Late-Quaternary Stratigraphy and Geoarchaeology of the Upper Neosho River Basin, East-Central Kansas

To be submitted in partial fulfillment
of the requirements for the degree of
Master of Arts

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ABSTRACT

In this study, a geoarchaeological approach was used to assess the potential for buried and surficial prehistoric cultural resources in the upper Neosho River basin of east-central Kansas. Specifically, lithostratigraphy (e.g. the DeForest Formation) and digital Soil Survey data (SSURGO) were used to estimate the relative ages of landform sediment assemblages (LSAs) in the study area. Surface-soil morphology was selected as a key indicator for predicting where the different members of the DeForest Formation occur, thereby providing estimated relative ages for LSAs. Field-truthing this hypothetical relationship between surface soils and members of the DeForest Formation included stratigraphic and geomorphic investigations. Numerical ages of alluvial deposits and associated buried soils were determined by radiocarbon dating. Some problems were encountered. For example, mapping late-Holocene members of the DeForest Formation is problematic based on SSURGO distributions because the data oversimplify the floodplain. Also, SSURGO data do not systematically or consistently map specific soils on alluvial/colluvial fans. Nevertheless, the results of this study suggest that surface soils are reliable indicators of the relative ages of early and middle Holocene LSAs, thereby providing archaeologists with a powerful tool for locating Paleoindian and Archaic cultural deposits in complex alluvial settings.

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FIGURES

TABLES

CHAPTER I

INTRODUCTION

Fluvial systems are dynamic environments punctuated by periods of erosion, sedimentation and landscape stability. An important facet of alluvial geoarchaeology is to determine how these processes act to destroy, preserve, and modify the archaeological record (Ferring, 1992; Waters, 1992). Cultural deposits can be removed from a drainage system through erosion, encapsulated by alluvium or modified by pedogenesis. Therefore, it is essential for archaeologists to understand landscape evolution (erosion, deposition, and landscape stability) in fluvial systems as it affects the spatial patterning of cultural materials (Bettis, 1992) and influences site formation processes (Holliday, 1992).

This study takes a geoarchaeological approach in assessing the spatial and temporal patterns of landscape evolution in the upper Neosho River basin of eastern Kansas (Figure 1.1). The history of late-Quaternary landscape evolution in the basin is poorly understood. Hence, the geologic potential for buried and surficial prehistoric cultural resources is unknown. The basic objective of this study is to determine whether alluvial deposits of certain ages are differentially but systematically preserved in the basin. The results of this investigation and other basin-wide studies (e.g. Thompson and Bettis, 1980; Bettis and Thompson, 1981; Mandel, 1988a, 1991a, 1994a, Mandel, et al. 1991; Beeton, 2007) "indicate that different geologic processes operating concurrently within a single drainage basin may differentially preserve the archaeological record and lead to erroneous conclusions about prehistoric

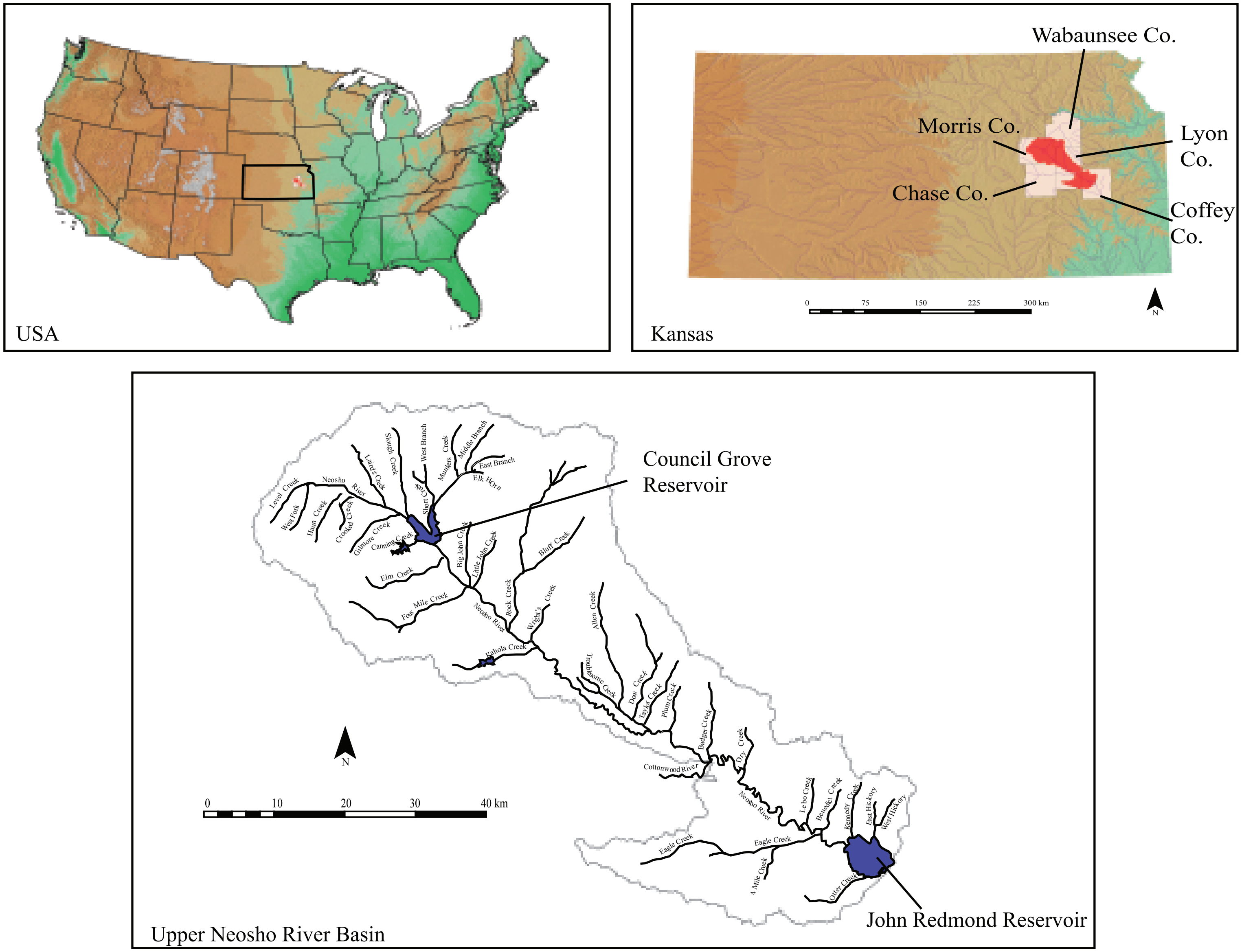


Figure 1.1. Upper Neosho River basin in Kansas, USA

settlement patterns" (Mandel, 2006a: 28). Therefore, this study provides a geologic context for the preservation of cultural deposits in the basin.

Research Objectives

This study focuses on the spatial and temporal patterns of landscape evolution in the upper Neosho River basin. The primary objectives of this investigation were to (1) identify and map the late-Quaternary landforms (i.e. floodplains, terraces, alluvial fans and colluvial aprons) in the upper Neosho River basin, (2) determine the soil-stratigraphy of the landform sediment assemblages (LSAs) and assign stratigraphic units (i.e. the DeForest Formation and Severance Formation), (3) determine the radiocarbon ages of alluvial deposits and associated buried soils, (4) evaluate the relationship between surface soil distributions and LSAs, (5) assess the geologic potential for buried and surficial prehistoric resources in the basin, and (6) create a predictive model for cultural deposits dating to specific periods.

Significance of Research

The significance of this study is fivefold. First, it expands our understanding of late-Quaternary landscape evolution in the upper Neosho River basin. Specifically, the research provides stratigraphic evidence for the spatial and temporal patterns of alluviation, erosion, and landscape stability. Second, it contributes to our understanding of the archaeology of the Flint Hills, Osage Cuestas and Central Plains, and provides predictive models for buried and surficial archaeological deposits dating to specific cultural periods in the basin. Third, the research provides important information on the relationships between surface soils and LSAs, and surface soils and archaeological site distributions. Fourth, it develops and evaluates a method for conducting basin-wide geoarchaeological studies in eastern Kansas. The geoarchaeological approach used in this study may be refined and expanded to assess the archaeological potential of other basins in eastern Kansas. Finally, this study provides important evidence regarding mid-Holocene (Archaic) site preservation and settlement of the broader Great Plains region, which has been a long standing anthropological issue.

Thesis Outline

This thesis consists of nine chapters. Chapter II describes the environmental setting of the upper Neosho River basin including physiography, bedrock geology, Quaternary geology, vegetation and climate. Chapter III divides more than 11,500 ^{14}C years of human occupation in the Central Plains into six cultural periods and describes each period. Chapter IV summarizes previous archaeological and geoarchaeological research in and around the study area. Chapter V explains the GIS mapping techniques and the field and laboratory methods. Chapter VI describes the individual study localities and the results of the radiometric and stratigraphic analyses. Chapter VII evaluates landscape evolution in the study area and presents the geoarchaeological conclusions and preliminary predictive models for locating buried and surficial archaeological resources in the basin. Chapter VIII evaluates whether surface soil distributions (via SSURGO data) can be used to map the members of the DeForest Formation and LSAs in the upper Neosho River basin. Chapter IX summarizes the results of this study and offers avenues for future research.

CHAPTER II

SETTING

The Study Area

The Neosho River basin covers an area of 32,116 km^2 (12,400 mi^2) and drains portions of Kansas, Missouri, Arkansas, and Oklahoma (Figure 2.1). The Neosho River basin measures approximately 756 km (470 mi) from its headwaters to its confluence with the Arkansas River (Juracek and Perry, 2004: 13). The drainage network of the Neosho begins in the Flint Hills and extends through the Osage Cuestas, Cherokee Lowlands, and Ozark Plateau physiographic provinces (Figure 2.2) (Juracek and Perry, 2004: 13). The headwaters in the Flint Hills and Osage Cuestas of eastern Kansas consist of two major streams: the Neosho River drains the northwestern segment of the basin, and the Cottonwood River drains the western segment. The Neosho and Cottonwood rivers converge near the City of Emporia in Lyon County, Kansas. From that point, the Neosho River basin continues through the Osage Cuestas physiographic province until it enters the Cherokee Lowlands physiographic province near the Kansas-Oklahoma border. In Oklahoma, the Neosho River is commonly referred to as the Grand River and drains into the Arkansas River near the city of Muskogee. The Arkansas River basin eventually drains into the Mississippi River in southeastern Arkansas.

The study area includes the northwestern segment of the upper Neosho River basin within Morris, Lyon, Coffey, Chase, and Wabaunssee counties of eastern Kansas (see Figure 1.1). This area does not include the western segment of the basin drained by the Cottonwood River. The Neosho River begins in name as a small second-order stream

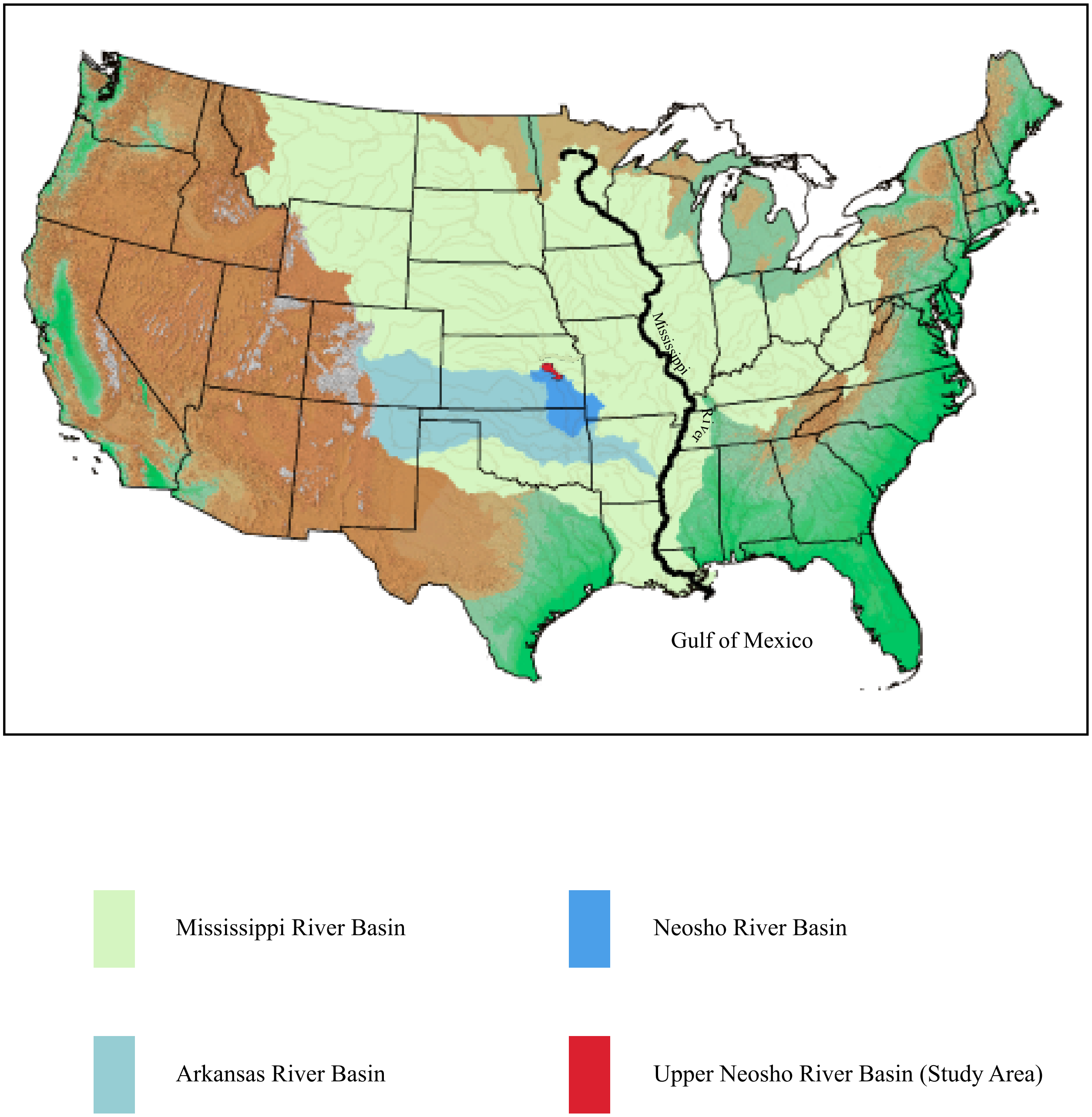


Figure 2.1. Study Area within the Mississippi, Arkansas, and Neosho River basins

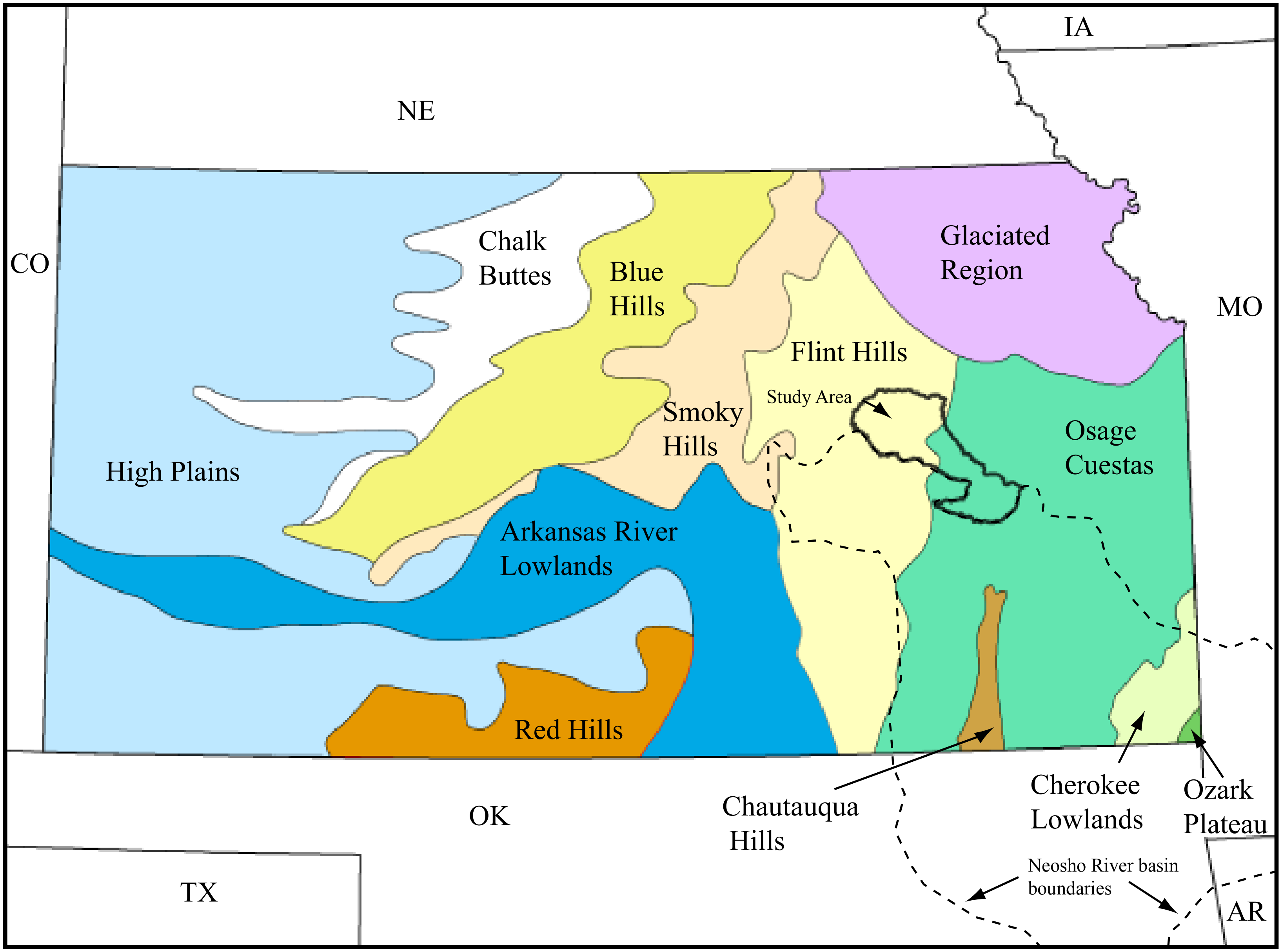


Figure 2.2. Physiographic Regions and Neosho River basin in Kansas

Adapted from Aber and Aber, 2007

based on Strahler's stream classification system (1964), until it is joined by Level Creek, (a third-order stream) in the extreme northeastern portion of the study area (Figure 2.3). The confluence of the Neosho River and the West Fork of the Neosho River (a third-order stream) to the northwest of the Council Grove reservoir expands the trunk of the Neosho River to a fourth-order stream. The Neosho River expands to a fifth-order stream after it is joined by Haun Creek, a fourth-order creek. The Neosho River increases to a sixth-order stream after it is joined by Munker's Creek. The Council Grove reservoir dam was constructed immediately downstream from this confluence. The confluence of the Cottonwood River (a sixth-order stream) and the Neosho River near Emporia increases the magnitude of the Neosho River to a seventh-order stream. The southern limit of the study area is the southern boundary of the John Redmond reservoir pool in Coffey County (i.e. the reservoir's dam).

From the Council Grove reservoir to the inlet of the John Redmond reservoir is a distance of about 134 river kilometers, or about 60 linear kilometers (Carswell and Hart, 1985: 3). Along this reach, the Neosho River valley is about 0.5 km wide near the city of Council Grove and is over 7 km wide (>4.3 mi), near its confluence with the Cottonwood River near Emporia (Carswell and Hart, 1985: 3).

The Cottonwood River originates in Marion County and is the largest tributary to the Neosho River within the study area. The Cottonwood drains approximately 4,942 km^2 above its confluence with the Neosho River. Other principal tributaries in the study area include Laird's Creek, Elm Creek, Munker's Creek, Big John Creek, Little John Creek, Rock Creek, Four-Mile Creek, Kahola Creek, Troublesome Creek and Eagle

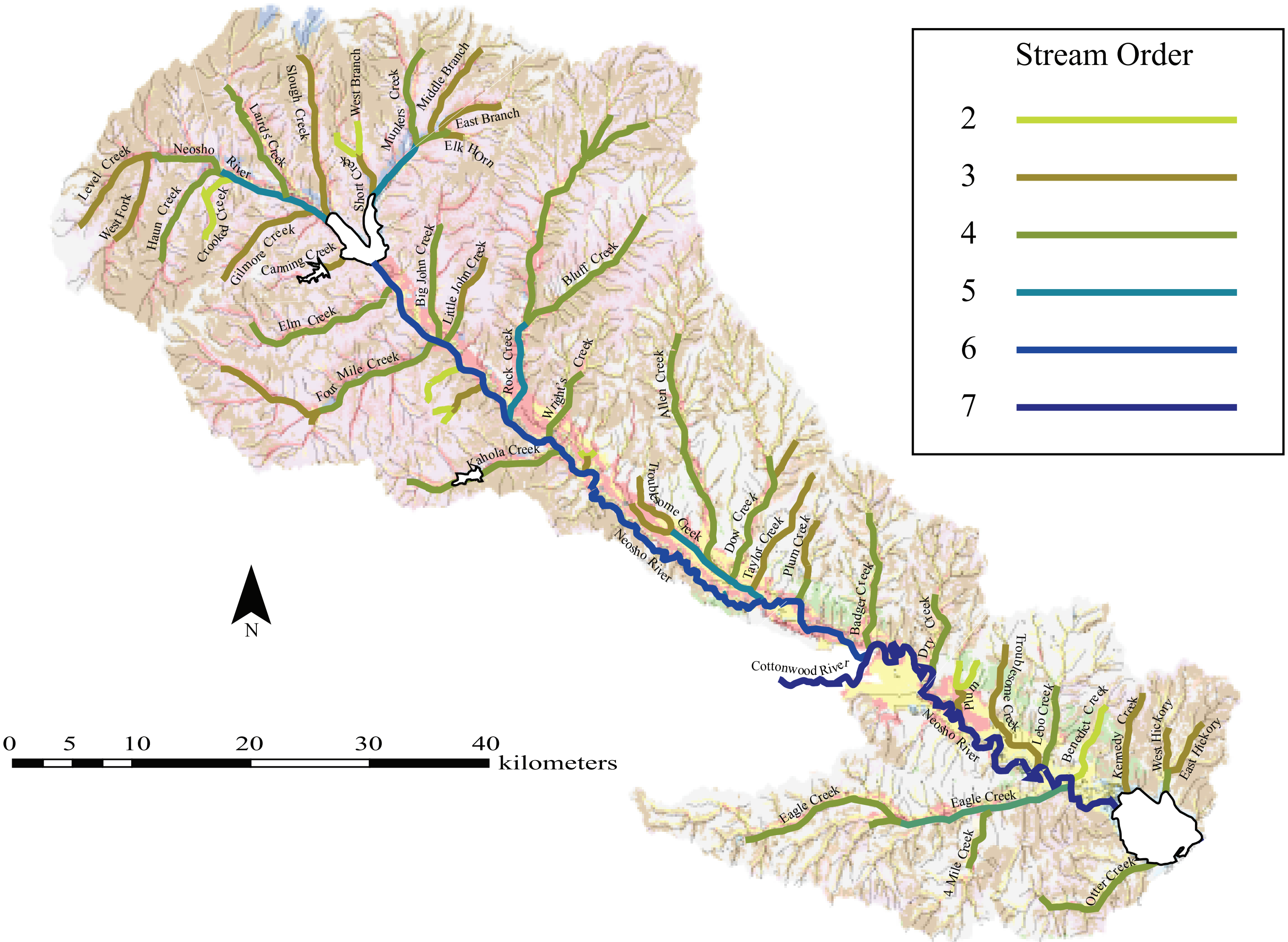


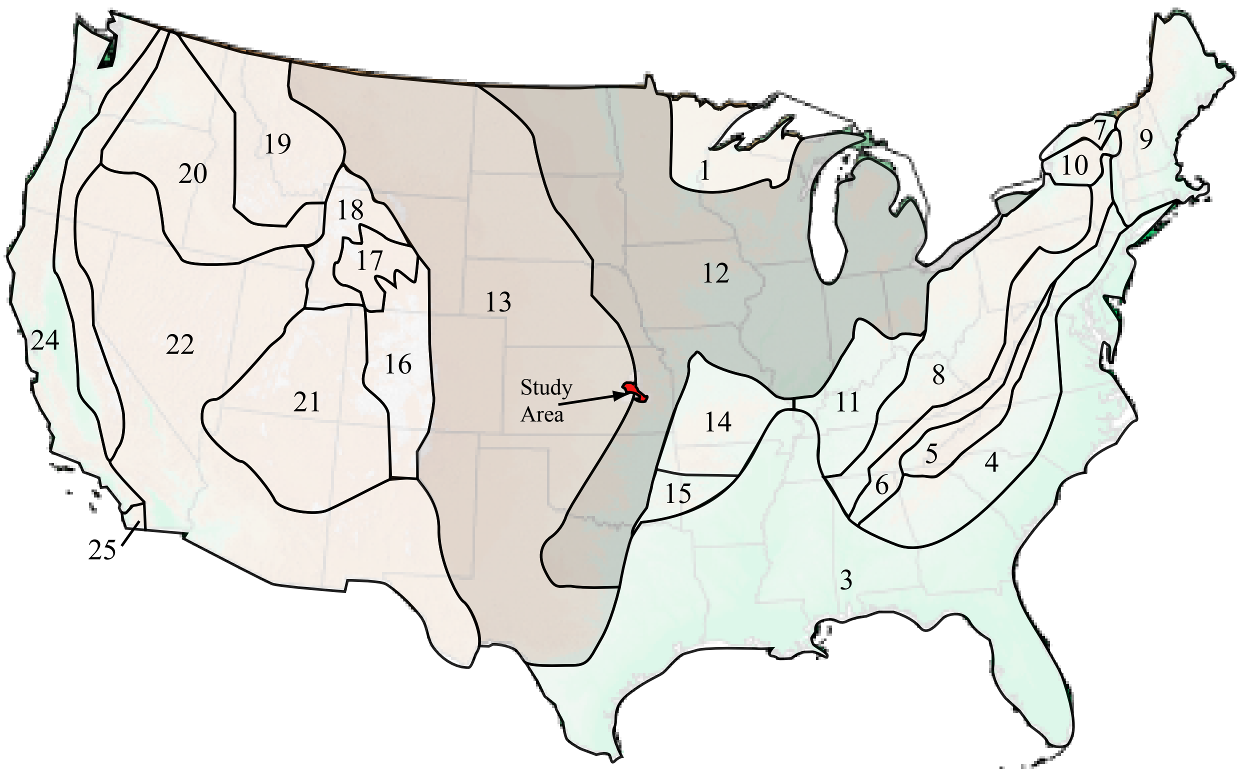
Figure 2.3. Schematic depiction of the upper Neosho River basin and Stream Order (Based on Strahler 1964)

Creek (see Figure 2.3). These tributaries, however, have drainage areas that are less than 518 km^2 (Carswell and Hart, 1985: 3).

Physiography and Bedrock Geology

The study area is within the Flint Hills subprovince of the Great Plains province and the Osage Cuestas subprovince of the Central Lowland province (Figure 2.4) (see Fenneman, 1931). The Great Plains region extends from the Gulf Coastal Plain of southern Texas to the Central Plains of Canada (Mandel, 2006a: 20). The Central Lowlands region is bordered by the Great Plains region to the west, the Ozark Plateaus and interior Low Plateaus to the south, the James physiographic province of the Canadian Shield physiographic division to the north, and the Appalachian Plateaus to the east (see Figure 2.1) (Fenneman, 1931; Bostock, 1967). The basin headwaters are located in the Flint Hills physiographic subprovince, whereas the downstream portion of the study area, just south of the city of Council Grove, is in the Osage Cuestas physiographic subprovince (see Figure 2.2). A prominent rocky escarpment nearly 100 m high separates the two regions (Mandel, 2006a:14).

In Kansas, the Flint Hills region ranges from 32 km to 128 km wide, extending from Marshall and Washington counties in the north to Cowley County in the south (Beeton, 2007: 22). Topographically, the Flint Hills uplands are characterized as gently rolling (Jurecek and Perry, 2004). High order streams in the uplands have formed prominent strath terraces which are erosional surfaces cut across bedrock and capped with little or no alluvium (Mandel, 2006a: 14). Low order streams in the uplands have deep, narrow valleys lined with outcropping rock ledges (Carswell and Hart, 1985: 4).



1. Superior Upland
2. Continental Shelf (not shown)
3. Coastal Plain
4. Piedmont
5. Blue Ridge
6. Valley and Ridge
7. St. Lawrence Valley
8. Appalachian Plateaus
9. New England
10. Adriondack
11. Interior Low Plateaus
12. Central Lowland
13. Great Plains
14. Ozark Plateaus
15. Ouachita
16. Southern Rocky Mtns.
17. Wyoming Basin
18. Middle Rocky Mtns.
19. Northern Rocky Mtns.
20. Columbia Plateaus
21. Colorado Plateaus
22. Basin and Range
23. Cascade-Sierra Mtns.
24. Pacific Border
25. Lower California

Figure 2.4. Physiographic Provinces of the United States (Adapted from Fenneman's 1931 map)

The topography of the Flint Hills was formed by erosion of resistant Permian limestones overlying softer Permian shales and sandstones. The differential erosion of these stacked shales and limestones has created a step-like landscape (Mandel, 2006b: 1). Chert nodules or layers are common in the limestones. Chert is less soluble (i.e. more resistant to weathering) than the limestone that encapsulates it. Weathering of the softer limestone leaves behind a clayey soil containing flint gravel. Cherty soils mantle the rocky uplands, slowing the process of erosion compared with areas where limestone bedrock does not contain chert (Buchannan, 1984: 19). Thus, chert remains in abundant supply and in many cases is easily quarried. The excess of chert in the limestone is an important characteristic of the Flint Hills environment because the native peoples used chert to make a variety of stone tools (Banks, 1990; Vehik, 1990; Stein, 2006).

In Kansas, the Osage Cuestas are bound to the north by the Kansas River, the Cherokee Lowland to the east, the Flint Hills to the west (Mandel, 2006a:12). Cuesta (Spanish for hill or cliff) is the term geologists use to describe ridges with steep, cliff-like faces on one side and gentle slopes on the other (USGS, 2005). The Osage Cuestas region is characterized by a series of east-facing ridges (or escarpments), between which are flat to gently rolling plains (Schoewe, 1949). The escarpments result from underlying Pennsylvanian limestones and shales that dip gently to the west and northwest. Each escarpment is capped by the more resistant limestone, and the gentle slopes are underlain by thick layers of less-resistant shale. The steep faces of the escarpments are about 15-60 meters high (USGS, 2005).

