in upland settings. First of all, each location, site, or profile must be considered individually. Considerable differences in soil profiles can occur even within the same site or general geographic setting. Second, not every upland will be stable enough to allow pedogenesis to occur. If a slope is not stable enough to support a soil, the chances are high that erosion is a significant factor at that location, and must be acknowledged in evaluating



Figure 5.6. Profile #1 at Carter Farm, Payne County, Oklahoma. The thickened melanized surface horizon is mainly 19th century midden.

Table 5.4. Description of Profile #1, Carter Farm, Payne County.

Recorded by David Cranford and James Clanahan,

	September 17, 2005.
A <sub>p</sub>	0.0 to 20.0cm, 7.5YR4/2 (brown) fine loamy sand, 5YR2.5/2 (dark reddish brown) when moist; weak very fine granular structure; slightly hard, very friable; non-sticky, slightly plastic; non-effervescent; common fine and medium roots; clear smooth boundary; 1 White ware sherd found near boundary; 20cm thick.
A <sub>1</sub>	20.0 to 35.0cm, 7.5YR4/3 (brown) very fine sandy loam, 5YR3/2 (dark reddish brown) when moist; weak fine granular structure; hard, friable; non-sticky, moderately plastic; non-effervescent; few fine and medium roots; abrupt wavy boundary; 15cm thick.
B <sub>t</sub>	35.0 to 53.0cm, 5YR4/3 (reddish brown) sandy clay loam, 5YR4/6 (yellowish red) when moist; strong fine granular structure; hard, firm; slightly sticky, very plastic; non- effervescent; few fine and medium roots; faint clay films; gradual smooth boundary; I8em thick.
B <sub>12</sub>	53.0 to 67.0cm, 5YR4/6 (yellowish red) sandy clay, 5YR4/4 (reddish brown) when moist; moderate medium angular blocky structure; very hard, friable; moderately sticky, very plastic; non-effervescent; distinct clay films; few fine and medium roots; clear smooth boundary: 14cm thick.
B <sub>d</sub>	67.0 to 93.0cm, 2.5YR4/6 (red) sandy clay, 2.5YR4/6 (red) when moist; moderate, medium angular blocky structure; very hard, friable; moderately sticky, very plastic; non-effervescent; few roots; abrupt smooth boundary; 26cm thick.
B/C	93.0 to 115.0+em, 2.5YR4/6 (red) sandy clay; massive structure; very hard, firm; moderately sticky, very plastic; slightly effervescent.

site integrity.

Rates and types of sedimentation will also vary from location to location. If archaeological deposits are discovered in upland sediments, caution should be used when interpreting the integrity of the site's context. As mentioned above, bioturbation, erosion, and a lack of sedimentation can contribute to artifact movement and/or mixing, though eolian deposition on uplands has the potential to preserve archaeological deposits.

The examples described in this chapter are meant to convey what some upland soils might look like in the Cross Timbers and to show that variation does exist. Upland soils found in the Cross Timbers area are relatively simple, consisting of thin surface horizons with usually well-developed



Figure 5.7. Profile #2 at Carter Farm, Payne County, Oklahoma. A pronounced E horizon is manifest 13 cm below the surface.

Table 5.5. Description of Profile #2, Carter Farm, Payne County, Oklahoma. Recorded by David Cranford and James Clanahan on September 17, 2005.

Ĩ	<b>O</b> ,	0.5 to 0.0cm, slightly decomposed organic material; abrupt, smooth boundary.
	A	0.0 to 13.0cm, 7.5YR5/2 (brown) sandy loam, 7.5YR3/2 (dark brown) when moist; weak, very fine granular structure; soft, very friable: non-sticky, non-plastic; non-effervescent; many fine and very fine roots; abrupt smooth boundary.
	Е	13.0 to 38.0cm, 7.5YR5/3 (brown) loamy sand, 7.5YR 4/4 (brown) when moist; weak, very fine granular structure; soft, very friable; non-sticky, non-plastic; non-effervescent; few modium and very coarse and many fine and very fine roots; abrupt smooth boundary.
1	В,	38.0 to 48.0cm, 7.5YR4/6 (strong brown) sandy clay loam, SYR4/4 (reddish brown) when moist; moderate fing granular structure; hard, firm; slightly sticky, slightly plastic; non-effervescent; few medium roots; clear smooth boundary.
	B <sub>12</sub>	48.0 to 70.0cm, 7.5YR4/6 (strong brown) sandy clay, 5YR4/6 (yellowish red) when moist; strong fine granular structure; very hard, very firm; sticky, very plastic; non- effervescent; few very coarse and medium roots; clear smooth boundary
	Ç	70.0 to 80.0+cm, 7.5YR5/6 (strong brown) sandy elay, 7.5YR4/6 (strong brown) when moist; massive structure; very friable, hard; slightly sticky, plastic; non-effervescent; very, few coarse route;

argillic B-horizons indicating significant, long-term stability. Due to the old age of these Bt horizons, archaeological remains, if present, are not expected to be found below the surface A horizon.

#### Acknowledgments

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# Chapter 6 The Powell Farm Hillside Paleosol

# James W. Clanahan and Jason Eads

# Introduction

In 1949, a recently built farm pond on the Powell farm in western Canadian County (Figure 6.1) was discovered not to be functioning as intended. Upon investigating the situation, the landowner saw that fossil bones were eroding out near the west end of the dam axis. In August of 1949, Dr. J. Willis Stovall, geologist-paleontologist at the University of Oklahoma, visited the site. Accompanied by students Jim Connell and Larry Baker, Dr. Stovall undertook recovery of the bones and succeeded in plaster-jacketing bones of mammoth, horse, and camel. These were returned to the University of Oklahoma's Museum of Natural History and soon forgotten. Dr. Stovall unfortunately died in 1953 and the fossils were set aside without ever being cleaned and studied. The find is located just northwest of the historic extent of the Cross Timbers (Figure 6.2).



Figure 6.1. Location of Canadian County within present Oklahoma.

During recovery of the bones at Powell farm, a small flint biface (Figure 6.3) was reportedly unearthed and given to a young boy, Frank Waller, who periodically brought fresh, cool water to the excavators. Again reportedly, Dr. Stovall gave the artifact to the boy, noting "You'll never find anything older than that!"

Around 1998, stories of the fossils and the artifact were brought to the attention of archaeologists and paleontologists at the Sam Noble Oklahoma Museum of Natural History (SNOMNH), the descendant institution of the University's old Museum of Natural History. As a consequence, preliminary investigations were undertaken at the location, now called Powell Farm, in an effort to identify where the fossils and artifact were found; to determine if all occurred together and, if so, to assess the age of the deposit that originally contained them. In January of 1999, a series of 32 cores were taken using a Bull probe by Don Wyckoff and Nick Czaplewski of SNOMNH. As a result, they determined that a gleyed lacustrine deposit was buried in a hill-



Figure 6.2. Location of the Powell Farm Exposure relative to the historic Cross Timbers. Adapted from A.H. Hanson's map for C.T. Foreman (1947).

side on both sides of the modern pond where the bones were originally found. This modern pond blocks a draw which drains about 40 acres to the north. A sample of the buried gleyed deposit was submitted for radiocarbon dating, and it yielded a result of around 21,000 years ago. Water screening of the gleyed sediment yielded small bones of muskrat, fish, and an amphibian, implicating that the sediment most probably had been a constant water source (Czaplewski, personal communication). No traces of a human presence were found in any of the cores taken in 1999.

Interest in the Powell Farm exposure, as it came to be called, waned until 2004. Then, Nick Czaplewski inadvertantly discovered the plaster jacketed bones recovered by Stovall and his students in 1949. These bones were among a number of miscellaneous fossils of uncertain provenience. That they could be identified as coming from the Canadian County fossil find was made possible because they were marked "ER-49", code for El Reno (the nearby town) and 1949. Upon cleaning the bones, they were

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Figure 6.3. The chipped stone biface (of Alibates flint) purportedly recovered during 1949 excavations of Pleistocene fauna at Powell Farm, Canadian County. Photo courtesy of Don Wyckoff and Meredith Sheets.

identifiable as elements from mammoth, horse, and camel. A 1949 newspaper account also listed ground sloth being discovered (Figure 6.4), but this identification was in error because there were fragments of a giant turtle. Also, a juvenile mastodon tooth was identified among the fossils.

In 2005, Wyckoff and Czaplewski returned to the site

with Dr. Brian Carter, soils scientist and geomorphologist at Oklahoma State University. Using a Livingston coring rig, they were able to sample and retrieve 40 cores approaching 20-30 feet in lenth from the hillside on both sides of the modern pond. Besides further substantiating the existence and exent of the gleyed sediments to an iceage pond, these cores revealed that ancient soils were also buried in the hill slope.

Modern erosion in the draw, now down cutting into this hill slope, revealed the upper part of the ice-age pond as well as traces of a buried soil almost directly above it. Because buried soils in association with ice-age deposits are virtually unknown along or near the historic Cross Timbers, we undertook a detailed study of the profile visible on the east side of the modern draw and pond. Our focus was to document and characterize the buried soil and its relationship to the gleyed sediments representative of the ice-age pond. Because the latter is currently the focus of research by Drs. Carter, Wyckoff, and Czaplewski, our goal is to report only the nature of a soil formed since ice-age times and exposed in a hillside near the historic Cross Timbers.

# **Area Description**

Canadian County comprises 891 square miles of central Oklahoma (Figure 6.1). The climate for Canadian County is moist sub-humid with warm summer temperatures that can become uncomfortably hot and winters that are generally moderate with brief periods of freezing temperatures with occasional snow. Precipitation averages about 29 inches for Canadian County (Mogg et al. 1960). The North Canadian valley is the primary drainage system. The North

Figure 6.4. September 8, 1949, Reno American newspaper article on the fossil finds at Powell Farm in Canadian County. Note a young Frank Waller seated at the left.



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Canadian valley alluvium is the primary water supply with a depth of 27 feet (Mogg et al. 1960). Powell Farm is located approximately six miles southwest of Calumet, Oklahoma, and is part of the Central Redbed Plains (Morris et al. 1976). The man-made pond at Powell Farm takes advantage of the natural terrain created by the Powder Face Creek drainage, which drains into the South Canadian River. The Canadian River, with the North Canadian, is the longest tributary of the Arkansas River. The southern boundary of Canadian County is formed by the Canadian River to which Powder Face Creek flows.

The soil series designated by the soil survey of Canadian County for the site located on Powell Farm is not representative of what was recorded in the profiles for this project. According to the soil survey, the soil series that should be found along Powder Face Creek and the site location is the Quinlan-Rock outcrop complex. The description for the Quinlan-Rock outcrop complex refers to moderately steep-to steep soils over sandstone (Permian) outcrops, with Quinlan soils on the crests and side slopes (Fisher and Swaford 1976).

Another soil series identified just outside the creek bottom is the Norge series. The Norge series is made up of gently sloping soils on the uplands, forming with cover made up predominantly of grasses and in material weathered from loamy sediments. Fisher and Swaford (1976) provide a description of a representative profile that includes a dark-brown surface layer of silt loam approximately 10 inches in thickness with the upper 5 inches of the subsoil being dark brown silty clay loam. The layer directly below the dark-brown surface layer contains reddish-brown silty clay loam and underneath that is a layer that is yellowishred silty clay loam (Fisher and Swaford 1976). Two of the soil types identified in the immediate proximity to the creek bottom are from the Norge Series. They are both identified as Norge silt loam but differ on the degree of slope: Norge silt loam (NrB) has a 1 to 3 percent slope whereas the Norge silt loam (NrC) has a 3 to 5 percent slope (Fisher and Swaford 1976). The profiles described here show that the Norge soil series is more representative of what is found at the Powell Farm site. There, the standard Norge soil series is interupted by the presence of the buried soil that rests directly above the gleyed pond deposit. A state soil map recently developed by Carter (1996) has Powell Farm located in an area designated as predominated by Pond Creek, Norge, Minco, Lovedale, Bethany mollisols.

#### **Methodology and Analysis**

Understanding what soils can reveal about site formation processes, landscape development, and past environments is essential to creating a more complete picture of the past. The development of a soil requires long periods of time and a relatively stable land surface, creating a zone in which human activities are more likely to be preserved (Mandel and Bettis 2001). A buried soil is identified in the four profiles from Powell Farm, suggesting a period of stability between depositional events. Soil horizons generally follow the land surface, and are characterized by several attributes, including color, texture, consistency, soil structure, nodules or concretions, voids, reaction to hydrochloric acid (effervescence), and boundary characteristics (Mandel and Bettis 2001). Soil samples were taken from two of the profiles at Powell Farm for radiocarbon testing. Archaeologists can identify areas that are more likely to contain archaeological materials when they have knowledge of the temporal and spatial patterns of buried soils (Mandel and Bettis 2001).

The Wisconsin-age pond deposit at Powell Farm is located east and west of a historic pond. The cores taken in May and June of 2005 documented the extent of the ancient pond deposit and determined that the eastern margin extends east and northeast from the modern pond(Figure 6.3). The pond deposit is approximately 1 to 3 meters below the surface on a hill slope. The ice-age pond deposit is exposed by a cut bank extending 20 meters slightly parallel north and south to the historic pond. Three profiles were excavated into the cut bank, exposing the stratigraphy and making it possible identify the ancient pond deposit and the overlying buried soil. The profiles are labeled North (N), Middle (M), and South (S; Figure 6.5). This southern profile was some 3 meters in length and the north end was considered profile 3 whereas the south end was considered profile 4. This long South profile was recorded in order to see how the pond deposit sloped due to erosion. Picks and shovels were used to expose the profiles, followed by knives and other implements to remove peds so that the structure of the soil could be determined. Soil colors were determined using Munsell soil color charts. Texture, structure, consistency, and pH were field judged using the Field Book for Describing and Sampling Soils version 2.0 published by the National Soil Survey Center. A 10% mixture of HCL was used to test the chemical response of the soils and presence of carbonates. In addition, a scaled drawing was made of each profile.

#### Results

Profile 1 had a total depth of 180 cm with an A horizon that is a weakly formed mollic epipedon, resting on a C horizon (Figure 6.4). The A horizon is a fine, granular, red loamy sand. No B horizon is present due to the suspected young age of the A horizon (Table 6.1). The focus of the research presented here is the buried A horizon that is directly below the C horizon. The buried A horizon is a coarse, sub-angular blocky, sandy clay that is described as dark grayish brown in color. The pond deposit is located directly below the buried A horizon and is described as a very course, angular blocky clay that is light brownish gray in color. Krotovinas appear throughout the A and C horizons.

The ice-age pond deposit has been radiocarbon dated



Figure 6.5. Powell Farm location topographic map showing Profiles N, M, and S of 2006 field study. Also shown are the locations of Giddings probe cores taken during a combined Oklahoma University and Oklahoma State University field project in May of 2005. Illustration courtesy of Don Wyckoff.

to 22,050  $\pm$  150 years (Beta-117166; Wyckoff and Carter 2005). Gleyed deposits, like those found at Powell Farm, result from poor water drainage, resulting in low oxygen content, creating reducing conditions that form iron and manganese compounds. These iron and manganese com-

pounds create the gray or bluish colors of the gleyed sediments. Mottling of gleyed deposits occurs when the water table fluctuates, producing varying oxidizing and reducing conditions (Rapp and Hill 1998). Several aquatic gastropods were recovered from the pond deposit, and these are



Figure 6.6. Closeup view east of Profile 1 (N in Figure 6.5). A melanized buried soil horizon is visible just above the irregular boundary of the gleyed Pleistocene pond deposit. The scale is in 10 cm increments. Photot taken October 8, 2005, by Don Wyckoff.

Table 6.1. Horizon Descriptions for Powell Farm Exposure Profile 1 by James Buchanan and Jason Eads, October 8, 2005.

Horizon	Depth	Field Descriptions
А	0.0 to 28.0 cm	5YR3/3 (dark reddish brown) sandy loam, 5YR4/4 (reddish brown) when moist; weak, fine granular structure; loose, non-sticky, non- plastic; many fine roots; non-effervescent; abrupt, smooth boundary.
С	28.0 to 84.0 cm	2/5YR4/6 (red) loamy sand, 5YR4/6 (yellowish red) when moist; weak, fine granular structure; loose, non-sticky, non-plastic; many fine roots; non-effervescent; abrupt, smooth boundary.
A <sub>b</sub>	84.0 to 101.0 cm	5YR4/6 (yellowish red) silty clay, 5YR4/4 (reddish brown) when moist; weak, fine granular structure; loose, non-sticky, non-plastic; non-effervescent; abrupt, smooth boundary.
CB <sub>k</sub>	101.0 to 173.0+ cm	Gley 1 6/10Y (greenish gray) clay, gley 1 7/10Y (light greenish gray) when moist; moderate, medium sub-angular blocky structure; slightly hard, friable; very sticky, very plastic; very effervescent; many calcium carbonate nodules, gastropods; yellow oxidation mottling (122-173+).

currently being analyzed by Luther Leith of the Sam Noble Oklahoma Museum of Natural History. It may be possible to generate precipitation and temperature trends by studying the gastropods preserved in the soils (Mandel and Bettis 2001). The pond deposit also contained calcium carbonate nodules, creating a very effervescent response. The evidence recovered bears witness to the prehistoric conditions that once existed at this location.

Similar to Profile 1, Profile 2 has a weakly formed mollic epipedon on the surface, resting on a C horizon (Figure 6.5). The total depth of the profile is 180 cm. The A hori-

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Figure 6.7. Looking east at Profile 2 (Middle Profile in Figure 6.5). This face has been picked to reveal the structure of the respective soil horizons. Note the gleyed Pleistocene pond deposit at the bottom. Photo taken October 8, 2005, by Don Wyckoff.

Table 6.2. Horizon Descriptions for Powell Farm Exposure Profile 2 by Nicholas Beale and Mike McKay, October 8, 2005.

Horizon	Depth	Field Description
A	0.0 to 30.0 cm	7.5YR3/4 (dark brown) silt loam, 7.5YR4/3) when moist; weak, fine granular structure; soft, very friable; non-sticky, non-plastic; many roots; non-effervescent; clear, smooth boundary.
С	30.0 to 83.0 cm	2.5YR4/6 (red) loamy sand, 2.5YR4/8 (red) when moist; weak, fine granular structure; soft, very friable; non-sticky, slightly plastic; few roots; few krotovinas; non-effervescent; clear, smooth boundary.
2AB <sub>b</sub>	83.0 to 105.0 cm	10YR4/2 (dark brown) sandy clay, 10YR4/3 (brown) when moist; moderate, coarse sub-angular blocky structure; slightly hard, very friable; moderately sticky, very plastic; few roots; non-effervescent; abrupt, wavy boundary.
CBk	105.0 to 180.0+ cm	2.5YR6/2 (light brownish gray) clay, 2.5Y7.2 (light brownish gray) when moist; strong, very coarse angular blocky structure; slightly hard, friable; sticky, very plastic; calcium carbonate nodules; gastropods; very effervescent; gleyed.

zon is fine, granular, dark reddish brown sandy loam (Table 6.2). The C horizon below the A is fine, granular, silt clay that is yellowish red. The pond deposit for this profile begins at approximately 105 cm. The ice-age pond deposit below the C horizon was determined to be a greenish gray, medium sub-angular blocky clay. This judgment is not in agreement with other profiles for this study. However, it

is important to remember that the profiles completed in this study are field judgments and will require laboratory work to determine the exact soil properties. Krotovinas were present in the bottom of the C horizon, the buried A, and the ancient pond deposit. This latter displayed yellow oxidation mottling from 122cm to the base. In addition to the mottling, calcium carbonates and aquatic gastropods



Figure 6.8. View east of Profile 3 (South Profile in Figure 6.5). This shows the melanized, potential buried A horizon over the south dipping Pleistocene pond deposit manifest in this southernmost exposure. The south dipping character is believed due to erosion of the ice-age pond sediment at some time after its deposition. Photo taken October 8, 2005, by Don Wyckoff. Scale is in 10 cm increments.

	2003.	
A	0.0 to 20.0cm, 5YR3/4 (dark reddish brown) loamy sand, 5YR4/4 (reddish brown) when moist; weak, very fine, granular structure; soft, very friable; slightly sticky, slightly plastic; many fine roots; non-effervescent; clear, smooth boundary.	
B <sub>t</sub>	20.0 to 43.0cm, 2.5YR** (red) loamy sand, 2.5YR4/6 (red) when moist; moderate, very fine, granular structure; loose, very friable; slightly sticky, slightly plastic; few fine roots; non-effervescent; gradual, smooth boundary.	
B <sub>t2</sub>	43.0 to 69.0cm, 5YR4/6 (yellowish red) loamy sand, 5YR4/6 (yellowish red) when moist; moderate, very fine granular structure; loose, very friable; sticky, slightly plastic; few fine roots; non-effervescent; abrupt, smooth boundary.	
2A <sub>b</sub>	69.0 to 76.0cm, 2.5YR6/2 (light brownish gray) sandy loam, 5YR5/2 (reddish gray) when moist; moderate, very fine granular structure; soft, very friable; slightly sticky, plastic; few fine roots; non-effervescent; clear, smooth boundary.	
CB <sub>k</sub>	76.0 to 95.0cm, 2.5Y6/2 (light brownish gray) sandy loam, 2.5Y5/1 (gray) when moist; massive structure; hard, friable; slightly sticky, plastic; many carbonate nodules; slightly effervescent; clear, smooth boundary; gleyed.	
CB <sub>k2</sub>	95.0 to 159.0cm, 2.5Y6/2 (light brownish gray) sandy loam, 2.5Y4/2 (dark grayish brown) when moist; massive structure; hard, friable; slightly sticky, plastic; many carbonate nodules; strongly effervescent; abrupt, smooth boundary; gleyed.	
CB <sub>k3</sub>	159.0 to 166.0cm, 5Y5/6 (olive; moist) sandy loam; massive structure; hard, friable; slightly sticky, plastic; many carbonate nodules; strongly effervescent; abrupt, smooth boundary; gleyed.	
CB <sub>k4</sub>	166.0+cm gley1 4/1 (dark greenish gray; moist) sandy loam; massive structure; hard, friable; slightly sticky, plastic; few carbonate nodules; strongly effervescer abrupt, smooth boundary; gleyed.	