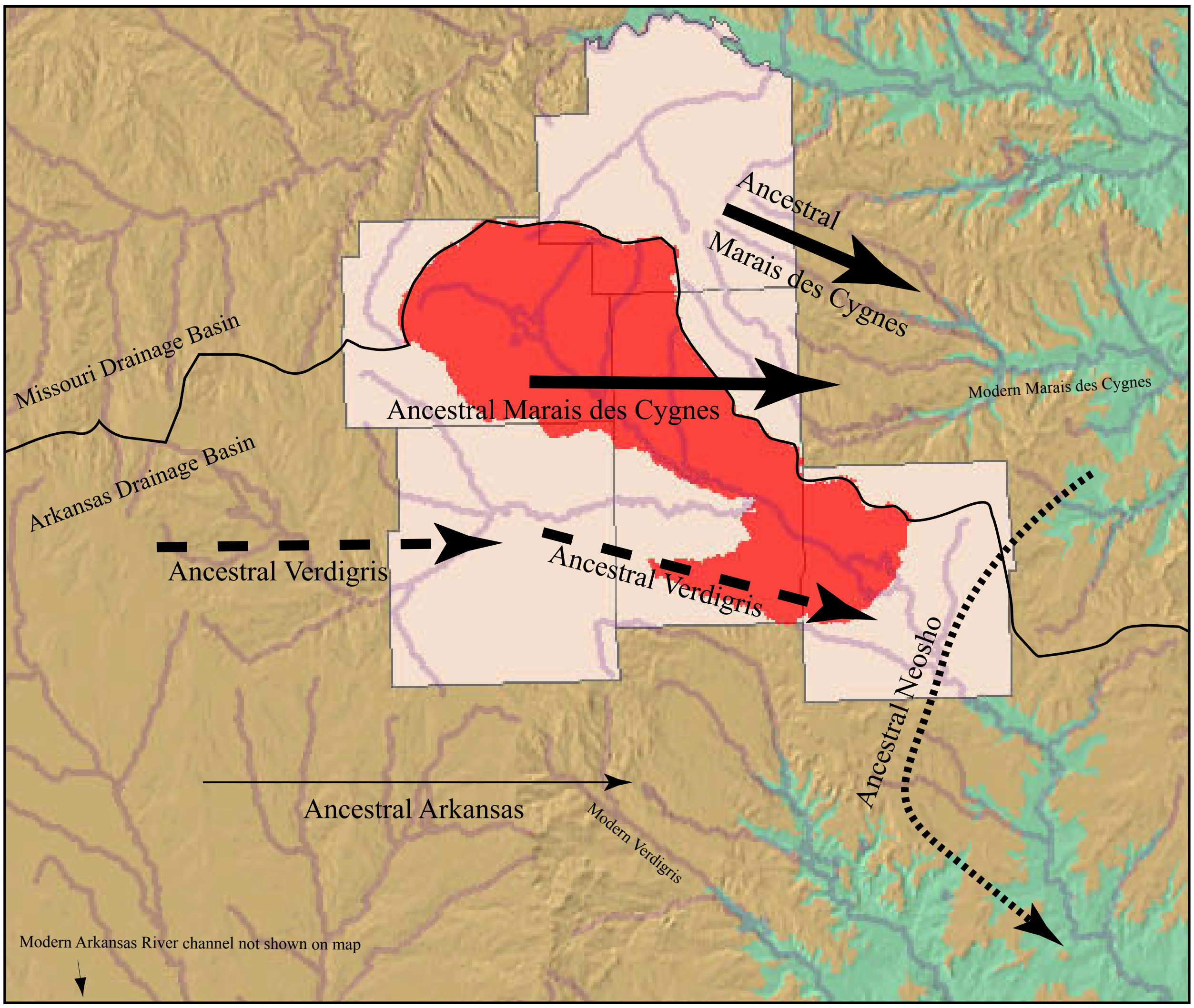
Although outcrops of chert are far less common in the Osage Cuestas than in the Flint Hills, there are abundant and widespread alluvial deposits of chert gravel on isolated hilltops, drainage divides, and high terraces in the basin. These upland alluvial deposits contain quartzite, fossilized wood and other exotic pebbles derived from the Rocky Mountains and the High Plains to the west. James Aber, Emporia State University, has used the distributions of upland gravels throughout central and eastern Kansas to suggest ancestral drainage routes of the Arkansas, Verdigris, Neosho and Marais des Cygnes river basins (Figure 2.5) (see Aber, 1992, 1997). According to Aber, the upper Neosho River basin gravels may reflect the course of the ancestral Marais des Cygnes during the Miocene, Pliocene or Pleistocene (see Aber, 1997: 29-31).

Quaternary Geology

Pleistocene Stratigraphy - Loess

The study area is at the southern extent of the Great Plains and Central Plains loess belts (Figure 2.6) (Muhs and Bettis, 2003). Loess is any terrestrial, wind-deposited sediment dominated by silt-sized particles consisting chiefly of quartz, feldspar, mica, and clay minerals (Muhs and Bettis, 2003: 54). Thin (estimated .3 m to 1.5 m) discontinuous loess deposits are found in the uplands and on some of the pre-Holocene-aged terraces (O'Conner, 1953). Konza and Smolan soils, which have formed in loess, are found in the basin but represent less than 1% of the total surface area in the basin. Regionally, loess mantles the High Plains of western Kansas and is found in deposits ranging from 18 m to 30 m thick along the bluffs of the Missouri River in northeast Kansas (Buchanan, 1984: 51).

Loess stratigraphy provides references to which more localized fluvial and colluvial units can be related (Mandel, 2006b: 1). Four stratigraphically superposed



Adapted from Aber, 1997

Figure 2.5. Proposed ancestral drainage routes based on distributions of upland gravels (Olpe soils)

Figure 2.6. Central Lowland and Great Plains Loess Belts

Adapted from Muhs and Bettis, 2003

loesses are found in northeastern Kansas: Loveland, Gilman Canyon, Peoria and Bignell (Mandel and Bettis, 2003). Based on regional stratigraphic relationships, Loveland loess deposits in northeastern Kansas are Illinoian in age (Marine Isotope Stage 6) (Mandel, 2006b). Luminescence dating (TL and IRSL) suggests deposition between about 160,000 and 130,000 yr B.P. (Mandel, 2006b). The Sangamon Geosol developed in the upper part of Loveland Loess between 125,000 and 55,000 yr B.P. (Isotope stages 5d and 3) (Mandel, 2006b:2). The Gilman Canyon Formation is a pedogenically altered early Wisconsinan loess found in northeastern Kansas. TL and radiocarbon ages place the Gilman Canyon Formation at 40,000 yr B.P. (uncorrected radiocarbon years ago) at its base to 24,000-23,000 yr B.P. at the top. The soil developed into the Gilman Canyon Formation is usually welded to the Sangamon Soil in northeastern Kansas (Mandel, 2006b: 2).

Peoria Loess was deposited during the late Wisconsin period (the last glaciation). In northeastern Kansas, radiocarbon ages from Peoria Loess range from 24,000-23,000 at its base to 12,000 yr B.P. near the top (Mandel, 2006b). The Brady Soil developed in the top of the Peoria Loess and formed around 10,500 and 9,000 yr B.P. (Johnson and Willey, 2000). The Brady Soil is generally found as a buried soil, covered by Bignell Loess. TL and radiocarbon ages in the Bignell Loess indicate episodic accumulation throughout the Holocene (Mason et al., 2006). Loess deposits are indicators of glacial conditions. Therefore, soils, such as Sangamon Geosol and Brady Soil, roughly correlate to interglacial periods, marked by warmer and more temperate conditions than during glacial periods (Mandel and Bettis, 2003).

Holocene Stratigraphy – The DeForest Formation

Holocene alluvial fills in the study area comprise the DeForest Formation. The DeForest Formation is a formal lithostratigraphic unit composed of fine-grained Holocene alluvium and colluvium (Mandel, 2006b: 2). It was originally defined by Daniels et al. (1963) in Iowa and has been extended into southeastern Nebraska (Dillon 1992; Mandel 1994b, 1999, Mandel and Bettis, 1995, 2001a), northwestern Missouri (Fosha and Mandel, 1991), and northeastern Kansas (Mandel et al., 1991; Mandel, 1994a, 2006b; Mandel and Bettis, 2001a, 2003; Mandel et al., 2006; Beeton, 2006) (Figure 2.7). The DeForest Formation consists of eight formal members. Five members of the DeForest Formation occur in the upper Neosho River basin: the Gunder, Honey Creek, Roberts Creek, Camp Creek, and Corrington.

The members of the DeForest Formation represent three long-term aggradation episodes separated by periods of drainage network entrenchment (Bettis, 1995: 1; Dillon and Mandel, 2008). According to Bettis (1995: 1), "in valleys of equal size the three periods of aggradation were roughly synchronous. However, a given period of alluvial filling was diachronous through the hierarchy of drainage elements in the region as a whole. Aggradation episodes began earlier in large valleys and transgressed into upper parts of the drainage networks on a temporal scale of centuries to millennia". In the midwest, aggradation and entrenchment episodes are most influenced by sediment availability, primarily Peoria Loess accumulation (see above) during the last glacial period, and a warming trend from the onset of the Holocene (Bettis, 1995: 1).

As aggradational episodes ended in the Neosho River basin, due to stream entrenchment for example, the former floodplains were no longer subject to continuous fluvial deposition and became quasi-stable. The processes and factors of soil

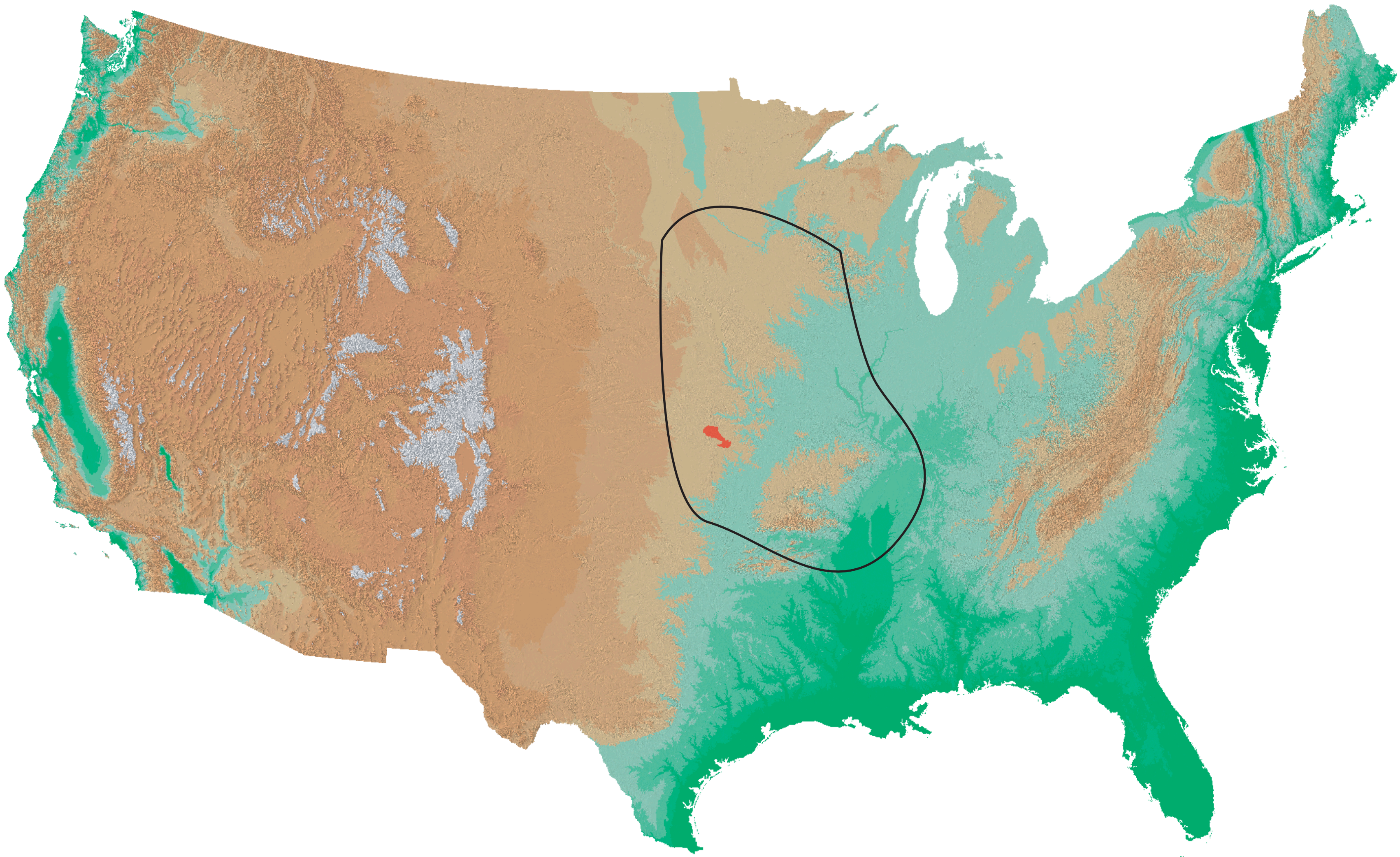


Figure 2.7. The Extent of the DeForest Formation

development outpaced deposition and soils formed on floodplains. Therefore, landscape stability is indicated by the presence of soils. Alluvial landforms that became stable at roughly the same time have shared weathering histories and their surface soils will exhibit similar morphological characteristics. A shared weathering history or time of landform stability results in similar lithologies.

The members of the DeForest Formation form in alluvial and colluvial fills with shared weathering histories and, as noted, depict three long-term aggradation episodes separated by periods of drainage network entrenchment (Bettis, 1995: 1; Dillon and Mandel, 2008). Landform sediment assemblages (LSAs) comprised of Gunder Member and Corrington Member alluvium and colluvium represent sediments that accumulated during the first aggradation episode. The Corrington Member is highly variable and confined to alluvial fans and colluvial slopes while the Gunder Member is assigned to Holocene terraces fills. The Corrington Member aggraded 9,000 to 3,000 ^{14}C yr B.P. Gunder Member deposits range in age from about 11,500 ^{14}C yr B.P. at the base of alluvial fills to about 2,000 ^{14}C yr B.P. at the surface (Mandel and Bettis, 2001a). In large valleys, Gunder Member is often represented in two separate fills: a strongly oxidized fill that probably dates from about ca. 10,500 ^{14}C yr B.P. at its base to ca. 5000 ^{14}C yr B.P. at its surface (early Gunder) and a moderately oxidized fill dating from ca. 5000 ^{14}C yr B.P. at its base to ca. 2500 ^{14}C yr B.P. at its surface (late Gunder) (Mandel, 1997).

The Honey Creek Member and Roberts Creek Member represent the second aggradation period. The Honey Creek Member aggraded between ca. 3,700 and 600 ^{14}C yr B.P. (Dillon, 1992; Dillon and Mandel, 2008), and the Roberts Creek Member ranges in age between 3,800 to 500 ^{14}C yr B.P. (Mandel and Bettis, 2003). The Roberts Creek Member consists of dark grayish brown to black organic-rich alluvium and occurs as channel fills and flood drapes (Mandel and Bettis, 2001a: 4). The Honey Creek Member is a grayish brown to brown silt loam with trough cross-bedding near its base (Mandel, 2006b).

The third aggradation episode is represented by the Camp Creek Member which accumulated after ca. 500 ^{14}C yr B.P. It consists of stratified to massive, very dark gray to brown silt loam to clay loam, commonly referred to as “post-settlement alluvium” (Mandel and Bettis, 2001a: 4).

Soils

Soil is a natural, three-dimensional body that has formed at the Earth’s surface, through the interactions of at least five soil-forming factors: climate, biota, relief, parent materials, and time (Schaetzl and Anderson, 2005: 9). Generally, soil development occurs on stable landforms, those that are neither eroding nor aggrading (Catt, 1986). Therefore, the presence of a soil denotes the passage of time under conditions of relative stability (Holliday, 1992: 103). Determining the amount of time that a landform is stable remains an important concept for the interpretation of archaeological sites and regions Mandel and Bettis, 2001b). Similarly, this concept is critical to geoarchaeological investigations of site stratigraphy, landscape evolution, and geochronology (Holliday, 1992:104).

Soils have predictable patterning across landscapes. The patterning is greatly influenced by parent material and landscape position. Soil science commonly defines parent material as the mineral or organic material in which the soil formed, including the kinds of rock from which the regolith is derived (Soil Survey Staff, 1993; Wysocki et al., 2005:168). Therefore, soils form into an extensive array of surficial geologic deposits including unconsolidated sediments (alluvial, glacial, marine, eolian), saprolite, and bedrock (weathered and unweathered) (Wysocki et al., 2005:167). In general, soils in the Neosho River basin have formed in Holocene alluvium, pre-Holocene alluvium, colluvium, loess, and bedrock residuum (Figure 2.8; Table 2.1).

Holocene alluvium has been deposited on the valley floor creating floodplain and low terrace sediment assemblages and it has accumulated as alluvial fan deposits on the valley margins. Verdigris, Ivan, Kennebec, and Lanton soils occur on floodplains, and Reading, Mason, Leanna, Chase and Osage soils occur on low (Holocene) terraces (Barker, 1974; Neill, 1981; Swanson, 1982). Mason, Reading, Tully, Irwin, and Dwight soils occur on alluvial fans (Barker, 1974; Neill, 1981; Swanson, 1982).

Pre-Holocene alluvium underlies high terraces and presumably has accumulated, along with colluvium, in alluvial fans. Ladysmith, Woodson, Olpe, and Kenoma soils have formed on pre-Holocene-aged high terraces and at higher positions in the basin (Barker, 1974; Neill, 1981; Swanson, 1982). High terrace sediments consist of alluvium and loess.

Soils formed in colluvium, loess, and bedrock residuum are typically found on the valley margins and in the uplands. Tully and Zaar soils have formed in colluvium. Konza and Smolan soils have formed in loess. Soils formed in bedrock residuum are differentiated by bedrock type. Bedrock type includes shale (Apperson, Clime, Dennis, Elmont, Eram, Martin, Summit, Vinland and Zaar soils), limestone (Clareson, Florence,

Soil Series	Geomorphic Surface	Parent Material	Taxonomy (subgroup level)
Ivan	floodplains (T-0)	calcareous, silty alluvium	Fine-silty, mixed, mesic Cumulic Hapludolls
Kennebec	floodplains (T-0)	silty alluvium	Fine-silty, mixed, superactive, mesic Cumulic Hapludolls
Lanton	floodplains (T-0)	alluvium	Fine-silty, mixed, thermic Cumulic Haplaquolls
Verdigris	floodplains (T-0)	silty alluvium	Fine-silty, mixed, active, thermic Cumulic Hapludolls
Chase	low terraces (T-1)	silty and clayey alluvium	Fine, smectitic, mesic Aquertic Argiudolls
Leanna	low terraces (T-1)	silty or clayey alluvium	Fine, mixed, thermic Typic Argialbolls
Mason	low terraces (T-1)	silty alluvium	Fine-silty, mixed, superactive, thermic Typic Argiudolls
Osage	low terraces (T-1)	clayey alluvium	Fine, smectitic, thermic Vertic Haplaquolls
Reading	low terraces (T-1)	silty alluvium	Fine-silty, mixed, superactive, mesic Pachic Argiudolls
Kenoma	high terraces	Pleistocene alluvial sediments	Fine, smectitic, thermic Vertic Argiudolls
Ladysmith	high terraces	fine-textured sediments (alluvium or loess)	Fine, smectitic, mesic Udertic Argiustolls
Woodson	high terraces?	clayey and silty sediments	Fine, smectitic, thermic Abruptic Argiaquolls
Olpe	hillslopes on uplands	gravelly Neogene alluvium	Clayey-skeletal, smectitic, thermic Typic Paleudolls
Tully	footslopes in uplands	clayey alluvium or colluvium	Fine, mixed, mesic Pachic Argiustolls
Dwight	hillslopes on uplands	clayey sediments	Fine, smectitic, mesic Typic Natrustolls
Irwin	hillslopes on uplands	clayey sediments	Fine, mixed, mesic Pachic Argiustolls
Smolan	hillslopes on uplands	loess (reddish brown)	Fine, smectitic, mesic Pachic Argiustolls
Konza	ridges on uplands	loess	Fine, smectitic, mesic Udertic Paleustolls
Apperson	hillslopes on uplands	residuum from shale	Fine, smectitic, thermic Vertic Argiudolls
Clime	hillslopes on uplands	residuum from calcareous clayey shale	Fine, mixed, mesic Udorthentic Haplustolls
Dennis	hillslopes on uplands	residuum from shale	Fine, mixed, thermic Aquic Argiudolls
Elmont	hillslopes on uplands	residuum from shale	Fine-silty, mixed, superactive, mesic Typic Argiudolls
Eram	hillslopes on uplands	residuum from shale	Fine, mixed, thermic Aquic Argiudolls
Martin	hillslopes on uplands	clayey shale	Fine, smectitic, mesic Aquertic Argiudolls
Summit	hillslopes on uplands	residuum from shale	Fine, smectitic, thermic Oxyaquic Vertic Argiudolls
Zaar	hillslopes on uplands	residuum from shale	Fine, montmorillonitic, thermic Vertic Hapludolls
Vinland	hillslopes on uplands	sandy and silty residuum from shale	Loamy, mixed, superactive, mesic, shallow Typic Hapludolls
Labette	hillslopes on uplands	residuum from limestone and shale	Fine, mixed, mesic Udic Argiustolls
Lula	hillslopes on uplands	residuum from limestone and shale	Fine-silty, mixed, active, thermic Typic Argiudolls
Florence	hillslopes on uplands	residuum from cherty limestone	Clayey-skeletal, smectitic, mesic Udic Argiustolls
Matfield	hillslopes on uplands	residuum from cherty limestone	Clayey-skeletal, smectitic, mesic Pachic Paleustolls
Shidler	hillslopes on uplands	residuum from limestone	Fine, mixed, thermic Aquic Argiudolls
Sogn	hillslopes on uplands	residuum from limestone	Loamy, mixed, superactive, mesic Lithic Haplustolls
Clareson	ridges on uplands	residuum from limestone	Clayey-skeletal, mixed, thermic Typic Argiudolls
Bates	hillslopes on uplands	residuum from sandstone and loamy shale	Fine-loamy, siliceous, thermic Typic Argiudolls
Collinsville	hillslopes on uplands	residuum from sandstone	Fine, mixed, thermic Aquic Argiudolls

Table 2.1 – Soils in the Upper Neosho River Basin and Their Typical Geomorphic Position

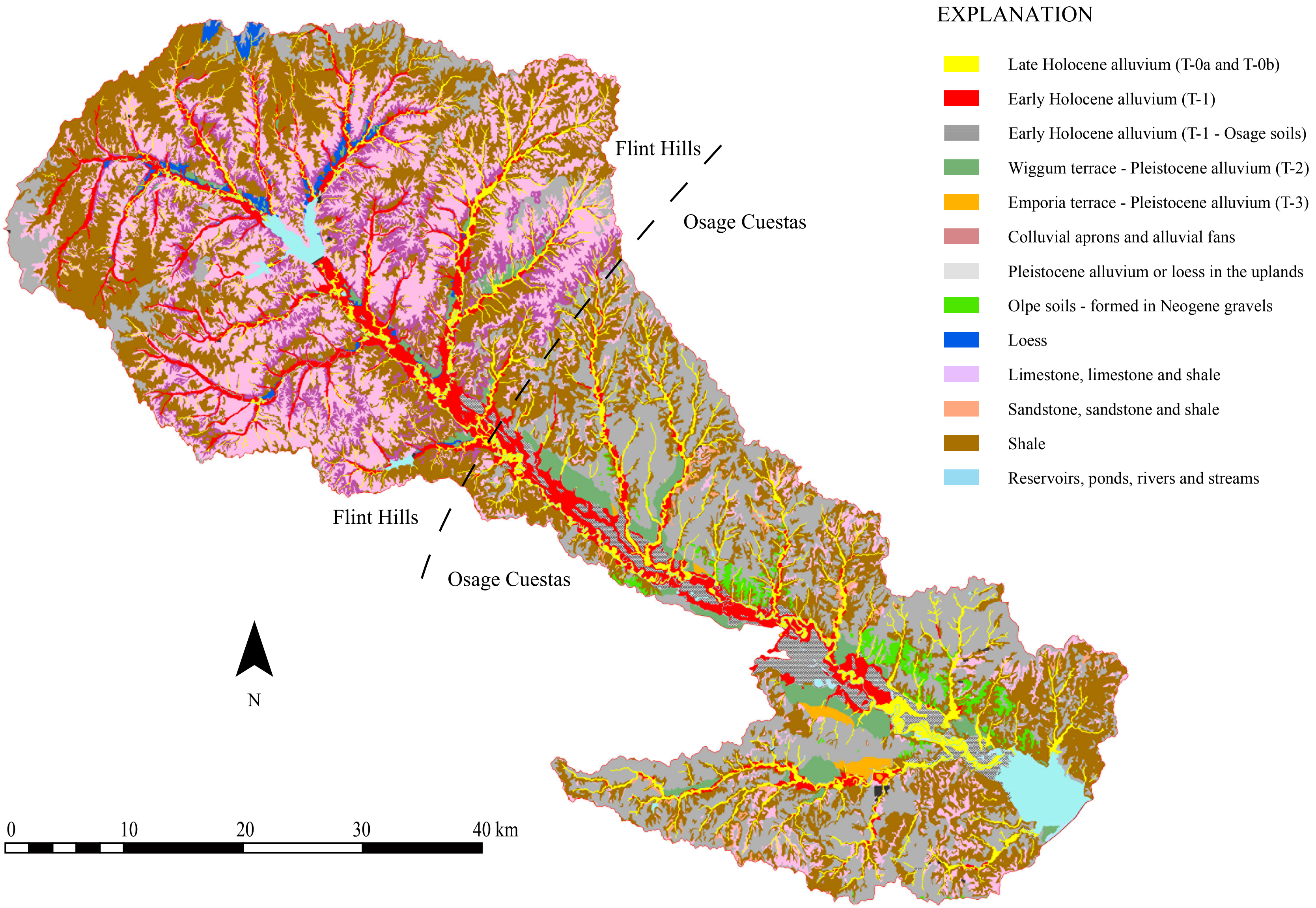


Figure 2.8. Soil parent material and LSAs in the study area (see Table 2.1 for list of soils series and associated parent material)

Matfield, Shidler, and Sogn soils), limestone and shale (Labatte and Lula soils), sandstone (Collinsville soils), and sandstone and shale (Bates soils).

Vegetation

The Flint Hills are in the North American grassland region commonly referred to as the Great Plains, Interior Grasslands, Prairie and Plains, or Prairie grassland province and the Osage Cuestas are in the Central Lowlands province. Tall-grass prairie is the natural vegetation of the Flint Hills and the Osage Cuestas (Mandel, 2006a). Tall-grass prairie is dominated by big bluestem and little bluestem. Riparian forests situated along the banks of the Neosho River are dominated by deciduous trees, including willow (*Salix sp*.), cottonwood (*Populus deltoides*), and elm (*Ulmus americana*). Stands of oak (*Quercus sp*.) occasionally occur on uplands, and ash (*Fraxinus sp*.), black walnut (*Juglans niagra*), and sycamore (*Ficus sycamorus*) are common in lower areas with reliable water sources (Küchler, 1974).

Climate

Modern Climate

Very cold winters and very hot summers characterize the modern climate of the study area. This continental climate is also defined by large daily and annual variations in temperature and cyclical variations in precipitation (Self, 1978:52) (Table 2.2). The growing season is approximately April through September (Table 2.3). Rains are heaviest in the late spring and early summer with a mean annual precipitation of 82.4 cm (Barker, 1974).

Month	Temperatures Average Daily Max. (°C / °F)	Temperatures Average Daily Min. (°C / °F)	Precipitation Average Total (cm / inch)
Jan.	4.6 / 40.2	-7.6 / 18.4	2.1 / 0.83
Feb.	7.8 / 46.0	-5.4 / 22.2	2.8 / 1.11
Mar.	13.3 / 55.9	-0.9 / 30.3	4.7 / 1.87
Apr.	19.9 / 67.9	5.8 / 42.4	7.3 / 2.88
May	24.8 / 76.7	11.2 / 52.2	11.5 / 4.53
Jun.	30.1 /86.2	16.7 / 62.0	11.8 / 4.64
Jul.	33.4 / 92.2	19.1 / 66.3	9.9 / 3.88
Aug.	33.1 / 91.5	18.9 / 65.2	10.0 / 3.95
Sep.	28.6 / 83.4	13.6 / 56.5	8.9 / 3.49
Oct.	21.9 / 71.5	7.0 / 44.6	6.4 / 2.51
Nov.	13.5 / 56.3	0.5 / 31.1	4.2 / 1.65
Dec.	6.6 / 43.8	-5.6 / 21.9	2.8 / 1.12
Year	19.8 / 67.6	6.0 / 42.8	82.4 / 32.46

Table 2.2. Temperature and Precipitation data for Council Grove (1909-1960) (Barker, 1974)

Probability	Dates for stated probability and temperatures				
	16°F	**20°F**	**24°F**	**28°F**	**32°F**
Spring					
1 year in 10 later than	March 30	April 7	April 11	April 25	May 6
2 years in 10 later than	March 24	April 1	April 6	April 20	May 1
5 years in 10 later than	March 12	March 22	March 28	April 10	April 20
Fall					
1 year in 10 earlier than	Nov. 10	Oct. 29	Oct. 21	Oct. 14	Oct. 4
2 years in 10 earlier than	Nov. 16	Nov. 3	Oct. 25	Oct. 19	Oct. 8
5 years in 10 earlier than	Nov. 28	Nov. 14	Nov. 4	Oct. 28	Oct. 19

Table 2.3 Probabilities of last freezing temperature in spring and first in fall (Barker, 1974)

In Kansas, the prevailing westerly winds and cyclonic frontal cells associated with Pacific air masses are largely responsible for short-term (daily and weekly) changes in weather (Self, 1978: 52). Seasonal variations in rain are due to warm, moist air masses from the Gulf of Mexico penetrating the region and converging with Pacific and Polar air masses (Self, 1978: 52). Most precipitation comes during the warm season. During the winter months, precipitation is due in large part to moist air being cooled in cyclonic storms. During the summer some rainfall is due to moist air being lifted and cooled by convection currents that cause thunderstorms (Self, 1978: 64).

There is a longitudinal (east-west) precipitation gradient across the Central Plains (Mandel, 2006a: 13). In Kansas, for example, mean annual precipitation ranges from approximately 40 cm along the western border to a high of approximately 106 cm on the Kansas-Missouri border in the east (Mandel, 2006a: 19). Over the last forty years or so in the Neosho River basin, mean annual precipitation ranges from about 85 cm (33.41 in) at the Council Grove Lake weather station (period of record 1964-2007) in the northwestern part of the basin, to about 90 cm (35.30 in) at John Redmond Lake weather station (period of record 1960-2007) in the southeast (High Plains Regional Climate Center, 2008). The John Redmond Lake station is approximately 50 km east of the Council Grove Lake station (see Figure 2.3).

Late-Quaternary Climates

In large part, this study evaluates the alluvial chronology of late-Quaternary landforms in the upper Neosho River basin. Most of the LSAs in the stream valley are comprised of sediment that was deposited under climatic conditions different from today. This section provides a brief overview of the climatic conditions of the late-Quaternary period. The Quaternary is a geologic period that includes the Pleistocene and Holocene Epochs. The Pleistocene Epoch began ca. 1.8 ma years ago and ended 10,000 ^{14}C yr B.P. The Holocene Epoch began 10,000 ^{14}C yr B.P. and extends to the present day. For this study, the late-Quaternary is divided into the late Pleistocene (25,000 - 12,000 ^{14}C yr B.P.), Pleistocene-Holocene transition (12,000 to 9000 ^{14}C yr B.P.), early and middle Holocene (9000 – 4000 ^{14}C yr B.P.), and late Holocene (4000 ^{14}C yr B.P. to present).

In the Central Plains, the late Pleistocene was dominated by glacial conditions. The Laurentide ice sheet was located about 650 km to the north of the study area (i.e. the southern extent of the James lobe), creating cold and dry conditions. Extensive loess deposition during this time is an indication of strong and persistent winds and decreased vegetation cover (Muhs and Bettis, 2003).

The Pleistocene-Holocene transition was a period of major environmental change in North America (Mandel, 2006a: 22). By 12,000 ^{14}C yr B.P., glacial conditions that had greatly influenced climate in the Central Plains were subsiding, resulting in increased seasonality and insulation during the summers (Kutzbach and Webb, 1993). This transition period reflected a general warming trend that followed the last glacial maximum (LGM) with episodic cooling (e.g. the Younger Dryas).

The early through middle Holocene (8000-4000 ^{14}C yr B.P.) was warm and dry. This period is often referred to as the Altithermal (Antevs, 1955), Hypsithermal (Deevey and Flint, 1957), or Atlantic climate episode (Baerreis and Bryson, 1965) (hereafter Altithermal). Increased aridity during the Altithermal is responsible for eastward expansion of the prairie, which reached a maximum by ca. 7000 ^{14}C yr B.P. but continued until ca. 4000 ^{14}C yr B.P. (Mandel, 2006a: 24).

The late Holocene (4000 yrs. ^{14}C yr B.P. to present) is marked by an increase in mean annual precipitation and the termination of the warm, dry conditions that characterized the Altithermal. The increase in effective precipitation increased vegetation density on the uplands, and forest and tall-grass prairies expanded westward, effectively pushing short-grass prairie back to the west (Mandel, 2006a: 24-25).

CHAPTER III

ARCHAEOLOGICAL CONTEXT

Current archaeological evidence suggests humans have continuously occupied the Central Great Plains of North America since at least 11,500 ^{14}C yr B.P. (~13,500 calendar years ago) (Hoard and Banks, 2006a: 1). In fact, some researchers have argued that human occupation of the Central Great Plain extends as far back as 20,000 years ago (e.g. Holen, 1997). Several major regional shifts in settlement patterns, technology, economy, and trade are evident in the archaeological record over that time (Wood, 1998). The approximate age of these shifts have been determined primarily through radiometric analysis, artifact seriation, or association with particular fauna. The shifts represent convenient time breaks (referred to as cultural periods herein) for discussion of the behavioral changes over time. This study segments human presence in the Central Plains into six cultural periods: Paleoindian (+11,500 to 9,000 ^{14}C yr B.P.), Archaic (9,000 to 3000 ^{14}C yr B.P.), Early Ceramic/Woodland (3,000 to 1,000 ^{14}C yr B.P.), Middle Ceramic (1,000 to 500 ^{14}C yr B.P.), Late Ceramic/Protohistoric (500 to 200 ^{14}C yr B.P.) and Historic (A.D. 1800 to present).

Archaeological evidence in the study area suggests human presence spans the Holocene. Of the 359 archaeological sites recorded in the study area, 100 sites have either individual artifacts or artifact assemblages assigned to one of the six cultural periods (Table 3.1). In actuality, a total of 145 components are represented because some of the 100 sites have multiple components. For example, twenty-three (23) sites have Paleoindian or Archaic components or artifacts, fifteen (15) sites have Early

Ceramic/Woodland components or artifacts, twenty-nine (29) sites have Middle Ceramic (Pomona) pottery, one (1) site has Late Ceramic/ Protohistoric (Great Bend aspect) pottery and seventy-seven (77) sites have Historic components or artifacts. The other sites in the basin that cannot be assigned to a specific cultural period have been lumped into a *prehistoric* category. In general, *prehistoric* sites did not yield diagnostic lithic tools or ceramic sherds and do not have materials common in the historic era (i.e. glass, metal, hard rubber etc.).

The following is a brief summary of these cultural periods and associated cultural components/complexes. Table 3.1 lists all of the cultural components represented in the study area and associated sites. This table also distinguishes the oldest component from the total component count because, as noted, some sites have multiple components. The oldest component indicates the total number of sites that have discernable components. The oldest component of a site is used to infer the surface ages of landforms in Chapter VII.

Paleoindian and Archaic

In the Central Great Plains of North America, hunting and gathering economies dominated the Paleoindian and Archaic periods (+11,500 to 3,000 ^{14}C yr B.P.) (Blackmar and Hofman, 2006: 46). Traditionally, cultural complexes attributed to the Paleoindian period (11,500-9000 ^{14}C yr B.P.) included early mammoth and bison hunting economies represented by Clovis (11,500-10,900 ^{14}C yr B.P.) and early bison hunting groups represented in Kansas by Folsom, Dalton, Scottsbluff, Plainview, Agate Basin, Hell Gap, Alberta, Cody and Allen-Fredrick complexes (10,800-7800 ^{14}C yr B.P.). Any cultural deposit pre-dating the Clovis time period (+11,500 ^{14}C yr B.P.) are typically referred to as Pre-Clovis. In Kansas, cultural complexes traditionally attributed to the Archaic period include Stigenwalt, Logan Creek, Munkers Creek, Black Vermillion, Chelsea, Nebo Hill, El Dorado, Colvin and Walnut (8750-1950 ^{14}C yr B.P.) (Blackmar and Hofman, 2006: Table 4.2). Generally, the Archaic period has been further segmented into Early, Middle and Late Archaic periods.

There is a significant overlap in radiocarbon ages at the end of the Paleoindian period and the beginning of the Archaic period (see above paragraph). In addition, Plains Archaic complexes had economic strategies that were comparable to those of the earlier (Paleoindian) bison hunters, for at least a portion of the year (Blackmar and Hofman, 2006:47). This ambiguous and likely contrived transition between the Paleoindian and Archaic periods has prompted Blackmar and Hofman (2006) to combine the Paleoindian and Archaic complexes into one Paleoarchaic cultural period. They argue that the people who lived during the Paleoarchaic period depended on a wide variety of plant and animal resources and procurement strategies and are not so easily segmented into groups based solely on hunting strategies (2006:64). While the Paleoarchaic designation may better reflect the gradient of cultural adaptations that occurred from 11,500 to approximately 3000 ^{14}C yr B.P., this study uses the traditional designations of Paleoindian and Archaic periods for the sake of convention and convenience. Perhaps breaking from convention, this study combines the Pre-Clovis period with the Paleoindian period. As such, for this study the Paleoindian period includes any cultural deposit date to before about 9000 ^{14}C yr B.P (i.e. +11,500 to 9,000 ^{14}C yr B.P.).

Early Ceramic/Woodland

The Archaic period ends with the appearance of relatively widespread ceramic vessel manufacturing ca. 3000-2500 ^{14}C yr B.P. and interment of the dead in earthen mounds (Logan, 2006: 91). While ceramic figurines and beads have been found in association with Archaic components (i.e. Munkers Creek) at the William Young and Coffey sites in Kansas, these finds are considered anomalous or localized based on the currently available information. Ceramic vessels, in contrast to figurines, may be evidence of the need to store surpluses of food, possibly associated with incipient agriculture. Therefore, evidence of the manufacture of ceramic vessels creates a convenient starting point for the Early Ceramic / Woodland period (3000 to 1000 ^{14}C yr B.P.).

Logan delineates the Woodland period into Early (2500 to 2000 ^{14}C yr B.P.), Middle (2000 to 1500 ^{14}C yr B.P.) and Late (1500 to 1000 ^{14}C yr B.P.) (2006: 76-92). In the study area, the Walnut cultural complex represents the Early Woodland, Snyder represents the Middle Woodland, and the Greenwood complex represents the Late Woodland. Other regional Middle Woodland complexes include Kansas City Hopewell, Valley, Cooper, Cuesta and Shultz (Logan, 2006: 79). A significant technological change toward the end of the Middle Woodland is the adoption of the bow and arrow, as indicated by the appearance of Scallorn points (Logan, 2006: 80). Six other cultural phases have been assigned to the Late Woodland Period in Eastern Kansas: Grasshopper Falls, Wakarusa, Deer Creek, Hertha, Bulter and Bemis Creek (Logan, 2006: 84).

Middle Ceramic

The Pomona cultural complex represents the Middle Ceramic period (1,000 to 500 ^{14}C yr B.P.) in the study area. Calibrated radiocarbon ages place Pomona around A.D. 700 to 1500 (Roper, 2006: 124). Therefore, the Pomona complex is roughly contemporaneous with the Central Plains tradition and the Steed Kisker complex which are located to the north and northeast of the study area, respectively. Commonly referred to as the Pomona focus in archaeological literature of the early and middle 20th Century, Pomona was later redefined as a variant of the Plains Village tradition (Brown, 1984:Abstract). The trend throughout this period is toward increased sedentism and use of agriculture (Roper, 2006:126).

Pomona settlement patterns and pottery manufacturing techniques are similar to that of the Central Plains tradition (CPt) and Steed Kisker complex. Much like CPt and Steed Kisker, most Pomona communities contain either isolated or small groups (two or three) of structures. No central Pomona villages have been found. In addition, Pomona sites have yielded collared rims and shell tempered pottery (Brown, 1984: 448).

Pomona variant differs from the CPt and Steed Kisker complex in that no earth lodges have been associated with Pomona sites. Pomona settlements are generally located on low terraces in sheltered areas along streams, while CPt complex and Steed Kisker complex earth lodges were typically constructed on high terraces or bluffs overlooking river valleys (Brown, 1984: 448-449). In addition, cultigens collected at both CPt and Pomona sites indicate different resource procurement strategies. For example, Pomona floral assemblages include goosefoot, pigweed, smartweed, bedstraw, wild grape, pecan, bulrush, grass and walnut (Roper, 2006: 125). On the other hand, cultivated corn (*Zea mays*), squash (*Cucurbita pepo*), sunflower (*Helianthus annuus*), marshelder (*Iva annua*), and common beans (*Phaseolus vulgaris*) have been found at Central Plains tradition sites in Kansas (Adair, 2006).

Late Ceramic/Protohistoric

In the study area, Great Bend aspect sites are the only cultural component of Late Ceramic/Protohistoric (A.D. 1500-1800) age. Great Bend aspect (A.D. 1500-1600) economic strategies included a mix of agriculture, fishing, hunting, and gathering. Primary crops were sunflowers, maize, beans and squash. They also grew tobacco (Blakeslee and Hawley, 2006: 173). The Late Ceramic/ Protohistoric period is typified by more intensive agriculture and large village site clusters (Blakeslee and Hawley, 2006: 167).

Historic Period

The Historic Period (A.D. 1800 to Present) was a complex and tumultuous period for Native Americans living in the Central Plains. Discussion of the historical events and processes that influenced the lives of the people living in the region is outside the scope of this study. However, there is potential for a wide range of Euroamerican and Native American archaeological deposits dating to this era. As such, a brief summary of the social and economic interactions involving Native American and European settlers in the study area is offered below. In this study, a distinction is made, when possible, between recorded archaeological Euroamerican and Native American Historic era sites.

Prior to and during the 19^{th} Century, the study area was part of the Osage Indians hunting grounds. The Osage had an extensive presence on the Neosho River in Kansas. During the historic period, Osage villages were located downstream from the study area in Neosho and Labette counties (Wedel, 1959: 56). In 1872, the Osage were moved to their reservation in Oklahoma (Wedel, 1959: 57-58).

In the late 1840s, the Kansa Indians were awarded a 256,000-acre reservation that extended from approximately the Council Grove reservoir south to the town of Americus. The Kansa lived in three main villages from 1847 to 1873 (Wedel, 1959: 53). The largest village was run by Hard Chief and was located on Kahola Creek near the modern town of Dunlap. Fool Chief's village was located in the Neosho River valley near Hard Chief's village. Another village was located near Big John Creek to the north. The Kansa were later moved to Oklahoma in the 1870s (Wedel, 1959).

In the 19^{th} Century, there was a varied and steadily increasing European influence in eastern Kansas. The Santa Fe Trail crossed through the study area at Council Grove, which became an important depot on the trail. French fur traders, American expansionists, Spanish explorers and British merchants likely traded in and explored the area.

Table 3.1. Cultural complexes and related sites in the study area

Cultural Complex / Phase	***Age Estimate***	***Oldest Component Count**	**Component count**	**Sites**
Historic				
Euroamerican / Kansa/ Osage	A.D. 1800 - 1950	**39**	71	**14CF101, 14CF102, 14CF103, 14CF104, 14CF105, 14CF337, 14CF350, 14CF351, 14CF359, 14CF391, 14CF1302, 14LY341, 14LY370, 14MO4, 14MO102, 14MO103, 14MO104, 14MO105, 14MO106, 14MO107, 14MO327, 14MO328, 14MO334, 14MO343, 14MO362, 14MO404,14MO423, 14MO424, 14MO601, 14MO605, 14MO606, 14MO607, 14MO608, 14MO609, 14MO610, 14MO611, 14MO612, 14MO701** (32 others part of multicomponent sites)
Kansa	A.D. 1847 - 1873	**5**	6	**14MO330, 14MO331, 14MO332, 14MO333, 14MO362,** 14MO412
Late Ceramic / Protohistoric				
Great Bend	A.D. 1500 - 1600	0	1	14LY328
Middle Ceramic / Plains Village				
Pomona Variant	*1300 - 500*	**25**	29	**14CF357, 14CF388, 14CF0393, 14CF398,14CF403, 14CF1314, 14CF1319, 14CF1320, 14CF1327, 14CF1328, 14CF1329, 14CF1336, 14LY312, 14LY313, 14LY314, 14LY315, 14LY322, 14LY323, 14LY326, 14LY327,** 14LY328, 14LY329**, 14LY333, 14LY334, 14LY353, 14LY420,** 14LY421, **14LY438,** 14MO359
Early Ceramic / Woodland				
Greenwood	*2000 - 1000*	**3**	5	14LY349, **14MO356**, **14MO357,** 14MO359, **14MO425**
***Archaic points†	*>2000*	**7**	7	**14CF37, 14CF45, 14CF48, 14CF394, 14CF396, 14CF1310, 14LY330**
Snyder†	*2000 - 1500*	**0**	2	14MO0411, 14MO0604
Walnut†	*2500 - 2000*	**0**	1	14MO0411
Paleoindian / Archaic				
El Dorado	*3950 - 3250*	**1**	3	14CF20, **14CF330**, 14MO304
Langtry†	*4500 - 3000*	**1**	1	**14MO604**
Nebo Hill†	*4550 - 2900*	**2**	2	**14CF20, 14LY470 (square-stemmed lancelot)**
Chelsea†	*4800 - 3950*	**2**	2	**14MO411, 14MO602**
Munkers Creek	*5800 - 4950*	**11**	11	**14LY329, 14LY441, 14LY482, 14LY484, 14LY709, 14MO304, 14MO356, 14MO359, 14MO403**, 14MO421, 14MO600**
Logan Creek†	*6150 - 5200*	**1**	1	**14LY328**
Scottsbluff†	*10,200 - 8200*	**1**	1	**14CF016**
Dalton†	*10,600 - 9300*	**2**	2	**14MO335, 14MO412**

† Based on the presence of points / **bold** = oldest component / *italics = radiocarbon yrs. B.P.*
*Most of These Sites Used for analyses in Chapter XIII
**Not in the KSHS database as Munkers Creek
***referred to as Gary-type, contracting stem, Archaic and Woodland points in KSHS Database

CHAPTER IV

PREVIOUS RESEARCH

Introduction

Geologic processes operating concurrently within a drainage basin may differentially preserve the archaeological record and lead to erroneous conclusions about prehistoric settlement patterns (Mandel 2006a: 28). As noted, the basic objective of the present study is to determine whether alluvial deposits of certain ages are differentially but systematically preserved in the upper Neosho River basin, providing a geologic context for the preservation of cultural deposits. As such, it represents the first investigation of its kind in the basin. The purpose of this chapter is to describe previous archaeological research in the basin. In addition, the chapter describes past studies of other drainages in eastern Kansas where the temporal and spatial patterns of landscape evolution have been considered. This chapter also discusses studies that have used soil morphology to determine the relative ages of geomorphic surfaces, which is a method adopted for the present study. Further clarification is provided in the summary at the end of this chapter.

Archaeological Research

There is a long history of archaeological research in Kansas (e.g. Brower, 1898; Winchell, 1912; Solecki, 1953; Wedel, 1959; Sperry, 1965; Eyman, 1966; Phenice, 1969; O'Brien, 1972; Johnson, 1973; Sorrell, 1975; Parks, 1978; Schmits, 1976, 1978; Brown, 1984; Adair, 1990; Hofman, 1994; Roper, 2000; Hoard, et al., 2004). However, until the passing of the National Historic

Preservation Act of 1966, the National Environmental Policy Act of 1969 and the Moss-Bennett Bill of 1974, investigations were sporadic and rarely conducted by trained archaeologists (Mandel, 2000: 94). Therefore, the Neosho River basin is somewhat rare in that trained archaeologists had conducted several archaeological investigations prior to the passing of these laws.

The impetus for archaeological research in the basin was the passage of the Flood Control Act of 1950. This act funded the construction of several reservoirs and flood diversion pools in Kansas and throughout the country. Typically, these projects were designed by the U.S. Army Corps of Engineers and involved the construction of a dam across a river valley, resulting in the flooding of extensive areas upstream. Two reservoirs, Council Grove and John Redmond, were proposed and eventually constructed in the upper Neosho River basin after the passage of this Act. The associated archaeological research utilized funds appropriated to the National Parks Service for archaeological assessments in river basins of the United States (Witty, 1982: 3). The law that mandated archaeological assessments was the Historic Sites Act of 1935. This Act was the precursor to the National Historic Preservation Act of 1966, the National Environmental Policy Act of 1969, and the Moss-Bennett Bill of 1974. Archaeological investigations in the basin typically consisted of (1) creating an archaeological inventory of archaeological sites through a surface survey, (2) determining the research potential of the sites through a limited testing program (e.g. shovel test pits), and (3) collecting a representative sample from the cultural deposits deemed potentially historically significant via excavation.

In Kansas, over 50 archaeological investigations have an association with reservoir/flood control pools (e.g. Witty, 1961, 1963, 1967, 1969, 1978, 1980, 1982; Marshall, 1972; Grosser, 1973; Johnson, 1973; Schmits, 1976; Rogers, 1976; Theis, 1981; Holen, 1997; Mandel, 2002). Regional archaeological syntheses (e.g. Wedel 1959, 1961, 1986; Adair, 1988; O'Brien, 1984; Hofman, 1994, 1996a, 1996b; Kay, 1998; Wood, 1998; Hoard and Banks, 2006b) have used the data collected from the reservoir/flood control pool construction projects to infer prehistoric behavior extending to at least 11,500 ^{14}C yr B.P.

Council Grove and John Redmond Reservoirs

In the study area, most archaeological investigations have been associated with the Council Grove and John Redmond reservoirs. As such, recorded archaeological sites are unevenly clustered around and within the reservoir areas. The Tulsa District of the U.S. Army Corps of Engineers began construction of the Council Grove flood control pool in 1960. It was operational in October of 1964 (Witty, 1982:1). The Tulsa District began construction of the John Redmond in July of 1959, completing the project in December of 1965 (Witty, 1980:1). This section of the thesis includes a brief history of the archaeological investigations at the Council Grove and John Redmond reservoirs and provides a summary of key archaeological sites found during those investigations.

<u>Council Grove Reservoir</u>

The dam structure for the Council Grove reservoir was built downstream from the confluence of Munkers Creek and the Neosho River. The resulting lake configuration is V-shaped (see Figure 2.2). In 1961, the Kansas State Historical Society (KSHS), in cooperation with the National Park Service, conducted archaeological investigations in the lake area including the lake itself before it was flooded. Thomas A. Witty, Jr. of KSHS headed the initial surface survey. Sixteen (16) prehistoric archaeological sites were recorded during the survey.

Three of the sites identified in the 1961 survey, Slough Creek (14MO308), Two Dog (14MO301) and William Young (14MO304), were subject to subsurface testing in 1962 and 1964. At the Slough Creek site, test excavations recovered Pomona cultural deposits. Excavations at the Two Dog site revealed pottery sherds and chipped stone tools that were assigned to the Greenwood Phase, an Early Ceramic/Late Woodland period technological adaptation. The William Young site was a deeply stratified, multi-component site (Witty, 1982:ii). Discrete cultural components at the site included Historic, Early Ceramic/Woodland, and Archaic periods (El Dorado and Munkers Creek complexes).

The William Young site is important to regional archaeological interpretations because it is the type locality for the Munkers Creek phase (see Witty, 1969), which is also referred to as a technological complex (Blackmar and Hofman, 2006). The site also has lithics assigned to the El Dorado complex, which is a Late Archaic adaptation (El Dorado discussed further with the Williamson site below). Munkers Creek is a middle to late Holocene adaptation generally found in central and northeastern Kansas. Munkers Creek deposits indicate a broad spectrum economy and a unique lithic toolkit typified by gouges (Blackmar and Hofman, 2006:62) and a long narrow biface (knife) that typically has a high sheen (Banks and Wigand, 2005:173). The sheen on Munkers Creek knives has been linked to sickle polish (Theis and Witty, 1992; Witty, 1982).

Other key sites with Munkers Creek components are Cow Killer-14OS347 (Reynolds, 1984) and Coffey-14PO1 (Schmits, 1976, 1978). Both sites were found subsequent to the excavations at the William Young site. The William Young site is notable in that two small triangular-shaped ceramic effigy heads came out of the same stratigraphic level as the Munkers Creek artifacts. These heads represent the earliest recorded occurrence of ceramic figurines in the United States (Blackmar and Hofman, 2006:64). Four radiocarbon determinations (3400 ± 500 ^{14}C yr B.P., 5340 ± 160 ^{14}C yr B.P., 7300 ± 2000 ^{14}C yr B.P., and 3100 ± 400 ^{14}C yr B.P.) established the initial chronology of the William Young site (Banks and Wigand, 2005:174). However, the radiocarbon samples were assayed by the Gakushuin (GaK) laboratory between 1963 and 1968 for radiocarbon analysis (Banks and Wigand, 2005:173). Blakeslee (1994, 1997) has demonstrated the inconsistency of the accuracy of GaK radiocarbon ages in the Central Plains.

The unreliability of GaK radiocarbon ages prompted Banks and Wigand (2005) to resample the William Young site to attain a more reliable chronology for the Munkers Creek phase/complex. Based on a new suite of radiocarbon determinations, they found that the Munkers Creek phase occurred between 5640 and 4850 ^{14}C yr B.P. (Banks and Wigand, 2005: 182) and not between 7300-3100 ^{14}C yr B.P. as indicated by the GaK ages.

Unrelated to Witty's investigations in the 1960s, Patricia O'Brien, Hal Rager and several graduate students at Kansas State University performed a surface reconnaissance at Council Grove Lake in 1979 and 1980. This work relocated some of the archaeological sites previously identified by Witty (see Witty 1961, 1982) and recorded 13 sites (O'Brien, 1983).

John Redmond Reservoir

The John Redmond reservoir was constructed downstream from the confluence of the Neosho and Cottonwood rivers in Coffey County. The dam spans more than 6.7 km across a broad valley. The Flint Hills National Wildlife Refuge (FHNWR) was established in 1966 as part of the John Redmond reservoir flood control project. The U.S. Fish and Wildlife Service manages the FHNWR, which includes 74.72 km^2 (18,463 acres) of land surrounding the reservoir pool.

In the early 1950s, prior to the construction of the John Redmond reservoir, the Strawn reservoir was proposed for this area. In 1953, Roscoe Wilmeth of Kansas State Historical Society (KSHS) conducted an initial survey of the originally proposed and much smaller Strawn reservoir (Moorman, 1953 cited in Witty, 1980). Wilmeth conducted a second survey in 1959 after the proposed Strawn reservoir was expanded and renamed John Redmond (Witty, 1980:1). In total, Wilmeth found 23 sites that required further investigation (Witty, 1961:37).

In June and July of 1963, KSHS conducted test excavations at four of the sites recorded by Wilmeth in 1959. Those sites were Williamson (14CF330), Gilligan (14CF322), Salb (14CF331) and Dead Hickory (14CF301). Wood charcoal from the Williamson site yielded radiocarbon ages of 3600 ± 100 ^{14}C yr B.P. and 3500 ± 100 ^{14}C yr B.P. (Hoard and Banks, 2006b:291). These ages are suspect because the samples were assayed by the GaK lab.

The Williamson site was located along Eagle Creek, a tributary of the Neosho River. It represents a multicomponent site. This site along with the Snyder site, located in Butler County, Kansas, was used to define the late Archaic adaptation called El Dorado (Grosser 1973, 1977; Schmits, 1980a, 1987; Hofman, 1996a:95). Radiocarbon ages place the El Dorado phase or complex around 3950 – 3250 ^{14}C yr B.P. Excavations at these sites have been important to regional interpretation of late Archaic seasonal subsistence strategies (Hofman, 1996a:95).

Jones and Witty place the occupation of the Gilligan site at "not much before A.D. 500 and not much after A.D. 700" based on the presence of Greenwood and Verdigris pottery types and one GaK lab radiocarbon determination (Jones and Witty, 1980: 125). Schmits tentatively describes the Salb site as a multicomponent habitation site (Greenwood phase and Pomona pottery) that had evidence of massive stratigraphic discontinuity (Schmits, 1980b: 130).

The Dead Hickory site was originally recorded by Wilmeth and later named the Schellenger site by Witty (1961). Schmits, however, continued to refer to the site as Dead Hickory. Excavations revealed four house floors. Occupation of the Dead Hickory site is considered a Middle Ceramic-Pomona focus site (Schmits, 1980b: 162).

In 1974, the Museum of Anthropology at the University of Kansas, conducted a partial survey of the John Redmond reservoir shoreline and excavated site 14CF335. Richard A. Rogers led the archaeological investigations (Rogers, 1976). Rogers would eventually use the data collected during this fieldwork for his dissertation research (see Rogers, 1984 - discussed below). Rogers recorded 37 sites during the 1974 field season. Excavations at 14CF335 included fifteen (15) 2 m x 2 m test units and a series of perpendicular backhoe trenches ranging from about 10 m to 75 m in length (Rogers, 1976: Figure 21).

Site 14CF335 is located on a T-2 surface along Eagle Creek, a tributary of the Neosho River. In the excavation report Rogers (1976) described three fluted points that were purportedly found on the T-2 surface by two separate collectors, Larry Truelove and Henry Thompson. According to Rogers:

> One of these [fluted points] was a Folsom point made from Alibates flint. This artifact should date to between 10,000 and 10,500 years old. The longest resembles a Clovis point (ca. 9,000 B.C. to 9,500 B.C.). It differs from most Clovis points by being more finely chipped and much wider across the midsection in proportion to its width across the base. It somewhat resembles a Browns Valley point in outline, but is much narrower. The third fluted point has a constricted waist like some fluted points from the Eastern United States (1976: 7-8).

The authenticity of these artifacts is in question. Jack Hofman, Department of Anthropology, University of Kansas, has examined the Folsom point described by Rogers (Jack L. Hofman, personal communication 2009). Hofman cautions that alibates is the most common material used to make modern replicas of Folsom points and that complete alibates Folsom points in pristine condition, as was the alleged Folsom point described by Rogers, are extremely rare (personal communication 2009). As mentioned, the Folsom and the other "Clovis-like" points described by Rogers belonged to artifact collectors. Collector Larry Truelove told Rogers he found the Folsom point and the Clovis-like point on the T-2 terrace at 14CF335. Another collector, Henry Thomsen, said he found the fluted point with a constricted waist on the same landform. The authenticity of the other points has not been evaluated. Due to the uncertainties surrounding the fluted points from 14CF335, they are not included in regional distribution maps of Paleoindian points (e.g. Hofman, 1994; Hofman and Hesse, 1996; Blackmar and Hofman, 2006).

In 1979, KSHS directed a survey and limited testing program within a portion of the John Redmond reservoir area. In total, 85 new sites were recorded, 28 previously recorded sites were relocated, and 25 sites were subject to limited testing (Theis, 1981). Theis (1981:I) concluded that the artifacts recovered indicate "the reservoir has been occupied intermittently, if not continuously, from the middle or late Archaic up to the present era, or from ca. 3000 B.C. to the present day. Most of the prehistoric sites appear to represent Middle Ceramic occupations presumed to date from ca. A.D. 1000-1500".

Geoarchaeological Studies

Many studies have focused on late-Quaternary alluvial stratigraphy in the Central Plains (e.g., Johnson and Martin, 1987; Bettis and Mandel, 1989, 2002; Mandel, 1989, 1991a, 1992a, 1994a, 1994b, 1994c, 1999, 2002, 2006b, 2008; May, 1989; Arbogast, 1991; Dillon, 1992; Martin, 1992; Mandel and Bettis, 2001a; Beeton, 2007; Dillon and Mandel, 2008). However, no previous studies have focused on late-Quaternary alluvial stratigraphy of the upper Neosho River basin. Consequently, relatively little was known about the composition and ages of the alluvial landform sediment assemblages in the basin.

Studies within the Project Area

There has been one attempt at reconstructing a relative chronology of the alluvial landforms in the study area as a framework for interpretation of the archaeological record. For his dissertation research, Rogers (1984) constructed alluvial chronologies for landform surfaces in the Arkansas and Kansas river basins. As noted, the Neosho River is part of the greater Arkansas River basin. His chronological scheme was based on recorded cultural assemblages and surface faunal collections found on terrace and floodplain surfaces and on gravel bars. He also evaluated faunal assemblages recovered from commercially excavated sandpits near Wichita, Kansas.

Rogers' study is relevant to the present study because he described the alluvial landforms in the Neosho River basin and he used archaeological and paleonotological materials that he collected during his 1974 archaeological survey at the John Redmond reservoir for his dissertation research. Rogers described five alluvial geomorphic surfaces: the floodplain, T-1, T-2, T-3 and T-4. He found that cultural and paleonotological materials found on the floodplain (T-0) and low terrace (T-1) surfaces dated to the Holocene. Materials on the T-2 and T-3 surfaces were typical of the Wisconsin glaciation period. Materials on the T-4 surface dated to the middle Pleistocene (1984:215).

Studies in the Vicinity of the Project Area

Seven geoarchaeological studies have focused on late-Quaternary alluvial stratigraphy in river valleys adjacent to the study area (Figure 4.1). In general, these studies used stratigraphy to describe LSAs, lithostratigraphy to determine the relative ages of the LSAs and radiocarbon assays to determine the spatial and temporal patterns of landscape evolution.