# Table 6.3. Horizon Descriptions for Profile 3 (north half of Profile S in Figure 6.5) by Elsbeth Dowd, October 8, 2005

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Table 6.4.	Horizon Description	s for South Half	of Profile 3 (South	Profile in Figure
	6.5) at Powell Farm.	<b>Description by</b>	Abbie Bollans and	Tom Jennings,
	October 8, 2005.			

Α	0.0 to 18.0cm, 7.5YR3/4 (dark brown; moist) sandy loam; weak, fine granular structure; soft, very friable; non-sticky, non-plastic; no roots; non-effervescent; clear, smooth boundary.	
BC	18.0 to 98.0cm, 7.5YR3/4 (dark brown; moist) loamy sand; weak, fine granular structure; soft, very friable; non-sticky, non-plastic; no roots; non-effervescent; abrupt, wavy boundary.	
2A <sub>b</sub>	98.0 to 113.0cm, 5YR4/6 (yellowish red; moist) loamy sand; weak, fine granular structure; soft, very friable; non-sticky, non-plastic; no roots; non-effervescent; abrupt, wavy boundary.	
2CB <sub>k</sub>	113.0 to 143.0cm, 2.5YR6/2 (light brownish gray; moist) sandy loam; weak, very fine sub-angular blocky structure; slightly hard, friable; slightly sticky, slightly plastic; very effervescent; abrupt, wavy boundary; mottled with 15% 2.5Y5/4(yellow); gleyed.	
2CB <sub>k2</sub>	143.0 to 170.0+cm, 2.5YR6/2 (light brownish gray; moist) sandy loam; weak, very fine sub-angular blocky structure; slightly hard, friable; slightly sticky, slightly plastic; very effervescent; very abrupt, wavy boundary; mottled with 40% 2.5Y5/4(yellow); gleyed.	

were discovered throughout the pond deposit, and, again, the acid test proved that the pond deposit was very effer-vescent.

Profile 3 had a total depth of 176 cm (Figure 6.6). The A horizon in this profile measures 20 cm a difference of 10 cm from Profile 1 to Profile 3, suggesting that erosion has eliminated some of the deposit (Table 6.3). The A horizon is very fine, granular sandy loam that is reddish brown in color. In Profile 3, the pond deposit starts at 76 cm below the surface, suggesting the possibility of more than one episode of deposition. The first deposition would be from 76 cm to 95 cm, and is described as very fine, sub-angular blocky, gray, sandy loam. The second possible is from 95 cm to 159 cm and is also a very fine, sub-angular blocky, sandy loam, but is described as dark grayish brown. A reduction-oxidation horizon from 159 cm to 166 cm was recorded and described as a sandy loam that was olive in color. Unfortunately, structure and consistency were not recorded for this horizon. The third possible deposition is from 166 cm to 176 cm, and it is a very fine sub-angular blocky, sandy loam that is described as dark greenish gray.

Profile 4 had a total depth of 143 cm with an A horizon that measured only 18 cm in thickness, a difference of 12 cm from Profile 1, again indicative of erosion (Figure 6.6). The A horizon is a fine, red, granular loamy sand, resting above a C horizon (Table 6.4). The C horizon is fine, red, granular loamy sand with the buried A underneath. The buried A is a fine, yellowish red, granular loamy sand. The pond deposit in this profile may have two possible depositional episodes. The first deposition measures from 113 cm to 143 cm, and it is very fine, light brownish gray, subangular blocky sandy loam. The second possible deposition is from 143 cm to 155 cm and is very fine sub-angular blocky light brownish gray, sandy loam. The degree of mottling in this profile is an indication of weathering due to fluctuating ground water levels.

#### **Interpretations and Discussion**

After looking at the profiles it is possible to determine that erosion is occurring, which is indicated by the decreasing thickness of the buried A horizon. The C horizon was relatively consistent through each profile with only minor variances due to field judging. The buried soil that occurs between the C horizon and the pond deposit was essential to formulating a chronological sequence. Samples were taken from profiles N and M of the buried A horizon for radiocarbon dating and sent to the Institute of Geological and Nuclear Sciences Limited in New Zealand. The results provided a date of 4,337 + 35 years BP (NZA-23712). The presence of the buried A horizon with an average of 12cm thickness indicates that a period of relatively stable environmental conditions did exist. The date provided by the buried A horizon and that from the pond deposit make possible a chronology for future archaeological research. This site is important because it shows some of the environmental conditions on the Southern Plains during the

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Wisconsinan glaciation. The bone bed in the pond deposit provides a glimpse into the type of fauna that prospered in this environment. Unfortunately, floral remains have not been preserved in this setting due to the water fluctuating through the pond deposit. It remains unclear whether or not the chipped stone biface found west of the historic pond was associated with the bone bed, though, in all likelihood, it probably originated from teh 4000 year-old soils and not the ice-age pond deposit. However, the dates provided here will make it possible to place any future discoveries in a chronological framework.

Powell Farm is significant because it is the furthest east a Wisconsinan full-glacial pond deposit has been found in Oklahoma. Numerous Wisconsinan pond deposits are located in northwestern Oklahoma, containing various faunal remains and some lithic artifacts. The one artifact (Figure 6.3) from Powell Farm is an elliptical biface that reportedly was from the bone bed, but if and how it came to be among the megafaunal remains again is unknown.

The buried soil, pond deposit, and gastropods found at Powell Farm offer an glimpse of past environmental conditions in a chronological framework. The information from Powell Farm combined with that from other locations such as the studies presented earlier in this monograph can provide researchers with a picture of the ancient conditions on a regional scale. These indicators of prehistoric climatic conditions offer a more complete picture for future research.

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# Chapter 7 Geoarchaeological Investigations at Rattlesnake Slough (34GR4) Southwestern Oklahoma

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#### Introduction

The Rattlesnake Slough (34GR4) site is located along the western bank of Lake Altus, Greer County, Oklahoma (Figure 7.1). In 1946, this section of the North Fork of the Red River was dammed to provide water for irrigation and recreational activities (Burton and Burton 1971). The area was not surveyed for cultural resources until after construction of the reservoir in 1968. Burton and Burton (1971) discovered in their reconnaissance survey a total of 19 sites with artifacts dating from Paleoindian through the Historic period. Since the original survey, archaeological work has focused on salvaging Woodland and late Prehistoric-age human burials exposed by wave action along the lake's shoreline (LeVick and LeVick 1966; Schneider 1967; Owsley et al. 1989).

Unfortunately, over the past 60 years very few attempts have been undertaken to conserve the abundant archaeological resources or to conduct excavations to recover artifacts in context before the fluctuating lake levels destroyed the integrity of sites. The best record from Lake Altus is a well-documented archaeological collection compiled by Lawrence and Gene LeVick (Moe 2009). The LeVicks began monitoring and collecting artifacts from Lake Altus sites in the late 1950s (Hurst and Wyckoff 2007). Artifacts were organized by site number designations. The diligence of the LeVicks preserved a portion of the archaeological record that would have been otherwise lost to erosion (Hurst and Wyckoff 2007; Moe 2009)).

As part of a study to examine the development of hunter-gatherer identity-based territories during the early Holocene period on the Southern Plains (Hurst 2007), late Paleoindian projectile points from the LeVick collection were examined. The largest portion of their collection is derived from the Rattlesnake Slough (34GR4) locality, from which they collected a total of 28 late Paleoindian projectile points (Figure 7.2). A subsequent visit was made to Rattlesnake Slough with the LeVicks to ascertain the potential for buried soils to provide an early Holocene context for the projectile point finds. On the visit several laterally exposed buried soils along the shoreline were observed. Clearly, the Rattlesnake Slough locality provided an opportunity to examine a potential early Holocene context, which is vital for further defining the chronological relationship between late Paleoindian projectile point styles (Holliday 2000a), finer resolution data for late Paleoindian behavior through possible feature analysis, and environmental change during the early Holocene.

This paper presents the results of investigations to ascertain the stratigraphic position and development of buried soils at Rattlesnake Slough. Paleosols were documented from six backhoe trenches, three cores, and test excavation units at Rattlesnake Slough, and a high terrace exposure of the Beachhaven locality (34GR8) located 1.2 km to the

Figure 7.1. Location of Lake Altus and the North Fork of the Red River in southwestern Oklahoma

5 cm Figure 7.2. Selected late Paleoindian points (LeVick collection) from Rattlesnake Slough, site 34GR4, Greer County, Oklahoma.



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Figure 7.3. Locations of 6 backhoe trenches, 3 cores, and the test excavation units dug in terrace deposits at Rattlesnake Slough, site 34GR4, Greer County, Oklahoma.

northwest of Rattlesnake Slough (Figure 7.3). The buried soils are described and interpreted for reconstructing the timing of terrace formation along the North Fork of the Red River in this area. Also discussed are the results of pollen analysis that examined environmental changes that occurred from the late Pleistocene to the middle Holocene.

#### **Physical Setting**

The North Fork of the Red River is one of many eastto-southeastern flowing rivers that cross-cuts the Central Lowlands (Figure 7.1). The headwaters of the North Fork of the Red River originate east out of the Southern High Plains near Amarillo, Texas, and join the Prairie Dog Town Fork of the Red River 12 miles northeast of Vernon, Texas where the Red River proper begins. The Central Lowlands is characterized by low relief (30 to 100 m) with hilly landforms caused by differentially resistant Permian age shale bedrock (Madole et al. 1991). The granitic Pennsylvanian age Wichita Mountains break up this low relief surface in southwestern Oklahoma.

Mean annual precipitation in this semiarid climate increases steadily from west to east grading from about 17-26 inches in the North Fork of the Red River drainage area (Daly et al. 1994). Most rainfall occurs in spring to early summer peaking in May in the form of local thunderstorms (Cooter 1991). The climate supports a mixture of short and mixed-grass prairies with cottonwood and willow common along streams and riverbanks.

## Methods

Six backhoe trenches, two test units, three soil cores, and the Beachhaven terrace exposure were documented. Initially, the geoarchaeological work was designed to cut

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two long backhoe trenches parallel and perpendicular to the long axis of the Rattlesnake Slough site. However, the water table limited the depth of the two trenches, and it was deemed more prudent to excavate short trenches at various intervals on both sides of Rattlesnake Slough. The trenches were cut into intersecting L-shapes to provide cross-sections. The three cores were pulled with a truck mounted bull probe. Based on the results of trenching, six 1m<sup>2</sup> units were excavated to ascertain whether a late Paleoindian component was encompassed by the buried soil exposed in Trench 6. Although a late Prehistoric and middle-early Archaic occupation were identified (Hurst et al. 2006) no artifacts dating to the late Paleoindian period were found.

Descriptions of sediments were made following standard pedologic nomenclature (Birkeland 1999; Soil Survey Staff 1999). Samples were removed for radiocarbon dating (Table 7.1), particle size analysis, and pollen analysis (Hurst et al. 2006). All trenches, cores, and test units were mapped in reference to an iron bar datum set by the Bureau of Reclamation.

Fifteen pollen samples were collected from Rattlesnake Slough (Table 7.2). Nine of the samples represent a column collected from Test Unit 2, near Trench 6, in 10 cm block samples. Early-middle Holocene soil dates from Trench 6 (Table 7.1) anchor the bottom and top of the area sampled in Test Unit 2. A modern surface sample also was examined. The remaining five samples were collected in five cm increments from soil Core #3. Core #3 was pulled near Core #1 to obtain pollen samples from the same early Holocene soil documented and dated in Core #1 (Figure 7.2). Pollen extraction and analysis methods followed the standard techniques set forth at the Paleoresearch Institute laboratory, Golden, Colorado (Hurst et al. 2006).

## Results

# Geoarchaeological Investigation

A total of five buried soils were documented ranging in

age from roughly 13,200 to 3000 <sup>14</sup>C yr B.P. (Table 7.1). Soil descriptions of each profile and core are provided in Table 7.3. At the Beachhaven locality, a buried soil with the horizonation of A/Bkb-Bkb was recorded 175 cm below the modern surface (Figure 4). The upper surface of this soil was dated to  $13,200 \pm 90$  <sup>14</sup>C yr B.P. (BETA-182387). The date establishes a minimum late Pleistocene estimate for the development of this terrace location.

Along the present lake shoreline, early Holocene-age soils were encountered in Trenches 1,5, 6, and Core #1. Organic sediments from the top of A horizons in Trenches 1 and 5 were dated to  $7480 \pm 50^{14}$ C yr B.P. (BETA-182388) and 9070  $\pm$  50 <sup>14</sup>C yr B.P. (BETA-182390), respectively (Table 7.1). In Trench 6 (Figure 7.4), the upper and lower portion of an A horizon returned radiocarbon ages of 6080  $\pm$  110 <sup>14</sup>C yr B.P. (BETA-182391) and 8200  $\pm$  110 <sup>14</sup>C yr B.P. (BETA-182392) indicating final burial of this soil was during the middle Holocene. A core probed the lower Btk horizon discovered at the bottom of the test units southwest of Trench 6 (Hurst et al. 2006). Core #2 was pushed down to a total depth of 255 cm and the Btk horizon began at a depth of 140 cm and extended to 225 cm below surface. In Core #1, at a depth of 170-245 cm, another early Holocene soil was discovered. The radiocarbon age of the lower portion of the Akb horizon was  $9730 \pm 60$  <sup>14</sup>C yr B.P. (BETA-182393).

A late Holocene soil was documented in Trenches 2 and 4. At Trench 2, a late Holocene soil was recorded above an early Holocene soil. The upper portion of this buried soil returned a radiocarbon age of  $2970\pm100$  B.P. <sup>14</sup>C yr (BETA-182389). In Trench 4, located northeast of Trench 2, the potential lower half of the soil dated from Trench 2 was found. The result of  $4080 \pm 100$  B.P. <sup>14</sup>C yr (BETA-182394) suggests the soil from Trenches 2 and 4 formed within a 1000 year span during the late Holocene.

To discern the timing of terrace development and lateral

 Table 7.1. Results of Radiocarbon Assays on Organic Sediment from 34GR4.

Site	Depth (cm) below surface	Lab Number	Conventional <sup>14</sup> C yr B.P.	δ <sup>13</sup> C
Beachhaven				· · · · · · · · · · · · · · · · · · ·
34GR8				
Profile	180-190	BETA-182387*	13,200± 90	-19.5
Rattlesnake				
Slough 34GR4				
Trench 1	120-130	BETA-182388*	7480±50	-20
Trench 2	58-68	BETA-182389	2970±100	-16.9
Trench 5	104-114	BETA-182390*	9070±50	-18.7
Trench 6	98-108	BETA-182391	6080±110	-19.1
Trench 6	150-160	BETA-182392	8200±110	-20
Core 1	235-245	BETA-182393*	9730±60	-18.9
Trench 4	106-116	BETA-182394	4080±100	-16.7

\* AMS Technique

Test Unit/ Core No.	Sample No.	Depth (cmbs)	Provenience/Description
Test Unit 2	16	0-10	Column sample from top 10 cm of modern surface
	9	70-80	Top of dated 2Ab horizon $6080\pm110$ $^{14}\mathrm{C}$ yr B.P.
	8	80-90	2Ab horizon, clay loam
	7	90-100	2Ab horizon, clay loam
	6	100-110	2Ab horizon, clay loam
	5	110-120	2Ab horizon, clay loam
	4	120-130	2Ab horizon, clay loam
	3	130-140	2Ab horizon, clay loam
	2	140-150	Bottom of dated 2Ab horizon $8200 \pm 110^{14}$ C yr B.P.
	1	150-160	Below dated soil, 2Btk horizon
Core 3	5	230-235	Top of dated soil, 2Abk horizon
	4	275-280	Bottom of dated soil, 2Abk horizon, $9730 \pm 60$ <sup>14</sup> C yr B.P
	3	295-300	Mottled transition layer
	2	300-305	Top of gleyed soil
	1	342-347	Bottom of gleyed soil

# Chapter 7: Geoarchaeological Investigations at Rattlesnake Slough (34GR4) Table 7.2. Provenience of Pollen Samples Removed from site 34GR4.



Figure 7.4. Soil profiles at Beachhaven locality (left) and Trench 6 (right) at Rattlesnake Slough (34GR4), Greer County, Oklahoma.
Location	Depth (cmbs)	Horizon	Color	Texture <sup>a</sup>	Structure <sup>b</sup>	Boundary <sup>c</sup>	Special Features
Beachhaven	0-36	ABk	7.5YR4/4	SCL	sbk	g, s	large CaCo3 nodules, layer of CaCo3 nodules at bottom of horizon
	36-180	ВК	7.5YR4/6	LFS	sbk	g, s	rootlets common, large CaCo <sub>3</sub> root casts
	180-240	2ABkb	7.5YR5/4	L	sbk	g, s	Mn nodues, Fe staining/ 13200±90 <sup>14</sup> C yr B.P.
	240-310	2Bkb	7.5YR5/8	L	sbk	g, s	$CaCo_3$ nodules and root casts
	310-341	3BC	10YR5/6	SCL	sbk	g, s	$CaCo_3$ nodules and root casts
	341-366	3C	7.5YR5/6	L	sbk	-	Large CaCo <sub>3</sub> nodules
Trench 1	0-20	С	с				modern blow Sand
	20-96	2Bkb1	7.5YR4/6	SiL	sbk	g, s	CaCo3 soft bodies
	96-120	2Bkb2	7.5YR4/3	SiL	sbk	g, s	CaCo3 soft bodies
	120-148	2Ab	7.5YR4/2	SiL	sbk	g, s	CaCo3 soft bodies/ 7480±50 <sup>14</sup> C yr B.P.
Trench 2	0-17	с					Modern
	17-58	A/Bb1	7.5YR4/6	SiL	sbk	g, s	
	58-76	A/Bb2	7.5YR4/3	SiL	sbk	g, s	2970±100 <sup>14</sup> C yr B.P.
	76-118	Bıkb	7.5YR5/3	L	sbk	g, s	Clay Accumulation
	118-150	Bkb	7.5YR5/3	SiL	sbk	-	CaCo3 soft bodies
Trench 3	0-10	С				a, s	modern blow sand
	10-120	Btkb	7.5YR4/4	SiL	sbk	a, s	missing A horizon is evident in rodent burrows. Color of missing A horizon is 7.5YR3/2.
	120-140	2Ab	7.5YR4/3	SiL	sbk	-	CaCo3 soft bodies, charcoal fragments

Table 7.3. Field Descriptions of Studied Profiles at Rattlesnake Slough (34GR4), Greer County, Oklahoma.

<sup>a</sup> SCL= sandy clay loam, LFS= loamy fine sand, L= loam, SCL= sandy clay loam, SiL=silt loam, CL= clay loam

<sup>b</sup> sbk= subangular blocky

<sup>c</sup> a= abrupt, g= gradual, s= smooth, w= wavy

migration of the North Fork, profiles from the trenches and cores were plotted in a west-to-east cross-sectional view (Figure 7.5). The lateral cross-section suggests the dated buried soils occur in segmented portions of terrace deposits that developed as the North Fork migrated to the east. A conceptual model of terrace development based on the cross-section is presented in Figure 7.6. The highest point on the landscape is the remnant late Pleistocene terrace (T-3) at the Beachhaven locality. After deposition of the T-3 terrace, the North Fork migrated to the east and pedogenesis is evident within alluvial sediments that formed the T-2 terrace throughout the early-to-middle Holocene. The late Holocene period is contained within the T-1 terrace indicated by a soil that developed from 4000 to 3000 <sup>14</sup>C yr B.P.

The formation of paleosols during the late Pleistocene, early-middle Holocene, and late Holocene indicates a reduction in sediment deposition associated with the timing of the North Fork's lateral migration. The buried soils indicate an environment conducive for supporting plant growth. Soils were not found in sediments dating between 6000 and 4000 <sup>14</sup>C yr B.P. during the height of the Altithermal period. This is possibly due to valley aggradation and reduced vegetation cover, which is the hallmark of this period (Holliday 1989).

### **Pollen Analysis**

Pollen samples removed from Test Unit #2 and Core



Figure 7.5. West to east cross section view of correlation of soil horizons manifest in the various geoarchaeological study units at Rattlesnake Slough (34GR4), Greer County, Oklahoma.



Figure 7.6. Conceptual model to terrace sequence and horizon development at Rattlesnake Slough (34GR4), Greer County, Oklahoma.