In the most recent study, Beeton (2007) studied late-Quaternary landscape evolution and geoarchaeology in the Cottonwood River basin. The Cottonwood River is the largest tributary of the Neosho River in the present study area. Beeton identified four

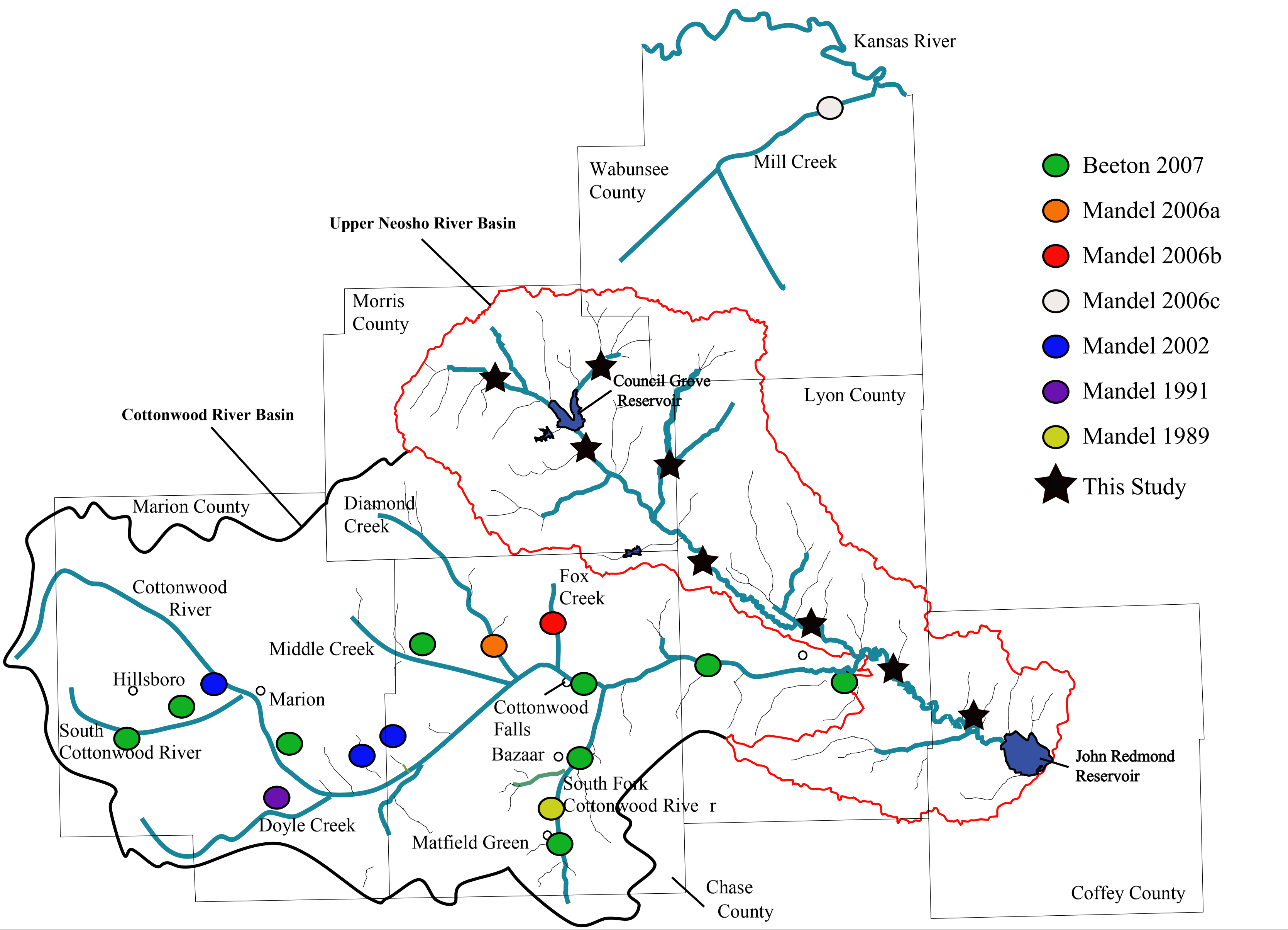


Figure 4.1. Studies referred to in text

LSAs in the valleys of small streams (i.e. first through third-order) in the Cottonwood River basin: a lower floodplain (T-0b), a slightly higher floodplain (T-0a), a low terrace (T-1), and a high terrace (T-2). He determined that the Camp Creek Member and the Honey Creek Member of the DeForest Formation underlie floodplain and low terraces and that the Severance Formation underlies high terraces in small valleys of the Cottonwood River. The Severance Formation is a late-Pleistocene aged informal lithostratigraphic unit recognized in eastern Kansas and Nebraska (Mandel, 2006b: 2). In large valleys, the valley floor consists of a modern floodplain (T-0), a low terrace (T-1), an intermediate terrace (T-2), and scattered remnants of a high terrace (T-3) that only occur on the north side of the trunk stream (Beeton, 2007: 147-148). Beeton established that Camp Creek, Honey Creek, Late Gunder and Early Gunder Members of the DeForest Formation occur within the landforms of large valleys (Beeton, 2007: 117-118).

Based on stratigraphy and radiocarbon determinations, Beeton was able to assess the spatial and temporal patterns of landscape evolution in the Cottonwood River basin. He noted that small valleys were zones of net sediment erosion during the early Holocene, and zones of net sediment storage during the late Holocene. By contrast, large valleys were zones of net sediment storage during the early and late Holocene. Aggradation in large valleys in the early Holocene was punctuated by periods of landscape stability at ca. 10,500 and 8,800 ^{14}C yr B.P., and another period of landscape stability was recorded at ca. 2,500 ^{14}C yr B.P. Few middle-Holocene ages have been recorded in the basin. The entire basin appears to be a zone of net sediment erosion during the middle Holocene. These patterns of erosion, deposition and stability are attributed to major climatic changes during the late Wisconsin and Holocene (Beeton, 2007: abstract).

Mandel (2006b) conducted a geomorphological investigation in Fox Creek valley within the Tallgrass Prairie National Preserve, Chase County, Kansas. Fox Creek is a third-order tributary to the Cottonwood River. Mandel examined cutbank exposures and deep cores to determine the soil stratigraphy and lithostratigraphy of the LSAs. He used radiocarbon dating to determine numerical ages of alluvial deposits and associated buried soils, thereby defining the temporal and spatial patterns of landscape evolution. He also assessed the geologic potential for buried prehistoric resources in the Fox Creek valley.

According to Mandel (2006b), the valley floor of Fox Creek consists of four Quaternary landforms: a low floodplain (T-0b), a slightly higher floodplain (T-0a), an alluvial terrace (T-1), and alluvial/colluvial fans. He determined that the T-0b is underlain by the Camp Creek Member, (2) the T-0a is underlain by the Honey Creek Member and the Roberts Creek Member, (3) the T-1 is underlain by Gunder Member, and, (4) alluvial/colluvial deposits are typical of the Severance Formation.

Using geomorphic, chronostratigraphic and soil-stratigraphic data, Mandel (2006b) predicted where buried archaeological deposits dating to specific cultural periods are likely to occur in the Fox Creek valley. He found there is a high geologic potential for buried Late Archaic and Early Ceramic and a moderate potential for Early Paleoindian cultural deposits associated with the T-1 fill (Gunder Member). There is a high to moderate potential for buried Early through Late Ceramic cultural deposits associated with the T-0a fill (Honey Creek and Roberts Creek Members). There is a low potential for alluvial/colluvial fans in the Fox Creek valley to contain buried Pre-Clovis cultural deposits (Mandel, 2006b: 27-29).

At the Claussen site, Mandel (2006c) describes three buried soils and two cultural horizons in a Holocene terrace (T-2). One cultural horizon is deeply buried and stratified. Based on a suite of radiocarbon assays, the horizon represents repeated occupation between ca. 9,200-8800 ^{14}C yr B.P. The other cultural horizon dates to the Middle Ceramic period and consists of deposits on the T-1 surface and in the paleochannel fills.

Claussen is located along a tributary (Mill Creek) of the Kansas River, situated just north of the drainage divide between the Neosho River and Kansas River basins. Mandel (2006c) determined the valley floor of Mill Creek consists of a modern floodplain (T-0), two Holocene terraces (T-1 and T-2) and a high Pleistocene-aged terrace (T-3). A paleochannel (possibly a flood chute) separates the T-2 and T-1 terraces at this locality. Based on stratigraphic analysis, the Camp Creek Member underlies the floodplain (T-0), the Honey Creek Member forms most of the valley fill beneath the T-1 surface, the Roberts Creek Member occurs in a filled paleochannel that runs along the scarp between the T-1 and T-2 surfaces, and Gunder Member comprises the T-2 terrace LSA (Mandel 2006c).

At the Diamond Creek site (14CS1338) Mandel (2006a:36) identified three buried soils and two cultural horizons in an alluvial fan. Diamond Creek is a tributary of the Cottonwood River and the fan formed where a first-order drainage element enters Diamond Creek. Charcoal from a hearth near the bottom of the fan yielded a radiocarbon age of 7820±80 ^{14}C yr B.P. (Mandel, 2006a: 36).

Mandel (2002) conducted geomorphological investigations in support of the archaeological survey of rural water district No. 5 in Marion and Chase counties. He identified four LSAs on the valley floor: the modern floodplain (T-0), a low terrace (T-1), a high terrace (T-2) and alluvial fans and colluvial aprons (Mandel, 2002).

Mandel (1991b) conducted a geomorphological study of the Whitewater River and Doyle Creek watersheds in southeast Kansas. These low order streams drain into the Cottonwood River in Marion County. The objective of the study was to determine the geologic potential for buried archaeological sites in the watersheds. Mandel reported six radiocarbon ages from alluvial fills in the Doyle Creek watershed. He identified a modern floodplain (T-0), a low terrace (T-1), and a high terrace (T-2). Valley fill beneath the T-1 terrace aggraded between ca. 2,110 and 2,900 ^{14}C yr B.P. Remnants of a T-2 terrace were observed in the western half of the Doyle Creek watershed, but the age of the T-2 fill is unknown (Mandel, 1991b).

Mandel (1989) conducted a geomorphological investigation as part of an archaeological survey of a proposed watershed structure in the upper South Fork Cottonwood River (Mandel, 1989). He described two Holocene terraces (T-1 and T-2) on the valley floor. A suite of radiocarbon ages suggests that the T-1 fill aggraded between ca. 2,300 and 900 ^{14}C yr B.P., and the T-2 fill aggraded between ca. 7,500 and 3,000 ^{14}C yr B.P. (cited from Beeton, 2007:18).

Soils and Soil Geomorphology Studies in the Great Plains

The present study uses Natural Resources Conservation Service (NRCS) soil survey information (i.e. SSURGO data) as a research tool. Previous archaeological investigations, including studies in Texas (Lake Creek valley, Mandel, 1987), Oklahoma

(Copan Lake area, Reid and Artz, 1984; Artz, 1985), and Iowa (central Des Moines River valley, Benn and Bettis, 1985; Bettis and Benn, 1984), have used soil distributions to help guide research. Reid and Artz's Copan Lake study in Oklahoma used the presence of soils with argillic horizons to delineate between older and younger LSAs. The present study follows the same procedure. The Copan Lake study is summarized below.

In 1980 and 1982, during archaeological surveys of the Copan Lake area in the Little Caney basin, Reid and Artz used the presence of soils with argillic B horizons to differentiate between areas with high potential for Archaic-aged archaeological sites (i.e. more than 2,000 years old) from areas with low potential for these sites (Artz, 1985; Reid and Artz, 1984). They reasoned that because it requires a minimum of 1,000 years for modern soils to form minimally developed argillic B horizons in the Little Caney valley, Archaic-aged cultural materials would most likely be associated with LSAs that have surface soils with argillic horizons and that those cultural materials would likely be deeply buried (Artz, 1985; Reid and Artz, 1984).

The term argillic is derived from the Latin word *argilla*, meaning clay. Argillic horizons form below the soil surface, have a higher percentage of silicate clay than overlying soil, and show evidence of clay illuviation (Birkeland, 1999: 5). Formation of argillic horizons involves a variety of factors, including climate, parent material, biota, topography, and time (Buol et al., 1989: 128-129). As such, argillic horizons develop at different rates depending on the environmental situation. For example, well-drained alluvial soils in the Flint Hills of eastern Kansas have minimally developed argillic horizons that formed in 1000-2000 years (Artz, 1983; Mandel, 1988b). In Oregon's Williamette valley, it is estimated to take ca. 5000 ^{14}C yr B.P. for a weak argillic horizon to form (Parsons et al., 1970). In contrast, minimally developed argillic horizons will form in approximately 2,000 years in Pennsylvania (Bilzi and Ciolkosz, 1977).

At the time of the Copan Lake survey, the NRCS had mapped surface soils formed in alluvium in the Little Caney basin as Osage, Verdigris and Mason series. Of the three soil series, only the Mason has an argillic horizon. Therefore, Reid and Artz (1984) reasoned the areas mapped as Mason series would have the greatest potential for Archaic-aged or older archaeological deposits buried in the alluvial fills. They used this method to focus survey efforts and modify testing methods.

It should be noted there is an inconsistency between the present NRCS description of Osage series soils and the description offered by Reid and Artz. This is pointed out because Osage series soils are found in the upper Neosho River basin. For example, Reid and Artz (1984: 102) describe the Osage series as weakly developed, possessing a dark gray, clayey A horizon with blocky structure overlying a massive, dark gray, clayey C horizon, but lacking a B horizon. The current NRCS description of Osage soils indicate a strongly-developed soil with A-Bss1-Bgss2-Bgss3-Bgss4-Bg horizonation. Hence, the current NRCS description of Osage soils morphology suggest a much longer weathering history than the Osage soil described by Reid and Artz.

Summary

Chapter IV describes several archaeological investigations conducted within the upper Neosho River basin. Most of the investigations used surface surveys to locate cultural deposits within the legal boundaries of John Redmond and Council Grove reservoirs. Archaeological surveys typically evaluate the ground surface and do not evaluate underlying sediments. As a result, the majority of archaeological sites in the basin were recorded because they were visible on the ground surface. Thus, archaeological site distributions in the basin are controlled by the age of landform surfaces, vegetation cover at the time of the survey, the size of the surveyed area and testing methods and probably do not reflect human preferences or length of occupation for a particular area or setting.

One study in the basin evaluated the archaeological record within the context of a dynamic alluvial system (see Rogers, 1984). It was designed to rectify some of the biases associated with conducting surface surveys. The study determined the relative ages of geomorphic surfaces in the basin through evaluation of the surface artifacts and paleonotological remains. However, the study only provided a relative assessment of the landform surface ages and did not provide numeric chronological data. Nor did it assess the alluvial stratigraphy of the basin's landforms.

No studies have focused on late-Quaternary alluvial stratigraphy within the study area until the present thesis. Consequently, relatively little was known about the actual ages of the alluvial LSAs in the basin.

There have been seven studies focused on late-Quaternary alluvial stratigraphy in eastern Kansas outside of the upper Neosho River basin. The present study adopted its approach to geomorphic investigation in the upper Neosho River basin from these studies.

Several archaeological investigations have used soil morphology to guide research. A study in the Little Caney valley of northeast Oklahoma (Artz, 1985) was especially innovative because it used the distribution of soils with argillic horizons to estimate the minimum age of geomorphic surfaces. The present study has adopted Artz's research method.

Discussion

Evaluation of the archaeological record without consideration of geologic factors can lead to erroneous conclusions regarding settlement patterns and land use. For example, some researchers (e.g. Malouf, 1958; Syms, 1969; Benedict, 1978) have proposed a mid-Holocene cultural hiatus in the Central Plains because relatively few Archaic sites dating from about 8000 to 4000 ^{14}C yr B.P. have been recorded (Mandel, 1995:38). The researchers attributed the mid-Holocene cultural hiatus to increased aridity on the Central Plains during the mid-Holocene Altithermal. According to Benedict (1978), Archaic hunters and gatherers were forced to leave the core of the Central Plains because of extremely adverse environmental conditions and displacement of native game. Others, including Reeves (1973) and Wedel (1986:80) have argued that the lack of recorded archaeological sites dating to the Altithermal is due to survey error, erosion, burial, or failure to recognize artifact types. Geomorphic data collected over the past several decades generally support the position of Reeves and Wedel that the lack of recorded Archaic sites in the Central Plains may be due more to survey error and the effects of geological processes (i.e. erosion and deposition) than cultural factors (see Reid and Artz, 1984; Artz, 1985; Mandel, 1987; Mandel, 1992a; Mandel 1995; Bettis and Mandel, 2002).

There is most certainly a cultural aspect to archaeological site distributions. For example, people may choose to occupy an area because it has ample water, fuel, food, and protection from the elements. People also may choose to live or not live in certain areas for other reasons. It is difficult, however, to determine which patterns in the archaeological record are product of cultural phenomena and which are controlled by geologic processes. While the geomorphological studies noted above provide a geologic framework with which to evaluate the archaeological record, the underlying questions pertaining to human agency remain, such as: Why do people live/hunt where they do? What are some technological and sociological responses to changing environments? How do these changes manifest in the archaeological record? Perhaps more relevant to the present study area is the question: How did people use and interact with the Plains during the Altithermal period?

Although addressing these questions are outside the scope of this thesis, the upper Neosho River basin may represent a "laboratory" for assessing human response to the Altithermal in east-central Kansas. A large number (n=11) of middle Holocene/ Archaic sites have been recorded in the basin. Archaeological excavations at the William Young and Williamson sites suggest that the middle and late Archaic archaeological record is intact and shallowly buried in terrace fills. Those findings brings us back to the bigger question: Is the rather large number of recorded mid-Holocene sites in the basin controlled by survey intensity, human settlement patterns, geologic processes, or, perhaps more likely, a combination of all these factors?

Were people frequenting the upper Neosho River basin during the middle Holocene because of favorable environmental factors? Today, the upper Neosho River basin has a good supply of surface water because of numerous springs and seeps (O'Connor, 1953; Sawin et al., 2002). Those sources of water may have been productive throughout the Holocene; hence providing a constant fresh water source humans and game. Also, the basin is oriented roughly north to south which would have provided relatively easy passage into the chert rich Flint Hills from the south. In addition, the basin is situated within an ecotone. Ecotones are spatial transition zones between two or more different plant communities, a tension belt that is narrower than the habitats of adjoining communities (Odum, 1971:157; Butzer, 1982). The ecotonal community commonly contains organisms from both communities and organisms which are characteristic of and often restricted to the ecotone. Often, both the number of species and the population density of some of the species are greater in the ecotone than in the surrounding communities (Odum, 1971:157). As such, the increased variety of plant and animal species in the upper Neosho River basin would have been attractive to human foragers. For example, the basin is currently dominated by tall grass prairie (see Chapter II - Vegetation). In Kansas, mixed tall and short grass prairies border the tall grass prairies to the west and mixed tall grass and oak hickory forests are to the east. During the Altithermal, warming conditions probably extended the mixed grass and short grass prairie communities further east (Baker et al., 2006). The upper Neosho River basin may have supported mixed grass or even short grass prairie vegetation, thereby, becoming more desirable for bison, an important food source for people during that time.

CHAPTER V

METHODS AND DATA SOURCES

Introduction

A geoarchaeological approach was used to assess the spatial and temporal patterns of landscape evolution in the upper Neosho River basin. ArcGIS 9.3 was used to produce maps and study area imagery, define the study area, select test localities, and map late-Quaternary landforms. Field methods involved stratigraphic analysis of late-Quaternary landforms. Laboratory methods included radiocarbon dating.

Chapter V begins with a description of the criteria used for selecting test localities. Next, the GIS-based procedures used for selecting localities, mapping soils and landforms, and producing imagery for this study are presented. Finally, field and laboratory methods are described.

Selecting Test Localities and Mapping Soils and Landforms

Eight localities were selected for detailed stratigraphic analysis (Figure 5.1). The following criteria were used to select the localities. First, it was essential to select study localities dispersed throughout the upper Neosho River basin. Second, localities had to be comprised of late-Quaternary alluvium or colluvium. Third, the landowner(s) must have given permission to access the areas of interest. Finally, the combined study areas must include the major landforms in the basin.

Data sources used for selecting test localities, mapping soils by parent material, defining late-Quaternary landforms, and conducting spatial analysis included topographic

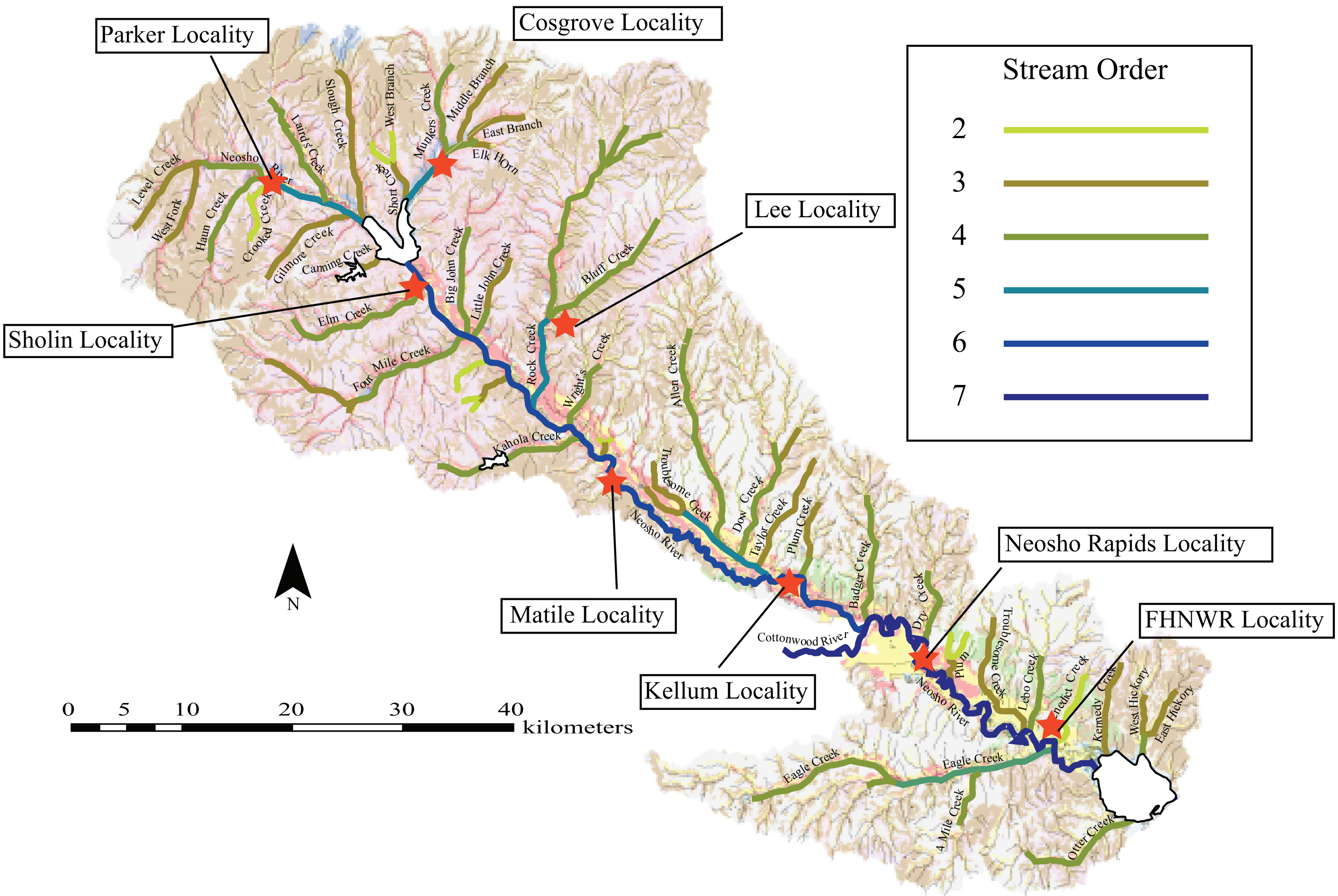


Figure 5.1. Study localities in the Upper Neosho River basin and stream order

maps (Digital Raster Graphics or DRG), aerial photographs (Digital Orthophoto Quadrangles or DOQ), National Hydrologic Data (NHD flowline), 8-digit hydrologic unit boundaries (HUC), digital Soil Survey polygons (SSURGO), Kansas State Historical Society's archaeological site polygons (KSHS), surfical geology polygons, and Public Land Survey System polygons (PLSS). HUC data were used to define the limits of the basin, which is also the boundary of the study area. DRGs, DOQs, and PLSS data sets provided report imagery, topography, roads, current land uses, and useful positional information, such as township and range. SSURGO data provided surface soil distributions and were used to define and delineate late-Quaternary landforms throughout the study area. Surficial geology polygons were used to delineate high terrace landforms in Lyon County. NHD flowline data were used to determine stream order. KSHS archaeological site data were used to determine the locations, ages, sizes, and types of recorded archaeological sites in the study area. KSHS data were also used for spatial statistical analysis. All data sources were referenced to the North American Datum of 1983 (NAD83) and reprojected to the UTM coordinate system, Zone 14.

Below is a step-by-step explanation of GIS-based data manipulation used in this study.

Step 1: Define the Upper Neosho River Basin – HUC Data

Hydrologic unit (HUC) boundaries were used to define the study area. HUC depict the limits of basins. A basin, which is synonymous with a watershed, is the area that drains surface water to a common outlet (Chang, 2008:302). This data set is state-wide and provides digital HUC boundaries at the 4-digit, 6-digit, 8-digit, and 11-digit level. The 4-digit level is the broadest representation of basins in Kansas and the 11-digit level is the most detailed representation, dividing the larger basin into several smaller sub-basins. It consists of geo-referenced digital map data and attribute data (USDA, 1998a). At the 8-digit level, a single polygon named *Neosho Headwaters, Kansas* was used to define the present study area. This polygon was extracted from HUC data using the *Select by Attribute* function in ArcMAP and saved as a separate layer.

Step 2: Clipping the Data Sets to the Study Area

Except for HUC and NHD flowline data sets that are provided at the state level, the data sets used in this study are at a county scale. As noted, the study area includes portions of Chase, Coffey, Lyon, Morris and Wabaunsee Counties. By combining the five individual county data sets into one layer, the amount of redundant processing was reduced and spatial analysis could be performed across county boundaries. The vector based data sets (i.e. SSURGO, KSHS, PLSS, and surficial geologic maps) were combined with the *Merge* function located in *Arc Toolbox / Data Management / General* tools. Raster data sets (i.e. DOQs and DRGs) were combined with the *Mosaic* function in *Arc Toolbox / Data Management / Raster* tools.

Once the data sets were combined they were clipped to the study area (i.e. the basin boundary represented by the HUC polygon). Data clipped to the HUC polygon can be viewed and manipulated inside its boundaries while the data outside of the polygon are either removed or are no longer visible.

There are different operations for "clipping" vector and raster data. For vector data, a clip may be considered a "cookie cutter" overlay. A bounding polygon layer (i.e. HUC polygon) is used to define the area for which features will be output (Bolstad, 2005: 332). The data that falls outside of the polygon is removed. The vector data sources were clipped to the HUC polygon using the *Clip* function in *Arc Toolbox / Analysis Tools / Extract* tools.

There is no clipping tool for raster datasets in ArcGIS 9.3. However, map algebra can be used to produce results similar to vector clipping as described above. Map algebra is the cell-by-cell combination of raster data layers. The combination entails the application of a set of local, neighborhood, and global functions to raster data (Bolstad, 2005: 348). To produce results similar to a vector data clip, the HUC polygon was first converted to a raster data model using the *Arc Toolbox / Conversion / to Raster / Polygon to Raster* tool. In the Raster Calculator the raster imagery (mosaics of DOQs and DRGs) were subtracted from the rasterized HUC polygon.

Step 3: Define Soils by Parent Material and Mapping Late-Quaternary Landforms

Natural Resource Conservation Service (NRCS) soil survey data (SSURGO) was used to map soils according to their parent material. Soils formed in Holocene alluvium include Verdigris, Ivan, Kennebec, Lanton, Reading, Mason, Leanna, Chase, and Osage. Soils formed in pre-Holocene alluvium include Ladysmith, Woodson, Olpe, and Kenoma. Soils formed in bedrock residuum, colluvium, and loess are typically found on the valley margins and uplands. Tully and Zaar soils have formed in colluvium. Konza and Smolan soils have formed in loess. Soils formed in bedrock residuum are differentiated by bedrock type. For example, the Apperson, Clime, Dennis, Elmont, Eram, Martin, Summit, Vinland, and Zaar soils formed in shale. Limestone derived soils include the Clareson, Florence, Matfield, Shidler, and Sogn series. The Labatte and Lula soils formed in limestone and shale. The Collinsville series formed in sandstone and the Bates series formed in sandstone and shale (Neill, 1981; Barker, 1974; Swanson, 1982). Soils in the Neosho River basin are listed in Table 2.1. This table also shows the soils parent materials and their taxonomic classification to the subgroup level.

SSURGO data were used to delineate late-Quaternary alluvial and colluvial landforms in stream valleys. Late-Quaternary landforms include floodplains, low terraces, high terraces, alluvial fans, and colluvial aprons. Soil morphology was used to differentiate floodplains from terraces. Specifically, low terraces, alluvial fans, and colluvial slopes with soils exhibiting argillic horizons were mapped as early and middle Holocene landforms. With the exception of Osage soils (discussed below), floodplains, channel fills, and terraces with surface soils lacking argillic horizons were mapped as late Holocene landforms. The NRCS Soil Survey website was consulted to check the accuracy of SSURGO data at each locality.

Floodplains are frequently flooded, level or gently sloping landforms with surface soils that do not have argillic horizons. Verdigris, Ivan, Kennebec, and Lanton soils were used to map the floodplain. Low terraces are rarely or occasionally flooded, relatively flat or gently sloping landforms that are slightly elevated above floodplains. Reading, Mason, Leanna, Chase, and Osage soils were used to map low terraces. Except for Osage soils, all low terrace soils have argillic horizons.

Osage soils are very deep, poorly drained soils with A-Bss-Bgss profiles that formed in thick deposits of clay-rich alluvium (40% to 60% clay in the Bgss horizon) adjacent to high-order streams, and have very slow permeability (USDA, 1998b). Typically, Osage soils have multiple Bgss horizons that when combined form a zone more than 100 cm. thick. Although no attempt was made to determine the numeric ages of the Osage soils in the upper Neosho River basin, it is assumed the formation of Osage soils was synchronous with other soils formed on the T-1 (e.g., Reading, Mason, Chase, and Leanna). Osage soils, however, have formed under more-saturated conditions than the Reading, Mason, Chase, and Leanna series.

Topographic maps and SSURGO data were used to map alluvial fans and colluvial slopes. Alluvial fans and colluvial slopes were mapped where fan-shaped contours occur at the mouths of low-order streams on topographic maps. According to the SSURGO dataset, Mason, Reading, Tully, Irwin and Dwight soils occur on alluvial fans and colluvial slopes. Surfical geology maps were used in Lyon County to map high terraces.

Step 4: Determining Stream Order – NHD Flowlines and RivEx

This study takes a basin-wide approach in assessing landscape evolution. Determining stream order is important because sedimentation in stream valleys is time transgressive. In the Midwest, sedimentation typically occurs first in the larger valleys and gradually migrates upstream into smaller valleys (Bettis, 1995). One objective of the basin-wide approach is to detect patterns of late-Quaternary erosion and sedimentation within drainage systems and thereby determine whether alluvial deposits of certain ages are differentially but systematically preserved in basins (Mandel, 2006d: 29). Therefore, determining stream order is critical because basin-wide studies typically contrast radiocarbon ages from LSAs in large and small valleys (e.g., Mandel, 1994d; Beeton, 2007).

Stream order has been determined for drainage elements in the study area based on Strahler's (1964) stream classification system. The National Hydrology Database (NHD) flowlines were processed in the RivEx computer program. NHD is a feature-based (vector) database that interconnects and uniquely identifies the stream segments or reaches that comprise the nation's surface water drainage system. More specifically, it contains reach codes for networked features and isolated lakes, flow direction, names, stream level, and centerline representations for areal water bodies (USGS, 1999). RivEx is a river network tool designed to run in ESRI ArcMap 9.1. RivEx allows for quality control of river networks (correcting disconnected lines) and defining river networks in a variety of stream classification systems (Hornby, 2008).

Field Methods

The soils and stratigraphy of late-Quaternary alluvial fills in the valley of the upper Neosho River were analyzed in five cutbanks and three cores among eight localities. Cutbank exposures were cleaned using a hand shovel, with at least one-half meter of surface material removed to minimize the effects of modern weathering. Also, 6.5-cm-diameter cores were collected with a trailer-mounted Giddings hydraulic soil probe. The cores were wrapped in foil and plastic and placed in core boxes. Cores were transported to the Kansas Geological Survey where they were split in half, described and photographed. Soils and sediments were described using standard procedures and terminology outlined by Birkeland (1999) and Schoeneberger, et al. (2002). The texture, structure, boundary characteristics, and Munsell matrix color of soil horizons were included in the descriptions of all sections. When present, root channels, krotovinas, clay films, mottling, and concretions were described. Carbonate morphology was defined according to the classification scheme of Birkeland (1999). Surface and buried soils were included in the stratigraphic framework of every core and section description. Soils were numbered consecutively, starting with 1 at the top of the section.

Informal terms are used to describe magnitude of soil development. A weakly developed soil has an A-C profile. A moderately developed soil has A-Bw horizonation. A strongly developed soil has an A-Bt, A-Bt-Btk or A-Bss-Bgss profile.

Laboratory Methods

Radiocarbon Dating

Eleven wood charcoal samples and one bulk sediment sample were collected from eight localities for radiocarbon dating. Samples collected for radiocarbon dating from cutbanks were removed in the field using a trowel, wrapped in aluminum foil, placed in an unsealed polyethylene bag, and transported to the Kansas Geological Survey (KGS). Samples collected from cores were collected during stratigraphic analysis at the KGS and wrapped in aluminum foil. The charcoal samples were dated at the Illinois Geological Survey's Isotope Geochemistry Laboratory using atomic mass spectrometry (AMS) (eight samples) and conventional methods (four samples). AMS was used for charcoal samples containing less than 2 to 4 grams of final carbon. The ^{14}C ages were δ^{13} corrected and reported in radiocarbon years before present (^{14}C yr B.P.).

The bulk soil sample collected for radiocarbon dating came from a buried soil. The radiocarbon ages determined on soil carbon extracted from this sample is a mean residence time for all organic carbon in the sample (see Campbell et al., 1967). Mean residence time provides a minimum age for the period of soil development, and provides a limiting age on the overlying material (Birkeland, 1999:137).

CHAPTER VI

RESULTS OF INVESTIGATION

This chapter presents the results of the stratigraphic investigations at eight field localities in the upper Neosho River basin (see Figure 5.1). The setting, spatial patterns of LSAs, surface-soil distributions, and stratigraphic data are presented. LSAs comprising the valley floor at each locality are described. Cultural deposits were recorded at the Parker and Cosgrove localities and are described after the presentation of the geomorphic and stratigraphic data at these localities.

The Parker Locality

The Parker locality is on the trunk stream of the Neosho River near the town of Parkerville, which is about 24 km northwest of the city of Council Grove, Kansas. The locality is south of the confluence of Haun Creek and north of the confluence of Crooked Creek (Figure 6.1). At the Parker locality, the Neosho River is a fifth-order stream.

The valley floor at the Parker locality is approximately 700 m wide. Late-Quaternary landforms consist of the modern floodplain (T-0a), a low terrace (T-1), a high terrace (T-2), and alluvial/colluvial fans. The T-0a is the lowest geomorphic surface in the valley and is frequently flooded. Its surface ranges from 3-30 m wide and is separated from the T-1 surface by a prominent 1 to 2 m-high scarp. The T-0a surface soil is mapped as the Ivan/ Kennebec silt loam (Barker, 1974).

The low, paired terrace (T-1) extends to the valley walls, the T-2 scarp, or the distal end of colluvial aprons. Its surface is about 200-550 m wide and gently slopes (0-

Figure 6.1

1%) toward the stream channel. Mason and Reading soils are mapped on the T-1 surface (Barker, 1974).

The T-2 surface is separated from the T-1 surface by an eroded, gently sloping 3 m-high scarp. The T-2 surface is extensive on the north side of the Neosho River valley. Its surface is approximately 200 m wide and is parallel to the river for about 1 km. The surface soil on the T-2 is mapped as Ladysmith silty clay loam (Barker, 1974).

Small, low-angle alluvial/colluvial fans have formed where first-order drainages enter the Neosho River valley, and large, low-angle colluvial aprons have formed on the valley margins. The distal ends of the fans grade to the T-1 and T-2 surfaces. A small fan was noted 50 m to the west of the described section and is mapped as part of the T-1 surface by the SSURGO data.

At the Parker locality the Neosho River has migrated laterally into its late-Quaternary fill, creating several cutbank exposures. A cutbank provided the opportunity to study a 6.3 m-thick section of the T-1 fill (Figure 6.2).

The Gunder Member of the DeForest Formation comprises the T-1 fill at the Parker locality. The Gunder Member is at least 6.3 m thick and consists of dark gray (10YR 4/1, dry) to yellowish brown (10YR 5/4, dry) silt loam and silty clay loam (Appendix I). The upper 5.5 m of the Gunder Member has been strongly modified by pedogenesis. Surface soils are Mollisols with thick, strongly-developed A-Bt-Btss profiles (see Figure 6.2). The Mason and Reading silt loam is mapped on the T-1 surface at the Parker locality cutbank (see Barker, 1974).

The deposits beneath the T-1 tend to be fairly silty and are low in sand content. According to Mandel (2006b: 10), the low sand content of terrace fills in the Flint Hills is

Figure 6.2

due to the primary source of the alluvium. Weathering of limestone and shale in the region generates few sand-sized particles, and erosion of loess on the uplands during the Holocene "would have contributed a large quantity of silt but little sand to the Holocene alluvium" (Mandel, 2006b: 10).

The T-0a and the alluvial/colluvial fans on the valley floor were not studied. However, cursory inspection of the sediments underlying the T-0a surface indicates the fills consist of modern alluvium (Camp Creek Member). There is very weak soil development and the T-0a fill is stratified almost to the surface.

A radiocarbon age of 9700 ± 210 ^{14}C yr B.P. was determined on wood charcoal from a cultural pit feature in the T-1 fill. The pit feature (discussed below) was recorded 3.95-4.20 m below the T-1 surface. The feature had a diffuse outline and a horizontal extent of at least 40 cm in the BC horizon of the surface soil. Based on the radiocarbon age, aggradation of the T-1 fill at the Parker locality began sometime before ca. 9700 ^{14}C yr B.P. and continued until sometime after that time. Soil evidence, however, may be used to infer when T-1 aggradation ceased. As noted in Chapter 2, soil development occurs on stable landforms, those that are neither eroding nor aggrading (Catt, 1986). Therefore, the presence of a soil denotes the passage of time under conditions of relative stability (Holliday, 1992: 103). According to Mandel (1988a), the minimum time necessary for an argillic horizon (Bt) to develop in alluvial sediments of the eastern Kansas is about 2000 years. The presence of a thick, strongly-developed surface soil with A-Bt-Btss horizonation suggests that the T-1 surface was exposed to subaerial weathering for at least 2000 years ^{14}C yr B.P.

A second radiocarbon assay was conducted on wood charcoal at the Parker locality. The sample was collected about 1 m below the pit feature and yielded an age of 8900 ± 70 ^{14}C yr B.P. Unlike the charcoal from the pit feature, this lower sample was collected within a mixed matrix of charcoal and silty clay loam and was not within a feature with definable boundaries. No cultural materials were found within the matrix. Upon reevaluation of the T-1 stratigraphy, it became clear that the charcoal used for the assay was collected from a slump deposit and was not in primary stratigraphic context.

Although the pit feature that was recorded in the T-1 fill at the Parker locality was not formally evaluated, culturally modified materials including a small burned bone fragment, a possible deer metapodial (distal metacarpal) that had evidence of rodent gnawing (Mark Volmut, personal communication 2009), and two tertiary chipstone chert flakes were recovered in the field (Figure 6.3). The chipstone flakes are Florence B Permian chert (Brendon Asher, personal communication 2009). In addition, a two-liter sample of pit feature matrix was collected for analysis of macrobotanical constituents and future analysis of microbotanical (phytolith) analysis. Flotation of the feature matrix did not yield macrobotanical remains. However, several small, burned, bone fragments including bird (possibly prairie chicken), rabbit, and vole or mole were recovered in the heavy and light fractions (Mark Volmut, personal communication 2009). A small portion of the two-liter sample was retained for future micorbotanical (phytolith) analysis.

Figure 6.3

The Cosgrove Locality

The Cosgrove locality is on Munker's Creek approximately 11.5 km north of the City of Council Grove. The locality is about 1 km south of the confluence with the Middle Branch of Munker's Creek (Figure 6.4). At the Cosgrove locality, Munker's Creek is a fifth-order stream. In much of the area surrounding the Cosgrove locality, the channel is against or near the eastern valley wall and a steep valley wall typically bounds the eastern side of the channel. On the west side of the stream channel, the valley floor gently dips eastward and is approximately 650 m wide.

The valley floor at the Cosgrove locality consists of four late-Quaternary landforms: the modern floodplain (T-0a), a slightly higher floodplain (T-0b), a terrace (T-1), and alluvial/colluvial fans. The modern floodplain surface (T-0a) is about 5 - 40 m wide. A gently sloping 0.5 m-high scarp separates T-0a from T-0b. The T-0b surface is approximately 50 m wide. There is a prominent natural levee on the T-0b surface immediately west of the stream channel. The T-0a and T-0b surfaces are not delineated from each other in the Soil Survey data (SSURGO), as both are mapped as Ivan and Kennebec silt loam (Barker, 1974). Cursory inspection of T-0a surface soil indicates an A-C profile typical of the Ivan and Kennebec silt loams. The surface soil developed in the T-0b fill has a cambic (Bw) horizon and, therefore, is not an Ivan or Kennebec silt loam.

A gently sloping 1 m-high scarp separates the T-0b and T-1 surfaces. On the west side of the stream channel, the T-1 surface is approximately 400 m wide and has a 1 to 3% slope. Remnants of the T-1 surface occur on the east side of the stream channel. The

Figure 6.4

T-1 surface soil is mapped as Mason and Reading silt loam and Chase silty clay (Barker, 1974).

Although the valley floor is dominated by the floodplain complex and T-1 terrace, large low-angle alluvial/colluvial fans have formed where some first and second-order drainages enter the valley. The distal ends of the fans grade to the T-1 surface. The fans are more common on the west side of the valley floor than on the east side of the valley. Soils on the fans are mapped as the Smolan, Irwin, and Tully series (Barker, 1974).

Munker's Creek has migrated laterally into its late-Quaternary fill, creating several cutbank exposures. A cutbank provided the opportunity to conduct a detailed subsurface investigation of the T-0b fill. Radiocarbon ages and the magnitude of soil development provide the basis for a numerical chronology of late-Quaternary degradation, aggradation, and landscape stability at the Cosgrove locality.

The T-0b fill at the Cosgrove locality is comprised of the Honey Creek Member (Figure 6.5). The exposed section of T-0b fill is 3.4 m thick and consists of dark grayish brown (10YR 4/2, dry) to brown (10YR 5/3, dry) silt loam and silty clay loam (Appendix I). The surface soil is a Mollisol with a moderately expressed A-Bw profile.

Radiocarbon ages were determined on two wood charcoal samples collected from the T-0b fill at the Cosgrove locality. The samples were collected from two thin (1-2 cm) charcoal lenses. There was no evidence of burned earth, and no cultural materials or obvious anthropogenic features were found in association with either charcoal lens. Charcoal collected at depths of 215-220 cm and 340 cm yielded radiocarbon ages of 1640±20 ^{14}C yr B.P. and 1960±70 ^{14}C yr B.P., respectively. The deepest charcoal sample (340 cm) was collected immediately above the contact with gravel. Based on the age of

Figure 6.5

the deepest charcoal lens, aggradation of the Honey Creek Member at the Cosgrove locality began ca. 2000 ^{14}C yr B.P. The age of the gravel beneath the Honey Creek Member remains unknown. T-0b aggradation was still occurring at ca. 1650 ^{14}C yr B.P., but it was beginning to slow down at that time, as indicated by the charcoal dating to 1640±20 ^{14}C yr B.P. in the BC horizon of the surface soil.

The alluvial chronology at the Cosgrove locality supports Mandel's assertion that the development of Bt horizons in alluvial soils of the Flint Hills requires at least 2000 years of landscape stability (Mandel, 1988b). As noted, soil development on the T-0b occurred after 2000 ^{14}C yr B.P. and quasi-landscape stability was achieved at or soon after ca. 1650 ^{14}C yr B.P. Hence, the A-Bw profile of the surface soil at the Cosgrove locality is a product of less than 2000 ^{14}C yr B.P. of pedogenesis, which apparently was not enough time to develop a Bt horizon.

Lee Locality

The Lee locality is on Rock Creek approximately 11.2 km southeast of the city of Council Grove and about 700 m south of the confluence with Bluff Creek (Figure 6.6). At the Lee locality, Rock Creek is a fifth-order stream.

The valley floor at the Lee locality is approximately 1 km wide and consists of four late-Quaternary landforms: the modern floodplain (T-0a), a low terrace (T-1), a high terrace (T-2), and alluvial/colluvial fans. The modern floodplain is about 40 m wide. The floodplain surface soil is mapped as Ivan/ Kennebec silt loam (Barker, 1974). A prominent 1-2 m-high scarp separates T-0a from T-1. On the west side of Rock Creek channel, the T-1 surface is about 250 m wide and has a 1- 3% slope. On the east side of

Figure 6.6

the channel, T-1 is approximately 500 m wide and has a 1-2% slope. Mason, Reading, and Chase soils are mapped on the T-1 surface (Barker, 1974).

The T-2 terrace occurs on both sides of the valley floor. A gently sloping 3 m-high scarp separates T-1 from T-2. The surface soil on the T-2 is mapped as Ladysmith silty clay loam (Barker, 1974).

Small, low-angle alluvial/colluvial fans have formed where some first-order drainages enter Rock Creek valley and large, low-angle colluvial aprons have formed on the valley margins. The distal ends of the fans grade to the T-1 and T-2 surfaces.

A core (Lee #1) was taken on the T-1 terrace at the Lee locality (see Figure 6.6). Based on the information gleaned from the core, the Gunder Member of the DeForest Formation comprises the T-1 fill at this locality (Figure 6.7). The Gunder Member is at least 7.2 m thick and composed of very dark gray (10YR 3/1, dry) to yellowish brown (10YR 5/4, dry) silt loam and silty clay loam (Appendix I). The upper 4.3 m of the Gunder Member has been strongly modified by pedogenesis. Surface soil is a Mollisol with a A-Bt profile.

A radiocarbon age of 3835 ± 20 ^{14}C yr B.P. was determined on wood charcoal from a charcoal lens in the T-1 fill. The charcoal lens was found within the core at 660 cm below the T-1 surface in the Cg2 horizon of the surface soil. Based on the radiocarbon age, aggradation of the T-1 fill at the Lee locality began sometime before ca. 3835 ^{14}C yr B.P.

The radiocarbon age of 3835 ^{14}C yr B.P. on wood charcoal located more than 6.5 m below the T-1 surface is puzzling considering the age of artifacts supposedly collected at site 14MO403 on T-1 at the Lee locality. Over the past several decades, local

Figure 6.7

collectors have gathered a considerable assemblage of chipped artifacts from the surface, and several of those artifacts may be attributed to the Munkers Creek complex (James Dougherty, personal communication 2009). Cultural material associated with Munkers Creek component sites in eastern Kansas typically date to 5800 - 4950 ^{14}C yr B.P. (see Banks and Wigand, 2005; Blackmar and Hofman, 2006). Therefore, the deeply buried charcoal that yielded the radiocarbon age of 3835 ^{14}C yr B.P. is at least 1000 years younger than the artifact assemblage on the T-1 terrace at the site. There are three plausible explanations for this discrepancy. First, it may be that deep root penetration or biota moved the charcoal down from higher up in the profile. Second, the radiocarbon age is in primary context and the "Munkers Creek" artifacts collected at the site were actually collected from another area of the site where fills are older than the those examined in the Lee locality core. Third, the radiocarbon age is correct and the artifacts collected on the T-1 are actually Late Archaic or early Woodland aged artifacts and are not associated with a Munkers Creek occupation.

The Sholin Locality

The Sholin locality is at the mouth of Elm Creek in the Neosho River valley. Elm Creek trends roughly southeast to northwest and enters the Neosho River valley from the west. The Sholin locality is about 0.8 km upstream from the confluence of Elm Creek and the Neosho River (a sixth-order stream). At the Sholin locality, Elm Creek is a fourth-order stream (Figure 6.8).

The Neosho River valley is about 2.0 km wide at the Sholin locality and consists of five LSAs: the modern floodplain (T-0a), a higher floodplain (T-0b), a low terrace (T-

Figure 6.8

1), a high terrace (T-2) and alluvial/colluvial fans. The T-1 and T-2 surfaces are former floodplains of the Neosho River. The Elm Creek floodplain complex (T-0a and T-0b) is inset into the T-1 fill of the Neosho River. The T-0a is about 5-80 m wide and, the T-0b surface is 50-250 m wide. A gently sloping 1 m-high scarp separates T-0a from T-0b. Surface soils developed in the T-0a and T-0b fills are mapped as Ivan and Kennebec silt loam (Barker, 1974). Cursory inspection of T-0a surface soil revealed the presence of an A-C profile typical of the Ivan and Kennebec silt loams, but the surface soil developed in the T-0b fill has a cambic (Bw) horizon and, therefore, is not an Ivan or Kennebec silt loam.

At the Sholin locality, T-1 is a paired terrace and is separated from T-0b by a prominent 2-3 m-high scarp. The T-1 surface is about 30-800 m wide, has a 1-3% slope, and is far more extensive on the east side of the valley than on the west side. At the Sholin locality, surface soils mapped on the T-1 surface include the Mason, Reading, Chase, and Osage series (Barker, 1974).

The T-2 terrace primarily occurs on the east side of the Neosho River valley at the Sholin locality and on the north side of the Elm Creek mouth. A gently sloping 3 m-high scarp separates T-1 from T-2 at the Sholin locality. At the Sholin locality, the T-2 surface is 0.4 km wide and is parallel to the river for about 2 km. The T-2 is not subject to flooding by the Neosho River. The surface soil on the T-2 is mapped as Ladysmith silty clay loam (Barker, 1974).

Although the valley floor is dominated by T-1 and T-2 at the Sholin locality, low-angle alluvial/colluvial fans have formed where some first and second-order drainages enter the Neosho River valley. The distal ends of the fans grade to the T-1 surface on the west side of the valley and the T-2 surface on the east. Soils on the fans are mapped as the Smolan, Tully and Reading series (Barker, 1974).

A core, Sholin #1, was taken on T-0b. A radiocarbon age provides the basis for the timing of late-Quaternary aggradation of the T-0b fills at the Sholin locality.

The T-0b fill at the Sholin locality is comprised of the Honey Creek Member (Figure 6.9). This fill is at least 5 m thick and consists of very dark gray (10YR 3/1, dry) to light brownish gray (10YR 6/2, dry) silt and silt loam (Appendix I). The surface soil is a Mollisol with a moderately expressed (A-Bw) surface soil.

A radiocarbon age of 1830±25 ^{14}C yr B.P. was determined on wood charcoal collected from the T-0b fill at the Sholin locality. The sample was collected from a 1 cm-thick charcoal lens in the C horizon at about 415 cm below the T-0b surface, or 75 cm above a bottom stratum consisting of gravel (see Figure 6.9). There was no evidence of burned earth, and no cultural materials or obvious anthropogenic features were found in association with the charcoal lens. Based on this radiocarbon age, aggradation of the Honey Creek Member at the Sholin locality began before 1830 ^{14}C yr B.P. and rapid aggradation of the T-0b continued for after that time. The age of the gravel beneath the Honey Creek Member remains unknown. Based on the moderate degree of soil development in the surface soil (i.e. the A-Bw profile and no Bt horizon), it is likely that the modern T-0b surface has been stable for at least 500 ^{14}C yr B.P. (see Mandel, 2006b).

Cursory examination of the T-0a and T-0b fills at the Sholin locality was possible because Elm Creek has migrated laterally into its late-Quaternary fill, creating a broad cutbank exposure. The cutbank provided the opportunity to see the cross-cutting relationship of the T-0a and T-0b fills. The T-0a fill appears laterally inset into the T-0b

Figure 6.9

fill. T-0a fills are comprised of post-settlement alluvium also known as the Camp Creek Member of the DeForest Formation. In profile there is veneer of Camp Creek Member overlying the T-0b fill, however, this veneer was not found in the core. In addition, an undercarriage of what appeared to be a late 19th Century wagon was eroding out of the base of the T-0a fills at the Sholin Locality, indicating the T-0a rapidly aggradated in the last 100-150 years.

The Matile Locality

The Matile locality is on the Neosho River approximately 15 km northwest of the city of Emporia and 4.3 km due west of the town of Americus. At the Matile locality, the Neosho River is a sixth-order stream (Figure 6.10).

The valley floor at the Matile locality is approximately 4 km wide and consists of four late-Quaternary LSAs: the modern floodplain (T-0a), a low terrace (T-1), a high terrace (T-2), and alluvial/colluvial fans. The modern floodplain surface (T-0a) is 3-20 m wide and is separated from the T-1 surface by a prominent 2 m-high scarp. The T-0a surface soil is mapped as Ivan silt loam (Neill, 1981).

The low, paired T-1 surface at the Matile locality extends 300-500 m to the valley wall on the west side of the Neosho River channel. On the east side of the channel, the T-1 surface is about 3.5 km wide and has a 1 to 3% slope. Mason, Reading, Chase and Osage soils are mapped on the T-1 surface (Neill, 1981).

The T-2 surface at the Matile locality gently rises toward the valley wall and is approximately 3-7 m above the elevation of the T-1 surface. O'Connor (1952: Plate 1) mapped the T-2 surface as the Pleistocene-aged Wiggam terrace (O'Connor,

Figure 6.10

1952[2007]). T-2 surfaces are extensive on the east side of the Neosho River valley. These large, gently sloping LSAs extend from Council Grove to Emporia. The surface soil on T-2 is mapped as Ladysmith silty clay loam (Neill, 1981).

At the Matile locality, low-angle alluvial/colluvial fans have formed where some first and second-order drainages enter the Neosho River valley. The distal ends of the fans grade to the T-1 surface on the west side of the valley and to the T-2 surface on the east side of the valley. Soils on the fans are mapped as the Smolan, Tully, Ladysmith, and Reading series (Neill, 1981).

The Matile locality is on a channelized segment of the Neosho River. According to the landowner, the U. S. Army Corps of Engineers straightened the Neosho River at the Matile locality and constructed a bridge for County Road 240 across the river (Phillip Matile, personal communication 2008). A result of the bridge construction and channelization project is a broad exposure of the T-1 fill (Figure 6.11).

The Gunder Member of the DeForest Formation comprises the T-1 fill at the Matile locality. The Gunder Member is at least 7.5 m thick and consists of very dark gray (10YR 3/1, dry) to yellowish brown (10YR 5/4, dry) silty clay. The surface soil developed in the T-1 fill at the Matile locality is a Mollisols with a thick, strongly-expressed A-Bt-Btk profile (Appendix I). The surface soil at the Matile locality is 4.3 m thick and is mapped as a Reading silt loam (see Neill, 1981).

There are at least three buried soils in the T-1 fill at the Matile locality. The uppermost buried soil (Soil 2) is 430 cm below the ground surface and is 90 cm thick. Soil 2 is composed of dark gray (10YR 4/1, dry) to dark grayish brown (10YR 4/2, dry) silty clay and has been truncated as indicated by a Bt-BC profile. The next buried soil

Figure 6.11

(Soil 3) is 520 cm below the T-1 surface and is 170 cm thick. Soil 3 consists of dark grayish brown (10YR 4/2, dry) to grayish brown (10YR 5/2, dry) silty clay and also is truncated (Btss-BC profile). The deepest buried soil (Soil 4) is 690 cm below the T-1 surface and is at least 55 cm thick. Soil 4 has a strongly-expressed A-Btk-Cg profile and consists of grayish brown (10YR 4/2, dry) silty clay. Soils 4 is at the Neosho River water level.

Radiocarbon ages were determined on three wood charcoal samples collected in the T-1 fill at the Matile locality. Two charcoal samples were collected from Soil 3 and one charcoal sample was collected from Soil 4. Charcoal collected from the upper portion of Soil 3 yielded a radiocarbon age of 8665 ± 25 ^{14}C yr B.P., and charcoal from the base of this soil yielded a radiocarbon age of 9000 ± 70 ^{14}C yr B.P.. Charcoal collected from the Cgb3 horison of Soil 4 yielded a radiocarbon age of 9410 ± 35 ^{14}C yr B.P. The buried soils indicate that aggradation of the T-1 fill at the Matile locality was punctuated by periods of landscape stability. Based on the radiocarbon ages, the T-1 fill began aggrading prior to 9410 ^{14}C yr B.P. Landscape stability was underway by at least ca. 9400 ^{14}C yr B.P. (Soil 4) and was interrupted by renewed aggradation at ca. 9000 ^{14}C yr B.P. There was an episode of cumulic soil development that spanned the period ca. 9000-8650 ^{14}C yr B.P., which is represented by Soil 3. Alluviation resumed after ca. 8650 ^{14}C yr B.P. and continued until Soil 2 formed. A final episode of alluviation resulted in the burial of Soil 2. Soil 1, the surface soil at the Matile locality, has a thick, strongly expressed A-Bt-Btk profile that probably represents at least 2000 years of landscape stability.

The Kellum Locality

The Kellum locality is on the Neosho River, downstream from the confluence with Allen Creek and upstream from the confluence with Plum Creek (Figure 6.12). At the Kellum locality, the Neosho River is a sixth-order stream.

The valley floor at the Kellum locality is approximately 2.5 km wide and is comprised of five late-Quaternary LSAs: the modern floodplain (T-0a), a low terrace (T-1), two high terraces (T-2 and T-3), and alluvial/colluvial fans. The modern floodplain surface (T-0a) is about 3-800 m wide and is separated from the T-1 surface by a gently sloping 1 m-high scarp. The T-0a surface soil is mapped as Ivan silt loam (Neill, 1981).

The T-1 surface dominates the valley floor and is 2.5 km wide. It is paired and has subtle depressions that mark the positions of flood chutes and abandoned channels. Oxbow lakes are common on the T-1 terrace in this part of the Neosho River valley. The soils on the T-1 are mapped as the Mason, Reading, Chase, and Osage series (Neill, 1981).

The T-2 surface is about 5 m above the elevation of the T-1 surface and is not subject to flooding. T-2 surfaces are extensive on both sides of the Neosho River valley at the Kellum locality. The surface soil on the T-2 is mapped as Ladysmith silty clay loam (Neill, 1981).

The T-3 surface is about 2 m above the elevation of the T-2 (O'Connor, 1952 [2007]). At the Kellum locality, the surface soil on T-3 is mapped as the Ladysmith and Smolan series (Neill, 1981).

At the Kellum locality, the Neosho River has migrated laterally into its late-Quaternary fill, creating several cutbank exposures. One of the cutbanks exposed a thick-

Figure 6.12

section of T-1 fill (Figure 6.13). Based on the results of the investigation, the Gunder Member comprises all of the T-1 fill in the section. The Gunder Member is 475 cm thick and consists of dark gray (10YR 4/1, dry) to yellowish brown (10YR 5/4, dry) silt loam and silty clay loam (Appendix I). The surface soil on the T-1 at the Kellum locality is 340 cm thick and has a well expressed A-Bt profile. This soil and is mapped as Reading silt loam (Neill, 1981).

There is a buried soil (Soil 2) in the T-1 fill at the Kellum locality. Soil 2 is 340 cm below the T-1 surface and is about 135 cm thick. Soil 2 consists of grayish brown (10YR 5/2, dry) silt loam and has been truncated as indicated by the absence of an A horizon. Soil 2 has a strongly expressed Bt-BC profile.

Radiocarbon ages were determined on two wood charcoal samples collected from the T-1 fill at the Kellum locality. The upper sample (215-220 cm below the surface) was collected from a 1-2 cm-thick charcoal lens in Soil 1, and the lower sample was collected from a possible cultural feature in the Btb horizon of Soil 2. The upper and lower charcoal samples yielded radiocarbon ages of 3590±20 ^{14}C yr B.P. and 4460±510 ^{14}C yr B.P., respectively.

Based on the radiocarbon ages, the T-1 fill began aggrading prior to 5000 ^{14}C yr B.P. Landscape stability was underway by at least ca. 4500 ^{14}C yr B.P. (Soil 4) and was interrupted by renewed aggradation that occurred between ca. 4500 and 3600 ^{14}C yr B.P. Alluviation slowed by ca. 3600 ^{14}C yr B.P., leading to the development of Soil 1. As previously noted, Soil 1 has a thick, strongly-expressed A-Bt profile, indicating that it is a product of at least 2000 years of pedogenesis.

Figure 6.13

The Neosho Rapids Locality

The Neosho Rapids locality is on the Neosho River approximately 4 km downstream from the confluence of the Cottonwood and Neosho Rivers (Figure 6.14). The locality is approximately 24 km southeast of Emporia and approximately 0.5 km west of the town of Neosho Rapids. The Neosho Rapids locality is on the northernmost portion of land owned by the Flint Hills National Wildlife Refuge. The Neosho River is a seventh-order stream at the Neosho Rapids locality.

The valley floor at the Neosho Rapids locality is more than 7 km wide and consists of three late-Quaternary landforms: the modern floodplain (T-0a), a low terrace (T-1), and a high terrace (T-2). The T-0a is 5-400 m wide and is separated from the T-1 surface by a prominent 1 m-high scarp. The T-0a surface soil is mapped as Ivan silt loam (Neill, 1981).

T-1 is the dominant LSA in the Neosho River valley at the Neosho Rapids locality. The T-1 surface is approximately 7 km wide and the soils are mapped as the Mason, Reading, Chase, and Osage series (Neill, 1981). The poorly drained, fine-textured Osage series covers the largest area of the four soils mapped on the T-1 surface at the Neosho Rapids locality. The well-drained Mason, Reading and Chase soils are mapped proximal to the Neosho River channel while Osage soils are mapped in distal areas. Osage soils have ubiquitous redoximorphic features and multiple Bgss horizons. The T-1 surface is marked by subtle depressions and abandoned channels, and oxbow lakes are common in this part of the Neosho River valley.

The T-2 surface is about 5 m above the elevation of the T-1 surface. The surface soil on T-2 is mapped as Ladysmith silty clay loam (Neill, 1981).

Figure 6.14

The Gunder Member of the DeForest Formation comprises the T-1 fill at the Neosho Rapids locality (Figure 6.15). The Gunder Member is at least 405 cm thick and consists of fine-grained, very dark gray (10YR 3/1, dry) to yellowish brown (10YR 5/4, dry) silty clay loam and silty clay (Appendix I). The upper 205 cm of the Gunder Member has been strongly modified by pedogenesis. Surface soils are Mollisols with strongly expressed A-Bt-Btss profiles. Chase soils are mapped on the T-1 surface at the Neosho Rapids locality (Neill, 1981).

A radiocarbon age of 2755 ± 20 ^{14}C yr B.P. was determined on wood charcoal from the T-1 fill at the Neosho Rapids locality. The sample was collected about 0.5 km downstream from the described section at a depth of 370 cm below the T-1 surface. The surface soil developed in the T-1 fill at the described section had similar solum thickness and morphological characteristics of the surface soil developed in the T-1 fill where the sample was collected. Chase silty clay loam is mapped on the T-1 surface at both locations (Neill, 1981). Based on the radiocarbon age, aggradation of the T-1 fill at the Neosho Rapids locality began before 2755 ^{14}C yr B.P. and continued after this time.

The time at which T-1 aggradation ceased is inferred from the soil evidence. As noted, the minimum time necessary for an argillic horizon to develop in alluvial sediments of the Flint Hills is about 2000 years (Mandel, 1988b). The presence of a strongly-developed surface soil with A-Bt-Btss horizonation suggests that the T-1 surface was stable for at least 2000 years.

Figure 6.15

Flint Hills National Wildlife Refuge Locality (FHNWR)

The FHNWR locality is in the Lebo Creek valley about 2 km north (upstream) of the confluence with Troublesome Creek and approximately 7 km east of Hartford, Kansas (Figure 6.16). The FHNWR locality is at the northern boundary of the Flint Hills National Wildlife Refuge. Lebo Creek is a fourth-order stream at this locality.