#3 have been combined into a single diagram (Figure 7.7). Samples from Test Unit#2 and Core # 3 are anchored by radiocarbon dates that span from the late Pleistocene to the middle Holocene, and are associated with the T-2 terrace. The pollen record from the core, which represents an earlier time period, exhibits evidence of vegetation considerably different from that recorded in the test unit. The 2Cg horizon at the base of the core is dominated by *Populus* pollen, indicating that these deposits, representing wet conditions, were located at the margin of a riparian vegetation zone, or perhaps within the riparian area, where cottonwood trees grew (Figure 7.6). This riparian area would have been associated with the North Fork of the Red River. In addition to *Populus* pollen, the lower two samples exhibited small quantities of *Juniperus*, *Pinus*, *Ulmus*, Apiaceae, *Artemisia*, *Cirsium*, Low-spine Asteraceae, High-spine Asteraceae, Cheno-am, *Sarcobatus*, *Eriogonum*, Fabaceae, and/or Poaceae pollen, indicating the presence of juniper, pine, elm, umbel family, sagebrush, thistle, and ragweed-type plants, that also include marshelder and cocklebur, various mem-



Figure 7.7. Pollen diagram from sediment samples collected from Core #3 and Test Unit #2 at site 34GR4, Greer County, Oklahoma.

### Chapter 7: Geoarchaeological Investigations at Rattlesnake Slough (34GR4)

bers of the sunflower family such as rabbitbrush, sunflower, and others. Cheno-ams, greasewood, wild buckwheat, legumes, and grasses in the local and/or regional vegetation communities. Pine and juniper pollen travel long distances on the wind and their presence might be the result of long distance wind transport of pollen, rather than local growth of pine and juniper. A few trilete smooth spores were recorded in these samples, indicating the presence of ferns in the local vegetation community. Quantities of microscopic charcoal observed in these sediments are lower than in the overlying samples.

The 2BC horizon from Core #3 exhibits more similarities to the dated soil overlying this level than to the underlying 2Cg layer. A radiocarbon age of  $9730 \pm 60$  <sup>14</sup>C yr B.P. is reported for the bottom of the dated soil represented by Sample 4. Samples 3, 4, and 5 all exhibit slightly to moderately elevated quantities of Pinus, Cheno-am, and Poaceae pollen, when compared with other samples from this site. Still, the quantities of Pinus pollen in these samples remains relatively small. Quantities of Artemisia, Low-spine Asteraceae, and High-spine Asteraceae pollen increase in these samples, with the single exception of the quantity of Low-spine Asteraceae pollen recorded in Sample 4. Cottonwoods have disappeared from the record and sagebrush, marshelder (or cocklebur or perhaps ragweed), various members of the sunflower family probably including rabbitbrush, Cheno-ams, and grasses became more abundant. This vegetation community is more similar to that expected on a terrace above the river, rather than in the active floodplain. This change in the pollen record suggests a change in the river channel (location or depth) and a resulting shift in the vegetation community in response to less ground moisture at this location. Other pollen types present in one or more of Samples 3, 4, and 5 include Juglans, Juniperus, Quercus, Apiaceae, Sarcobatus, Fabaceae, Trifolium praetense-type, Polemoniaceae, and Shepherdia, indicating local growth of walnut trees, juniper, oak, a member of the umbel family, greasewood, legumes, clover, a member of the phlox family, and buffaloberry shrubs or trees. Sample 4, associated with a radiocarbon age of 9730  $\pm$  60 <sup>14</sup>C yr B.P., yielded the largest quantity of charcoal, suggesting the possibility that it is associated with human occupation of the area.

The sequence from Test Unit 2 begins with Sample 1 collected from the 2Btk horizon, beneath the dated buried soil. The rest of the samples were collected from the 2Ab horizon that yielded bottom and top radiocarbon ages of  $8200 \pm 110$  and  $6080 \pm 110$  <sup>14</sup>C yr B.P. The entire pollen record from Test Unit 2 provides a different signature than that seen in the 2ABk horizon at the top of Core #3, al-though there are some similarities. The increases in *Artemisia*, Low-spine Asteraceae, High-spine Asteraceae, and Cheno-am pollen are sustained or continued in the lower samples from Test Unit 2. In fact, High-spine Asteraceae pollen is the dominant pollen in most of the samples exam-

ined from Test Unit 2. The exceptions are Sample 8, where High-spine Asteraceae and Malvaceae pollen co-dominate and Sample 9 where Malvaceae pollen is dominant. Highspine Asteraceae includes rabbitbrush, which probably was abundant in this area, as well as a wide variety of other shrubby plants and herbaceous plants such as sunflower and aster. Cirsium pollen becomes a regular part of the record, indicating the presence of thistle in the local vegetation community. Quantities of Low-spine Asteraceae pollen fluctuate, probably in response to the degree of sediment disturbance. Cheno-am pollen frequencies decline rapidly in this soil. Malvaceae pollen is present in substantial quantities, which is surprising considering that insects transport this pollen. Malvaceae pollen includes the genera Malva (mallow) and Callirhoe (wine cup), which have a similar morphology to one another. Sphaeralcea pollen is present in small quantities in some, but not all, of the Test Unit 2 samples. Onagraceae pollen is present in many of the Test Unit 2 samples. Members of this family are commonly found in disturbed soils. Fireweed, which grows in response to local fires, is part of this family. Poaceae pollen is present in smaller quantities than in samples from Core #3, which is not surprising, since the signature for this soil indicates that it accumulated under drier conditions than did the soil in the upper portion of Core #3.

Pollen present occasionally and in small quantities in samples from Test Unit 2 includes Juniperus, Pinus, Quercus, Tilia, Apiaceae, Boerhaavia-type, Brassicaceae, Sarcobatus, Cyperaceae, Ephedra torrevana-type, Eriogonum, Euphorbia, Fabaceae, Ipomoea, Kallstroemia, Lamiaceae, Opuntia, Plantago, and Rosaceae, representing juniper, pine, oak, basswood, a member of the umbel family, spiderling, a member of the mustard family, greasewood, sedges, ephedra, wild buckwheat, spurge, a member of the legume family, morning glory, caltrop a member of the mint family, prickly pear cactus, plantain, and a member of the rose family. Other than noting the presence of these taxa, there is no particular pattern to their occurrence. It is interesting to recover Tilia pollen from this part of Oklahoma, since it does not grow in the area today. Presence of this pollen underscores the differences in climate and vegetation between more than 8000 <sup>14</sup>C yr ago and today.

Small quantities of trilete smooth spores were noted in four of the samples from Test Unit 2 and probably represent wind transport of these spores from ferns growing in the shade of trees in the riparian vegetation community along the North Fork of the Red River. Recovery of single Zygnema-type and Concentricyste forms in Sample 3 represents the presence of freshwater algae. Recovery of a single Pistillipollenites in the modern surface sample suggests deterioration of Eocene age bedrock in the area.

In summary, the pollen record examined from Rattlesnake Slough documents significant vegetation change between the gleyed deposits in the core, predating 9700 <sup>14</sup>C yr B.P. and the vegetation community established by 8200 <sup>14</sup>C yr B.P. Prior to 9700 <sup>14</sup>C yr B.P., the North Fork of the Red River ran close to the area represented in Core #3, leaving gleyed deposits and a record of the presence of cottonwood trees. The vegetation community changed as the channel and floodplain of the North Fork of the Red River migrated to the east forming the T-2 terrace (Figure 7.5) and becoming drier prior to 9700 <sup>14</sup>C yr B.P.

The vegetation community established during the early Holocene included sagebrush, various members of the sunflower family, including marshelder or cocklebur or ragweed, rabbitbrush, sunflower, and probably various others. Cheno-ams were more abundant than they are today and might have included saltbush and/or goosefoot and perhaps other plants of this group. Grasses were more abundant than they are today. By 8200 <sup>14</sup>C yr B.P the area represented in Test Unit 2 exhibited a vegetation community typical of a relatively dry terrace overlooking the river, indicating that the water table was lowered relative to the sediments that were accumulating in this area. Members of the mallow family were more abundant in the local vegetation community than they are today and Cheno-ams declined in abundance. Members of the chicory tribe of the sunflower family were moderately abundant, while grasses decline in frequency during the early Holocene to proportions similar to today. Examination of this pollen record indicates that by 8200 <sup>14</sup>C yr B.P. a vegetation community was established that differed from the modern community primarily in supporting more members of the chicory tribe of the sunflower family and more members of the mallow and evening primrose families. The consistency in the pollen record for the interval of soil accumulation between 8200 and 6100 <sup>14</sup>C yr B.P. is not surprising, since this interval represents the beginning of the middle Holocene, which is hotter and drier on the Southern Plains (Holliday 1989).

#### **Discussion and Conclusions**

This study identified several paleosols within alluvial sediments of the North Fork of the Red River dating to the late Pleistocene, early-middle Holocene, and late Holocene periods. The early Holocene sediments might be the source for the late Paleoindian artifacts discovered by the LeVicks. Future Paleoindian investigations at Lake Altus should focus on excavating within these buried soils to find features and artifacts to better delineate chronology and hunter-gatherer behavior during the early Holocene.

Finding depositional settings on the Southern Plains with pollen has proven difficult. However, a few important studies offer some insights into environmental change during the early Holocene transition. One of the earlier pollen studies in the region was at the Domebo Clovis mammoth kill site (Wilson 1966). The pollen record from deposits dating between 11,400-10,000 <sup>14</sup>C yr B.P. suggested the area was a lightly forested riparian environment surrounded

by grasslands with grasses and composites predominating.

Pollen has also been recovered from a profile located along Bull Creek in the panhandle of Oklahoma (Bement and Carter 2004; Bement et al. 2007). There grass pollen was dominant from the late Pleistocene up until 8500 <sup>14</sup>C yr B.P. After this date, sagebrush, sunflower, and cheno-ams become more prevalent, marking a change to more xeric conditions of the Altithermal period.

Farther away in central and south-central Texas, pollen from Hershop and Boriack bogs offers information about climate during the early Holocene period. At Hershop Bog the pollen record indicates a decline in tree pollen 10,500 <sup>14</sup>C yr B.P and an increase in grass pollen (Larsen et al. 1972; Bousman 1998). At 8600 <sup>14</sup>C yr B.P., grass is the most frequent pollen type at Hershop bog. A change in pollen at the late Pleistocene/early Holocene boundary at Hershop bog suggests a warming trend and expansion of the grasslands into a previously wooded area.

A similar pattern of grassland expansion was found at Boriack bog (Holloway and Bryant 1984). Spruce pollen is prevalent at 15,000 <sup>14</sup>C yr B.P., and there is a shift to a higher frequency of grass pollen and Asteraceae at 9000 <sup>14</sup>C yr B.P. implying an open parkland environment. Woodlands become reestablished sometime between 9000 and 8000 <sup>14</sup>C yr B.P., and a grassland community comes back to dominate the pollen record after 8000 <sup>14</sup>C yr B.P during the middle Holocene.

Along the margins of the eastern Plains in southeastern Oklahoma, sediments from Ferndale Bog provided important insights to vegetation change during the early Holocene (Albert 1981; Bryant and Holloway 1985). Before 12,000 <sup>14</sup>C yr B.P., the vegetation was an open woodland dominated by pine and oak trees with some grasses and composites (Bryant and Holloway 1985). From 12,000 to 10,000 <sup>14</sup>C yr B.P, there is a shift to a higher frequency of grass pollen. A grassland community continues to be prevalent, but with an increase in forbs that is characteristic of tall grasses today between 10,000 to 9000 <sup>14</sup>C yr B.P. Oak also increases during this time frame.

On the Southern Plains other paleoclimatic proxies including geomorphic studies, stable carbon isotopes, and vertebrate research (Johnson 1987; Ferring 1990, 2001; Holliday 1997, 2000b; Balinsky 1998; Nordt et al. 2002; LaBelle et al. 2003; Lewis 2003; Bement et al. 2007), confirm the most abrupt and dramatic climatic shift occurred 11,000 <sup>14</sup>C yr B.P. at the beginning of the Younger Dryas period (Anderson 1997; Haynes 2008). After 11,000 <sup>14</sup>C yr B.P. there are climatic fluctuations, but not to the same degree that occurred 11,000 <sup>14</sup>C yr B.P. (Hurst 2007). The next major climatic change happens 8000 <sup>14</sup>C yr B.P. with the beginning of the middle Holocene and Altithermal period. The height of xeric conditions transpired 6000 and

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4500 <sup>14</sup>C yr B.P. (Holliday 1989; Bement et al. 2007).

The results from Rattlesnake Slough generally support the regional paleoclimate proxy data. At Rattlesnake Slough, pollen from gleved deposits below the 9700 <sup>14</sup>C vr B.P. dated soil, indicative of a wet riparian vegetation zone. may correlate with the late Pleistocene before the onset of the Younger Dryas and subsequent drying trend. Unfortunately, the age of the gleved deposits is unknown but its stratigraphic position suggests that it correlates with the late Pleistocene period. During the early Holocene after 9700 <sup>14</sup>C yr B.P. pollen from Rattlesnake Slough suggests there is a general drying trend until 6000 <sup>14</sup>C yr B.P. Notably absent at Rattlesnake Slough are sediments containing buried soils dating between 6000 to 4000 <sup>14</sup>C yr B.P. This is probably caused by xeric conditions during the height of the Altithermal when valleys may have been aggrading and/or reduced vegetation cover limited pedogenesis. Soil formation is evident once again in sediments during the late Holocene at Rattlesnake Slough between 4000 and 3000 <sup>14</sup>C yr B.P.

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# Chapter 8 Summary Perspectives of Soils and Prehistory along Oklahoma's Cross Timbers

# Don G. Wyckoff, Elsbeth Dowd, and David J. Cranford

### The Cross Timbers and Osage Savannah

The preceding chapters describe different soil profiles exposed in valley and upland settings along or near the historic Cross Timbers (Figure 8.1). Although breached by several major rivers, including the prehistorically favored Washita and its fertile terraces (Bell 1984a; Bell and Brooks 2001; Brooks et al. 1985; Drass 1997), this ecological region merits archaeological attention. Some 200 years ago, the Cross Timbers formed a notable boundary on the Southern Plains. It was where the grasslands of the Southern Plains met the margins of a diminished, even depauperate, western edge of deciduous woodlands that extended eastward across southeastern North America. Commonly characterized (Foreman 1947; Francaviglia 2000) as a tangle of scrub oak, the Cross Timbers were much more than the post oaks (Quercus stellata) and blackjacks (Q. marilandica) that prevailed there (Dyksterhuis 1948). In actuality, the Cross Timbers were a segment of a large ecological transition zone (an ecotone) between the grasslands to the west and woodlands to the east .

Known as the Osage Savannah (Figure 8.2), this ecotone was defined and described by botanists and ecologists (Bruner 1931; Blair and Hubbell 1938; Carpenter 1940) as a dynamic biotic region where tall and mixed grasslands are isolated by extensive stands of scrub oaks. Where the grasslands and woodlands flourished within the Osage Savannah was not fortuitous. The isolated, yet often expansive, stretches of prairie occurred where rolling landscapes formed on shale or limestone bedrock. The soils of these prairies are compact and have little pore space between soil particles with which to hold moisture (Gray and Bakhtar 1973). Thus, they usually become dry during the summer as increasing heat enhances evaporation and transpiration. These soils can support the growth of grasses and forbs but not more sturdy, larger plants such as trees. In contrast, the scrub oak forests prevail where hills and ridges have sandy to rocky soils that can hold more moisture through the growing season (Gray and Bakhtar 1973; Johnson and Risser 1972). Also, on rocky slopes where sandstone or sandy limestone is prevalent, exposed rocks help protect young trees from natural or human induced fires.

As noted above, the historic distribution of the Osage Savannah's scrub oak woodlands and the prairie patches they enclose are greatly influenced by edaphic (soil character) factors. Obviously, the prevailing climate is also integral. Today, the north-south extent and east-west expanse (some 17,000 square miles estimated by Duck and Fletcher 1945: Table 1) of the Osage Savannah is where substantial precipitation (11 to 13 inches) falls between April and June but decreases (to 9 to 10 inches) through July, August, and September as late growing season temperatures tend to increase (Johnson and Duchon 1995:17-18, Fig. 3.1). These late growing season high temperatures are commonly accompanied by less (and spotty) rain and increasing evaporation. Such conditions stress plants as they pull moisture from the ground and release it through photosynthesis and transpiration. Based on nearly a century of weather records from stations within the Osage Savannah, this biotic region occurs where the annual precipitation ranges from 36 to 42 inches a year, with a third of that occurring during the growing season, which is 196 days in the north part of the region and 231 days in the south (Johnson and Duchon 1995:Fig. 3.11).

Since the 1940s, the Osage Savannah and its Cross Timbers margin (Figure 8.3) have been undergoing impor-



Figure 8.1. The historic Cross Timbers as recorded by Foreman (1947) and the locations described and reported in this monograph: 1, Carter Farm; 2, Powell Farm; 3, Mustang Creek; 4, Menzie Farm; 5, Pond Creek; 6, Pumpkin Creek; and 7, 34GR4.



Figure 8.2. Duck and Fletcher's (1943) game map of Oklahoma based on Blair and Hubbell (1938:Fig.1) biotic regions of Oklahoma. The Postoak-Blackjack Oak Forest and intervening Tallgrass Prairie depictions are the Osage Savannah biotic region of Blair and Hubbell (1938). The Cross Timbers comprise the western margin of the Postoak-Blackjack Oak Forest. Image courtesy of the Oklahoma Biological Survey.

tant changes, largely due to the impact of more and more people. Interstate 35 now runs north and south along and through portions of the Cross Timbers. Oklahoma towns like Ardmore, Norman, Moore, Oklahoma City, Edmond, and Guthrie have grown, and their suburban eastern margins have been carefully placed or carved out of the Cross Timbers' scrub oak woodlands. This blurring and modification of the Cross Timbers has also been accompanied by an increasingly rapid invasion by eastern red cedar (Juniperus virginiana). Enhanced seed dispersal by bird droppings has enabled dark stands of these evergreens to dominate where post oak and blackjack stands formerly stood and also to spread into adjacent savannah grasslands. Besides pulling inordinate amounts of moisture from the soil, red cedar is a ready fuel for wildfires such as the disasterous ones of 2006 and 2009.

The recent development of country estates and suburbs in the Oklahoma Cross Timbers has been accompanied by continued concern and increased efforts at suppressing wildfires, whether of natural or human origin. Yet historical perspectives of the Cross Timbers reveal that fire was an important ingredient in the distribution and character of this ecotone border. For example, on August 26, 1853, while surveying a potential railroad route from Arkansas to California, Lt. A.W. Whipple was near the Cross Timbers in present-day McClain County, Oklahoma, and observed

> After travelling about five miles, our progress was suddenly arrested by a burning prairie. The grass was tall, thick, and dry. The wind had driven the widespread flames over the crest of a hill, directly toward us; and now they came leaping into the air, roaring in the



Figure 8.3. The Cross Timbers mapped across counties in Texas Oklahoma, and Kansas. Adapted from Francaviglia 2000:Fig. 1-18 and based on studies by Harrison (1974) and Gray and Galloway (1959).

distance; and crackling fearfully as they approached. There seemed to be no safety except in flight (Foreman 1941:67-68). Some nine years earlier, Josiah Gregg (1844:200) had

described the Cross Timbers and noted

Most of the timber appears to be kept small by the continual inroads of the 'burning prairies'; for, being killed almost annually, it is constantly replaced by scions of undergrowth; so that it becomes more and more dense every reproduction. In some places, however, the oaks are of considerable size, and able to withstand the conflagrations.

Rice and Penfound (1959:597) argue that heavy grazing and historic efforts to control grassfires have favored the expansion of Cross Timbers woodlands since historic settlement. But their extent and composition are also determined by climatic conditions.

### The Effects of Historic Climatic Fluctuations

Since statehood, Oklahoma's Osage Savannah and its western edge, the Cross Timbers, have experienced two brief, but severe, dry periods. From 1933 through 1939 and from 1954 through 1956 are identified (Doerr 1962, 1963; Rice and Penfound 1959) as periods of significant drought in Oklahoma with 1936 and 1954 being the years with the least amount of moisture recorded at most weather stations across the state. Although important botanical studies were published in the 1930s (e.g., Bruner 1931; Blair and Hubbell 1938; Little 1938, 1939), the actual field work for most of these was undertaken before the droughts and thus don't address the effects on vegetation.

During the 1950s, however, botanists Elroy Rice and William Penfound undertook a significant study of Oklahoma's upland forests. By monitoring 208 woodland stands across the state, they discerned that oak savannah settings like those of the Cross Timbers grew where annual precipitation averaged between 25 and 32 inches, whereas an oakhickory savannah more common to the northern and eastern parts of the Osage Savannah was associated with 32 to 40 inches of precipitation a year (Rice and Penfound 1959). But between 1954 and 1957, growing season precipitation was reduced from 30 to 50%, and upland stands of woodlands lost variable numbers of trees (ibid.). For the region of the Osage Savannah this loss was around 11% (Rice and Penfound 1959: Table VII), but for the Cross Timbers manifest just west of Love County (Figure 8.3) the loss was over 12% (Rice and Penfound 1959:Fig. 17). One surprise was the significant loss of blackjacks throughout the Cross Timbers and Osage Savannah. For example, where the Cross Timbers extend west of Love County, Oklahoma, over 81% of the blackjack trees died in contrast to only 8.5% of the post oaks (Rice and Penfound 1959:604). These researchers believe this disproportionate loss was due to blackjacks' ready adaptation to spread into less edaphically favorable niches during growing seasons with normal rainfall, but because these niches went seasonally dry quicker during the drought years blackjacks paid the price.

The significance of tree loss during the relatively short (4 years) drought of the 1950s should not be minimized. If upland forests can die back 4 to 40% as they did during this period (Rice and Penfound 1959:Fig. 17), how much did they suffer and change during more lengthy, more intensive droughts being recognized in prehistory?