The valley floor at the FHNWR locality is about 1 km wide and consists of two late-Quaternary landforms: the modern floodplain (T-0a) and alluvial/colluvial fans. The T-0a is the lowest geomorphic surface in the Lebo Creek valley and is frequently flooded. The T-0a surface is 20-900 m wide and grades to the alluvial/colluvial fans on the eastern side of the valley. This surface is characterized by prominent ridge and swale topography. The T-0a surface soil is mapped as Verdigris silt loam and Lanton silty clay loam (Swanson, 1982).

Large, low-angle alluvial/colluvial fans have formed where some first and second-order drainages enter the Lebo Creek valley at the FHNWR locality. The distal ends of the fans grade to the T-0a surface. At the FHNWR locality, fans are more common on the east side of the valley floor than on the west side. Soils on the fans are mapped as the Mason, Dennis, and Summit series (Swanson, 1982; Soil Survey Staff, 2009).

A core was taken on an alluvial fan at the FHNWR locality. The upper 120 cm of the alluvial fan consists of reduced black to very dark gray (10YR 3/1, dry) to grayish brown (2.5Y 4/2, dry) silty clay loam and clay loam that has been strongly modified by soil development (A-Bt profile) (Appendix I). The fan deposits resemble reduced units of the Gunder Member of the DeForest Formation (Figure 6.17). Alluvial fans consisting of Gunder Member deposits have been identified in the eastern Plains

Figure 6.16

Figure 6.17

(e.g. Mandel, 1997). Therefore, it is reasonable to define the FHNWR locality as a Gunder fan.

A buried soil (Soil 2) with At-Bt horizonation was recorded at a depth of 120. The surface soil (Soil 1) is welded to Soil 2. Soil welding, or "overprinting," accounts for the clay films in the Atb horizon of Soil 2. Soil 2 is at least 25 cm thick and consists of fine-grained, very dark gray (10YR 3/1, moist) to dark gray (10YR 4/1, moist) silty loam with many dark yellowish brown (10YR 4/4) mottles (Appendix I). Angular, subangular, subrounded, and rounded pebbles are scattered through the matrix of Soil 2. Hence, Soil 2 formed in colluvium or residuum, whereas the overlying sediment is alluvium. The core was stopped by gravels or bedrock at approximately 145 cm below the surface.

The upper 15 cm of Soil 2 was collected for radiocarbon dating. Decalcified organic carbon from this sample yielded a radiocarbon age of 16,930±60 ^{14}C yr B.P. Radiocarbon age determinations on soil provide a mean residence time for all organic carbon in the sample, resulting in a minimum age for pedogenesis and providing a limiting age on overlying material (Birkeland, 1999). Based on the radiocarbon age of the Atb horizon of Soil 2, the landscape was stable around 17,000 ^{14}C yr B.P. An alluvial fan prograded over the stable surface soon after 17,000 ^{14}C yr B.P.

The surface soil where the core was taken is mapped as the Summit series, a soil formed in Pennsylvanian-age shale residuum or colluviated clay (Soil Survey Staff, 2009). However, there is a 120 cm-thick unit of alluvium on the fan at the FHNWR locality, so the Summit soil is not at the surface.

CHAPTER VII

LANDSCAPE EVOLUTION AND GEOARCHAEOLOGY

This chapter summarizes the spatial and temporal patterns of landscape evolution in the upper Neosho River basin. First, a summary and description of the landform sediment assemblages (LSAs) in the basin is presented, and LSAs are placed within a lithostratigraphic framework. Next, an alluvial chronology is proposed for the various landforms. In addition, the geologic potential for buried and surficial cultural deposits is discussed. Finally, the geoarchaeological predictive models are presented.

LSAs of the Upper Neosho River Basin

Introduction

Geomorphological investigations were conducted at eight localities in the upper Neosho River basin. The localities were in the valleys of fourth through seventh-order streams (Table 7.1). The investigations focused on late-Quaternary landform sediment assemblages (LSAs) at the localities. LSAs are landforms and underlying genetically related packages of sediment and associated soils that have predictable age relationships in drainage systems (Mandel, 2005: 12).

Locality	Stream / Stream Valley (if different)	Stream Order	LSAs Found	LSA(s) Studied
Sholin	Fox Creek / Neosho River	4th / 6th	T-0a, T-0b, T-1, T-2, A/C fans	T-0b
FHNWR	Lebo Creek	4th	T-0a, A/C fans	A/C fan
Parker	Neosho River	5th	T-0a, T-1, T-2, A/C fans	T-1
Cosgrove	Munker's Creek	5th	T-0a, T-0b, T-1, T-2, A/C fans	T-0b
Lee	Rock Creek	5th	T-0a, T-1, T-2, A/C fans	T-1
Matile	Neosho River	6th	T-0a, T-1, T-2, A/C fans	T-1
Kellum	Neosho River	6th	T-0a, T-1, T-2, T-3, A/C fans	T-1
Neosho Rapids	Neosho River	7th	T-0a, T-1, T-2, A/C fans	T-1

Table 7.1. Geomorphic Setting of Study Localities

Six late-Quaternary LSAs were identified in the study area (see Table 7.1). However, all LSAs are not present at each study locality. The LSAs include the modern floodplain (T-0a), a slightly elevated floodplain (T-0b), a low terrace (T-1), two high terraces (T-2 and T-3), and alluvial/colluvial fans (Figure 7.1). Soil-stratigraphic analysis of valley fill beneath the T-1 terrace was conducted at the Parker, Lee, Matile, Kellum, and Neosho Rapids localities. T-0b fill was examined at the Cosgrove and Sholin localities, and alluvial/colluvial fan deposits were described at the FHNWR locality (Figure 7.2).

As previously noted, alluvial and colluvial deposits of certain ages are preserved in the Neosho River basin, and these deposits are associated with specific landforms. Understanding the spatial and temporal patterns of late-Quaternary sedimentary deposits has important implications for explaining apparent gaps in the archaeological record, and for predicting the locations of buried cultural deposits (Mandel, 2006b: 27). This study considered geomorphic and soil-stratigraphic data and the archaeological record to predict where buried and surficial materials for each cultural period may occur in the drainage network (Tables 7.2 and 7.3). In other words, this study determines the geologic potential for buried and surficial cultural deposits dating to different periods among LSAs in the study area.

Two criteria were used in this study to determine the geologic potential for buried cultural deposits: the age of alluvial fills and whether buried soils are present. For example, the floodplain has no potential for Paleoindian artifacts (>9000 ^{14}C yr B.P.) because the deposits comprising floodplain fills are less than 2,000 years old.

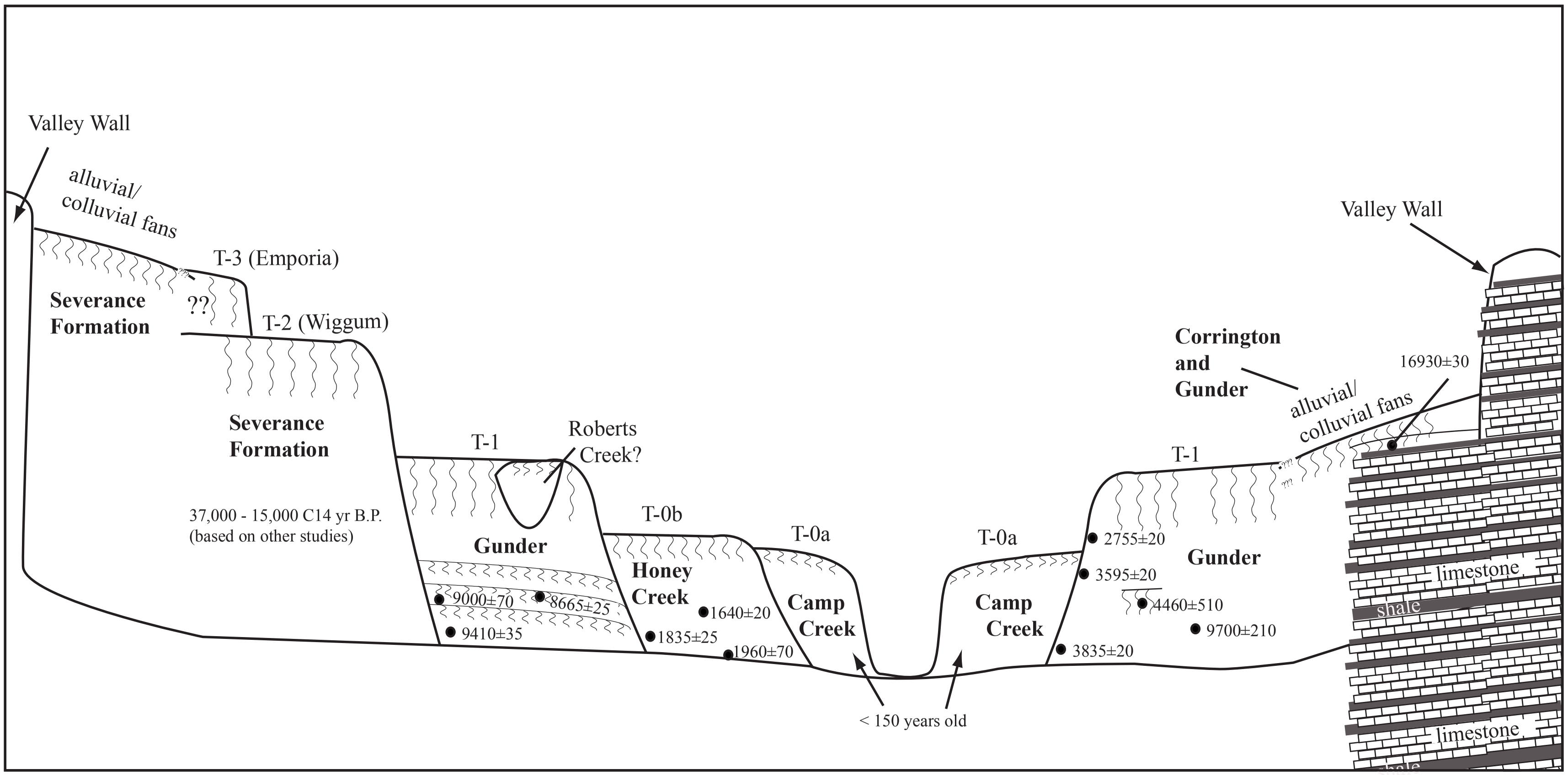


Figure 7.1. Idealized cross-section of the Upper Neosho River basin’s LSAs showing lithostratigraphy and C14 Ages

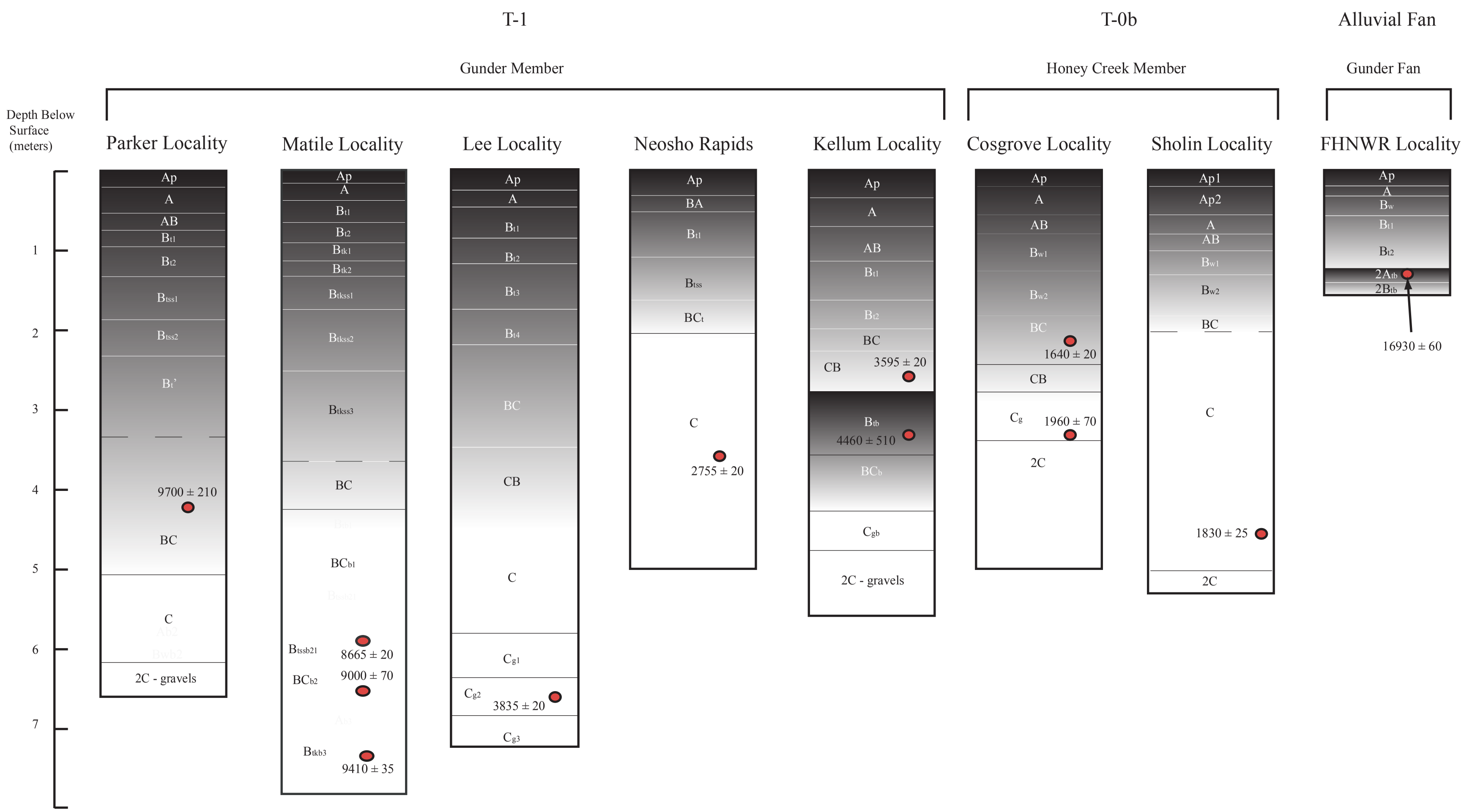


Figure 7.2. Soil Stratigraphy and Chronostratigraphy of study localities

		Floodplain		Low Terraces		Channel Fills		High Terraces	Alluvial/ Colluvial Fans	
		T-0a	T-0b	T-1				T-2 | T-3		
Cultural Period	Time	Camp Cr. Member	Honey Cr. Member	Gunder Member	Reduced Gunder Member	Camp Cr. Member	Roberts Cr. Member	Severance Formation	DeForest Formation Members	Severance Formation
Paleoindian	+11,500 - 9,000	–	–	+++	+	–	–	+	+	+
Archaic	9,000- 3000	–	–	+++	+	–	+++	–	+++	–
Early Ceramic/ Woodland	3,000- 1,000	–	+++	++/+	+	–	+++	–	–	–
Middle Ceramic	1,000- 500	–	+++	–	–	–	+++	–	–	–
Late Ceramic/ Protohistoric	500- 200	+	–	–	–	++	++	–	–	–
Historic	200 - 50	+++	–	–	–	++	+	–	–	–

–	Not Possible
+	Low Potential
++	Moderate Potential
+++	High Potential

Table 7.2. Archaeological predictive model for buried cultural deposits in the Upper Neosho River basin

Cultural Period	Time (14C yr B.P.)	Floodplain		Low Terraces		Channel Fills		High Terraces	Alluvial/ Colluvial Fans	
		T-0a	T-0b	T-1				T-2 / T-3		
		Camp Cr. Member	Honey Cr. Member	Gunder Member	Reduced Gunder Member	Camp Cr. Member	Roberts Cr. Member	Severance Formation	Gunder & Corrington Members	Severance Formation
Paleoindian	+11,500 - 9,000	–	–	–	–	–	–	+++	–	+++
Archaic	9,000- 3000	–	–	+++	+	–	–	+++	+++	+++
Early Ceramic/ Woodland	3,000- 1,000	–	+++	+++	+	–	++	+++	+++	+++
Middle Ceramic	1,000- 500	–	+++	+++	+	–	+++	+++	+++	+++
Late Ceramic/ Protohistoric	500- 200	+	+++	+++	+	–	+++	+++	+++	+++
Historic	200 - 50	+++	+++	+++	+	++	+++	+++	+++	+++

–	**Not Possible**
+	**Low Potential**
++	**Moderate Potential**
+++	**High Potential**

Table 7.3. Archaeological predictive model for surficial cultural deposits in the Upper Neosho River basin

Conversely, T-1 has a high potential for late Paleoindian deposits because the T-1 fill has sediments older than 9000 years and buried soils occur in the fill. The presence/absence of Holocene-age buried soils is important in the assessment of geologic potential because they represent previously stable land surfaces that developed recognizable horizonation (Mandel, 1992a; Mandel and Bettis, 2001b). As Hoyer (1980) pointed out, if the probability of human use of a particular landscape position was equal for each year, it follows that the surfaces that remained exposed for the longest time would represent those with the highest probability for containing cultural materials.

Geomorphic and soil-stratigraphic data also were used to determine the geologic potential for archaeological deposits on surfaces of landforms. Surfaces that have been exposed the longest have the greatest potential for long records of human occupation, For example, the T-2 and T-3 terraces have been stable for at least the past 12,000 years, so these geomorphic surfaces have great potential for yielding cultural deposits dating to Paleoindian and all subsequent cultural periods. By contrast, the T-0b floodplain has been stable for less than 1500 years. Hence, only Middle Ceramic and younger cultural deposits will occur on the T-0b surface.

The Floodplain Complex (T-0a and T-0b)

At least one floodplain was identified at all of the study localities. The T-0a is the lowest floodplain surface and ranges from 3 to 400 m wide, and is frequently flooded. Remnants of a higher floodplain (T-0b) occur in some of the valleys and were found at the Sholin and Cosgrove localities. The T-0b surface is 0.5 to 1.5 m above the T-0a surface and ranges from 50 to 250 m wide. SSURGO data maps the modern floodplain

(T-0a) and the higher floodplain (T-0b) as a single soil unit and the soil assigned to the floodplain varies by county. The floodplain is mapped as Ivan silt loam and Ivan and Kennebec silt loam in Morris County, Ivan silt loam and Verdigris silt loam in Lyon County, and Verdigris silt loam and Lanton silty clay loam in Coffey County. These soils series are appropriate for the T-0a surface because they typically have an A-C profile. However, the soils formed on T-0b have A-Bw profiles and are not Ivan, Kennebec, Verdigris, or Lanton soils.

The Camp Creek Member of the DeForest Formation underlies the T-0a surface. The Camp Creek Member is characterized by weakly developed surface soils (A-C profiles) and evidence of stratification almost to the top of the fill, and it consists of sediment that accumulated after ca. 500 ^{14}C yr B.P. (Mandel and Bettis, 2003; Mandel, 2006b). Based on the presence of late 19th/ early 20th Century cultural debris eroding out of the base of T-0a fill at the Sholin locality, aggradation of the fill occurred within the last 100-150 years.

Valley fill beneath the T-0b surface consists of the Honey Creek Member. Surface soils formed in the T-0b fill are characterized by moderately expressed profiles with A-Bw horizonation. Based on radiometric ages determined on charcoal, fine-grained alluvium comprising the T-0b fill at the Cosgrove and Sholin localities began aggrading around 2000 ^{14}C yr B.P. The morphology of surface soils suggests the T-0b surface became stable by ca. 500 ^{14}C yr B.P. (see Mandel, 2006b).

Geologic Potential for Buried and Surficial Cultural Deposits: the Floodplain

The geologic potential for buried prehistoric cultural materials in the Camp Creek Member beneath the T-0a is low. The fill is a product of rapid aggradation in an unstable geomorphic setting. Therefore, it is not likely that *in situ* cultural deposits will be located in the T-0a fill. Furthermore, based on the weakly developed surface soils of the Camp Creek Member, the T-0a fill may not be old enough to contain prehistoric cultural deposits. There is, however, a high potential for Historic cultural deposits on the T-0a surface and within the T-0a fill.

There is moderate to low geologic potential for buried prehistoric cultural deposits in the Honey Creek Member beneath the T-0b surface. The T-0b fill apparently aggraded fairly rapidly and was likely an unstable environment until ca 1650-500 years ago. Based on the radiocarbon ages determined on materials from the T-0b fill for in the study areas, the fills may contain buried Early Ceramic/Woodland and Middle Ceramic cultural deposits. The T-0b surface may contain Early Ceramic/Woodland, Middle Ceramic, Late Ceramic/Protohistoric, and Historic cultural deposits.

Low Terraces (T-1)

A low terrace (T-1) is present at seven of the eight study localities. The T-1 surface is separated from the floodplain surface by a gently sloping to prominent 1-3 m-high scarp. Typically, the T-1 surface is paired and gently sloping 1-3%. The width of the T-1 terrace ranges from 250 m in fourth and fifth-order stream valleys (see Lee and Sholin localities) to over 7 km in seventh-order stream valleys (see Neosho Rapids locality). T-1 surface soils include the Mason and Reading silt loams, Chase silty clay, Osage silty clay, and Leanna silt loam.

The Gunder Member of the DeForest Formation underlies T-1. Gunder Member deposits described at the Parker, Lee, Matile, Kellum, and Neosho Rapids localities are typically moderately oxidized and have strongly-developed surface soils. Based on radiometric analysis at the Parker and Matile localities, T-1 sediments began accumulating before 9700 ^{14}C yr B.P. Surface-soil morphology (i.e. A-Bt, A-Bt-Btk, and A-Bt-Btss profiles) at the five localities in the basin suggests the T-1 surface has been stable for at least 2000 years.

At one locality, Matile, three buried soils were recorded in the T-1 fill. Based on the radiocarbon ages of wood charcoal within the two lower buried soils at the Matile locality, sedimentation was punctuated by periods of stability between 9410 ^{14}C yr B.P and 9000 ^{14}C yr B.P., at ca. 8665 ^{14}C yr B.P., and again at an undetermined time after 8665 ^{14}C yr B.P.

At the Sholin and Neosho Rapids localities, the T-1 surface is marked by subtle depressions and abandoned channels. Oxbow lakes are common as well. The T-1 surface is separated from the surface of the abandoned channel fills by a gently sloping 0.5 to 2 m-high scarp. In the Flint Hills, channel fills associated with T-1 LSAs are typically comprised of Camp Creek Member or Roberts Creek Member alluvium (see Beeton, 2007; Mandel, 2006b, 2006c). Roberts Creek Member alluvium aggraded between ca. 3,800 and 500 ^{14}C yr B.P., and the Camp Creek Member consists of sediment that accumulated after about 500 ^{14}C yr B.P. (Mandel, 2006b, 2006c)

Geologic Potential for Buried and Surficial Cultural Deposits: T-1 Terrace

There is moderate to high geologic potential for buried prehistoric cultural deposits in the Gunder Member underlying the T-1. Gunder Member may contain buried Paleoindian and Archaic cultural materials and has a moderate to low potential for Early Ceramic/Woodland cultural deposits. The T-1 surface could contain Late Archaic, Early Ceramic/Woodland, Middle Ceramic, Late Ceramic, Protohistoric, and Historic cultural materials.

To illustrate how this study can be applied directly to archaeological analysis, the chronostratigraphy of the William Young (14MO304) site (Table 7.4) has been juxtaposed with the stratigraphy of the Parker Locality (Figure 7.3). As noted in Chapter IV, the William Young site is the type locality for the Munkers Creek technological

Stream Basin/ Site - Stream	Stream Size	LSA*	Material Dated	Depth (m)	C14 Age (B.P.)	Lab. Number	Reference
Neosho River / William Young (14MO304)							
Munkers Creek	Large	T-1	Charcoal	0.85	5255±40	ISGS-A0508	Banks and Wigand, 2005
	Large	T-1	Charcoal	1.18	3,400±500	GaK-596	Witty, 1982
	Large	T-1	Charcoal	1.25	5630±70	Beta-29436	Banks and Wigand, 2005
	Large	T-1	Charcoal	1.46	5,340±160	GaK-297	Witty, 1982
	Large	T-1	Charcoal	1.8	7,300±2000	GaK-1735	Witty, 1982
	Large	T-1	Charcoal	1.95	6200±160	ISGS-5626	Banks and Wigand, 2005
	Large	T-1	Charcoal	1.95	3,100±400	GaK-595	Witty, 1982

Table 7.4 - Radiocarbon Ages by Depth for Two Archaic Sites in the Basin

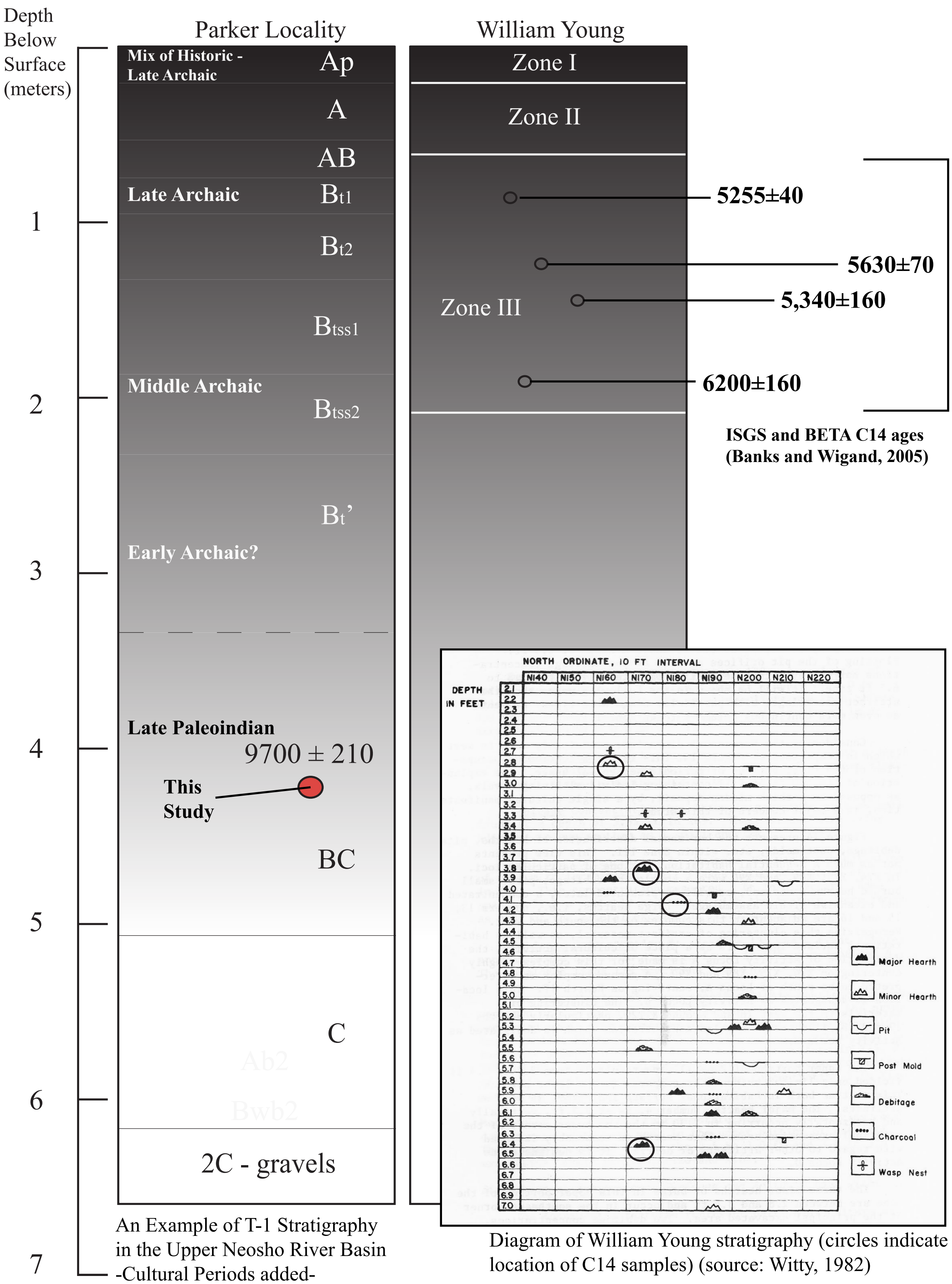


Figure 7.3. Radiocarbon ages and stratigraphy from the William Young Site within the T-1 fill

complex (Blackmar and Hofman, 2006). Munkers Creek is a middle to late Archaic adaptation generally found in central and northeastern Kansas. The site also has lithics assigned to the Late Archaic El Dorado complex. As noted in Chapter IV, the Gak laboratory dates for William Young appear problematic and should be disregarded. However, Banks and Wigand (2005) recently redated the William Young site. Based on the chronostratigraphy of William Young, the elusive Middle Archaic record may be present in the T-1 fill of high-order streams in the study area (see Figure 7.3).

High Terraces (T-2 and T-3)

High terraces in the Neosho River basin are pre-Holocene in age, laterally extensive, and gently sloping landforms. There are two high terraces in the study area: T-2 and T-3. The T-2 and T-3 are referred to as Wiggum and Emporia terraces, respectively (O'Connor, 1952[2007]). The Emporia terrace is higher and older than the Wiggum terrace. In some instances a high terrace has been noted in the study area but not designated as the Wiggum or Emporia terrace (O'Connor, 1952[2007]).

High terraces were noted at Parker, Lee, Sholin, Matile, Kellum, and Neosho Rapids localities. At the Kellum locality both the T-2 and T-3 terraces are present. The T-2 terrace was identified at the Matile locality. At the Parker, Lee and Sholin localities the T-2 terrace is present (see O'Connor, 1952[2007]).

High terraces are not subject to flooding by the Neosho River. In the study area, high terraces are generally separated from the T-1 surface by a 3 m to 7 m scarp and are 85 m to 1.3 km wide. For example, the T-3 terrace occurs at the Kellum locality 7 m above the T-1 and the T-2 occurs 3-5 m above the T-1. There are instances where the high terraces are paired; however, they are usually unpaired. In the Neosho River valley, high terraces are mainly located on the eastern margins of the valley. The soils on these surfaces are mapped as Ladysmith silty clay loam and Kenoma silt loam.

In a separate study, Beeton conducted stratigraphic analysis of high terrace fills in the South Cottonwood river valley. He determined the high terrace fills were characteristic of the Severance Formation (Beeton, 2007: 47). As noted earlier, the Severance Formation is an informal lithostratigraphic unit recognized in eastern Kansas and Nebraska (Mandel, 2006b: 2). Radiocarbon ages for the Severance Formation at other localities in the eastern Plains indicate that it aggraded between ca. 37,000 and 15,000 ^{14}C y. B.P. (see Mandel and Bettis, 2001a, 2003; Mandel, 2006b).

Geologic Potential for Buried and Surficial Cultural Deposits: T-2 and T-3

The geologic potential for buried prehistoric cultural deposits in the fills beneath the T-2 and T-3 surfaces is considered low. These fills are presumed to be greater than 13,500 years old (11,500 ^{14}C yr B.P.), pre-dating Clovis occupation in North America. However, the fills have low potential for pre-Clovis cultural deposits.

The geological potential for cultural deposits on the T-2 and T-3 surfaces is high as these surfaces have been stable for at least 12,000 years. Hence, Paleoindian, Archaic, Early Ceramic/Woodland, Middle Ceramic, Late Ceramic, Protohistoric, and Historic cultural materials may occur on the T-2 and T-3 surfaces.