# Prehistoric Climatic Fluctuations and Change: Effects on the Cross Timbers and Osage Savanna

Documented by extensive tree ring findings (Benson et al. 2007; Cook et al. 2007; Herweijer et al. 2007; Stahle et al. 2007), decade and multi-decade long droughts occurred in the eleventh, twelfth, and thirteenth centuries from the Southwest into the Midwest. Undoubtedly, these played key roles in the radical demographic shifts and cultural changes manifest in these regions. Being 5 to 10 times longer than the 1950s dry spell, and assuming the same air flow patterns prevailed (Borchert 1950), these prehistoric "megadroughts" must have had profound effects on the extent and character of the Osage Savannah biotic region and especially its western edge, the Cross Timbers.

In recent years, the antiquity and climatic effects of the Cross Timbers have come to be appreciated. Tree ring studies conducted at numerous locations have revealed that many stands of scrub oak along the Cross Timbers include trees, usually post oak, that are 250 to as much as 350 years old (Stahle 1997; Stahle and Hehr 1984; Stockton and Meko 1983). Notably, blackjack oaks older than 100 years are rare (Stahl and Hehr 1984:563), again attesting to this species' proclivity to spread into marginal niches that are among the first to be adversely affected when precipitation declines.

Although the studied post oaks don't record the prehistoric long droughts that affected ancient Puebloans and Cahokia's Mississippian communities, repeated tree ring records attest to harsh droughts between 1759 and 1761, in the early 1820s, and right before and during the Civil War (Stockton and Meko 1983:Table 4). These were as intense and as long as those experienced during the Dust Bowl and more so than what occurred in the 1950s (Stockton and Meko 1983). Again, as with the prehistoric megadroughts, we don't know the actual effects on the Cross Timbers or the Osage Savannah, but these droughty fluctuations must have killed off many trees (both post oak and blackjack) and opened niches to invasion by pioneering weeds, forbs, and grasses on scales larger than reported by Rice and Penfound (1959).

What happened earlier in prehistory is also unclear. Regrettably, no dated pollen records of any great length are available for the Cross Timbers or the Osage Savannah (but see Hall 1980 and 1982 for short records of potentially wind-winnowed pollen from rock shelters in the northern Osage Savannah), so we have no record directly relevant to documenting or understanding when the biotic region, and

especially the Cross Timbers, formed or changed since the Wisconsinan ice age. Nearby, but located on the ecologically sensitive west edge of the Ouachita Mountains, Ferndale Bog (Atoka County, Oklahoma) has been cored twice and yielded pollen records extending back some 5500 and 11,800 radiocarbon years respectively (Albert 1981; Bryant and Holloway 1985). With the longest core dating to nearly 12,000 years ago, Ferndale Bog pollen spectra from around 10,000 to nearly 5000 years ago are mainly grasses and forbs (Bryant and Holloway 1985:Fig. 6; Holloway 1994), implicating that this now-forested western segment of the Ouachita Mountains was oak-hickory savannah with deciduous woodlands restricted to mesic niches and along streams.

Given these findings, we contend that the Osage Savannah and the Cross Timbers had far different configurations, if they existed at all, in the early Holocene than they did 150 years ago. Moreover, the Ferndale Bog pollen record shows the oak-hickory-pine woodlands of the mid-1800s developed some 2500 to 3000 years ago (Bryant and Holloway 1985:Fig. 6; Holloway 1994). On that basis it makes sense that the Osage Savannah and its Cross Timbers segment began attaining their historic distributions then, too. In summary, we suspect these biotic settings are very recent in origin.

# The Significance of Buried Soils along the Cross Timbers

The soil profiles reported in the preceding chapters were studied and formally described in order to acquaint graduate students in archaeology with basic techniques for systematically describing soils, especially those in which archaeological sites might occur. However, because of their diversity, the locations reported herein also helped the students appreciate how and why so much variation in soils occurs over short distances but yet in settings that share many geologic, geomorphic, and ecological characteristics. That knowledge and appreciation deserves to be shared with everyone interested in Oklahoma's past. Thus this monograph.

From the preceding paragraphs it should be obvious just how dynamic the Cross Timbers, the western margin of the Osage Savannah biotic region, are and have been. This woodlands margin could expand, contract, and change character as a result of wildfires and fluctuation environmental conditions. These latter are best evidenced by distinct sequences of narrow tree rings that attest to specific calendar years of inadequate moisture, especially before and during the growing season. But, as noted, tree ring studies only get us back about four centuries, and they only provide clues to short-term changes in the environment. These are important, and they most probably played a notable, though underappreciated, role in the shifting settlements of Southern Plains Wichita groups before and during their earliest contacts with the Spanish and French (Vehik 2002). Likewise, the dendrochronological records for widespread megadroughts earlier in prehistory (11th, 12th, and 13th centuries) probably bear witness to moisture declines long suspected (Wyckoff 1980) responsible for demographic shifts and cultural changes among the people (Wichita and Kichai?) responsible for the mound building Harlan and Spiro cultural phases (Bell 1984b; Brown 1984) in eastern Oklahoma. But how do we get at earlier prehistoric changes and their effects on groups frequenting or residing throughout what is now central Oklahoma?

Whereas narrow tree rings attest to annual and longer interval droughts, buried soils bear witness to periods of landscape stability and sufficient moisture and plant growth to add carbon to the surface soil horizon. For the student contributors to this monograph, and hopefully for you the reader, an important discovery is that small or tributary valley settings in central and south-central Oklahoma often contain stratified, multiple, buried soils. These are traces to former floodplain or terrace surfaces. Typically dark (melanized) in color, these former surface soils result from carbon input through periods of climatic stabilty when grasses, forbs, and other plants could grow in abundance and some roots would annually die and decompose. Because of this carbon enrichment, these traces of once stable surfaces can be radiocarbon dated. The results can then be used to ascertain if there existed a regional sequence of intervals when this woodlands-prairie border experienced climatic conditions involving surplus effective moisture, many seasons of good plant growth, and, consequently, inhibited erosion. With their ground surfaces stabilized, the minor or tributary valleys we studied could be expected to develop luxurious niches where nut and berry producing plants grew and where game animals might be frequent. In essence, buried soil horizons with attributes commonly associated with surface soil horizons are clues to past settings and the climates that created them. They represent former surfaces of the ground on which plants grew, animals walked, and, potentially, humans seeking those plants and animals camped or foraged. Given the continued spotty record of human prehistory in settings away from major river valleys in central and south-central Oklahoma (Brooks and Drass 1984; Kawecki and Wyckoff 1984), finding and studying these buried soils is our best chance to learn what people were doing in settings away from the major valleys over the past 10,000 years or more.

### The Early Recognition of Buried Soils

For Oklahoma the recognition and climatic implications of buried soils (or paleosols as they are now often called) have a long and somewhat illustrous history. As early as 1932, during early years of the Dust Bowl, Oklahoma A.&M. (now Oklahoma State University) researchers Horace Harper and Charles Hollopeter briefly summarized observations of buried soils and the water or wind processes behind their burial along the Salt Fork of the Arkansas River in Grant County. This earliest report of buried soils

is noteworthy because Harper and Hollopeter (1932:63) report seeing two such soils a this location and they pinpoint critical factors in forming such soils:

- 1. buried soils aren't the simple result of sediments deposited by wind or water;
- buried soils result when surface deposits of such sediments undergo a lengthy interval in which organic matter accumulates in them and fine soil particles (such as silt and clay) are moved downward in the profile to develop noticeable layers (today called soil horizons);
- these soil layers (horizons) are distinguished by particular colors and structure as a result of weathering during the interval they are the ground surface; and
- subsequent to their development these surface soils may be buried by sediments carried by streams or by wind, and these sediments will display none of the characteristics of the former soils.

Given that these observations were published nine years before H. Jenny's (1941) classic *Factors in Soil Formation*, Harper and Hollopeter were making astute observations. They even note that once buried, former surface soils could become water saturated and undergo further changes (Harper and Hollopeter 1932).

Harper (1933, 1934) continued reporting investigations of buried soils as the 1930's drought intensified. Ironically though, while recognizing that such soils weere traces to past landscapes and climates, his primary concern was to establish the age of the deposits that buried the former surfaces. His 1933 study focused on buried soils under sand dunes along the Cimarron River in Major County (Figure 8.4). His 1934 paper summarized buried soils at 3 locations in Payne County, 2 in both Garfield and Grant counties, and 1 each in Alfalfa and Grady counties (Figure 8.4). Combined, these two reports detail exposures in floodplains and terraces along the Cimarron and South Canadian rivers, but many of the exposures were along small drainages flowing in different directions in the uplands away from such valleys. Because a single buried soil, one often composed of clay-rich particles (today it would be called an argillic horizon), was manifest at the diverse locations, and because the sediments over this paleosol did not show much soil development, Harper (1934) tried to correlate the profiles over this buried soil with periods of loess deposition, probably during the last glacial period (now called the Wisconsinan). Surprisingly, he had little to say about the character of the buried soil itself or the climatic and ecologic conditions that contributed to its development.

Only a year after Harper's summary, however, pioneer palynologist, ecologist, and conservationist Paul B. Sears and colleague Glenn Couch (1935) recognized that many of the buried soils were rich in organic matter (humus) and were clearly soils that had developed of former stable surfaces of valley settings. Most importantly, Sears and Couch (ibid.) saw these buried "strata" (their term) as viable sources from which to gather information about previous climates. The eleven locations they visited were along the Arkansas, Cimarron, North Canadian, South Canadian,



Figure 8.4. Locations of 1930s studied sites where buried soils were reported: 1, Harper and Hollopeter 1932; 2, Harper 1933; 3, Sears and Couch 1935; 4, Hedges 1935. Map adapted from Oklahoma Biological Survey illustration.

Washita, and Red River's North Fork in locations more dispersed than those reported by Harper (Sears and Couch 1935:Fig. 1). At eight of their locations they observed stratified sequences involving four humus-rich soils; five of these spots occur close to the Cross Timbers (Figure 8.4). While noting their intent to study these profiles and buried soils in order to correlate them and to assess clues for different climates, little record exists that they followed up on this line of research. Sears left the University of Oklahoma in 1938 to assume a position at Oberlin College in Ohio, but he left behind a legacy that included his acclaimed assessment (Sears 1935a) of modern farming's role in the genesis of the Dust Bowl, one of the first attempts to use prehistoric pollen to place an archaeological site (Spiro Mounds no less!) in its temporal and ecological context (Sears 1937), and several studies of Midwest pollen records documenting ecological (and inferentially climatic) changes after the last glaciation (Sears 1930, 1931, 1932a, 1932b, 1935b, 1935c; Sears and Couch 1935).

During his tenure with the University of Oklahoma Department of Botany, Paul Sears did influence several graduate students in their thinking about ecological character and changes over time in Oklahoma drainage basins. In particular, in 1935, two M.A. students finished diverse studies in the South Canadian River basin near Norman. Harold Hefley (1935, 1937) compiled a notable synthesis of the Canadian River's floodplain-terrace sequence and the plant-insect distributions associated with these different alluvial landforms. Especially significant for our monograph's theme, however, is R.F. Hedges' (1935) study of gastropods (snails) recovered from buried soil sequences exposed in ravines draining uplands and terraces along the Canadian near Norman. Our cursory review of the literature leads us to believe Hedges' work was the first study of fossil snails from buried soils on the Southern Plains. Of the four locations studied by Hedges (Figure 8.4), two manifested two stratified paleosols and the other two had three such soils. These yielded 22 different taxa of snails, and 21 of these were terrestrial (land) forms. Lacking historic distribution studies of the land species, and having no other Southern Plains fossil snail collections with which to compare, Hedges (1935:49-50) could only observe that land snails were more than ten times abundant in the buried dark soils as in the intervening red (alluvial or aeolian) horizons. Despite his inability to make correlations between his snail assemblages and the former settings they inhabited, Hedges' (1935) findings clearly showed that buried melanized soils (and the fossils contained therein) were viable sources for documenting prehistoric stabilized settings and the ecological and climatic conditions that created them.

### Recent Studies of Paleosols along the Cross Timbers

After World War II, archaeological research in the Oklahoma Cross Timbers was mainly focused on prehistoric camps and villages along the Canadian, Washita, and Red rivers where they enter this ecotone (Bell 1958, 1961; Bell and Baerreis 1951; Duffield 1953; Ray 1960; Schmitt 1950; Schmitt and Tolden 1953; Sharrock 1959a, 1959b, 1961; Wyckoff 1964). Only with the later construction of Bureau of Reclamation and Corps of Engineers reservoirs near Edmond, Norman, and Sulphur did we begin to gain some perspective on human prehistory in tributary valleys to major streams in central and southern Oklahoma (Barr 1965, 1966; Hartley 1976; Lawton 1958; Williams 1955). While artifacts were found attesting to occupations earlier than Plains Villager times, the emerging impression was that little human prehistory was manifest or preserved in these more upland settings where the Cross Timbers prevail (Hartley 1976:96-99).

That impression began to be dispelled with the publication of Contributions to Cross Timbers Prehistory (edited by Kawecki and Wyckoff 1984) and Hunters of the Forest Edge (Reid and Artz 1984) by the Oklahoma Archeological Survey. The latter monograph documented prehistoric archaeological sites, several in radiocarbon dated soils buried under alluvium, in the Little Caney basin of northern Oklahoma's Osage Savannah. In contrast, Contributions to Cross Timbers Prehistory contained descriptions of six diverse archaeological sites scattered from Oklahoma and Pottawatomie counties in the north to Marshall County in the south. Although none were radiocarbon dated at the time, these sites yielded artifacts attributable to middle and late Holocene hunter-gatherers and to later Holocene semisedentary groups who made cordmarked pottery and used corner-notched arrowpoints. In essence, these sites attest to occupations dating roughly from 6000 to perhaps 1000 years ago. Most importantly, several bore witness to having been buried by fluvial, eolian, or colluvial processes (Wyckoff 1984). Consequently, such sites indicate that significant segments of prehistory in Oklahoma's Cross Timbers are deeply buried and thus not visible to the usual pedestrian surveys conducted by archaeologists working in the region.

Not considered in the 1984 Cross Timbers prehistory compilation were substantive studies of dated, buried soils with artifacts reported west of that ecotone as it was defined by Foreman (1947). Specifically, findings at the Domebo site, Cedar Creek, and Delaware Canyon (Table 8.1) are pertinent to piecing together prehistoric ecological and climatic conditions and human activities along a fluctuating, when present, Cross Timbers boundary (Figure 8.5). The information from these locations can now be supplemented with more recently recovered data from several other sites and localities along this border (Table 8.1). As Figure 8.5 shows, all of these places are adjacent or withing post oak-blackjack dominated woodlands that stretch northwest from this ecotone. The linear stands occur on sandy soils, some developed in dune fields that formed north or northeast of paralleling, braided river beds. Buried soils have

# Table 8.1. Other Locations in or near the Cross Timbers where Records for Dated Paleosols Exist.

Site or Locality	Description and discussion	References
Black Bear Creek, Pawnee County No. 1 in Figure 7.5	Buried soils at different depths along two tributaries to Black Bear Creek, a tributary to the Arkansas River. A C14 date of 1150 years ago on the shallow soil contrasts with a result of 3590 on the deepest buried soil.	McQueen et al. 1993.
Canyon Road Site (34CN46) Canadian County No. 2 in Figure 7.5	Some 7 m of red sediments exposed in advancing nick points along one branch of a short tributary to the South Canadian River. Various profiles reveal complicated fills in a canyon bottom; some fills contain prehistoric hearths dating from roughly 900 to nearly 2500 years ago. A thin midden 7.3m below the floor of the canyon yielded a bone awl, a corner notched arrow point, and radiocarbon dates of 2490±60 radiocarbon years before present (WSU-2970) and 2790±100 rcybp (WSU-3531).	Taylor 1984, 1987.
Carnegie Canyon, Caddo County No. 3 in Figure 7.5	Some 30 m of sediments and underlying Permian sandstone exposed along tributary to the Washita River. 3 major units identified in unconsolidated sediments. Unit C: sandstone rubble and gravel colluvium cemented by carbonates and largely draped along canyon wall. Unit B: some 9 m of homogeneous red sand in which 3 paleosols are evident. Unit A: some 2 m of red sandy sediments containing 2 buried soils, the uppermost being historic. Prehistoric hearths and 63 buried tree stumps (mostly <i>Juniperus virginiana</i> ) yielded 16 radiocarbon dates ranging from 2300 to 4500 years ago, most being from 2600 to 3200 years ago.	Lintz and Hall 1983.
Cedar Creek, Washita County No. 4 in Figure 7.5	A Washita River tributary long recognized for yielding many Folsom and early Holocene artifacts. In anticipation of upstream watershed impoundment construction, a geoarchaeological reconnaissance was undertaken in the 1970s. Although scattered, a "blue clay" deposit long thought the source of late Pleistocene fossils and artifacts was found covered by colluvial deposits, some containing buried, weakly developed soils in different terrace settings. Three radiocarbon dates ranging from 9640 to 1475 years ago appear relevant to different stratified deposits.	Hofman 1988, 1993; Nials 1977; Wyckoff 2008.
Cimarron River Dunes, Alfalfa and Major Counties No. 5 in Figure 7.5	Extensive dune fields were studied on the floodplain and different terrace settings north and south of the Cimarron River in northwestern Oklahoma. Paleosols were found at different depths in four cores taken at four different settings. A soil sample from each paleosol was radiocarbon dated, resulting in dates varying from 11,300, 7645, 6385, and 1200 years ago.	Brady 1989
Cow Creek, Payne County No. 6 in Figure 7.5	Tributary to Cimarron River; excavated profile in floodplain revealed buried soil at 193 cm below the surface. C14 dates on soil yielded results of 1200 to 1600 years ago. Three OSL dates on sediments above the paleosol are incompatible with the radiocarbon results.	Lepper et al. 2003.
Deer Creek Drainage, Oklahoma County No. 7 in Figure 7.5	Studies at several locations in the upper end of this tributary to the Cimarron River. More than 13 m of profiles recorded in 2 cores, 1 backhoe trench, and 3 deep exposures along Deer Creek and its tributaries. 11 radiocarbon dates obtained from 3 paleosols; one around 400 years old, another from 1100 to 1650 years old, and a third around 9700 years old. Report identifies the Piedmont paleosol.	Carter 1990; Brakenridge 1990; Hofman and Drass 1990.
Delaware Canyon, Caddo County No. 8 in Figure 7.5	Studied 6 locations in a setting designated for upstream impoundment construction; stream is tributary to Washita River. From 4 to 11 m of stratified sediments and paleosols (5) exposed, with archaeology occurring in many of the latter. 15 radiocarbon dates help establish age of soil formation and a notable erosional period. Location contains formally described Caddo County paleosol.	Ferring 1982; Hall 1982; Pheasant 1982.
Domebo Site, (34CD50) Caddo County No. 9 in Figure 7.5	Washita River tributary where mammoth remains and Clovis spear points were found in Unit 2, the second lowest of 6 recognized stratigraphic units that comprise the "Domebo Formation", a 10 m thick exposure. Unit 2 is a darkened, gleyed paludal deposit dated to around 11,000 years ago. The upper 8 m of the profile includes red to light brown sandy sediments with some hints of soil development.	Albritton 1966 Hofman 1988; Leonhardy 1966; Wilson 1966.
Washita River Flood Plain Garvin County No. 10 in Figure 7.5	A steep cut bank on east side of the Washita River revealed two buried soils below the flood plain. One at about 1.5 m below the surface dated to roughly 2200 radiocarbon years ago, whereas a second, at 2.9 m below the surface, dated nearly 4000 radiocarbon years ago.	Drass 1997:150- 152.



Figure 8.5. Locations where buried soils have been previously documented and radiocarbon dated near the Cross Timbers. Numbers refer to sites or localities listed in Table 8.1. The Cross Timbers are the western edge of the Postoak-Blackjack Oak Forest identified in this illustration. Map courtesy of the Oklahoma Biological Survey.

been found under some of these dune fields, and the few that have been radiocarbon dated attest to the soils forming during different intervals from early to late Holocene times (Brady 1989; Wyckoff and Carter 1992:68). Dark and relatively thick, these buried soils look like those formed under grasslands, so they provide maximum ages for the spread of today's scrub oak woodlands. Notably, these northwestern extensions were not recognized and incorporated into Foreman's (1947) depiction of the historic Cross Timbers.

### Prehistoric Landscape Stability along the Cross Timbers

Four newly studied locations with dated, buried soils are reported in this volume. In combination with 10 similarly studied locations in Table 8.1, these places and their dated profiles can be used to assess whether local or regional periods of landscape stablility occurred prehistorically along the known historic expression of the Cross Timbers in Oklahoma. Periods of landscape stability are of special interest to archaeologists because they represent times when climatic conditions favored plant growth, which, in turn, might have attracted game and the human societies dependent on both of those food sources. Whether such climatic conditions encouraged the presence and/or expansion of the Cross Timbers is also of interest. Prehistoric tree stumps and plant pollen are two potential lines of more direct evidence with which to study the prehistoric extent of the Cross Timbers. Although a few locations have yielded such evidence (Table 8.1), our best clues to past settings are the former surface soils (discussed herein) that are now buried in valleys. Gray and Bakhtar (1973) have thoroughly described and discussed the character of various soil profiles manifest along the Cross Timbers in south-central Oklahoma. We can compare these descriptions with the paleosol profiles reported in this volume and elsewhere (Table 8.1) to ascertain whether or not blackjack and post oak woodlands were present prehistorically.