Alluvial/Colluvial Fans

Both large and small, low-angle alluvial/colluvial fans are common where first and second-order drainages enter the Neosho River valley. The distal ends of the fans grade to the T-1, T-2, or T-3 surfaces. Small fans grading to the T-1 surface were noted at the Matile and FHNWR localities. Large low-angle fans are present at the Cosgrove, Sholin and Kellum localities. Soils mapped on fans include Mason, Reading, Smolan, Irwin, Ladysmith, Kenoma, Summit and Tully series (Barker, 1974; Neill, 1981; Swanson, 1982).

In the study area, one radiocarbon age of 16,930 ± 60 ^{14}C yr B.P. was determined on a buried soil in an alluvial/colluvial fan. The deposits above the buried soil are typical of Gunder fans. As noted, Gunder fan deposits have characteristics identical to Gunder Member alluvium and occur in areas that do not have extensive loess deposits (Rolfe Mandel, personal communication 2009). However, based on studies in the Cottonwood River basin (which adjoins the upper Neosho River basin) fans also can be comprised of the Severance Formation or the Corrington Member of the DeForest Formation. For example, Mandel (2002, 2006b) radiocarbon dated fan deposits in the valleys of Diamond Creek and Fox Creek, both located in the Cottonwood River basin. At the Diamond Creek fan, Mandel (2006c: 36) identified three buried soils and two cultural horizons. Charcoal from a hearth near the bottom of the fan yielded a radiocarbon age of 7820±80 ^{14}C yr B.P. The lithology of the Diamond Creek fan indicates that it is comprised of the Corrington Member.

In Fox Creek valley, Mandel (2006b) studied large, low-angle alluvial/colluvial fans that had formed where first and second-order drainage elements enter the valley. He studied fan sediments in three cores and determined that the fans consisted of the Severance Formation. Decalcified organic carbon from buried soils yielded radiocarbon ages of 24,560 ± 350 and 22,620 ± 350 ^{14}C yr B.P. These ages are consistent with other ages determined on material from the Severance Formation (37,000 and 15,000 ^{14}C yr B.P.) (see Mandel and Bettis, 2001a, 2003).

Geologic Potential for Buried and Surficial Cultural Deposits: alluvial/colluvial fans

The geologic potential for cultural materials in fan deposits or on fan surfaces depends on the age of the fan. In the absence of radiometric dating, the age of fan deposits may be inferred from the lithology of the fans. If the fans are comprised of the Severance Formation, the potential for buried cultural deposits is low. However, those fans have some potential for buried pre-Clovis cultural deposits and Paleoindian through Historic-age cultural materials may occur on the surfaces of the fans.

If the fans are comprised of the Corrington Member or Gunder fan deposits, there is high potential for buried cultural deposits. Corrington and Gunder fans typically aggraded between 9,000 and 3,000 ^{14}C yr B.P. in eastern Kansas, and typically have buried soils (Mandel and Bettis, 2003). Hence, these fans may contain late Paleoindian and Archaic cultural deposits.

The geological potential for cultural deposits on Corrington and Gunder fans also is high. These landforms have been stable since approximately 3000 ^{14}C yr B.P. (Mandel and Bettis, 2003; Mandel, 1995). Late Archaic, Early Ceramic/Woodland, Middle Ceramic, Late Ceramic, Protohistoric and Historic cultural materials may thus occur on their surfaces.

CHAPTER VIII

GIS-BASED EVALUATIONS OF SSURGO DATA

This chapter consists of two sections. Section 1 evaluates whether the members of the DeForest Formation can be mapped using digital county-wide soil survey data (SSURGO) in the upper Neosho River basin. Section 2 tests whether archaeological site distributions correlate with SSURGO-derived delineations of early and middle Holocene LSAs and late Holocene LSAs in the study area.

Section 1: Surface Soils (SSURGO Data) and the DeForest Formation

Introduction

All deposits of fine-grained Holocene alluvium and colluvium in the upper Neosho River basin have been assigned to the DeForest Formation, a formal lithostratigraphic unit found throughout the eastern Plains. The DeForest Formation members have predictable chronological and spatial distribution patterns throughout drainage networks (Bettis, 1995). Episodes of alluviation are time-transgressive throughout such drainage networks. As such, radiocarbon ages for the members of the formation predictably vary throughout a drainage system (Bettis, 1995). Therefore, understanding where members of the DeForest Formation occur in the upper Neosho River basin was important for estimating the relative ages of sediments throughout the basin.

Unfortunately, there are no reliable methods for mapping where members of the DeForest Formation occur in the basin without conducting fairly extensive geomorphic and stratigraphic research, as demonstrated in this study. If a mapping method was devised that could reliably indicate the distribution of DeForest Formation members then, as noted above, it would be possible to determine where sediments of particular ages are stored in a given stream basin. If one can establish where sediments of particular ages are stored then the geologic potential for cultural resources can be determined. This section evaluates a method developed specifically to map the members of the DeForest Formation using digital county-wide soil survey data (SSURGO). The results of the experimental mapping exercise are compared with findings in the field.

Background

The members of the DeForest Formation represent three long-term aggradation episodes separated by periods of drainage network entrenchment. In the Midwest, aggradation and entrenchment episodes are mostly influenced by sediment availability, primarily Peoria Loess accumulation during the last glacial period, and a warming trend from the onset of the Holocene. The Corrington and Gunder members represent the first aggradation episode. The Corrington Member is limited to alluvial fans and colluvial aprons and aggraded between ca. 9,000 and 3,000 ^{14}C yr. B.P. (Mandel and Bettis, 2001a). Gunder Member deposits range in age from about 11,500 ^{14}C yr. B.P. at the base of fills to about 2,000 ^{14}C yr. B.P. at the surface (Dillon and Mandel, 2008). The Honey Creek and Roberts Creek members represent the second aggradation period. The Honey Creek Member aggraded between ca. 3,700 and 600 ^{14}C yr. B.P. (Dillon, 1992; Dillon and Mandel, 2008), and the Roberts Creek Member ranges in age between 3,800 and 500 ^{14}C yr. B.P. The third aggradation episode is represented by the Camp Creek Member which aggraded after ca. 500 ^{14}C yr. B.P. (Mandel and Bettis, 2003).

In the present study, six late-Quaternary LSAs were identified in the study area: T-0a, T-0b, T-1, T-2, T-3 and alluvial/colluvial fans. The members of the DeForest Formation occur in the fills of the T-0a (Camp Creek Member), T-0b (Honey Creek Member), T-1 (Gunder Member), and in some alluvial/colluvial fan deposits (Corrington and Gunder fans) (see Figure 7.1).

Methods

The distributions of alluvial soils with argillic (Bt) horizons (Reading, Mason, Chase, and Leanna series) or A-Bss-Bgss profiles (Osage series) were used to map the Gunder Member of the DeForest Formation. In eastern Kansas, alluvial soils usually develop argillic horizons in about 2000 years (Mandel, 1988b) and, as noted above, the Gunder Member deposits are typically older than 2000 ^{14}C yr. B.P. Soils with A-Bss-Bgss profiles (Osage series) were also selected to represent the Gunder Member because such profiles are indicative of long-term soil development. In addition, soils with A-Bss-Bgss profiles typically occur adjacent to soils with A-Bt profiles on T-1 terraces in the study area.

Alluvial soils that do not have A-Bt or A-Bss-Bgss profiles (i.e. Ivan, Kennebec, Verdigris, and Lanton series) were used to map late Holocene members of the DeForest Formation, such as Honey Creek and Camp Creek. In eastern Kansas, alluvial soils that have been stable for less than 2000 years typically have A-Bw or A-C profiles (Mandel, 1988b).

The Corrington Member of the DeForest Formation was not mapped using SSURGO data because SSURGO data does not systematically map specific soils on alluvial/colluvial fans. Therefore, most alluvial/colluvial fan LSAs in the basin could not be isolated with SSURGO data. In addition, alluvial/colluvial fan deposits were examined at only one field locality (FHNWR) and, as such, the field-truth data are limited.

The *Select by Attribute* function in ArcGIS was used to select soil series polygons from SSURGO data. The soil polygons were saved into Gunder Member, Honey Creek Member, and Camp Creek Member bins.

Results

The results of soil-stratigraphic and geomorphic investigations in the upper Neosho River basin were used to evaluate the hypothetical relationship between surface soils with particular morphologies and the distributions of the members of the DeForest Formation. Based on the results of field investigations at five localities in the basin (Parker, Lee, Matile, Kellum, and Neosho Rapids), the soils formed on the T-1 surface had A-Bt profiles and were mapped as such by SSURGO data. Furthermore, the T-1 fills consist of moderately oxidized, fine-grained overbank deposits typical of the Gunder Member of the DeForest Formation.

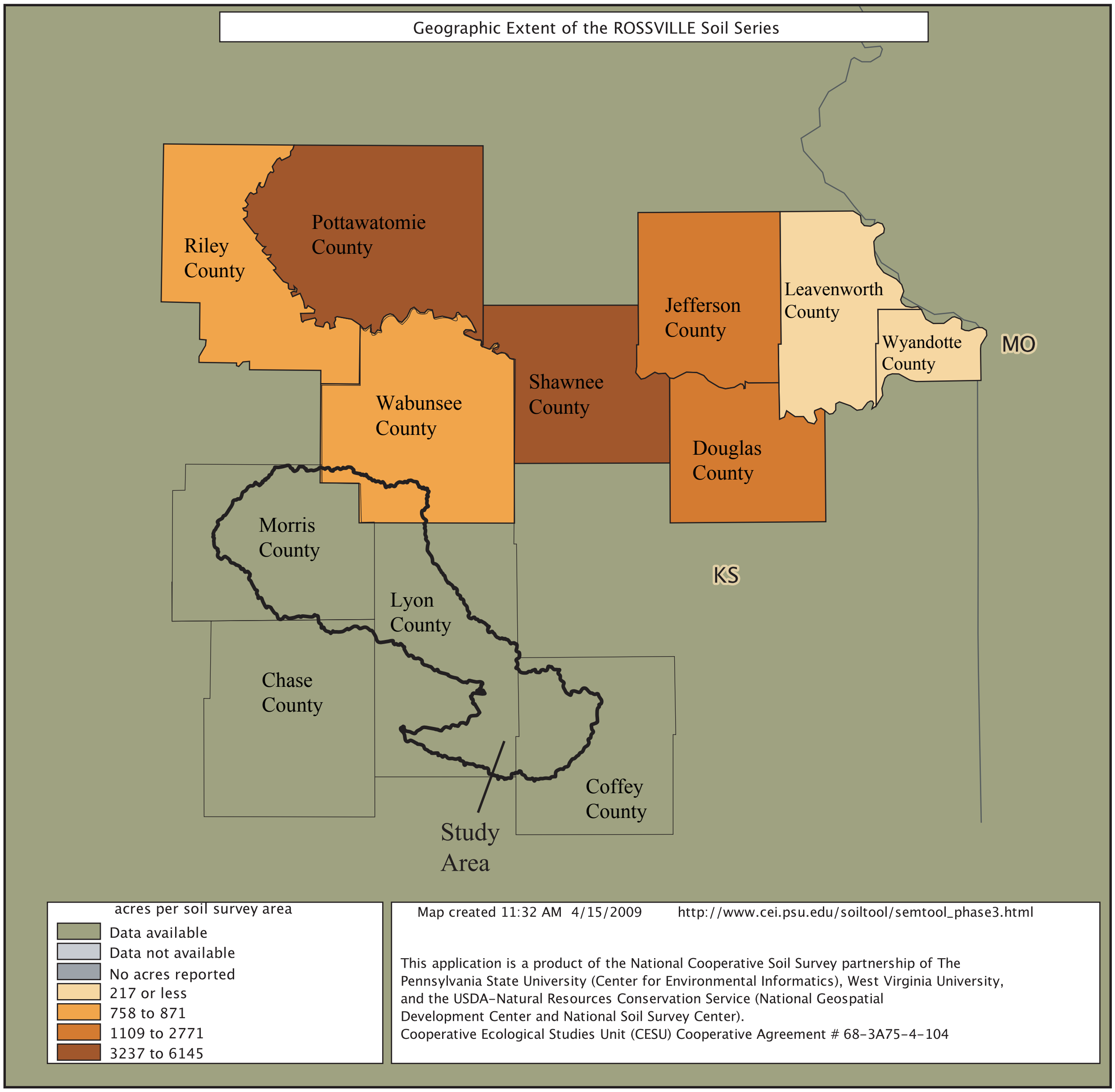
The results of soil-stratigraphic and geomorphic investigations at two localities Cosgrove and Sholin in the upper Neosho River basin, indicate that it is not possible to accurately map the late-Holocene members of the DeForest Formation (i.e. Camp Creek, Honey Creek, and Roberts Creek) with SSURGO data because it appears SSURGO data depictions of the floodplain are over-simplified. For example, the surface soils examined at the Cosgrove and Sholin localities in Morris County were mapped as Ivan and Kennebec silt loams, which have A-C profiles (Barker, 1974). However, the soils described in the field at the Cosgrove and Kellum localities have A-Bw profiles, and, therefore, were not Ivan or Kennebec soils. These surfaces were typically about 0.5 m above the lower floodplain (T-0a) surface. The T-0a does in fact have soils with A-C profiles developed on its surface that resemble Ivan silt loams. Therefore, it was concluded that the floodplain is more complex than originally mapped by SSURGO data and is comprised of at least two surfaces: T-0a and T-0b.

A complicating and possibly contributing factor to SSURGO's oversimplification of the floodplain geomorphologic setting is that the SSURGO dataset for Morris County does not have an alluvium soil with an A-Bw profile (see Barker, 1974). In Morris County, soils formed in alluvium include Mason, Reading, Chase, Osage, Ivan, and Kennebec series. As noted, Mason, Reading, and Chase soils have A-Bt profiles and form on low terraces. Osage soils have A-Bss-Bgss profiles and also form on low terrace surfaces and, as noted, Ivan and Kennebec series have A-C profiles and form on the floodplain.

The fact that alluvial soils with A-Bw profiles were found in Morris County and no such soils are included in the SSURGO dataset suggests it may be necessary to extend another soil series with A-Bw profiles into the upper Neosho River valley. For example, the soils formed on T-0b at the Cosgrove and Sholin localities of Morris County resemble the Rossville series. Rossville soils have A-Bw profiles and, similar to the Ivan series, are fine-silty, mixed, superactive, mesic Cumulic Hapludolls. Rossville soils occur in the southern part of northeast Kansas along the Kansas River, including Wabaunsee County. Wabaunsee County abuts Morris County to the northeast, and extends into the northeastern portion of the study area. Rossville soils also occur in Riley, Pottawatomie, Shawnee, Jefferson, Douglas, Leavenworth, and Wyandotte counties (Figure 8.1). If Rossville soils were extended into Morris County it may be possible to delineate the T-0a and T-0b surfaces using SSURGO data. If the extent of the T-0a and T-0b surfaces were determined then the late-Holocene members of the DeForest Formation could be mapped.

Summary

This section evaluated whether the distributions of surface soils with particular morphological characteristics correlate to the distributions of underlying DeForest Formation members. Specifically, the Gunder Member of the DeForest Formation was mapped in the study area based on the presence of surface soils with A-Bt profiles (Mason, Reading, Chase, and Leanna series) or A-Bss-Bgss profiles (Osage series). Late Holocene members of the DeForest Formation, such as Honey Creek and Camp Creek, were mapped in areas where surface soils formed on alluvial landforms that do not have A-Bt or A-Bss-Bgss profiles. The results of this evaluation suggest that surface soil morphology (i.e. A-Bt and A-Bss-Bgss profiles) can be used to indicate where the Gunder Member of the DeForest Formation occurs in the study area. However, it is not possible to accurately map the late-Holocene members of the DeForest Formation in the study area because SSURGO data over-simplify soil distributions on the floodplain. In addition, it is not possible to accurately map the Corrington Member using SSURGO data because SSURGO does not systematically or consistently map specific soils on alluvial/colluvial fans. Therefore, most alluvial/colluvial fan LSAs cannot be isolated with SSURGO data.



Map showing county distribution and acreage of the Rossville soils series. The upper Neosho River basin and Morris, Lyon, Chase, and Coffey counties have been added to the original NRCS derived map.

Figure 8.1. Rossville soil series extent

Section 2: Surface Soils (SSURGO Data) and the KSHS Database

Introduction

Section 1 evaluated whether surface soils (via SSURGO data) indicate the distribution of specific members of the DeForest Formation. The results of that evaluation suggest that surface soils do in fact indicate where the Gunder Member occurs in the study area. However, surface soils did not accurately indicate where the late-Holocene members of the DeForest Formation occur in the study area because SSURGO data over-simplify floodplain soil distributions. While mapping all of the members of the DeForest Formation in the basin with SSURGO does not appear feasible at this time, the results of the Section 1 evaluation suggest that it is possible to differentiate between early and middle Holocene landforms (i.e. alluvial fills that aggraded prior to 2000^{14}C yr B.P.) and late Holocene landforms (i.e. alluvial fills that aggraded after 2000^{14}C yr B.P.) with SSURGO data.

To further test whether "old" (>2000 ^{14}C yr B.P.) and "young" (<2000 ^{14}C yr B.P.) landforms can be differentiated with SSURGO data, Section 2 compares the distribution of archaeological sites (using Kansas State Historical Society's archaeological site database) with SSURGO derived "old" and "young" landforms. This evaluation is based on the premise that "early" sites will be found on "old" landforms and not on "young" landforms.

As indicated above, in order to compare the distribution of archaeological sites with SSURGO derived landforms it was necessary to divide landforms into "old" and "young". It was also necessary to segment archaeological sites into "early" and "late". Landforms were divided into "old" and "young" following the methods of Section 1.

Therefore, this study defined “old” alluvial landforms as those with Mason, Reading, Leanna, Chase and Osage surface soils because these soils have A-Bt profiles or A-Bss-Bgss profiles. “Young” landforms were defined as alluvial landforms with Ivan, Kennebec, Verdigris, and Lanton surface soils because these soils do not have argillic horizons or A-Bss-Bgss profiles.

This study divided archaeological sites into “early” (>2000 ^{14}C yr B.P.) and “late” (<2000 ^{14}C yr B.P.) categories based either on the presence of diagnostic artifacts or where ^{14}C ages have been determined. The KSHS archaeological site database was searched using the *Specific Component* and *Artifacts* fields. These fields were used because the *General Component* field in the KSHS database is typically too broad in terms of temporal determinations. In the study area, “early” sites included those with Paleoindian, Archaic, Woodland, contracting stem, or Gary-type chipped stone points eras. In addition, “early” sites included those with artifacts typical of the El Dorado, Langtry, Nebo Hill, Chelsea, Munkers Creek, Logan Creek, Scottsbluff, and Dalton cultural complexes (see Table 3.1). “Late” sites consisted of Greenwood and Pomona cultural complex artifacts. Some of the sites with known ages and soil association were defined as “Historic” while others were associated with the Kansa reservation, which was within the study area ca. 1847-1873. The Kansa sites were placed in a separate category from other historic sites that typically have Euroamerican artifacts or known Historic era features.

The *Select by Attribute* function in ArcGIS was used to select archaeological site polygons from the KSHS database. The archaeological site polygons were saved into Early, Late, Historic, and Kansa bins. The same method was used to select “old” and "young" landforms (described above) from SSURGO data. The *Select by Location* function was then used to spatially evaluate whether the centroid of the archaeological site polygons were located on "old" or "young" landforms.

Results

Of the 359 archaeological sites recorded in the study area, 100 sites have either individual artifacts or artifact assemblages that could be assigned to Early, Late, Historic, or Kansa bins (Table 3.1). Of the 100 sites that could be assigned to Early, Late, Historic, or Kansa bins, 94 sites also could be assigned to either an "old" or "young" landform. Spatial evaluation of archaeological site polygons and surface soil derived landforms in ArcGIS determined that 19 of the 94 sites are "early" sites; 16 "early" sites are located on "old" landforms and three "early" sites are located on "young" landforms.

As noted in the introduction of Section 2, this evaluation is based on the premise that "early" sites will be found on "old" landforms and not on "young" landforms. As such, the fact that three "early" sites were found on "young" landforms prompted closer examination of the three sites. Review of their site records revealed that each "early" site found on a "young" landform is located on a topographic high within the area designated as floodplain in the SSURGO dataset. Two of the sites are located on natural levees adjacent to oxbow lakes and the third site record references a topographic high on the floodplain. Therefore, the three "early" sites probably were found on "young" landforms because the soil data is either too general or are mapped at too small a scale to pick up these subtle micro-high relief areas. In addition, the presence of "early" sites on natural levees of the floodplain indicates that these areas should be evaluated separately from the floodplain. The natural levees adjacent to oxbow lakes probably have a higher potential for occupation than the lower areas of the floodplain because of drainage conditions.

Summary

Section 2 evaluated whether SSURGO data can be used to delineate the upper Neosho River basin alluvium into “old” (>2000 ^{14}C yr B.P.) and “young” (<2000 ^{14}C yr B.P.) landforms. The evaluation involved segmenting KSHS archaeological site data into “early” (>2000 ^{14}C yr B.P.) and “late” (<2000 ^{14}C yr B.P.) sites and comparing the distributions of sites with SSURGO derived “old” landforms and not on “young” landforms. The results of the comparison revealed three “early” sites were located on “young” landforms. These three “early” sites were situated on subtle micro-high relief areas of the floodplain, such as natural levees adjacent to the oxbow lakes. The results indicate that the SSURGO data depictions of the floodplains are too general to pick up topographic highs. Therefore, subtle micro-high relief areas in the floodplain probably have a higher potential for occupation than the lower areas of the floodplain because of drainage conditions and should be evaluated separately from the floodplain.

CHAPTER IX

SUMMARY

This study used a geoarchaeological approach to assess the spatial and temporal patterns of landscape evolution in the upper Neosho River basin. Prior to this study, the history of late-Quaternary landscape evolution in the upper Neosho River basin had not been examined. Hence, the geologic potential for buried and surficial prehistoric cultural resources was unknown. The basic idea of the study was to determine whether alluvial and colluvial deposits of different ages are differentially but systematically preserved in the basin. Once the location and ages of basin deposits were determined the geologic potential for cultural deposits was inferred.

This study is important for a number of reasons. First, it provides stratigraphic evidence for the spatial and temporal patterns of late-Quaternary landscape evolution in the basin. Second, it contributes to our understanding of the archaeology of the Flint Hills, Osage Cuestas and Central Plains, as it develops and evaluates models for determining the geologic potential for buried and surficial archaeological deposits dating to specific cultural periods in the Neosho River basin. Third, it provides evidence for deeply buried early and middle Holocene sediments and, therefore, contributes data related to mid-Holocene/Archaic site preservation. Fourth, it evaluates relationships between surface soils, archaeological site distributions and landform sediment assemblages (LSAs). Finally, this study develops and evaluates a method for conducting basin-wide geoarchaeological studies in eastern Kansas. The geoarchaeological approach used in this study may be refined and expanded to assess the archaeological potential of other basins in eastern Kansas.

As noted in Chapter I, the primary objectives of this investigation were to: (1) identify and map late-Quaternary LSAs (i.e., floodplains, terraces, alluvial fans and colluvial aprons) in the upper Neosho River basin; (2) determine the soil-stratigraphy of LSAs and assign stratigraphic units (i.e., the DeForest and Severance Formations); (3) determine the radiocarbon ages of alluvial deposits and associated buried soils; (4) evaluate the relationship between surface soil distributions and LSAs; (5) assess the geologic potential for buried and surficial prehistoric resources in the basin; and, (6) create and evaluate predictive models for surficial and buried cultural deposits dating to specific periods. Each research objective will now be addressed and recommendations made for future research in the upper Neosho River basin.

Eight localities were chosen for detailed geomorphic and stratigraphic study on fourth through seventh-order streams in the study area. Six late-Quaternary LSAs were found in the basin. The LSAs include the modern floodplain (T-0a), a slightly elevated floodplain (T-0b), a low terrace (T-1), two high terraces (T-2 and T-3), and alluvial/colluvial fans (see Figure 7.1).

This study evaluated the T-0b, T-1, and alluvial/colluvial fan LSAs in five cutbank exposures and three cores. Soils and sediments were described in each cutbank and core. Soil-stratigraphic evidence and radiocarbon analysis were used to determine the age of the fills. Soils were important to this study because they indicate periods of landscape stability. The stratigraphy of LSAs not evaluated in this study (i.e. T-0a, T-2, and T-3) was inferred from the results of other studies in eastern Kansas.

The stratigraphy of all six LSAs found in the upper Neosho River basin will be discussed from lowest to highest landscape position. The geologic potential for buried and surficial prehistoric resources will follow each LSA description (see Tables 7.2 and 7.3).

The Camp Creek Member of the DeForest Formation underlies the T-0a surface in the study area and consists of sediment that accumulated after ca. 500 ^{14}C yr B.P. (see Mandel and Bettis, 2003; Mandel, 2006b) and possibly as late as 100-150 years ago. The Camp Creek Member is characterized by weak pedogenic development (i.e., A-C profiles) and is stratified almost to the top of the fill. There is no geologic potential for buried prehistoric or Protohistoric cultural materials in the Camp Creek Member beneath the T-0a, and high potential for buried Historic cultural materials. There is moderate potential for Historic cultural deposits on the T-0a surface.

Valley fills beneath the T-0b surface in the study area consist of the Honey Creek Member of the DeForest Formation. Based on radiometric ages determined on charcoal in T-0b fills for this study, the fine-grained alluvium comprising the T-0b fill began aggrading around 2000 ^{14}C yr B.P. Surface soils formed in the T-0b fill have moderately expressed profiles with A-Bw horizonation and have not developed argillic (Bt) horizons, indicating the T-0b surface became stable by ca. 1000-500 ^{14}C yr B.P. (see Mandel, 2006b). The T-0b fills have a moderate to low potential for containing buried Early Ceramic/Woodland and Middle Ceramic cultural deposits. The T-0b surface has moderate to low potential for Early Ceramic/Woodland cultural deposits and high potential for Middle Ceramic, Late Ceramic, Protohistoric, and Historic cultural deposits.

The Gunder Member of the DeForest Formation underlies the T-1 surface in the study area. Gunder Member deposits beneath the T-1 typically are moderately oxidized with strongly expressed surface soils (i.e. A-Bt, A-Bt-Btk, A-Bt-Btss or A-Bss-Bgss profiles), indicating the T-1 surface became stable by at least 2000 ^{14}C yr B.P. (see Mandel, 1988a). This study determined that in the basin Gunder Member sediments beneath the T-1 surface began aggrading before 9700 ^{14}C yr B.P. and, in some areas, sedimentation was punctuated by periods of stability between 9410-9000 ^{14}C yr B.P., ca. 8665 ^{14}C yr B.P., and, after 8665 ^{14}C yr B.P. At one locality (Kellum), sedimentation was punctuated by a period of stability ca 4000 ^{14}C yr B.P. Gunder Member has moderate to high potential for containing buried late Paleoindian and Archaic cultural materials and moderate to low potential for Early Ceramic/Woodland cultural deposits. The T-l may have potential for early Paleoindian and perhaps Pre-Clovis aged deposits as well, however, based on the data presented in the study the potential remains undetermined. The T-1 surface has high potential for Archaic, Early Ceramic/Woodland, Middle Ceramic, Late Ceramic, Protohistoric, and Historic cultural materials.

The Pleistocene-aged Severance Formation probably underlies the T-2 terrace, and perhaps the T-3 terrace, in the basin (see Mandel and Bettis, 2001a, 2003; Mandel, 2006b; Beeton, 2007). Radiocarbon ages for the Severance Formation at other localities in the eastern Plains indicate that it aggraded between ca. 37,000 and 15,000 ^{14}C y. B.P. (Mandel, 2006b: 2). As the fills are presumed to be greater than 12,000 years old, the geologic potential for buried prehistoric cultural deposits in the fills beneath the T-2 and T-3 surfaces is considered low. However, the fills could contain pre-Clovis cultural deposits. The geological potential for cultural deposits on the T-2 and T-3 surfaces is high. These surfaces have been stable for at least 12,000 years (see Mandel, 2006b and Beeton, 2007). Hence, Paleoindian, Archaic, Early Ceramic/Woodland, Middle Ceramic, Late Ceramic, Protohistoric, and Historic cultural materials may occur on T-2 and T-3 surfaces.

Alluvial/colluvial fans in the study area consist of the Severance Formation, and the Corrington Member, and Gunder Member. The geologic potential for buried prehistoric cultural deposits in Severance Formation fans is considered low. However, the potential for surficial deposits from Paleoindian to the Historic periods is high. The Corrington Member and Gunder Member fans aggraded between 9,000 and 3000 ^{14}C yr B.P. (Mandel, 1995; Mandel and Bettis, 2003). There is low potential for pre-Clovis cultural deposits in Gunder fans. There is low potential for buried late-Paleoindian cultural deposits and high potential for buried Archaic cultural deposits in Corrington Member and Gunder fans. The geological potential for cultural deposits on the surfaces of Corrington and Gunder fans is high. There is a high potential for late-Archaic, Early Ceramic/Woodland, Middle Ceramic, Late Ceramic, Protohistoric, and Historic cultural materials on Corrington and Gunder fans.

In addition to determining the geologic potential for LSAs in the basin, this study used ArcGIS to evaluate whether digital county-wide soil survey data (SSURGO) can be used to map the distribution of the DeForest Formation members that have formed in alluvium (see Chapter VIII). The results of the evaluation indicate that SSURGO data, and more specifically, surface soils with A-Bt and A-Bss-Bgss profiles, indicate where Gunder Member of the DeForest Formation occurs within valley fills. However, late-Holocene members of the DeForest Formation cannot be mapped based on surface soil distributions because SSURGO data oversimplify the floodplain. Furthermore, it may not be possible to accurately map the Corrington Member of the DeForest Formation using SSURGO data because SSURGO data do not systematically map specific soils series on alluvial/colluvial fans.

An additional GIS-based evaluation conducted in this study involved spatial comparisons of archaeological site distributions and SSURGO data. Comparison of archaeological site distributions with SSURGO data was based on the premise that "early" sites will be found on "old" landforms and not on "young" landforms. The results of the comparison revealed three "early" sites were located on "young" landforms. These sites were situated on subtle micro-high relief areas of the floodplain, such as natural levees adjacent to the oxbow lakes. The results indicate that the SSURGO data depictions of the floodplains are too general to pick up topographic highs. Therefore, subtle micro-high relief areas in the floodplain probably have a higher potential for occupation than the lower areas of the floodplain because of drainage conditions and should be evaluated separately from the floodplain.

Future Research

Additional research would enhance our understanding of the late-Quaternary landscape evolution in the upper Neosho River basin. Specific research needs are presented below.

Future research should center on refining our understanding of the alluvial chronology of the late-Quaternary fills in the basin. There are several LSAs within the upper Neosho River basin that have not been numerically dated. For example, the ages of fills beneath the high terraces (T-2 and T-3) in the basin are unknown. In the absence of datable carbon, optically stimulated luminescence (OSL) could be used to determine the ages of the high terrace fill. In addition, a basal RC date at or near the contact of fine-grained sediments at valley floor gravels could help determine if the T-1 has potential for containing early Paleoindian and Pre-Clovis deposits.

The use of high resolution digital elevation models (DEMs) may be used to refine distributions of LSAs in the basin. As noted, this study used SSURGO data to define the LSAs in the upper Neosho River basin. However, late-Holocene LSAs could not be mapped based on surface soil distributions because SSURGO data oversimplify the floodplain. The use DEMs may help delineate late-Holocene LSAs thereby eliminating the oversimplification problem.

Coring along cross-valley transects would be helpful in defining the stratigraphy and spatial pattern of LSAs in the upper Neosho River basin. Cutbanks and single core inspection provided only a two-dimensional view of valley fills and excluded analysis of the stratigraphic relationships across the valley floors. Cores would be particularly useful for tracing buried soils across the valley and could be combined with radiocarbon data to trace buried landscapes that may contain cultural deposits.