Before presenting our compilations and correlations of dated, buried soils, readers need to be aware of some issues affecting radiocarbon dates on soils. Nearly 100 radiocarbon dates (including both routine and accelerator mass spectometer [AMS]) are available for the study area. While a few of these results were obtained from charcoal recovered from archaeological or other contexts in buried soils, most of these dates were derived from carbon-rich organic matter in these paleosols.

Radiocarbon dates on soils are actually derived by dating carbon in decomposed and often chemically alterred organic matter or humus. While soil is principally composed of sand, silt, and clay, these inorganic particles can affect organic matter. The mineralogy of those particles is conducive to diverse chemical processes that "fix" or retain carbon compounds within vertical zones (horizons) of a soil profile. Soil horizons at or near the ground surface incorporate organic matter from grass, forb, and tree rootlets that grow and die there. When a surface soil horizon is stable for a long time, it continues to accumulate organic matter over decades and even centuries. Consequently, soil samples submitted for radiocarbon or AMS dating may contain carbon from organic matter that accumulated over many years. The younger carbon incorporated in such situations affects the dating process, making the soil appear more recent than its original date of formation. This is important if we are interested in the *initial* date of soil formation, which would indicate the *beginning* of a period of landscape stability. Basically, we must keep in mind that submitted soil samples tend to yield dates younger than when the soil began to form.

Also, depending on the carbon chemistry and length of time of carbon input (the length of active soil formation involving incorporation of organic matter), radiocarbon dates on paleosols merit careful scrutiny. Much research has been undertaken by several radiocarbon labs to try to resolve the complicated issues of carbon chemistry, time, and reliable date acquisition from buried soils. Readers desiring to learn more about this research and these findings are referred to Dörr and Münnich 1980; Holliday 2004:178-184; Schaetzl and Anderson 2005:600-612; Scharpenseel and Becker-Heidmann 1992; Tamm and Östlund 1960; and Wang, Amundson, and Trumbore 1996. Because the paleosols we are studying are usually buried by thick layers of wind- or water-borne sediments, they usually are not adversely affected by historic plant growth. When these buried soils were on the surface, however, they experienced influxes of organic matter until they were buried. The most recently added organic matter, which may have been incorporated many years after the initial formation of the horizon, skews the radiocarbon dates towards results younger than those of initial soil formation (pedogenesis) and landscape stablization.

Finally, in compiling radiocarbon dates for buried soils in or near the Cross Timbers, we present the results as reported by the respective radiocarbon laboratories. That is, we cite the dates as radiocarbon years before present (rcybp), without applying any of the corrective approaches that make the results calendrically relevant. These corrective procedures are based on atmospheric carbon dioxide fluctuations during and after the last glaciation. The techniques for correcting radiocarbon dates have been evolving for over two decades, and improvements in determining calendrical results are being published on an increasingly regular basis. In this monograph, rather than using a specific correction formula that will be out of date within a year or two of publication, we simply present the dates as reported by the labs. Individuals wanting to determine the calendrically relevant results may do so at their leisure using whichever formula that pleases them. Where available, we will present the  $\delta^{13}$ C ratios because these imply the type of vegetative cover that existed on the now buried soils

(Holliday 2004:225-231).

### Paleosols of the Late Pleistocene

Paleosols older than 12,000 years ago have yet to be reported in the region of Oklahoma's Cross Timbers. They probably exist but just haven't been recognized and dated. A possible example of such an ancient paleosol is shown in Figure 5.1. This well defined, 40cm thick, calcium carbonate-rich (calcic) horizon is manifest about a mile upstream from the Pond Creek exposure discussed by Cranford and Dowd (this volume). It occurs where Pond Creek has cut into an east sloping hillside, but the calcic horizon dips south from a meter below the crest of the present slope to some 4m below the surface some 20m south. It formed on top of Permian-derived silty clay loams. The thickness, size and degree of carbonate cementation (Stage III of Gile et al. 1966), and coloration of this calcic horizon indicate a period of much less effective precipitation than that which occurs today. While potentially attributable to an early to middle Holocene interval of desert-like conditions, no comparable calcareous horizons are noted (Gray and Bakhtar 1973) for the Cross Timbers. On this basis we suspect the Pond Creek calcic horizon is very old, perhaps even a relic of the last interglacial of some 110,000 years ago.

Another paleosol is of interest although it was discovered far west of our Cross Timbers study area. This late Pleistocene soil was found 175cm below the surface of an eroding terrace along the North Fork of the Red River in Greer County, Oklahoma (Hurst 2007; Hurst et al. 2006). Dated at 13,200 +/- 90 rcybp (Beta 182387). This 60cm thick horizon contained manganese nodules and manifested iron staining, both being attributes attesting to considerable precipitation moving through this former surface soil. Such conditions in far western Oklahoma are evidence of rather lush conditions extant there during waning stages of the last glaciation. No soil of comparable age had been dated within the Cross Timbers region, but the hilltop profiles at the Pumpkin Creek site (34LV49) discussed by Cranford (Chapter 5, this volume) also show extensive reduction and oxidation characteristics that likely resulted from more effective precipitation during the last glaciation.

The Domebo Formation. Oklahoma's most famous Paleoindian site, the Domebo Clovis mammoth kill, is in southern Caddo County where the Cross Timbers have a western extension (Table 8.1; Figure 8.5). Noted Texas geologist Claude C. Albritton (1966) studied the setting, described the stratigraphy, and recognized the deposit yielding mammoth bones and Clovis artifacts as the Domebo Formation. This formation is the highest of four benches or deposits of Quaternary alluvium Albritton discerned along this minor tributary to the Washita River. The other three alluvial deposits are all cut into the Domebo Formation are are thus younger (Albritton 1966).

The Domebo Formation was formally defined at a 12m

profile naturally exposed adjacent the mammoth remains and associated artifacts. The soil horizons and sediment strata manifest in this profile were assigned to upper and lower members of the Domebo Formation (Albritton 1966:11-12). The upper member includes 9.75m of sand to sandy silt soils and sediments (2 erosional discontinuities recorded) that accumulated after the lower member (ibid.). The lower member exceeds 2.0m in thickness and is capped by Stratum 2, a dark, olive gray, silty clay which contained chipped stone artifacts (mainly of Texas flint), a single Imperial mammoth, scattered bones of bison (*B. antiquus or occidentalis*) and other smaller vertebrates, and both aquatic (fresh water) and terrestrial snails (Cheatum and Allen 1966; Mehl 1966; Slaughter 1966).

Originally, three radiocarbon dates (Table 8.2) were run on soil and wood from the dark horizon that caps the lower member of the Domebo Formation (Figure 8.6). A fourth date was derived by accelerator dating a sample of an elm stump radiocarbon dated during the initial research (Table 8.2; Stafford et al. 1987:Table 1), and a fifth date was obtained on another stump more recently found weathering from the dark horizon (Table 8.2; Hofman 1988). The Domebo mammoth bones and associated wood played a notable role in developing and demonstrating the viability of AMS technology in deriving dates from different amino acids preserved in ancient bones (Stafford et al. 1987, 1991). One consequence was that Stafford and colleagues effectively refined the date of the Domebo mammoth kill to



Figure 8.6. View of boundary between dark lower member and light colored upper member of the Domebo Formation at the Domebo site (34CD50), Caddo County, Oklahoma. Photo courtesy of Jack Hofman; taken with Tom Stafford in 1989.

Table 8.2. Radiocarbon Dates on the Domebo Formation, Domebo Site (34CD50), Caddo County, Oklahoma.

RCYBP	Sample number, description, and context	References
9400 ± 300	OX-56; organically enriched soil collected near the skull of the mammoth; upper unit (2) of lower member of Domebo Formation.	Leonhardy and Anderson 1966: 24-25.
10,123 ± 280	SMU-610; lignitic wood sample: recovered from soil of upper unit (2) of lower member while water-screening microfossils.	Leonhardy and Anderson 1966: 24-25.
10,980 ± 70	Beta-24212; stump exposed in upper unit (2) some 50m downstream from mammoth.	Hofman 1988.
11.045 ± 647	SM-695; wood sample from possible winged elm ( <i>Ulmus alata</i> ) stump found some 30 m downstream and 0.76m deep in upper unit (2) of lower member.	Leonhardy and Anderson 1966: 24-25.
11,490 ± 450	AA-823; redating of another sample from the clm stump ( <i>Ulmus alata?</i> ) Represented and dated by sample SM-695 above.	Stafford et al. 1987:Table 1.

around 11,000 rcybp (Stafford 1984; Stafford et al. 1987, 1991). But this age doesn't precisely date the dark horizon, of interest here, in which the bones and artifacts were found. The results from age assessments of soil and wood (Table 8.2) may be more relevant for our study of paleosols and climatic conditions, and they imply that this organically rich horizon developed between nearly 12,000 and 9100 years ago (when figuring in the  $\pm$  factors).

Since the 1950s, Oklahoma Anthropological Society members have been finding Paleoindian projectiles in canyons and deeply incised creeks in west-central Oklahoma (Bell 1954, 1957; Gettys 1984; Hofman 1988). Frequently mentioned for these settings was a "blue clay" in which bison and sometimes mammoth bones occurred and from which Clovis, Folsom, and Plainview projectiles were thought to have washed. The dark upper part of the Domebo Formation's lower member was thought to exemplify this "blue clay". While compiling information on Folsom artifact finds in Oklahoma, Jack Hofman (1988, 1993) undertook to visit, inspect, and date exposures where dark sediments seemed to be yielding such Paleoindian projectiles. He also examined the possibility that the Domebo Formation might be more widespread than just the deeply incised stream and type site in south-central Caddo County. By correlating six radiocarbon dates on tree stumps and soils from two other drainages within 60km of the Domebo site, Hofman (1988:87) concluded that the Domebo Formation's lower member dated from 12,000 to 9000 years ago and had formed in several Caddo and adjacent county settings.

Without question, late Pleistocene and early Holocene climatic conditions over western Oklahoma were different than those of today. But given the sandy loam texture of valley fills developed from the Permian shale and sandstone bedrock prevalent there, we believe it unlikely that a soil forming in such materials could persist for three millennia, particularly in the canyon-like settings where Hofman documents the lower member of the Domebo Formation. Given the local relief and sandy character of these settings today, thunderstorms dropping 10 to 15 cm of rain cause tremendous cutting and filling in very localized drainages. Given the inability to discern good in situ deposits containing late Pleistocene fauna and artifacts, we suspect the dark upper part of the Domebo Formation's lower member was periodically incised and more recent organic matter deposited, thus the unusual date on soil from the site (Table 8.2). Even a quick glance at the upper boundary of this lower member reveals it is irregular, diffuse, and capped by stratified sediments (Figure 8.6). These clues appear to us as evidence that the post-mammoth/Clovis taphonomic history at the Domebo site is far more complicated than interpreted in 1966 and that mixing of early Holocene sediments (and thus a date of 9400 rcybp) could easily have happened.

To further assess whether or not widespread occurrences

of roughly contemporaneous late Pleistocene to early Holocene soils occur along or near today's Cross Timbers, we have compiled 16 radiocarbon dates from locations in central and west-central Oklahoma (including those used by Hofman 1988) in Table 8.3. Most of these locations are shown in Figure 8.5. Using the plus/minus factors for each of these dates we have plotted them in Figure 8.7. Some chronological overlap is manifest for the four earliest dates (from Howard Gully and the Campbell locality), and this overlap does correspond to most of the dates available for the Domebo site and formation (Table 8.2). For this reason, we concur that around 11,000 rcybp an organically enriched soil had formed in settings from southwestern to north-central Oklahoma, and this corresponds to the upper part of the lower member of the Domebo Formation. Notably, little evidence for the existence of the Cross Timbers occurs with the Domebo Formation. A dated stump in the lower member was elm, and the prevailing tree pollen recovered from the dark soil around the mammoth consisted mainly of grass and forbs (Wilson 1966:Fig. 35). Although somewhat diverse, the tree pollen spectra attest to species noted for pollenation through wind and none of these spectra exceed 10%. Given this low quantity, these arboreal species were most likely not living along the drainage when Clovis hunters dismembered the mammoth. Oak pollen is very minimally represented. Oak produces large quantities of wind-borne pollen grains, so its 6% presence in the mammoth-bearing deposit is a figure more probably resulting from long distance transport and not from oak woodlands nearby.

Table 8.3.	Late Pleistocene-Early Holocene Radiocarbon Dates from
	Central and Southwestern Oklahoma.

RCYBP	Sample number, description, and context	References
9070 +	Beta-182390: AMS date on sediment from the 2AB horizon as manifest	Hurst 2007:44-69:
50	between 104-170 cm below the surface in Trench 5 at site 34GR4. Greer	Hurst et al., this
	County. 13C/12C ratio, -18.7 0/00.	volume
9220 +	Beta-22427: Cedar Creek, Washita County: stump (species not	Hofman 1988.
120	identified) in dark sediment exposed in incised creek bed.	
9335 +	UGa-1732; Cedar Creek, Washita County; dark sediment exposed deep in	Nials 1977.
125	creek bank.	
9490 +	Beta-24211; Cedar Canyon, Caddo County; stump (species unidentified)	Hofman 1988.
80	eroding out of dark sediment in freshly washed creek bed.	
9580 <u>+</u>	Beta-20948; Cedar Canyon, Caddo County; sample from a second stump	Hofman 1988.
100	(species unidentified) croding from dark sediment in freshly washed creek	
	bed.	
9645 <u>+</u>	UGa-1728; Cedar Creek, Washita County; dark sediment exposed deep in	Nials 1977.
110	creek bank.	
9690 <u>+</u>	Beta-25297; Deer Creek drainage, Oklahoma County; soil from Horizon	Hofman and
90	30 at 13.21-13.5 m below the surface in the Briscoe core.	Drass 1990.
9730 ±	Beta-182393; soil sample from 170-245 cm below surface in Horizon	Hurst 2007:44-69;
60	3ABk of Core #1 at 34GR4, Greer County. <sup>13</sup> C/ <sup>12</sup> C ratio,18.9 o/oo.	Hurst et al., this
		volume.
9780 <u>+</u>	Beta-22428; Cedar Canyon, Caddo County; sample from 3 <sup>rd</sup> stump	Hofman 1988.
90	exposed in dark silty sediment of freshly exposed creek bed.	
9980 <u>+</u>	Beta-25296; Deer Creek drainage, Oklahoma County; soil from Horizon	Hofman and Drass
110	26 at 10.72-11.66 m below the surface in the Briscoe core.	1990.
10,030	GX-31270; Howard Gully site (34GR121), Greer County; soil sample	Hurst 2007:70-127.
<u>+</u> 280	from Horizon 2Akb3 at 95cm below the surface and below a bison bone	
	bed containing San Patrice-like projectile. C/ C ratio, -23.3 0/00.	
10,614	NZA-21569; Howard Gully site (34GK121), Greer County; charcoal	Hurst 2007:70-127.
± 40	sample from Horizon 2Akg3b8 in Profile 2 of 2004 field work; believed to	
10.010	be organic enriched lens discussed and dated by Holman (1991).	11.6
10,810	NZA-1401; Howard Outly site (340K121), Order County, charcoal	riotman et al. 1991.
<u>.</u> 110	sample from lowest organizative enriched fens in deep iterich dug in 1987	
	Pad Diver	
11.060	Beta-20350: Howard Gully site (34GB121) Greet County: sample of	Hofman et al
+ 220	organic enriched sediments from lowest of such horizons exposed in deen	1001
	trench due in 1987 in floor of small drainage among thick sand deposits	
	south of North Fork of Red River.	
11.200	GX-31271: Howard Gully site (34GR121). Greet County: organic	Hurst 2007:70-
+ 340	enriched soil from top of Horizon 2Akgb2 expressed at 134 to 155 cm	127.
	below the surface of floor of small drainage off thick sand deposits south	
	of North Fork of Red River. Believed the same deposit dated by samples	
	Beta-20359, NZA-1461, and NZA-21569. 13C/12C ratio, -23.3 0/00.	
11,345	GX-14707; Campbell locality, Major County; dark brown paleosol	Brady 1989:Table
+ 475	between 2 74 and 3 15 m in 4 72 m deen core taken between sand dunes	15



Figure 8.7. Plots of the radiocarbon dates listed in Table 8.3 using the one-sigma factor for each date. The plots are arrangedwith oldest to the left and more recent to the right.

With little overlap of dates between roughly 10,800 and 10,000 rcybp, we fail to see much evidence that a regional stability led to widespread pedogenesis during that period. However, nine radiocarbon dates show some overlap and continuity starting around 10,000 years ago and persisting to around 9400 years ago (Figure 8.7). These dates come from north-central, central, and southwestern Oklahoma (Table 8.3), and we interpret them as indicating an important period of soil development and widespread landscape stability. This period corresponds with the widespread use of San Patrice, Plainview, Packard, and Dalton projectile points that are now being found from eastern to west-central Oklahoma (Hurst 2007; Jennings 2008).

The six locations with dated, buried soils listed in Table 8.3 are mainly deeply incised stream sides and bottoms; only two, the Campbell locality and site 34GR4, represent larger terrace or upland settings. The dated soils tend to be dark from accumulations of soil organic matter, and several are thick enough to probably attest to mollic epipedons. Information on soil chemistry is insufficient to confirm the grasslands' origins of such surface horizons, but they most probably originate with such vegetation. For only three of the dates are the isotope  $\delta^{13}$ C ratios available: 2 from Howard Gully and 1 from site 34GR4. The  $\delta^{13}$ C ratios for these two nearby locations range from -18.7 to -23.3%, and such results tend to support the conclusion that grasses and forbs growing under conditions cooler than today were present between 11,000 and 9000 rcybp (Holliday 2004:225).

### Early to Middle Holocene Paleosols in or near the Cross Timbers

In paragraphs above we took issue with Jack Hofman's (1988) interpretation that the Domebo Formation developed and persisted for over 3000 years. Instead, by using more radiocarbon dates than Hofman had available 20 years ago, we have demonstrated that there were two different soils represented, not one. Besides some dates supporting the development of a soil around 11,000 rcybp, or Clovis times, a cluster of other available radiocarbon dates (Figure 8.7) supports the interpretation of a soil forming in central and southwestern Oklahoma around 9500 years ago.

This time falls within the very early part of the Holocene, the last 10,000 years of earth's geologic history (Farrand 1990:20-21). For North America the early Holocene is often perceived as dating from 10,000 to around 7000 years ago, or the period when continental glaciers were rapidly retreating to their source localities in the Canadian Rockies and places near Hudson Bay. This process has long been thought to result from steadily warming global temperatures and the gradual development of the zonal climatic patterns manifest today across North America (Borchert 1950; Guthrie 1984; Kutzbach and Guetter 1986). Such thinking originated with the findings and interpretations of Ernst Antevs, a Swedish born geologist who specialized in lake, stream, and wind borne sediments. Invited in the early 1920s to bring his expertise to the United States, Antevs began field work in New England and Canada but increasingly spent more and more time in the Great Basin, the Southwest, and the Southern High Plains through the rest of his career (Haynes 1990; Smiley 1974). Drawing on his and others' geological, paleontological, and palynological findings, Antevs (1955) published his classic "Geologic-Climatic Dating in the West" in American Antiquity. There, Antevs summarized his evidence of ice age (late Pleistocene) and post-ice age climatic events and their resulting geologic deposits in western North America. Although warming temperatures and accompanying drying pervade Antevs' view of the early Holocene, he did recognize (ibid.) that this trend was interrupted by several harsh intervals of erosion.

The scattered, diverse, and often limited evidence available to Antevs for deducing Holocene climatic changes is far more abundant and complicated than he could have suspected. This is especially true for the early Holocene segment of 9000 to 6000 years ago. Since 1990, deep cores in Greenland's interior ice field have yielded long, accurately dated, detailed records of oxygen and carbon isotope changes during and after the last glaciation (Alley 2002; von Grafenstein et al. 1998). For the early Holocene, the isotope changes attest to dramatic, rapid shifts between warm-dry and cool-moist climatic fluctuations, and the accurate dates for these shifts can be correlated with episodic sediment and ocean current, especially the Gulf Stream, changes in the north Atlantic. The emerging picture is one that entails multiple, massive pulses of glacial meltwater bursting through dams of ice and glacial debris in Canada and draining into the Atlantic and Gulf of Mexico by way of the Mississippi River, the Great Lakes and St. Lawrence seaway, and several outlets into Hudson's Bay (Barber et al. 1999; Clarke et al. 2003; Eyles 2006; Jakobsson 2008; Leverington et al. 2002; Seidov and Maslin 1999). The full scale and exact timing of these freshwater flood events is only now beginning to be fully appreciated, but they clearly played key roles in early Holocene climatic fluc-

Chapter 8: Summary Perspectives of Cross Timbers Soils and Prehistory

 
 Table 8.4. Early Holocene Radiocarbon Dates from Central and Southwestern Oklahoma.

RCYBP	Sample number, description, and context	References
6080 <u>+</u>	Beta-182391; site 34GR4, Lake Altus, Greer County; soil	Hurst 2007: Tables
110	sample from very upper part of 2Ab horizon (with some	4.0 and 4.9; Hurst
	calcium carbonate enrichment) exposed between 98 and	et al., this volume
	160 cm below the surface in Trench 6. $\delta^{13}C = -19.1 \text{ o/oo.}$	
6200 ±	Beta-215951; Mustang Creek floodplain, Canadian County;	Beale and McKay.
50	upper 10 cm of silty clay Ab-V horizon exposed at 280 to	this volume.
	400 cm below the surface in Core #2. $\delta^{13}C = -18.3 \text{ o/oo.}$	
6385 <u>+</u>	GX-14709; Ames locality, Major County; clayey A	Brady 1989:110-113
285	horizon found in core at 244 cm below the surface;	and Table XV.
	dune deposits attaining 152 cm in thickness occur here.	
7380 <u>+</u>	Beta-210183; Mustang Creek floodplain, Canadian County;	Beale and McKay.
40	lower 10 cm of silty clay Ab-V horizon exposed at 280 to	this volume.
	400 cm below the surface in Core #2. $\delta^{13}C = -19.8 \text{ o/oo.}$	
7480 ±	Beta-182388; site 34GR4, Lake Altus, Greer County; soil	Hurst 2007:Tables
50	sample taken from thin 2Ab soil horizon exposed 120 to	4.0 and 4.4; Hurst
	148 cm below the surface in Trench 1. $\delta^{13}C=-20$ o/oo.	et al., this volume
7645 <u>+</u>	GX-14708; Brinson locatity, Major County; darkened clay	Brady 1989:113-114
280	loam horizon found at 213 cm below the surface in a small	and Table XV.
	interdune depression.	
8030 <u>+</u>	Beta-215952; Mustang Creek floodplain, Canadian County;	Beale and McKay,
80	soil sample from uppermost 10 cm of buried sandy clay	this volume.
	loam 2Ab-VII horizon found at 440 to >456 cm below the	
	surface in Core #2. $\delta^{13}C = -19.5 \text{ o/oo.}$	
8200 <u>+</u>	Beta-182392; site 34GR4, Lake Altus, Greer County; soil	Hurst 2007:Tables
110	sample from lowest part of silt loam 2Ab horizon (with	4.0and 4.9; Hurst
	some calcium carbonate enrichment) exposed between 98	et al., this volume.
	and 160 cm below the surface in Trench 6. $\delta^{13}C = -20 \text{ o/oo.}$	
8400 +	Beta-22430; Cedar Canyon, Caddo County; tree stump	Hofman 1988.
360	exposed in dark sediment adjacent current stream bed.	

tuations, including several intensive droughts as well as some intervals of climatic amelioration when plant growth and landscape stability returned to the Southwest and the Southern Plains (Alley et al. 1997; Anderson et al. 2002; Davis 1984).

For the Southern Plains, the early Holocene was more than just 3000 years of gradual warming and drying. Such a trend is suggested by the Ferndale Bog pollen record with its increasing grass and forb spectra above late Pleistocene spectra attesting to oak-pine savannah (Bryant and Holloway 1985:Fig. 6). Intervals of alternating drought and moist conditions are not evident in the late Pleistocene to middle Holocene record at this location which is near today's Osage Savannah. But based on our findings, at least three intervals of stability and soil formation occurred between 10,000 and 6000 years ago along today's western border of the Osage Savannah. One is our already discussed interval around 9500 rcybp as evidenced by dated buried soils in central and southwestern Oklahoma. Hints of two other early Holocene intervals of effective moisture appear evident. We emphasize appear because our compilation found only nine radiocarbon dates on paleosols for the period of 9000 to 6000 radiocarbon years ago (Table 8.4). Notably, no radiocarbon dates are available that are entirely restricted (using their one-sigma factors) for the interval of 9000 to 8500 years ago or for the interval of 7000 to 6500 years ago. However, these two apparent breaks in the record become blurred when these nine dates and their one-sigma factors are plotted (Figure 8.8).

A glance at Figure 8.8 leads to the conclusion that the nine dates could attest to two intervals of soil development between 9000 to 6000 radiocarbon years before present (rcybp). One of these seems to start around 8300 rcybp and continues to around 7500 rcybp, whereas a later cluster



Figure 8.8. One-sigma plots of radiocarbon dates listed in Table 8.4. The plots are arranged from oldest (left) to the youngest (right).

(of only 3 dates) falls around 6200 rcybp. Figure 8.8, however, does not convey the whole picture because the dates were arranged chronologically, not contextually. The two apparent clusters are actually bound together by two sets of dates derived from sampling the top and bottom 10 cm of two different paleosols. One of these (at Mustang Creek) is just west of the historic Cross Timbers (Figure 8.9). The other is shallowly buried in a terrace along the North Fork of the Red River in Greer County (Figure 8.9), well west of our study area but of interest because the location contains evidence of multiple prehistoric occupations through the Holocene (Hurst 2007; Moe 2009).

Early Holocene surface stability of the North Fork terrace is evidenced by samples Beta-182391, Beta-182392, and Beta-210183 (Table 8.4). The first two samples yielded results indicating the now buried, organically enriched surface soil began forming around 8200 rcybp and continued accumulating soil organic matter to around 6000 rcybp. That this terrace surface was relatively stable for over 2000 years is further affirmed by sample Beta-210183 (7480  $\pm$ 50 rcybp) which comes from the same horizon but from an exposure (Trench 1) some 100 m away from where its top and bottom were dated (Trench 6).

In contrast, the soil-sediment sequence at Mustang Creek (Figure 2.14) includes a 4.4 m deep paleosol (Horizon VII of Beale and McKay, this volume) that had already formed (prior to 8000 rcybp) before the North Fork terrace paleosol, but the Mustang Creek locality then underwent erosion, leaving nearly 4.0 m of sandy silty sediment before the next paleosol formed. This next buried soil (Horizon V of Beale and McKay, this volume) began stabilizing and accumulating soil organic matter around 7380 rcybp and attained 62 cm in thickness by 6200 rcybp when it, too, was covered with alluvium (Table 8.4; Figure 2.14).

The remaining few dates for the early Holocene include a tree stump (Beta-22430) from Cedar Canyon in Caddo County and two dates (GX-14708 and GX-14709) on soils under sand dunes along the Cimarron River in Major County (Table 8.4;Figure 8.9). Although some 700 years different in age, the sub-dune paleosol dates fall within the time frame that the North Fork terrace paleosol and the second lowest paleosol (Horizon V) along Mustang Creek were being formed. The tree stump date has a large one-sigma factor but still correlates with the early development of the North Fork terrace paleosol.

Although only nine dates are available, they bear witness to at least two intervals of soil formation and landscape stability between 9000 and 6000 years ago. One such interval is around 6000 years ago, whereas the other is some two millennia earlier, or around 8200 years ago.

The evidence for soil development and landscape stability around 8200 rcybp is especially interesting. This time is contemporaneous with long accumulating ice core, geological, and palynological clues for the advent of cool to cold climatic conditions in northern hemisphere regions (Alley et al. 1997; Beget 1983; von Grafenstein et al. 1998). The cause for this early Holocene cold spell now appears to be major influxes of cold glacial meltwater into the Gulf of Mexico and the north Atlantic (Alley et al. 1997; Clarke et al. 2003; von Grafenstein et al. 1998), and the source of this meltwater is believed to be prehistoric Lake Agassiz, an estimated 163,000 km<sup>3</sup> superlake located over western Ontario and adjacent parts of Manitoba and Saskatchewan (Clarke et al. 2003; Jakobsson 2008; Leverington et al. 2002).

On the Southern Plains, cooler temperatures or just increased cloudiness could have lessened evaporation, thus increasing effective precipitation. This would have enhanced the growth of grass and forbs which, in turn, would have helped stabilize a drying, eroding landscape in the early Holocene. Notably, all of the early Holocene dates for which there are  $\delta^{13}$ C values show the latter occurring in a narrow range of -20 o/oo to -18.3 o/oo (Table 8.4). These  $\delta^{13}$ C fractionation figures are between what would be expected for cool season and warm season vegetation cover (Holliday 2004:225-227). So, the fractionation figures in Table 8.4 would appear to result from a mixture of cool and warm season vegetation. Calcium carbonate enhancement is noted for the North Fork terrace paleosol (Table 8.4), indicating that sometime during its formation precipitation levels were insufficient to flush soil carbonates through the profile. Regrettably, these carbonates were not dated, so we don't know when these less moist interval(s?) occurred.

Between 8200 and 6200 rcybp, our study area was obviously under periodic environmental stress. "Dune systems are good indicators of climatic change, especially departures towards aridity" (Holliday 2001:101-102). Based on the dated paleosols in Major County (Table 8.4), eolian sand deposition was active after 7600 and 6300 rcybp, because these dated soils are overlain by dunes (Brady



Figure 8.9. Locations where early to middle Holocene (9000 to 6000 radiocarbon years before present) paleosols have been radiocarbon dated: 1, Mustang Creek, Canadian County; 2, Site 34GR4, Greer County; 3, Cedar Canyon, Caddo County; and 4, the Ames and Brinson localities in Major County dune fields along the Cimarron River. Map courtesy of the Oklahoma Biological Survey.

1989). The Major County dunes are part of the extensive dune field that parallels the north side of the Cimarron River from where it exits a deep canyon in northeastern New Mexico to its juncture with the Arkansas River some 560 km downstream. Similar dune fields occur on the north side of the North Canadian and South Canadian rivers which roughly parallel but lie south of the Cimarron. In Dewey County, just north of the Oakwood community, a low dune cross-sectioned by State Highway 33 was profiled and found to overlie several gleyed soils, one of which yielded a radiocarbon date of 6960 ± 150 rcybp (Beta-37701; Wyckoff and Carter 1992). Thus eolian dunes formed after that. Today, this dune covered ridge between the South and North Canadian rivers supports one of the northwest trending fingers of historic Cross Timbers scrub oak woodlands (Figure 8.9).

Active dune formation during the early Holocene has been variously reported for the Southern Plains. Muhs and Holliday (2001) discuss various sheet sands and dune fields on the Southern High Plains and their eastern border. While different dune forms and drift trends are noted, they (ibid.) report that Southern High Plains eolian sands are mainly local in origin and rarely have preserved evidence that they were active during early to middle Holocene times. In a subsequent study of Southern High Plains eolian sand deposits, Holliday (2001) presents over 50 radiocarbon dates associated with such deposits and notes that few (<30%) attest to dune activity between 8000 and 3000 years ago. However, notable deposits of wind blown silt dating to intervals within these 5000 years do choke the shallow swales and draws that drain southeastly off the Southern High Plains (Holliday 1995, 2001).

Lengthy intervals of drought with its lessened vegetation cover and episodes of blowing silt and sand obviously would have affected Southern Plains foragers during early and middle Holocene times. Especially stressful would have been the sparse or sporadic presence of bison, a principal prey for Southern Plains hunters since late Clovis times (Bement and Carter 2006). One can't help but wonder if the generations of early Holocene people noticed the fewer, patchier herds of bison? Certainly they must have noticed morphological changes in the animals themselves. The overall trend of diminishing size from late Pleistocene Bison antiquus to late Holocene Bison bison has long been recognized (Hay 1914; Hill et al. 2008; McDonald 1981; Wyckoff and Dalquest 1997). While the reason for size reduction is usually explained as environmental (the warming, drying trend through the Holocene and its concommitant effects on plant species density and forage quality for large herbivores), archaeologists have raised the question whether human predation of bison might also have played a role in the observed size reduction of bison. Very recently, Hill and colleagues (2008) compiled measurements and attributes of Great Plains bison humori and calcanie dating from around 37,000 to 250 years ago. Their findings reveal punctuated size changes that correlate best with adverse climatic conditions through the Holocene and not with indications that human hunting played a role with bison diminution through the Holocene (ibid.). The most significant size reductions are evidenced for bison dating to early Holocene intervals around 10,000 and 7000 years ago (Hill et al. 2008:Figs. 4-7).

Archaeologist David Meltzer has long maintained an interest in the character of early and middle Holocene climate and especially its effects on Southern Plains hunter-gatherers. Among his research contributions are the finding and dating of 86 pits dug at Mustang Springs near the southern end of the Southern High Plains in west Texas (Meltzer 1991, 1999; Meltzer and Collins 1987). Meltzer provides insightful clues bearing on the human origin of these pits and their purpose to get at water as the land was drying and the water table lowering. By measuring their depths and radiocarbon dating the lowest sediment from the shallowest to the deepest, these pits were dug between 6800 and 6600 years ago as the water table dropped some 3.0 meters (Meltzer 1991:255). Similar but fewer pits or wells have been reported at Rattlesnake Draw and Blackwater Draw, eastern New Mexico (Green 1962; Meltzer and Collins 1987; Smith et al. 1966). The well at Blackwater Draw is believed to be several millennia later while those at Rattlesnake Draw are about the same age as the ones at Mustang Springs (Meltzer and Collins 1987).

Lessened eolian activity and more landscape stability occurred around 6000 years ago. Soil horizon development around 6200 rcybp is evident at the same widespread locations where pedogenesis was noted occurring around 8200 rcybp (Table 8.4; Figure 8.9). The  $\delta^{13}$ C fractionation results available for this near mid-Holocene soil development are within the range of the 8200 rcybp paleosols and are interpreted to attest to a vegetation cover of both warm and cool season grasses and forbs. Although the findings seem widespread (Figure 8.9), it is likely that intervals of erosion locally interrupted soil development.

North of our study area, extensive sand and loess deposits accumulated south of the Arkansas River from eastern Colorado to south central Kansas (Arbogast 1995; Arbogast and Muhs 2000; Feng 1991; Frye and Leonard 1952; Madole 1995; Simonett 1960). The studies of these eolian deposits reveal they were active many times during and after the last glaciation, and middle Holocene dune formation is certain. Olson et al. (1997) report well formed dunes underlain by a paleosol that developed between 6700 and 6000 years ago. This age makes this paleosol contemporaneous with the ones we've identified for central and northwestern Oklahoma. For this reason, we believe that regional, not just local, landscape stability occurred some 6200 radiocarbon years ago along the eastern margin of the High Plains from the South Canadian River to the Arkansas River and maybe beyond that.

Archaeological evidence for hunter-gatherer occupations during this ameliorated period is sparse for the region where the Cross Timbers would eventually develop. Just west of this region, however, the Gore Pit site in Comanche County (Figure 8.9) merits notation. Situated along East Cache Creek and just south of the east end of the Wichita Mountains, the Gore Pit site (34CM111) appears to represent a favored setting frequented around 6000 years ago (Hammatt 1976). Exposed in a huge pit dug for fill for a raised highway, numerous shell middens, several burned rock features (roasting ovens) and a semiflexed burial were found 5 to 6 m below the present floodplain of East Cache Creek (ibid.). Directed by archaeologists with the Museum of the Great Plains, many Oklahoma Anthropological Society members carefully uncovered the burial and at least two of the rock-filled roasting ovens. A radiocarbon date for the burial was  $7100 \pm 350$  years before present (GX-2009), whereas dates on the burned rock features were 6030 ± 300 b.p. (SM-775) and 6145 ± 130 b.p. (GX-1558; Bastian 1964; Hammatt 1976:267-268). No diagnostic artifacts were found with the burial or the roasting ovens, but a variety of flake tools, including Clear Fork gouges, and a scatter of dart points (mainly heavily reworked, elliptical, side-notched or corner-removed forms) found across the former surface bear witness to a reliance on Ogallala quartzite (Hammatt 1976). The hafted bifaces and sparse faunal remains attest to some hunting, but scraper or pulping planes as well as grinding basins and hand stones are interpreted as evidence for intensive plant gathering and processing (ibid.).

At Gore Pit, the camp traces seem like they were associated with a paleosol. Soils scientist Joe Nickols (1976) made a brief study of the site and noted the lowest horizon was dark with some calcium carbonate accumulation. Snails recovered from this artifact-bearing horizon attest to both perennial water and at least scattered riparian woodlands (Cheatum 1976). Above this horizon alluvial sediments prevailed.

# The "Altithermal Long Drought" and Landscape Stability in Central Oklahoma

Familiar with dramatic post-glacial pollen changes in northern Europe and having discovered evidence for marked lake lowering and permanent ice loss in Great Basin settings, Antevs (1955:328-329) proposed an *Altithermal Long Drought* that began some 7000 years ago and persisted to around 4000 years ago in western America. Subsequent findings have indicated local perturbations and differences in the Great Basin climatic record (Mehringer 1986), but warm and dry conditions did prevail over some regions, including parts of the Great Basin, the Southwest, and the Southern Plains. On the Southern High Plains, evidence of persistent wind erosion, few clues to the presence of bison herds, and several examples of hunting-gathering groups digging wells to lowering water tables are documented for the period of 7500 to 4500 years ago (Dillehay 1974; Flynn 1982; Green 1962; Holliday 1989, 1995, 2001; Meltzer 1991, 1999; Meltzer and Collins 1987; Smith et al. 1966).

By 6000 years ago, many regions of North America were experiencing the brunt of Antevs' "Long Drought". Climatological geographers Cary Mock and Andrea Brunelle-Daines (1999) believe the locations of low and high pressure systems and the airflow of August 1955 closely approximate weather conditions around 6000 years ago. To discern the nature of those conditions they utilized such proxy evidence as dated lowered lake levels, plant macrofossils, and fossil pollen records (ibid.). But for August of 1955 they had access to high resolution climatic records for locations of high and low pressure zones and the airflow patterns associated with them (ibid.). The conditions in 1955 included above average monsoonal precipitation in the Southwest and marked drying and warming in the Great Basin, the Plains, the Midwest, and the Northeast. The conditions that contributed to this weather pattern included a dominant thermal low over the Southwest, a strong subtropical high off the Pacific coast, and low pressure with strong westerlies over Canada (Mock and Brunelle-Daines 1999:543). The overall effects of the August 1955 conditions mirror those evidenced by proxy finds for 6000 years ago. Yet to be resolved, however, is what factors contributed to the persistence of these conditions through the Altithermal millennia as perceived by Antevs (1955).

So what are the ramifications of the "Altithermal Long Drought" for central Oklahoma? As noted in the previous section, plenty of evidence exists for erosion and active dune formation interspersed with brief intervals of soil development and stable landscapes. We have already documented a series of radiocarbon dates on buried soils attesting to good plant growth and stable landforms around 6200 rcybp. Moreover, we also have 16 dates for buried soils that formed between 6000 and 3000 years ago (Table 8.5). Their one-sigma plots are shown in Figure 8.10. These dates come from nine locations that are widespread along the historic border of the prairie and the Cross Timbers (Figure 8.11). A glance at Figure 8.10 reveals three likely intervals of soil development: 5500, 4500, and 3000 radiocarbon years before present.

Three samples (Beta-210182, Beta-16986, and Beta-16988 in Figure 8.10) overlap around around 5500 rcybp. Although few, these results are exciting. All come from Mustang Creek, a very small (23,000 hectares) watershed draining to the North Canadian River just west of presentday Oklahoma City (#4 in Figure 8.11). The samples came from two different exposures of stratified paleosols that were several kilometers apart along Mustang Creek (see Beale and McKay, this volume). Consequently, we believe that the Mustang Creek basin experienced landscape stability and soil development that began around 5500 rcybp and that persisted for several centuries.

Table 8.5.	Middle Holocene Radiocarbon Dates from Central and
	Southwestern Oklahoma

RCYBP	Sample number, description, and context	References
3010 ± 50	Beta-2781; Carnegie Canyon, Caddo County; outer rings of cedar (Janiperas sp.) stump (#10) found 870 cm below surface in canyon wall. $\delta^{12}C=-24.08$ .	Lintz and Hall 1983; 216.
3040 ± 70	Beta-3079: Carnegie Canyon, Caddo County; splinters of cedar ( <i>Juniperus</i> sp.) wood recovered during coring at depth of 2900 cm below the surface; sample believed displaced from higher horizon during coring. $\delta^{3}C = -26.17$ .	Lintz and Hall 1983: 218.
3060 ± 50	Beta-2624; Carnegie Canyon, Caddo County: outer rings of cedar (Juniperus sp.) stump (#1) exposed 920 cm below the surface in the canyon wall.	Lintz and Hall 1983: 212.
3080 ± 40	Beta-218658; Pond Creek, Cleveland County; gleyed sediment some 400 cm below the floodplain surface and >200 cm below already defined Pond Creek Paleosol.	Cranford and Dowd, this volume.
3120 ± 70	Beta-25321; Deer Creek, Oklahoma County; soil organic matter from second paleosol that was exposed between 165 and 211 cm below the surface at Highway 4 bridge over Deer Creek.	Hofman and Drass 1990:92.
3130± 40	Beta-210185; Pumpkin Creek, Love County; soil organic matter in $3B_{\oplus}$ horizon exposed between 180 and 287 cm below the surface in west bank of creek. $\delta^{13}C^{+=}$ -18.6 o/oo.	Bollans and Jennings, this volume.
3140 ± 60	Beta-2778; Carnegie Canyon, Caddo County; outer rings of roots to cedar (Juniperus sp.) stump (#13) exposed 1000 cm below surface in canyon wall. $\delta^{13}C=-24.29 \text{ o/oo.}$	Lintz and hall 1983: 214.
3590 ± 80	Beta-35497; Turkey Creek, Pawnee County; soil organic matter from A horizon buried at 391 cm below the surface in exposed creek bank.	McQueen et al. 1993: 134.
3960 ± 70	Beta-72381: Archaeological site 34GV108, Washita River, Garvin County; soil organic matter from Horizon 7 at 280 to 295 cm below the surface. Fire-cracked rock and a corner-notched dart point reportedly found in this horizon.	Drass 1997;150.
$4040 \pm 100$	Beta-26715; Deer Creek, Oklahoma County; soil organic matter from fourth lowest buried A horizon; sample collected between 300 and 325 cm below the surface in the Briscoe Core.	Hofinan and Drass 1990:93.
$4080 \pm 100$	Beta-182394; Archaeological site 34GR4, Greer County; soil organic matter from calcium carbonate enriched Horizon 2A <sub>8</sub> B <sub>4</sub> 2 exposed between 106 and 128 cm below the surface in Trench 4, <sup>13</sup> C=-16.7 o/oo.	Hurst 2007:Table 4.7; Hurst et al., this volume.
4337 ± 35	NZA-23712; Powell Farm, Canadian County; soil sample from thin, irregular, darkened horizon exposed 95 to 105 cm below the surface on eroded band and directly overlying Wisconsinan pond deposit. <sup>13</sup> C= -23.9 o/oo.	Clanahan and Eads, this volume.
4550 ± 70	Beta-4637; Carnegie Canyon, Caddo County; cedar ( <i>Juniperus</i> sp.) stump (#48) exposed 1120+ cm below surface in canyon wall; date thought too early relative to other stumps manifest 200 to 500 cm higher in profile. <sup>11</sup> C=-24,57 0/00.	Lintz and Hall 1983: 218.
5400 ± 120	Beta-16988; Mustang Creek, Canadian County; soil organic matter from paleosol 2A <sub>b</sub> (Horizon XVI) exposed between 240 and 268+ cm below the surface in the bank of Mustang Creek in 1986.	Beale and McKay, this volume.
5520 ± 250	Beta-16986; Mustang Creek, Canadian County; soil organic matter from Horizon VII, an A <sub>8</sub> horizon manifest from 265 to 350 cm below the surface as exposed in deep gulley and recorded in 1986.	Beale and McKay, this volume.
5590 ± 50	Beta-210182; Mustang Creek, Canadian County; soil organic matter from Horizon IV, an A <sub>b</sub> horizon manifest from 185.5 to 212.5 cm below the surface of floodplain adjacent creek. $\delta^2 C = -19.8$ doto.	Beale and McKay, this volume.