Further research in the upper Neosho River basin should include paleoenvironmental studies. For example, T-1 fill at the Matile locality appears to have a near-complete Holocene sedimentary record. Analysis of stable carbon isotopes, phytoliths, and land snails at that locality might clarify our understanding of the paleoenvironmental conditions in the basin.

The present study provides the archaeological community with predictive models for locating buried and surficial prehistoric cultural deposits. It also recorded buried cultural deposits at the Parker locality and surficial deposits at the Cosgrove locality.

However, detailed archaeological investigations were not conducted in the study area. Future archaeological studies should consider testing the model and the recorded sites.

Many other factors are important to archaeological site prediction, including trade routes, the locations of bedrock outcrops, stream confluences, oxbow lakes, and high points on terraces (Beeton, 2007: 154). These factors should be used in conjunction with the results of this study to further refine the archaeological potential of the upper Neosho River basin.

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APPENDIX I: SOIL DESCRIPTIONS

General Field Form: **Parker Locality**

Landform: T-1

Slope: 0 to 1 percent

Parent material: alluvium

Vegetation: hayed field

Surface Soils Mapped as (NRCS): Mason Soil series (NRCS: Morris County - sheet 15, 1974)

GPS: N 38° 44 ' 50.0 ", W 96° 38 ' 44.7 "

Field Observation Method: cutbank exposure

Comments: Charcoal fragments collected at a depth of 395-420 cm from a cultural feature yielded a conventional radiocarbon age of 9700 ± 210 yr B.P.

Depth (cm)	Soil Horizon	Unit	Description
			DeForest Formation: Gunder Member
0 - 20 cm	A_p	I	Dark grayish brown (10YR 4/2, dry | 10YR 3/2, moist) silt loam; weak fine granular structure; friable; many fine and very fine roots; common worm casts and open burrows; abrupt smooth boundary.
20 - 52 cm	A	I	Very dark gray (10YR 3/1, dry | 10YR 2/1, moist) silt loam; weak fine subangular blocky parting to weak fine granular structure; common fine and very fine roots; hard; common worm casts and open worm burrows; gradual smooth boundary.
52 - 70 cm	AB	I	Very dark gray (10YR 3/1, dry | 10YR 2/1, moist) silt loam; weak fine subangular blocky parting to moderate medium and coarse granular structure; hard; common fine and very fine roots; common worm casts and open worm burrows; gradual smooth boundary.
70 - 90 cm	B_{t1}	I	Very dark grayish brown (10YR 3/2, dry | 10YR 2/2, moist) silty clay loam; moderate medium prismatic parting to moderate fine subangular blocky structure; hard; few inclusions of brown (10YR 4/3) silty clay loam; discontinuous dark gray (10 YR 4/1) clay films on ped faces and macro pores; common fine and very fine roots; common worm casts and open worm burrows; common fine and very fine pores; gradual smooth boundary.
90 - 130 cm	B_{t2}	I	Dark gray (10 YR 4/1) clay films are common continuous; interior peds are dark grayish brown (10YR 4/2) silty clay; moderate medium and coarse prismatic parting to moderate medium angular blocky structure; very hard; common fine inclusions of brown (10YR 4/3) silty clay loam; common fine and very fine roots; common worm casts and open worm burrows; common fine and very fine pores; gradual smooth boundary.
130 - 190 cm	B_{tss1}	I	Everything as above and common intersecting slickenedsides that are 5 to 10 cm long on horizonal axis; few faint dark gray (7.5YR 4/1) and yellowish brown (10YR 5/4) mottles; gradual smooth boundary.
190 - 225 cm	B_{tss2}	I	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) silty clay; moderate medium prismatic parting to moderate fine and medium angular blocky structure; very hard; common discontinuous dark grayish brown (10YR 4/2) clay films on ped faces; many prominent intersecting slickenedsides that are 5 to 10 cm long on horizonal axis; mottles as above; few very fine roots; few fine pores; gradual smooth boundary.

General Field Form: **Parker Locality**

Landform: T-1

Slope: 0 to 1 percent

Parent material: alluvium

Vegetation: hayed field

Surface Soils Mapped as (NRCS): Mason Soil series (NRCS: Morris County - sheet 15, 1974)

GPS: N 38° 44 ' 50.0 ", W 96° 38 ' 44.7 "

Field Observation Method: cutbank exposure

Comments: Charcoal fragments collected at a depth of 395-420 cm from a cultural feature yielded a conventional radiocarbon age of 9700 ± 210 yr B.P.

Depth (cm)	Soil Horizon	Unit	Description
			DeForest Formation: Gunder Member
225 - 335 cm	B_t'	I	Grayish brown (10YR 5/2) silty clay loam; moderate medium prismatic parting to moderate medium subangular blocky; hard; common fine distinct yellowish brown (10YR 5/6) mottles; fine distinct discontinuous dark grayish brown (10YR 4/2) clay films in macropores and along root channels; gradual smooth boundary.
335 - 505 cm	BC	I	Grayish brown (10YR 5/2) silty clay loam; weak fine subangular blocky parting to weak fine granular structure; hard; common fine distinct yellowish brown (10YR 5/6) mottles; moderate fine and very fine pores; few very fine roots; gradual smooth boundary.
505 - 610 cm	C	I	Grayish brown (10YR 5/2) silty clay loam; massive; hard; common fine faint yellowish brown (10YR 5/6) mottles and few fine distinct yellowish brown (10YR 5/8) and strong brown (7.5YR 4/6) mottles; abrupt wavy boundary.
610 - 630cm+	2C	II	Stratified chert-rich gravels.

General Field Form: **Cosgrove Locality**

Landform: T-0b

Slope: 0 to 1 percent

Parent material: alluvium

Vegetation: cultivated field (soy beans)

Surface Soils Mapped as (NRCS): Ivan Soil series (NRCS: Morris County - sheet 17, 1974)

GPS: N 38° 45 ' 20.8 ", W 96° 28 ' 31.3 "

Field Observation Method: cutbank exposure

Comments: Charcoal fragments collected at depths of 215-220 cm and 340 cm yielded radiocarbon ages of 1640 ± 20 (AMS) and 1960 ± 70 yr B.P. (conventional C14 dating), respectively.

Depth (cm)	Soil Horizon	Unit	Description
			DeForest Formation: Honey Creek Member
0 - 20 cm	A_p	I	Dark grayish brown (10YR 4/2, dry | 10YR 3/2, moist) silt loam; weak fine granular structure; friable; many fine and very fine roots; clear smooth boundary.
20 - 50 cm	A	I	Very dark brown (10YR 3/2, dry | 10YR 2/2, moist) silt loam; weak fine granular structure; common worm casts; common fine and very fine roots; gradual smooth boundary.
50 - 70 cm	AB	I	Dark grayish brown (10YR 4/2, dry | 10YR 3/2, moist) silt loam; few inclusions of brown (10YR 4/3, dry) silt loam; very weak fine subangular blocky parting to moderate fine granular structure; many common worm casts and open worm burrows; common fine and very fine roots; gradual smooth boundary.
70 - 120 cm	B_{w1}	I	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) silty clay loam; common inclusions of brown (10YR 4/3, dry) silt loam; weak medium subangular blocky parting to weak fine subangular blocky structure; friable; common worm casts and open worm burrows; common fine and very pores; common fine and very fine roots; gradual smooth boundary.
120 - 180 cm	B_{w2}	I	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) silty clay loam; weak medium prismatic parting to weak fine subangular blocky structure; friable; few fine patchy clay films of ped faces; few worm casts and open worm burrows; few fine and very fine pores; few fine and very fine roots; gradual smooth boundary.
180 - 250 cm	BC	I	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) silt loam; very weak medium prismatic parting to very weak fine subangular blocky structure; friable; few fine and very fine pores; few fine and very fine roots; gradual smooth boundary.
250 - 280 cm	CB	I	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) loam interbedded with silty clay loam; common gray (10YR 5/1) reduction zone along macropores; weak coarse prismatic parting to weak fine subangular blocky; firm; common fine faint brown (7.5YR 4/3 and 10YR 5/4) mottles; few lenses of gravel; many medium and coarse pores; gradual smooth boundary.

General Field Form: **Cosgrove Locality**

Landform: T-0b

Slope: 0 to 1 percent

Parent material: alluvium

Vegetation: cultivated field (soy beans)

Surface Soils Mapped as (NRCS): Ivan Soil series (NRCS: Morris County - sheet 17, 1974)

GPS: N 38° 45 ' 20.8 ", W 96° 28 ' 31.3 "

Field Observation Method: cutbank exposure

Comments: Charcoal fragments collected at depths of 215-220 cm and 340 cm yielded radiocarbon ages of 1640 ± 20 (AMS) and 1960 ± 70 yr B.P. (conventional C14 dating), respectively.

Depth (cm)	Soil Horizon	Unit	Description
			DeForest Formation: Honey Creek Member
280 - 340 cm	C_g	I	Gray (5YR 5/1, dry | 5YR 4/1, moist) stratified silty clay loam and loam; massive firm many fine medium distinct brown (7.5YR 4/3) mottles; common lenses of pebbles; abrupt wavy boundary.
340 - 395 cm	2C	I	Gravel; single grain; loose.

General Field Form: **Lee Locality**

Landform: T-1

Slope: 0 to 1 percent

Parent material: alluvium

Vegetation: cultivated field

Surface Soils Mapped as: Mason Soil Series (NRCS: Morris County - sheet 46, 1974)

GPS: N 38º 37' 31.55", W 96º 22' 21.64

Field Observation Method: Giddings push core

Comments: Charcoal fragments collected at a depth of 660-665 cm yielded an AMS radiocarbon age of 3835 ± 20 yr. B.P.

Depth (cm)	Soil Horizon	Unit	Description
			DeForest Formation: Gunder Member
0 - 20 cm	A_{p1}	I	Gray (10YR 5/1, dry | 10YR 4/1 moist) silt loam; weak fine granular structure; very friable; many fine and very fine roots; commom very fine vesicular pores; abrupt boundary.
20 - 40 cm	A	I	Dark grayish brown (10YR 4/2, dry | 10YR 3/2, moist) silt loam; weak fine granular structure; common fine, very fine and medium roots; gradual boundary.
40 - 75 cm	B_{t1}	I	Dark gray (10YR 4/1, dry | 10YR 2/1 moist) silty clay loam; moderate medium to weak fine prismatic parting to moderate fine granular structure; friable; discontinuous dark gray (10 YR 4/1) clay films on ped faces and macropores; common fine and very fine roots; gradual boundary
75 - 125 cm	B_{t2}	I	Dark gray (10 YR 4/1) common distinct continuous clay films; interior peds are dark yellowish brown (10YR 4/4) silty clay loam; moderate medium prismatic parting to moderate fine and very fine subangular blocky structure; hard; common fine and very fine roots; common fine and very fine roots; gradual boundary.
125 - 175 cm	B_{t3}	I	Dark grayish brown (10YR 4/2) silty clay loam; weak fine to very fine prismatic parting to weak fine subangular blocky structure; hard; common distinct discontinuous dark gray (10 YR 4/1) clay films on the ped faces and along root channels; few very fine and fine roots; gradual boundary.
175 - 220 cm	B_{t4}	I	Dark grayish brown (10YR 4/2, dry | 10YR 3/2, moist) silty clay loam; weak fine to very fine subangular blocky parting to moderate medium and weak fine granular structure; friable; few discontinuous clay films along root channels; very few very fine and fine roots; gradual boundary.
220 - 350 cm	BC	I	Dark yellowish brown (10YR 5/3, dry | 10YR 4/3, moist) silty clay loam; weak fine subangular blocky parting to weak fine granular structure; friable, slighlty plastic, non sticky; no roots; gradual boundary.
350 - 435 cm	CB	I	Grayish Brown(10YR 5/2, dry | 10YR 4/2, moist) silty clay loam; weak fine subangular blocky parting to weak fine granular structure; very friable, slighlty plastic, non sticky; no roots; gradual boundary.

General Field Form: **Lee Locality**

Landform: T-1

Slope: 0 to 1 percent

Parent material: alluvium

Vegetation: cultivated field

Surface Soils Mapped as: Mason Soil Series (NRCS: Morris County - sheet 46, 1974)

GPS: N 38º 37' 31.55", W 96º 22' 21.64

Field Observation Method: Giddings push core

Comments: Charcoal fragments collected at a depth of 660-665 cm yielded an AMS radiocarbon age of 3835 ± 20 yr. B.P.

Depth (cm)	Soil Horizon	Unit	Description
			DeForest Formation: Gunder Member
435 - 580 cm	C	I	Brown (10YR 5/3, dry | 10YR 4/3 moist) silty clay loam; massive; laminated with light yellowish brown (10YR 6/4, dry) brown silt; very friable; slightly plastic, nonsticky; no roots; abrupt boundary.
580 - 640 cm	C_{g1}	I	Dark gray (5Y 4/1, dry | 10YR 3/2, moist) silty clay loam; massive; very friable; slightly plastic, nonsticky; no roots; abrupt boundary.
640 - 690 cm	C_{g2}	I	Dark gray (5Y 4/1, dry | 10YR 3/2, moist) silty clay; massive; many fine and medium rounded, subrounded and well rounded pebbles; abrupt boundary.
690 - 720+ cm	C_{g3}	I	Dark gray (5Y 4/1, dry | 10YR 3/2, moist) silty clay loam; massive; common reddish brown (5Y 4/4, dry) mottles of iron-manganese masses, many within a layer 8cm thick and 10cm below the gravels in the Cg2 horizon.

General Field Form: **Sholin Locality**

Landform: T-0b

Slope: 0 to 1 percent

Parent material: alluvium

Vegetation: grasses

Surface Soils Mapped as: Ivan Soil Series (NRCS: Morris County - sheet 31, 1974)

GPS: N 38° 39' 11.7", W 96° 29' 27.7"

Field Method: Giddings push core

Comments: Charcoal fragments collected at a depth of 420-425 cm yielded an AMS radiocarbon age of 1835 ± 25. There are many bands of charcoal throughout the core.

Depth (cm)	Soil Horizon	Unit	Description
			DeForest Formation: Honey Creek Member
0 - 25 cm	A_{p1}	I	Brown (10YR 5/3, dry | 10YR 4/3, moist) silty clay loam with bands of dark gray (10YR 4/1) sandy loam; weak fine granular structure; very friable; many fine and very fine roots; commom very fine vesticular pores; abrupt boundary .
25 - 55 cm	A_{p2}	I	Dark grayish brown (10YR 4/2, dry | 10YR 3/2, moist) silty clay loam; weak fine granular structure; common fine, very fine and medium roots; abrupt boundary.
55 - 85 cm	A	I	Dark grayish brown (10YR 4/2, dry | 10YR 3/2, moist) silt loam; weak fine subangular blocky parting to weak fine granular structure; many common worm casts and open worm burrows; common fine and very fine roots; gradual boundary.
85-95 cm	AB	I	Dark gray (10YR 4/1, dry | 10YR 3/1, moist) silt loam; weak fine subangular blocky parting to weak fine and moderate medium granular structure; many common worm casts and open worm burrows; common fine and very fine roots; gradual boundary.
95 - 130 cm	B_{w1}	I	Dark gray (10YR 4/1, dry | 10YR 3/1, moist) silty clay loam; moderate to fine subangular blocky parting to weak fine subangular blocky structure; friable; few clay coats on pores and ped faces; common fine and very fine vesicular pores; few very fine and fine roots; gradual boundary.
130 - 185 cm	B_{w2}	I	Dark grayish brown (10YR 4/2, dry | 10YR 3/2, moist) silty clay loam; weak fine prismatic parting to weak fine subangular blocky structure; friable; common fine and very fine vesicular pores; few very fine and fine roots; gradual boundary.
185 - 200 cm	BC	I	Brown (10YR 5/3, dry | 10YR 4/3, moist) silty clay loam; weak medium prismatic parting to very weak fine subangular blocky; faint bedding that has been disarticulated; few fine and very fine vesicular pores; few very fine and fine roots; gradual boundary.
200 - 500 cm	C	I	Grayish brown (10YR 5/2, dry | 10YR 4/3, moist) silty clay loam laminiated with silty bands of light yellowish brown; hard; mildly effervescent; distinct bedding; abrupt boundary.
500+ cm	2C	I	Gravel; single grain; loose.

General Field Form: **Matile Locality**

Landform: T-1
Slope: 0 to 1 percent
Parent material: alluvium
Vegetation: cultivated field (soy beans)

Surface Soils Mapped as (NRCS): Reading Soil series
(NRCS: Lyon County - sheet 26, 1981)
GPS: N 38° 30 ' 30.3 ", W 96° 18 ' 42.5 "
Field Observation Method: cutbank exposure

Comments: Charcoal fragments collected at a depths of 600-605cm, 645-650cm, and 745-750cm yielded radiocarbon ages of 8665 +/- 20 (AMS), 9000+/- 70 (Conventional C14 dating), and 9410 +/- 35 yr B.P., respectively.

Depth (cm)	Soil Horizon	Unit	Description
			DeForest Formation: Gunder Member
0 - 10 cm	Ap	I	Dark gray (10YR 4/1, dry | 10YR 3/1, moist) silty clay; moderate medium granular structure; friable; many fine and very fine roots; common worm casts and open worm borrows; clear smooth boundary.
10 - 30 cm	A	I	Dark gray (10YR 4/1, dry | 10YR 3/1, moist) silty clay; strong fine angular blocky parting to moderate medium granular structure; friable; many fine and very fine roots; gradual smooth boundary.
30 - 60 cm	Bt1	I	Dark gray (10YR 4/1, dry | 10YR 3/1, moist) silty clay; weak fine prismatic parting to medium fine subangular blocky structure; Few discontinuous clay films on ped faces; few fine and very fine roots; few worm casts; gradual smooth boundary.
60 - 95 cm	Bt2	I	Dark gray (10YR 4/1, dry | 10YR 3/1, moist) silty clay; weak medium prismatic parting to moderate medium subangular blocky structure; hard; common fine continuous black (10YR 2/1) clay films on ped faces; very few fine and very fine roots; gradual smooth boundary.
95 - 105 cm	Btk1	I	Dark gray (10YR 4/1, dry | 10YR 3/1, moist) silty clay; moderate medium prismatic parting to moderate medium angular blocky structure; very hard; common medium black (10YR 2/1) continuous clay films clay films on ped faces and in root channels; few manganese nodules; common medium spherical carbonate nodules; gradual smooth boundary.
105 - 125 cm	Btk2	I	Gray (10YR 5/1, dry | 10YR 4/1, moist) silty clay; moderate medium prismatic parting to angular blocky structure; very hard; common fine faint reddish brown (5YR 4/4) mottles; common medium continuous clay films clay films on ped faces; few hard manganese nodules; common medium spherical carbonate nodules; gradual smooth boundary.
125 - 185 cm	Btkss1	I	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) silty clay; weak medium prismatic parting to weak fine angular blocky structure; friable; common fine faint reddish brown (5YR 4/4) mottles; common medium continuous clay films on ped faces; few manganese nodules; common medium irregular carbonate nodules; distinct slickened sides on ped faces; gradual smooth boundary.

General Field Form: **Matile Locality**

Landform: T-1
Slope: 0 to 1 percent
Parent material: alluvium
Vegetation: cultivated field (soy beans)

Surface Soils Mapped as (NRCS): Reading Soil series
(NRCS: Lyon County - sheet 26, 1981)
GPS: N 38° 30 ' 30.3 ", W 96° 18 ' 42.5 "
Field Observation Method: cutbank exposure

Comments: Charcoal fragments collected at a depths of 600-605cm, 645-650cm, and 745-750cm yielded radiocarbon ages of 8665 +/- 20 (AMS), 9000+/- 70 (Conventional C14 dating), and 9410 +/- 35 yr B.P., respectively.

Depth (cm)	Soil Horizon	Unit	Description
			DeForest Formation: Gunder Member
185 - 260 cm	B_{tkss2}	I	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) silty clay; weak medium prismatic parting to weak fine angular blocky structure; friable; common fine faint reddish brown (5YR 4/4) mottles; common medium continuous clay films on ped faces; few hard manganese nodules; common medium irregular carbonate nodules; gradual smooth boundary.
260 - 380 cm	B_{tkss3}	I	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) silty clay; strong coarse angular blocky structure; friable; few fine discontinuous clay films on ped faces; few fine irregular carbonate nodules in matrix; few distinct slickened sides on ped faces; gradual smooth boundary.
380 - 430 cm	BC	I	Dark grayish brown (10YR 4/2, dry | 10YR 3/2, moist) silty clay; weak fine subangular blocky to weak fine granular structure; friable; common fine faint reddish brown (5YR 4/4) mottles and dark gray stains; abrupt clear boundary.
430 - 480 cm	B_{tgb1}	II	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) silty clay; moderate medium prismatic parting to moderate medium subangular blocky structure; few fine discontinuous clay films on ped faces; gradual smooth boundary.
480 - 515 cm	BC_{gb1}	II	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) silty clay; moderate fine angular blocky parting to medium fine subangular structure; abrupt smooth boundary.
515 - 595 cm	$B_{tss1gb2}$	III	Dark grayish brown (10YR 4/2, dry | 10YR 3/2, moist) silty clay; moderate medium prismatic parting to moderate medium angular structure; few distinct slickened sides on ped faces; gradual smooth boundary.
595 - 640 cm	$B_{tss2gb2}$	III	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) silty clay; weak fine prismatic parting to weak fine subangular blocky structure; few distinct slickened sides on ped faces; gradual smooth boundary.

General Field Form: **Matile Locality**

Landform: T-1
Slope: 0 to 1 percent
Parent material: alluvium
Vegetation: cultivated field (soy beans)

Surface Soils Mapped as (NRCS): Reading Soil series
(NRCS: Lyon County - sheet 26, 1981)
GPS: N 38° 30 ' 30.3 ", W 96° 18 ' 42.5 "
Field Observation Method: cutbank exposure

Comments: Charcoal fragments collected at a depths of 600-605cm, 645-650cm, and 745-750cm yielded radiocarbon ages of 8665 +/- 20 (AMS), 9000+/- 70 (Conventional C14 dating), and 9410 +/- 35 yr B.P., respectively.

Depth (cm)	Soil Horizon	Unit	Description
			DeForest Formation: Gunder Member
640 - 685 cm	BC_{gb2}	III	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) silty clay; moderate medium subangular blocky parting to weak fine subangular blocky structure; smooth clear boundary.
685 - 720 cm	A_{gb3}	IV	Dark gray (10YR 4/1, dry | 10YR 3/1, moist) silty clay; weak fine subangular parting to moderate medium and coarse granular structure; gradual smooth boundary.
720 - 750+ cm	B_{tkgb3}	IV	Dark gray (10YR 4/1, dry | 10YR 3/1, moist) silty clay; weak fine subangular blocky parting to moderate medium granular structure.

General Field Form: **Kellum Locality**

Landform: T-1

Slope: 0 to 1 percent

Parent material: alluvium

Vegetation: cultivated field (soy beans)

Surface Soils Mapped as: Reading Soil Series (NRCS: Lyon County - sheet 38, 1981)

GPS: N 38° 25 ' 32.1 ", W 96° 08 ' 06.7 "

Field Observation Method: cutbank exposure

Comments: Charcoal fragments collected at depths of 255-260cm and 340-345cm yielded radiocarbon ages of 3595 ± 20 (AMS) and 4460 ± 510 yr. B.P. (conventional C14 dating) respectively. Gravels are located at a depth of 420 cm.

Depth (cm)	Soil Horizon	Unit	Description
			DeForest Formation: Gunder Member
0 - 35 cm	A_p	I	Grayish brown (10YR 5/2, dry | 10YR 4/1, moist) silty clay loam; weak fine granular structure; very friable; many fine and very fine roots; many common worm casts; abrupt smooth boundary.
35 - 75 cm	A	I	Dark gray (10YR 4/1, dry / | 10YR 3/1, moist) silty clay loam; weak fine granular structure; friable; many fine and very fine rootlets; many common worm casts; gradual smooth boundary.
75 - 110 cm	AB	I	Dark gray (10YR 4/1, dry / | 10YR 3/1, moist) silty clay loam; weak fine subangular blocky parting to weak fine granular structure; friable; common very fine roots; many worm casts and open worm burrows; gradual smooth boundary.
110 - 160 cm	B_{t1}	I	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) silty clay loam; weak medium prismatic parting to moderate fine subangular blocky structure; firm; many discontinuous dark gray (10YR 4/1, dry) clay films on ped faces; common worm casts; common fine and medium roots; many fine and very fine pores; gradual smooth boundary.
160 - 195 cm	B_{t2}	I	Grayish brown (10YR 4/2, dry | 10YR 3/2, moist) silty clay; weak fine to very fine angular blocky parting to medium and fine subangular blocky structure; friable; few discontinuous clay films along root channels; very few very fine and fine roots; gradual smooth boundary.
195 - 220 cm	BC	I	Dark yellowish brown (10YR 5/3, dry | 10YR 4/3, moist) silty clay loam; weak fine subangular blocky parting to fine granular structure; friable; no roots; gradual smooth boundary.
220 - 270 cm	CB	I	Yellowish Brown (10YR 5/4, dry | 10YR 4/4, moist) silty clay loam; weak fine subangular blocky parting to weak fine granular structure; very friable; no roots; abrupt clear boundary.
270 - 360 cm	B_{tb1}	II	Dark grayish brown (10YR 4/2, dry | 10YR 4/2, moist) silty clay; weak fine prismatic parting to weak fine subangular blocky structure; few fine discontinuous clay films on ped faces; gradual smooth boundary.
360 - 420 cm	BC_{b1}	II	Dark grayish brown (10YR 4/2, dry | 10YR 3/2, moist) silty clay; weak fine subangular blocky to weak fine granular structure; friable; common fine faint reddish brown (5YR 4/4, dry) mottles and dark gray stains; abrupt clear boundary.

General Field Form: **Neosho Rapids Locality**

Landform: T-1

Slope: 0 to 1 percent

Parent material: alluvium

Vegetation: grasses

Surface Soils Mapped as (NRCS): Chase Soil Series (NRCS: Lyon County - sheet 45, 1981)

GPS: N 38° 22 ' 05.8 ", W 96° 00 ' 29.9 "

Field Observation Method: cutbank exposure

Comments: Charcoal fragments collected at a depth of 365-370 cm yielded an AMS radiocarbon age of 2755 ± 20 yr. B.P. The charcoal was collected from the T-1 fill approximately 1.5 km downstream from the soil described here and was located at N 38º 21' 30.1", W 96º 00' 38.6".

Depth (cm)	Soil Horizon	Unit	Description
			DeForest Formation: Gunder Member
0 - 30 cm	Ap	I	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) silty clay loam; weak fine granular structure; friable; many fine and very fine roots; common worm casts and open burrows; abrupt smooth boundary.
30 - 55 cm	BA	I	Dark gray (10YR 4/1, dry | 10YR 3/1, moist) silty clay loam; moderate medium prismatic parting to weak fine subangular blocky; very hard; many fine and very fine roots; few worm casts and open worm burrows; few fine and very fine pores; gradual smooth boundary.
55 - 125 cm	Bt	I	Dark gray (10YR 4/1, dry | 10YR 3/1, moist) silty clay; moderate medium and coarse prismatic parting to moderate medium angular blocky structure; very hard; common distinct continuous dark gray (10YR 4/1) clay films on ped faces and macro pores; common fine and very fine roots; common fine and very fine pores; gradual smooth boundary.
125 - 175 cm	Btss	I	Grayish brown (10YR 5/2, dry | 10YR 4/2, moist) silty clay; moderate medium prismatic parting to moderate medium and fine angular blocky structure; common distinct discontinuous dark gray (10YR 4/1) clay films on ped faces; many fine distinct yellowish brown (10YR 5/6 and 5/8) mottles and few fine prominant 7.5 YR 4/6 mottles; common fine and very fine, hard iron and manganese concretions; many intersecting slickensides 2-5cm long along horizontal axis; few fine and very fine roots; few fine and very fine pores; gradual smooth boundary.
175 - 205 cm	BCt	I	Yellowish brown (10YR 5/4, dry | 10YR 4/4, moist) silty clay; moderate medium and coarse prismatic parting to weak fine subangular blocky structure; hard; mottles as above; faint bedding; few discontinuous grayish brown (10YR 5/2, dry) clay films along ped faces and root channels; common fine and very fine pores; gradual smooth boundary.
205 - 405+ cm	C	I	Stratified yellowish brown (10YR 5/4, dry | 10YR 4/4, moist) and pale brown (10YR 6/3, dry | 10YR 5/3, moist) silt loam; massive; friable; finely laminated within beds; many fine distinct yellowish brown (10YR 5/6 and 5/8, dry) mottles and few fine hard manganese and iron oxide concretions; many fine and very fine pores; no roots.

General Field Form: **Flint Hills National Wildlife Refuge (FHNWR) Locality**

Landform: Alluvial Fan

Slope: 0 to 1 percent

Parent material: alluvium, colluvium, soil residuum?

Vegetation: grasses

Surface Soils Mapped as: Summit Soil Series (NRCS SSURGO Data)

GPS: N 38° 25 ' 32.1 ", W 96° 08 ' 06.7 "

Field Observation Method: Giddings push core

Comments: Decalcified organic carbon from the upper 15 cm of the 2Atb horizon yielded a radiocarbon age of 16,930 ± 60 14C yr B.P.

Depth (cm)	Soil Horizon	Unit	Description
			DeForest Formation: Gunder Member Fan
0 - 20 cm	A_p	I	Very dark gray (10YR 3/1, dry | 10YR 4/1, moist) silty clay loam; weak fine granular structure; very friable; many fine and very fine roots; many common worm casts; clear boundary.
20 - 30 cm	A	I	Dark gray (10YR 4/1, dry / | 10YR 3/1, moist) silty clay loam; weak fine subangular blocky parting to weak fine granular structure; very friable; few fine rootlets; gradual boundary.
30 - 55 cm	B_w	I	Dark grayish brown (10YR 4/2, dry | 10YR 3/2, moist) silty clay loam; moderate medium subangular blocky parting to weak fine subangular blocky; friable; common very fine roots; gradual boundary.
55 - 80 cm	B_{t1}	I	Grayish Brown (10YR 5/2, dry | 10YR 4/2, moist) silty clay; medium to fine subangular blocky parting to very fine angular blocky; firm; few discontinuous dark gray (10YR 4/1, dry) clay films; few fine roots; gradual boundary.
80 - 120 cm	B_{t2}	I	Grayish brown (2.5YR 5/2, dry | 2.5YR 4/2, moist) clay loam; moderate angular blocky parting to fine angular blocky; few discontinuous dark gray (10YR 4/1, dry) clay films; few medium very dark gray (10YR 3/1, dry) mottles; few fine and very fine roots; abrupt boundary.
120 - 130 cm	$2A_{tb}$	II	Dark grayish brown (10YR 4/1, dry | 10YR 3/1, moist) silty loam; moderate fine prismatic parting to moderate medium and coarse granular structure; subrounded and subangular gravels; few discontinuous dark gray (10YR 4/1, dry) clay films; hard manganese and iron oxide concretions; common reddish brown (5YR 4/4, dry) mottles; few fine roots; gradual boundary.
130 - 140+ cm	$2B_{tb}$	II	Gray (10YR 5/1, dry | 10YR 4/1, moist) silty loam; strong coarse prismatic parting to fine and medium angular blocky structure; subrounded and subangular gravels; few discontinuous dark gray (10YR 4/1, dry) clay films; hard manganese and iron oxide concretions; common reddish brown (5YR 4/4, dry) mottles; few fine roots.