Figure 8.10. One-sigma plots of radiocarbon dates listed in Table 8.5. The plots are arranged from oldest (left) to the youngest (right).

Part of our excitement with the Mustang Creek findings stem from the fact that these dates compare well with recently acquired dates on as yet undescribed paleosols in northern Oklahoma and southeastern Kansas. In 2006, coring at the Burnham Homeplace (a in Figure 8.11) in Woods County of northwestern Oklahoma revealed a shallowly buried soil that was radiocarbon dated at 5320  $\pm$  40 BP (Beta-218659); the <sup>13</sup>C/<sup>12</sup>C ratio for this sample was -17.0 o/oo. This mid-Holocene paleosol overlay one dating more than 15,000 years ago. The stratigraphy rep-



Figure 8.11. Locations of buried soils with radiocarbon dates attesting to soil development between 6000 and 3000 years ago. The locations are: 1, Turkey Creek, Pawnee County; 2, Deer Creek, Oklahoma County; 3, Powell Farm, Canadian County; 4, Mustang Creek, Canadian County; 5, Pond Creek, Cleveland County; 6, Site 34GV108, Garvin County; 7, Pumpkin Creek, Love County; 8, Carnegie Canyon, Caddo County; and 9, site 34GR4, Greer County. Letters designate dated, but as yet undescribed paleosols, at the Burnham Homeplace (a) in Woods County and along Opossum Creek (b) in Nowata County.

resented by these buried soils has yet to be formally described. Likewise, another buried soil manifest, but not yet formally described, has been discovered along Opossum Creek in Nowata County in northeastern Oklahoma (b in Figure 8.11). Shown in Figure 8.12, the "Possum Creek" paleosol yielded a date of  $5220 \pm 40$  BP (Beta-246820;  $\delta^{13}$ C ratio equals -19.5 o/oo) from the lowest 10 cm of the soil and a date of 4480  $\pm$  40BP (Beta-246819;  $\delta^{13}$ C ratio equals -14.6 o/oo) from the uppermost 10 cm of this 40 to 45 cm thick horizon. This paleosol does contain chipped stone artifacts and remains of a roasting oven dating to 4320 ± 40BP (Beta-246821). Finally, communications with Michael Stites, a graduate student at the University of Wyoming, indicate that a 5200 year-old soil has been found in southeastern Kansas. Because this recent finding is under study by Kansas archaeologists and geoarchaeologists no firmer details are available at this time.

So, with the Mustang Creek paleosols, those from northwestern and northeastern Oklahoma and adjacent southeastern Kansas indicate that a regional occurrence exists for soils that began forming between 5500 and 5200 radiocarbon years ago and that they persisted to around 4500 rcybp. The significance of these dates lies not only in their bearing witness to a period of regional ameliorated climate and its attendant growth of vegetation, but they also correlate nicely with the slowly accumulating chronology for the Calf Creek Complex.

Table 8.6 lists 20 radiocarbon dates associated with Calf Creek (Bell or Andice in Texas) artifacts and assemblages from Oklahoma and Texas. The one-sigma results for each of these dates are plotted in Figure 8.13. Although the compiled dates span more than two millennia, the majority overlap and cluster between 5200 rcybp and 4500 rcybp (Figure 8.13).

We believe the contemporaneity between the paleosol dates and those for the Calf Creek archaeological manifestation is significant documentation that these middle Holocene hunters and gatherers flourished during an interval of climatic and ecological optimum in what otherwise was a warm dry period. Manifest at rock shelters, open camps, and occasional bison kills from southwestern Texas north through Oklahoma and into southeastern Kansas and adjacent Missouri and Arkansas, the Calf Creek Complex includes a variety of chipped stone tools relating to hunting and gathering (Decker et al. 2000; Dickson 1970; Johnson 1964, 1991; Mahoney et al. 2003; Ray and Lopinot 2003; Stites 2006; Thurmond and Wyckoff 1998; Wyckoff 1995; Wyckoff and Shockey 1994, 1995). Among the diagnostics of this material culture are deeply basally-notched, large, wide projectile points and other bifaces knapped from high quality chert (Figure 8.13 and 8.14). North of the Red River, these well made objects were commonly knapped from chert or quartzite which had been heat-treated one or more times. Besides heat treating favored stone, some



Figure 8.12. The middle Holocene paleosol manifest along Opossum Creek in Nowata County, Oklahoma. Traces of a burned rock feature are evident near the middle of the horizon.

regional differences in stem form are becoming apparent, and it is likely that other hafted biface forms were also in use (Wyckoff 1995). While the wide bifaces with long, down-projecting barbs were sometimes argued to have been knives, the discovery of a split and fractured specimen in the right horn core of a juvenile bison proves they also served as projectiles (Figure 8.14; Bement et al. 2005). The inner ear bone of this bison skull yielded a date of 5120  $\pm$  25 (UCIAMS-11696). This rare association was found eroding from a creek bank adjacent the Arkansas River a few miles upstream from Tulsa, Oklahoma. The material of the projectile is believed to be heat-treated Keokuk chert from the Ozark Plateau some 70 miles to the east.

Within our compilation of middle Holocene dates on buried soils, six fall between 4500 and 3500 rcybp (Figure 8.10). Three tend to overlap around 4000 rcybp. These come from widely scattered locations in central and southwestern Oklahoma. With only three such dates from three widely separated spots, we hesitate to say too much about their significance. At the very least, these dates and their contexts should alert future researchers to watch for evidence of a short interval of ameliorating climate around 4000 rcybp. The other three dates within the 4500-3500 bp time frame also come from widely scattered places, and they could attest to at least local settings briefly undergoing landscape stability and modest soil development.

Seven samples cluster around 3000 years ago, and these come from five localities ranging from central to southcentral and west-central Oklahoma. Such a widespread distribution is interpreted to indicate that soil development around 3000 rcybp was regional, not just local, in extent. The  $\delta^{13}$ C isotope numbers available for these dates range from -18.6 o/oo to -26.17 o/oo. Such numbers would appear to indicate a return of woody plants, forbs, and grasses resulting from cool seasonal growth (Dörr and Münnich 1980; Holliday 2004:225; Waller and Lewis 1979).

# Table 8.6. Radiocarbon Dates from Southern Plains Sites with Calf Creek (or Bell and Andice) Cultural Components.

<sup>14</sup> C Date B.P.	Sample # and Description	References	
>3520	Tx-289, Landslide site (41BL85), Bell County, Texas; date on bison bone from Feature 2, one of 5 hearths associated with Occupational Phase 3 which included Bell variety of Calf Creek projectiles.	Sorrow et al. 1967:3-41.	
4380± 110	AA-20401, Richard Beene site (41BX831), Bexar County, Texas; date on upper Medina pedocomplex which yielded a few fragments of Bell or Andice variety of Call Creek points.	Thoms et al. 2007: Table 4.2.	
4430 ± 55	GX-21746, Richard Beene site (41BX831), Bexar County, Texas; AMS date on charcoal from upper Medina pedocomplex that yielded a few fragments of Bell or Andice variety of Calf Creek points.	Thoms et al. 2007: Table 4.2.	
4510 ± 110	AA-20407, Richard Beene site (41BX831), Bexar County, Texas; AMS date on charcoal fragments from upper Medina pedocomplex which also yielded a few fragments of Bell or Andice variety of Calf Creek points.	Thoms et al. 2007: Table 4.2	
4570 ± 70	Beta-38700, Richard Beene site (41BX831), Bexar County, Texas; soil carbon from upper Medina pedocomplex which also yielded a few fragments of Bell or Andice variety of Calf Creek points. $\delta^{13}C=$ -26.30 o/oo.	Thoms et al. 2007: Table 4.2.	
4440 <u>+</u> 110	Tx-660, Arenosa Shelter (41VV99), Val Verde County, Texas; date from Stratum 32 which yielded examples of "Early Barbed" points likely of Bell variety of Call Creek.	Dibble 1997; Valastro and Davis 1970a, 1970b.	
4670 ± 70	Tx-773, Arenosa Shelter (41VV99), Val Verde County, Texas; date from Stratum 32 as above.	Dibble 1997; Valastro and Davis 1970a, 1970b.	
5360 ± 170	Tx-313, Arenosa Shelter (41VV99), Val Verde County, Texas; date from Stratum 32 as above.	Dibble 1997; Valastro and Davis 1970a, 1970b.	
$\frac{4480 \pm 60}{60}$	CAMS-14502, Woodrow Heard site (41UV88), Uvalde County, Texas; charcoal from Unit IIb of terrace fill which yielded 10 Bell variety of Calf Creek points. 8 <sup>13</sup> C=-25.4 0/00.	Decker et al. 2000: Table 6.	
4680 <u>+</u> 60	CAMS-14503, Woodrow Heard site (41UV88), Uvalde County, Texas; charcoal from Unit IIb of terrace fill which yielded 10 Bell variety of Calf Creek points. δ <sup>13</sup> C=-24.8 o/oo.	Decker et al. 2000: Table 6.	
4770 ± 60	Beta-166717, Royal Coachman site (41CM111), Comal County, Texas; date on charcoal from Unit 9 (70-80 cm below surface) which yielded a Bell point	Mahoney et al. 2003.	



Figure 8.13. One-sigma plot of radiocarbon dates associated with the Calf Creek material culture as listed in Table 8.6

# Late Holocene Climate and the Emergent Cross Timbers

Diverse clues to fluctuating climatic conditions between 3000 rcybp and the present come from scattered localities along the northern and western margins of the Osage Savannah. Paleoecologist Stephen Hall (1982) studied pol-

4770	Tx-3606, Granberg II site (41BX271), Bexar County,	Johnson 1991:155.
±	Texas; wood charcoal from zone #5 where Bell variety of Calf Creek points recovered along with Farly	
110	Triangular bifaces, Clear Fork and Guadelupe adzes, and corner-removed dart points.	
5650	Beta-112981, Woodrow Heard site (41UV88), Uvalde	Decker et al. 2000:
± 50	County, Texas; charcoal from Unit IIb of terrace fill which yielded 10 Bell variety of Calf Creek points. <sup>13</sup> C= -22.6 o/oo.	Table 6.
4780	Beta-154415, Pavo Real site (41BX52), Bexar County,	Collins et al. 2003.
±40	Texas; live oak wood from Feature 10, a rock-filled shallow basin some 20-25 em below the surface; some 10 Bell or Andice variety of Calf Creek points believed to relate to this period of site use.	
4960	Tx-525, Devel's Mouth site (41VV188), Val Verde	Johnson 1964; Sorrow
<u>+</u>	County, Texas; charcoal from stratum with Early Archaic occupations including some using Early	1968.
100	Barbed points of Bell or Andice variety of Calf Creek points.	
4990	NZA-6601, Kubik site (34KA354), Kay County,	Neal 1999.
±	Oklahoma; charred wood from level 15 of square 0-0 which yielded Calf Creek materials.	
100		
5020	NZA-6602, Kubik site (34KA354), Kay County,	Neal 1999.
±	0-0 which yielded Calf Creek materials.	
120	Bata 08146 Kubili sita (24KA254) Kau County	Nex1 1000
+	Oklahoma: split sample of charred nut busks from	ivear 1999.
60	level 16 of square 0-0 which also yielded Calf Creek materials.	
5120	UCIAMS-11696, petrous bone from juvenile bison	Bement et al. 2005.
± 25	skull with embedded Calf Creek point found in Arkansas River, Tulsa County, Oklahoma.	
5730	Beta-28192, Arrowhead Ditch site (34MS174),	Wyckoff et al. 1994.
±	Muskogee County, Oklahoma; charcoal from burned rock feature found below Calf Creek point, thus older	
160	than Calf Creek occupation.	



Figure 8.14. View of the juvenile bison skull with a shattered Calf Creek projectile embedded in it that was found eroding into the Arkansas River west of Tulsa, Oklahoma.

len and snail samples recovered from fill in rockshelters in Oklahoma's northernmost extent of this biotic district. In this same region, archaeologist Kenneth Reid and geoarchaeologist Joe Artz (1984) also discerned important records of alluviation and soil development. In southwestern Oklahoma seminal research on paleosols and archaeology was undertaken in Delaware Canyon of Caddo County by C.R. Ferring and his research team (Ferring 1982). Finally, Stephen Hall and Chris Lintz (1983, 1984) report the remarkable find of >60 tree stumps in situ with different paleosols in the thick fill of Carnegie Canyon of Caddo County, a location within our region of interest and one

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Figure 8.15. Calf Creek Complex diagnostics from Oklahoma: upper left, resharpened Calf Creek point (Bell variety) of heat treated Florence flint from Kay County; upper right, heavily resharpened Calf Creek diagnostics (Bell and Andice varieties) of heat treated Frisco chert from 34MR65, Murray County; lower left, slightly resharpened Calf Creek (Bell variety) of Woodford chert from Red Clay site in Haskell County; and lower right, resharpened Andice variety of Calf Creek of Edwards chert from Stephens County.

which we have already cited.

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From their documentation of soil profiles in the Little Caney drainage of north-central Oklahoma, Reid and Artz (1984:160-172) report substantial alluvial deposition between roughly 3800 to 2200 rcybp. Subsequently, between 2000 and 1300 rcybp, melanization and thickening of a now-buried suface soils occurred (ibid.). Notably, this dark, thick former surface soil (the Copan Paleosol) varied in development depending on its location in the drainage, with stabilization and soil development beginning somewhat earlier along the watershed's middle reaches (Reid and Artz 1984:17-172). This Copan Paleosol is frequently described as a cumulic soil, or one which attains thickness primarily through addition of darkened soil particles washed from upstream. Recent work by an Oklahoma State University team reveals the Copan and similar Caddo County paleosols actually result from several diverse processes and that considering the Copan paleosol as primarily an example of cumulic pedogenesis is equivocal (Carter et al. 2009). Still, the overall alluvial record in north central Oklahoma seems congruent with Hall's (1982) interpretation of pollen and snail findings. He believes these attest to the localities experiencing more effective moisture between 2000 and 1000 rcybp, with drier conditions occurring thereafter (ibid.). The lush woodlands common to the bottomlands today are believed (ibid.) to have evolved as the regional water table dropped, thus making it possible for tree roots to thrive and not be supersaturated with moisture.

For Carnegie Canyon in Caddo County of southwestern Oklahoma (Figure 8.16), Steve Hall and Chris Lintz (1983, 1984) correlate a series of dated tree stumps and the character of the soils in which they grew with intervals of fluctuating water tables (and thus indirectly climate) between 3200 years ago and the present. Found as deep as 29 m below the surface, 42 of 63 stumps of juniper, cottonwood, mulberry, and walnut were associated with three melanized, and sometimes calcic, buried soils(Carter et al. 2009; Lintz and Hall 1983). Radiocarbon dates on 16 different stumps (Table 8.7) chronologically position the stratigraphic succession of sediments and respective paleosols and help demonstrate that the locality was drier than today between 3200 and 2600 rcybp (ibid.). After that, however, moist conditions prevailed until around a millenium ago, whereafter the setting came under less effective precipitation conditions like those that exist today (Hall and Lintz 1984).

Though not as deeply stratified as at Carnegie Canyon, a similar sequence of sedimentation, pedogenesis, and cutting and filling is also well documented for Delaware Canyon some 30 km east of Carnegie Canyon (Figure 8.16) but still in Caddo County (Ferring 1982; Hall 1982; Pheasant 1982). Radiocarbon dates on buried soils or archaeological contexts within them (Table 8.7) closely compare with the Carnegie Canyon findings. In essence, between 1950 and 1000 radiocarbon years before present a well developed, melanized soil (the *Caddo County paleosol*) formed but was subsequently truncated by cutting and filling (ibid.). This, in turn, was followed by at least a meter of alluviation and eventual (around 800 rcybp) development of the Delaware Creek paleosol (Ferring 1982). Some alluviation occurred after that but it, too, underwent soil development near historic settlement of the region in the 1880s.

These different finds attest to climatic and landscape changes over the past 3000 years. We contend that the Southern Plains biotic districts historically known for Oklahoma attained their compositions and extents during these three millennia. A major basis for our contention is the continuous pollen records from Ferndale Bog. Situated on the climatically and ecologically sensitive west edge of the Ouachita Mountains, or just 160 km (100 miles) east of the Cross Timbers, pollen spectra from Ferndale Bog bear witness to the sporadic establishment of the historically recorded pine-oak-hickory forest since 3000 years ago (Figure 3.5; Albert 1981; Bryant and Holloway 1985: Fig. 6). Although comparable pollen records are lacking for central and south-central Oklahoma, the historic Osage Savannah and its western margin, the Cross Timbers, most likely developed during this time.

Forty-six radiocarbon dates relate to soil development and landscape changes within or near out study area since 3000 years ago (Table 8.7). These dates come from the locations shown in Figure 8.16. Among these locations are the above mentioned dated soils and tree stumps at Carnegie Canyon and the buried soils, erosion evidence, and incorporated archaeological materials at Delaware Canyon, both in Caddo County. The one-sigma plots for all 46 dates are shown in Figure 8.17. These results comprise over half of the dates available for buried soils along or near the historic Cross Timbers. Their quantity undoubtedly is linked to the frequent creek bank and gully exposures of late Holocene deposits in south-central and southwestern Oklahoma. Also, these exposures often contain archaeological materials, thus offering opportunities to gather information on specific cultural assemblages, their chronologies, and the ecologic-climatic conditions associated with them.

The dates and their one-sigma plots display an almost continuous overlap for the past 3000 years (Table 8.7 and Figure 8.17). However, several plateaus occur as a result of multiple radiocarbon dates clustering at particular intervals.

One such cluster includes ten samples that fall within the interval of 3000 to 2500 years ago (Figure 8.17). One of these samples is from a buried soil at archaeological site 34GR4 out on the western edge of the Wichita Mountains (Figure 8.16). Another is from a deeply buried soil in the Deer Creek watershed of Oklahoma County in central Oklahoma. But the majority come from the series of dated



Figure 8.16. Locations with buried soils radiocarbon dated to the last 3000 years along the Cross Timbers and adjacent localities. The locations are: 1, Bear Creek, Pawnee County; 2, Mt. Zion dunes, Major County; 3, Cow Creek, Payne County; 4, Deer Creek watershed, Oklahoma County; 5, Mustang Creek, Canadian County; 6, site 34CN46, Canadian County; 7, Delaware Canyon profiles and archaeological sites, Caddo County; 8, Carnegie Canyon, Caddo County; 9, site 34GR4, Greer County; 10, Pond Creek, Cleveland County; 11, Washita River, Garvin County; and 12, Pumpkin Creek, Love County.

"C Date B.P.	Sample # and Description	References
118±53	AA-68186, Pumpkin Creek Exposure, Profile C, Love County; bulk sediment sample from Horizon 2AB manifest 51cm below the surface. <sup>13</sup> C/ <sup>12</sup> C ratio, -19.9 o/oo.	Bollans and Jennings, this volume.
120 ± 70	0 ± 70 Beta-71753. Pond Creek Exposure, Profile A, Cleveland County; bulk J sediment sample of melanized buried soil found 74 to 95cm below the surface; this is the next to highest buried soil in the profile.	
333 <u>+</u> 38	3 ± 38 AA-68187, Pumpkin Creek Exposure, Profile A, Love County; a melanized soil (Horizon 4Ab) formed at top of cut-and-fill exposed at south end of long north-south creek bank profile. <sup>13</sup> C/ <sup>12</sup> C ratio, -18.5 of one	
400 <u>+</u> 60	Beta-26007, Spring Creek Exposure, Oklahoma County; uppermost buried soil; sample from 1.53 to 1.58 cm below the surface; designated as Horizon #7 (A,b) and considered as Local Paleosol #1.	Carter 1990; Brakenridge 1990; Hofman and Drass 1990
460 ± 65	UGA-2646, archaeological site 34CD257, Northwall 10 profile, Caddo County; Horizon IIIA12b at 150 to 160 cm below surface; the date is less than half as old as charcoal dated in horizons above and below.	Pheasant 1982:90.
473 <u>+</u> 77	73 ± 77 SMU-598, archaeological site 34CD258A, Caddo County; date on charcoal from prehistoric hearth intrusive into Delaware Creek paleosol, 115-125 cm below site datum; believed to relate closely to sample SMU-597.	
570 ± 80	Beta-16987, Mustang Creek Exposure, Profile 3, Canadian County; bulk sediment sample from melanized buried soils 74 to 105 cm below the surface.	Beale and McKay, this volume.
$\frac{609 \pm}{100}$	SMU-597, archaeological site 34CD258A, Caddo County; charcoal from 100 to 110 cm below site datum in buried A horizon considered equivalent to Delaware Creek paleosol.	Pheasant 1982:92.
621 <u>+</u> 38	1 ± 38 AA-68190, Pond Creek Exposure, Profile A, Cleveland County; bulk sediment sample from 45-55 cm below surface in uppermost buried soft. <sup>11</sup> C/ <sup>12</sup> C ratio, -16.7 0/00.	
783 ± 47	83 ± 47 AA-68189, Pond Creek Exposure, Profile A, Cleveland County; bulk sediment sample from 190 to 200 cm below the surface in the third biebest buried soli. <sup>11</sup> C/ <sup>12</sup> C ratio. <u>177</u> , 7000.	
870 ± 70	Beta-71754, Pond Creek Exposure, Profile A, Cleveland County; sediment sample from top 5 cm of <i>Pond Creek Paleosol</i> , a melanized horizon manifest from 182 to 273 cm below the surface.	Cranford and Dowd Table 4.2, this volume.
910 <u>+</u> 38	0 ± 38 AA-68188, Pond Creek Exposure, Profile A, Cleveland County; Horizon 4Ab, top 10 cm of the Pond Creek Paleosol. <sup>13</sup> C/ <sup>12</sup> C ratio, 18.3 o/co.	
920 <u>±</u> 50	Beta-6643, archaeological site 34CN46, Profile 2-South, Canadian County; charcoal from Feature 2 (ash and charcoal lens) within clay enriched horizon (Level VII).	Taylor 1984:32.
1020 ± 110	UGA-2645, archaeological site 34CD257, Caddo County; charcoal from Horizon IIIA1b, 140 to 150 cm below the surface.	Pheasant 1982:90.
1025 ± 100	UGA-2644, archaeological site 34CD257, Caddo County; Northwall 10 stratigraphic profile, charcoal from 130 to 135 cm below the surface in borizon IIcb/IIIA1b.	Pheasant 1982:91
1070 ±	SMU-635, archaeological site 34CD257, Caddo County; top of horizon	Pheasant 1982:91.

Table 8.7. 1	Late Holocene	Radiocarbon	Dates from	n Oklahoma	Locations	Shown in	Figure 8.15.
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C Date B.P.	Sample # and Description	References
1085 ± 75	UGA-2647, archaeological site 34CD257, Caddo County; Northwall 10 stratigraphic section, charcoal from 160 to 170 cm below the site datum in Horizon IIA12b.	Pheasant 1982:90
1100 ± 70	Beta-52398, Wishon core, Deer Creek drainage, Oklahoma County; bulk sediment from Horizon A,2b, a buried soil at 1.2 to 1.4 m below the surface; considered as Local Paleosol 2 and likely equivalent to upper Piedmont Paleosol.	Brakenridge 1990: Table 19; Carter 1990:Table 15; Hofman and Drass 1990.
1100 ± 70	Beta-25295, Briscoe core, Deer Creek drainage, Oklahoma County; bulk sediment from Horizon A,3b manifest 183 to 236 em below the surface and likely equivalent to Piedmont Paleosol.	Brakenridge 1990: Table 19; Carter 1990:Table 15; Hofman and Drass 1990.
1150 ± 100	Beta-35495, Crystal Creek profile, Bear Creek drainage, Pawnee County; Crystal Creek type section, bulk sediment from paleosol manifest at 138 to 335 cm below the surface.	McQueen et al. 1993.
1200 <u>+</u> 70	GX-14707, core taken at Mt. Zion location, Major County; sediment from paleosol manifest at 2.08 m below the surface, the middle of three paleosols found in this 4.88 m long core.	Brady 1989:108- 110.
1210 ± 60	Beta-31826, Cow Creek Exposure, Cimarron River drainage, Payne County: bulk sediment of buried soil at 230 to 260 cm below surface.	Lepper et al. 2003.
1230 ± 40	Beta-210184, Pumpkin Creek Exposure, Love County; Profile C, Horizon 3Ab, 88 to 118 cm below surface, bulk sediment from 96 cm below the surface. <sup>10</sup> Cl <sup>2</sup> C ratio17.9 o/oo.	Bollans and Jennings, this volume.
1325 ± 80	UGA-2648, archaeological site 34CD257, Caddo County; Northwall 10 stratigraphic profile, charcoal from 175 to 185 cm below the site datum in Horizon IIIA13b.	Pheasant 1982:90.
1330 ± 60	Beta-26008, Spring Creek profile, Deer Creek drainage, Oklahoma County; bulk sediment sample from Horizon A3b manifest 2.54 to 2.79 m below the surface. Correlates with upper Piedmont Paleosol in this drainage.	Brakenridge 1990: Table 19; Carter 1990:Table 16c; Hofman and Drass 1990.
$1330 \pm 70$	Beta-71755, Pond Creek Exposure, Cleveland County; melanized sediment from bottom 10 cm of Horizon 4Ab (182-273 cm below surface) which is the <i>Pond Creek Paleosol</i> .	Cranford and Dowd Table 4.2, this volume.
1400 <u>+</u> 70	Beta-25322, Bluff Creek Exposure, Deer Creek drainage, Oklahoma County; bulk sediment from Horizon A3b manifest 1.32 to 1.78 m below the surface and believed representative of Upper Piedmont Paleosol.	Brakenridge 1990; Table 19; Carter 1990:Table 16d; Hofman and Drass 1990.
1500 ± 90	SMU-733, archaeological site 34CD258D, Caddo County; charcoal from 90 to 100 cm below site datum in Horizon IIA14/IIC1.	Pheasant 1982:91.
1610 ± 70	Beta-33924, Cow Creek Exposure, Cimarron River drainage, Payne County; bulk sediment of a buried soil manifest 267 to 333 cm below the surface.	Lepper et al. 2003.
1650 ± 90	Beta-26009, Piedmont Bridge Exposure, Deer Creek drainage, Oklahoma County; bulk sediment sample of top of uppermost welded soil manifest 1.25 to 1.65 cm below the surface.	Brakenridge 1990; Table 19; Carter 1990:Table 16e; Hofman and Drass 1990.
1667 ± 70	Beta-7111, archaeological site 34CN46, Canadian County; charcoal from hearth exposed 460 to 490 cm below the surface in Profile 15.	Taylor 1984:81-83.

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### **Chapter 8: Summary Perspectives of Cross Timbers Soils and Prehistory**

tree stumps associated with buried soils recorded in Carnegie Canyon some 96 km (60 miles) east-northeast of site 34GR4. The Carnegie Canyon stumps primarily occur 7.5 to 8.8 m below the surface and are mainly juniper (Juniperus cf. virginiana) along with single examples of black walnut (Juglans nigra) and cottonwood (Populus sp.). As

140	Sample # and Decemintian	<b>P</b> .(
Data	Sample # and Description	References
DB		
1744 +	SMI 1-636 archaeological site 34CD258D Caddo County: charcoal from	Phearant 1087-01
151	100 to 110 cm below site datum in horizon IIA15/IIC2.	T Incasain 1904. 71.
1820 +	Beta-6574, archaeological site 34CN46, Canadian County: Profile 7.	Taylor 1984-42-50
70	charcoal found with burned rock some 6.3 m below the surface in Level	
	XX.	
2005 ±	UGA-2649, archaeological site 34CD257, Caddo County; charcoal	Phcasant 1982:90.
105	recovered from 190 to 200 cm below site datum in Horizon IVCab.	1
2240 ±	Beta-72380, archaeological site 34GV108, Washita River bank, Garvin	Drass 1997,
120	County; sediment sample of melanized buried soil 170 to 215 cm below	
	the surface.	
2320 ±	Beta-2784, Carnegie Canyon, Caddo County; outer rings of cottonwood	Lintz and Hall 1983:
70	stump (#29) found 8.9 m below the surface. 13C/12C ratio, -26.35 o/oo.	Appendix C.
2490 ±	WSU-2870, archaeological site 34CN46, Canadian County; Profile 16,	Taylor 1984:84.
60	charcoal from a hearth exposed 6.0 m below the surface.	
2600 <u>+</u>	Beta-2776, Carnegie Canyon, Caddo County; outer rings of black walnut	Lintz and Hall 1983:
60	stump (#5) found 5.5 m below the surface. <sup>13</sup> C/ <sup>12</sup> C ratio, -24.02 o/oo.	Appendix C.
2680 <u>+</u>	Beta-2783, Carnegie Canyon, Caddo County; outer rings of juniper stump	Lintz and Hall 1983:
60	(#28) found 7.6 m below the surface. 13C/12C ratio, -26.03 o/oo.	Appendix C.
2680 <u>+</u>	Beta-26010, Bluff Creek Exposure, Deer Creek drainage, Oklahoma	Brakenridge 1990:
80	County; bulk sediment sample from buried soil observed 4.5 m below the	Table 19; Carter
	surface.	1990:Table 16d;
		Hofman and Drass
		1990.
2730 <u>+</u>	Beta-2782, Carnegie Canyon, Caddo County; outer rings of juniper stump	Lintz and Hall 1983:
60	(#22) found 8.8 m below the surface. <sup>13</sup> C/ <sup>12</sup> C ratio, -23.26 o/oo.	Appendix C.
2810 <u>+</u>	Beta-2775, Carnegie Canyon, Caddo County; wood from juniper stump	Lintz and Hall 1983:
50	(#4) found 8.3 m below the surface. "C/"C ratio, -21.04 o/oo.	Appendix C.
2820 <u>+</u>	Beta-2779, Carnegie Canyon, Caddo County; wood from juniper stump	Lintz and Hall 1983:
50	(#14) found 10.6 m below the surface. "C/"C ratio, -21.56 o/oo.	Appendix C.
2960 <u>+</u>	Beta-2780, Carnegie Canyon, Caddo County; wood from cottonwood	Lintz and Hall 1983:
50	stump (#16) found 8.9 m below the surface. "C/"C ratio, -27.87 o/oo.	Appendix C.
2970 <u>+</u>	Beta-182389, archaeological site 34GR4, Greer County; melanized	Hurst 2007:Table
100	sediment from Horizon A/B2 manifest 58 to 76 cm below the surface.	4.1; Hurst et al.,
L	"C/"C ratio, -16.9 o/oo.	this volume.
2990 <u>+</u>	Beta-2777, Carnegie Canyon, Caddo County; wood from juniper stump	Lintz and Hall 1983:
50	(#29) found 8.0 m below the surface. "Cr <sup>12</sup> C ratio, -23.38 o/oo.	Appendix C.

interpreted by Hall and Lintz (1984), the prevalence of juniper trees is evidence the water table was low when this now deeply buried soil was the surface; junipers don't grow well when their roots are water saturated.

Given the three widely separated localities with buried soils yielding dates of 2900 to 2600 rcybp, we believe these findings are evidence of regional climatic amelioration leading to substantial landscape stability and soil development. The <sup>13</sup>C/<sup>12</sup>C ratios available for dates to this interval range from -16.9 to -27.87 (Table 8.7). The lowest ratio occurs with the buried soil at archaeological site 34GR4, the westernmost location yielding dates in this interval. This lowest <sup>13</sup>C/<sup>12</sup>C ratio (-16.9 o/oo) approachs levels common to today's warm, dry grasslands on the Southern Plains. But the other ratios are low enough to implicate more cool grassy environs. Most of these samples do come from Carnegie Canyon, a deeply incised setting that does tend to stay cooler than adjacent uplands.

Only three samples date to the interval of 2500 to 2000 rcybp (Figure 8.17), and only two of these (one from Carnegie Canyon and one from the Washita River in Garvin County) essentially overlap. On the basis of these three samples it is difficult to perceive much widespread soil development or stable landforms during these five centuries.

After 2000 rcybp, however, six samples implicate that floodplains in upland drainages were stabilizing and sup-



Figure 8.17. One-sigma plots of radiocarbon dates listed in Table 8.7. The plots are arranged from oldest (left) to the youngest (right).

porting sufficient forb and grass growth to initiate carbon recycling and melanization of topsoils at four rather widely scattered locations. This appears to have started around 1800 rcybp, and this is roughly the inception of the Caddo County paleosol. The locations include Delaware Canyon, a small canyon (with archaeological site 34CN46) off the Canadian River in Canadian County, the Deer Creek watershed in Oklahoma County, and Cow Creek in Payne County (Figure 8.16). This interval of soil development may have lasted to around 1500 rcybp when it was interrupted by drought and/or erosion. The pertinent radiocarbon samples are SMU-636, Beta-6574, Beta-7111, Beta 26009, Beta-33924, and SMU-733 in Table 8.7. Regrettably, none of these samples were reported with their <sup>13</sup>C/<sup>12</sup>C ratios, so we have no way to assess the character of the vegetation associated with these former surface soils.

Twelve radiocarbon dates fall within and two others straddle the late part of the period from 1500 to 1000 rcybp (Table 8.7 and Figure 8.17). Among these are the samples that supported the original identification of the Caddo County paleosol (Ferring 1982); these samples include charcoal from archaeological features at sites 34CD257A and 34CD258B, which were incorporated within the Caddo County paleosol. Diagnostic artifacts from these buried features and soil horizons included corner-notched arrowpoints and contracting stem large projectiles or knives, all considered (Ferring 1982) as Plains Woodland cultural objects. Notably, however, somewhat contemporaneous paleosols are now known in dune fields in Major County, the Deer Creek watershed in Oklahoma County, the Cow Creek watershed in Payne county, the Bear Creek drainage in Pawnee County, and the Pond Creek drainage in Cleveland County (Figure 8.16). The dates from these locations tend to refine the age of the Caddo County paleosol. Basically, a case can be made that the Caddo County paleosol did not develop for as long as originally interpreted (Pheasant 1982) and that the paleosol formed between 1800 and 1500 rcybp should not be designated as the Caddo County paleosol. Because these contemporaneous, melanized, buried soils span the western and southwestern extents of the Cross Timbers we believe they attest to a notable period of effective moisture that enhanced grass and forb growth (thus the carbon recycling and melanization). We recommend this broad regional occurrence be referred to as the Caddo County paleosol. As Hall (1982) has already noted, these organically enriched soils are not what would be expected under the scrub oak cover of the historic Cross Timbers. With their thick, darkend A horizons, these soils most likely result from seasonal (late summer or fall?) precipitation that enhanced expansion of grasslands while inhibiting (due to raised water tables) growth and expansion of scrub oak or other bottomland woodlands. The single available <sup>13</sup>C/<sup>12</sup>C ratio (-17.9 o/oo from Pumpkin Creek) is midway between levels common to cool or warm grassland conditions.

The most recent 13 radiocarbon dates in Figure 8.17 cluster between 800 and 400 radiocarbon years before present. Rarely are more than five samples in such clusters, but they do come from multiple localities along the historic Cross Timbers: the Pumpkin Creek drainage in Love County, the Pond Creek drainage in Cleveland County, the Deer Creek drainage in Oklahoma County, and archaeological sites 34CD257 and 34CD258A in Delaware Canyon of Caddo County (Table 8.7 and Figure 8.16). The respective buried soils are often thin and only slightly melanized. Only five of the dates on these soils were analyzed for  $\partial^{13}C$ ratios (Table 8.7), and these results range from -19.9 to -16.7 o/oo. Such figures implicate a mixture of cool and warm season vegetation. Consequently, we would think that they bear witness to brief intervals of ameliorated climate during nearly a millennium when upland erosion and valley alluviation was prevalent. Dates from Delaware Canyon and Pond Creek are on soil organic matter from the tops and bottoms of buried horizons. These attest to soil development between 800 and 500 rcybp. But overall, our findings seem to support Stephen Hall's (1982, Hall and Lintz 1984) conclusion that the prevailing climate of the past 1000 years has been less moist than that of the period from 2000 to 1000 radiocarbon years before present.

The two most recent radiocarbon dates in Table 8.7 are on thin, slightly darkened horizons most likely buried by sediments from erosion associated with historic farming along the Cross Timbers. As previously noted, much of the Cross Timbers landscape is underlain by sandy soils. Even if by teams of horses or mules, clearing and tillage of Cross Timbers sandy settings made them susceptible to erosion by both wind and water.

#### Conclusions

Focusing on Oklahoma, this volume presents the findings from studying buried soils manifest at five locations along or near the historic Cross Timbers. This tangle of scrub oak woodlands comprises the western edge of the Osage Savannah biotic district in Oklahoma, but these woodlands extend south as two prongs adjacent the Blackland Prairie and more westerly Cretaceous geologic formations in Texas. Except for the Washita River valley, archaeological evidence for a human presence in the Oklahoma Cross Timber had been disappointingly minimal. A 1984 compilation (Kawecki and Wyckoff 1984) of Oklahoma Cross Timbers archaeological finds revealed that diverse kinds of open camps were present, but they were buried by fluvial, colluvial, or eolian deposits. Lacking funds to date most of these archaeological sites, their ages only could be inferred by comparing diagnostic artifacts with material culture assemblages for which some chronology was known. Without any radiometric determinations, the 1984 compilation could not assess the timing of the intervals of wind and water erosion that contributed the deposits in or between which the archaeological sites were buried.

This new volume was stimulated primarily by the work of graduate students in a course on geoarchaeology. During the fall of 2005, these students learned standardized methods for recording soil characteristics, and they applied those methods at four deep exposures of multiple buried soils along today's Cross Timbers. Most importantly the students had access to funds to radiocarbon date most of the buried soils they studied. The basic operating assumptions underlying these studies were: 1, organically darkened (melanized) buried soils represented former surfaces of the ground; 2, as such, they comprised settings on which diverse vegetation thrived; and, 3, such settings undoubtedly were amenable to wildlife that favored such ecological niches and the predators, including humans, that hunted those creatures or utilized plant products in those niches. In essence, the newly studied profiles had the potential of revealing when and how long historic Cross Timbers landscapes were sufficiently stable that plants, animals, and Native Americans dependent on them were present.

This summary chapter was written because the students' findings would be most meaningful if combined with similar evidence from the sporadic archaeological or pedological studies near the Cross Timbers. This ecological region does run roughly north and south through central Oklahoma, but dense scrub oak woodlands also extend northwest along sandy terraces and uplands paralleling the Washita, South Canadian, North Canadian, and Cimarron rivers. Thus, dated buried soils, some containing archaeological sites, along these drainages were included in this synthesis chapter. As a result, we compiled information on more than 90 radiocarbon dates derived from paleosols recorded in or near the Cross Timbers of Oklahoma.

The 90 radiocarbon dates range from more than 11,000 radiocarbon years before present (rcybp) to the near present (Tables 8.2-8.7). By plotting their one-sigma factors we ascertained clusters of radiocarbon dates attesting to 9 intervals of soil development and landscape stability since late Pleistocene times. These nine intervals (and their recognized paleosols) are:

800 to 400 rcybp (*Delaware Creek paleosol*) 1400 to 1100 rcybp (*Caddo County paleosol*) 1800 to 1500 rcybp 2900 to 2600 rcybp 5500 to 4900 rcybp (*Mustang Creek paleosol*) 6200 rcybp 8300 to 7500 rcybp 10,000 to 9400 rcybp 11,500 to 10,900 rcybp (*Domebo paleosol*)

We offer this sequence as an outline meriting further documentation and confirmation or correction. In particular, more dates are needed and more studies should be undertaken to assess the processes behind the accumulation of thickened, melanized paleosols that are becoming recognized more often in valleys of upland settings in

central and south-central Oklahoma. As Carter and colleagues (2009) have demonstrated, such thickened former A-horizons could and did develop under different processes, not solely the cumulic processes usually attributed to them. The potential that these buried soils can yield at least phytoliths is an exciting research development (Carter et al. 2009) because such proxy plant material can then be used to characterize the nature of the vegetation communities that grew on these former surfaces. While most of the profiles studied herein were dominated by sandy soil particle fractions, and thus are conducive to water percolation and leaching, we believe that some buried soils will have sufficient silt to clay particle accumulations that they will preserve pollen, snails, and perhaps other proxy evidence of the climates responsible for these soils. We believe it important to keep looking and to keep trying to recover such evidence.

We recognized that almost every synthesis such as this chapter goes out of date soon after it is published. We hope this volume and this chapter will stimulate such research. Clearly, much has been learned since the 1930s when Sears and his contemporaries first recognized the presence and significance of buried soils in Oklahoma. As archaeologists, we know these soils can help us tell much better stories about the people who frequented and resided here in the past. Given the demands our present society places on food and water from these lands, we need to know more about what happened in the past.

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