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Basin-scale reconstruction of the geological context of human settlement: an example from the lower Mississippi Valley, USA

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ABSTRACT

Large river valleys integrate hydroclimatic change differently than smaller ones. Whereas sedimentary deposits in smaller valleys serve to record temporally short-lived and/or low-amplitude hydrological and geomorphic responses, larger valleys are relatively insensitive to changes at these scales. However, because of their size, larger valleys archive sedimentary records of longer-term, geographically extensive flooding and climate-related landscape evolution. Recent work in the Upper Tensas Basin of the lower Mississippi River Valley, USA, demonstrates the utility of analyzing sediments from a large, geomorphically and fluvially complex river basin as a proxy for significant climatic and landscape changes and their relation to human history. A ~6000 year sedimentary archive is used to explore the interplay between climate change, landscape evolution, and human responses to changing environmental parameters. Once the Mississippi River basin stabilized following glacial retreat and deceleration of sea-level rise, the history of the river and its inhabitants was dominated by long periods of landscape stability punctuated by episodes of significant landform alteration. Modifications of the landscape are correlated with intervals of rapid climate change recorded in globally distributed multiproxy data sets. Periods of significant landscape instability and fluvial re-adjustment are recorded for the periods ca 4800–3800, 3000–2500, and 1000–800 cal BP. These punctuations in the history of the lower Mississippi Valley are related to periods of major cultural transformation and suggest climate change plays a significant role in the long-term history of human occupation in this river valley. This research demonstrates how geoarcheology can provide information on human–environmental relationships and long-term landscape histories at temporal and spatial scales relevant to understanding cultural responses to climate change.

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1. Introduction

In alluvial settings, basin-scale reconstructions of the physical environment provide critical clues to long-term patterns of historical development and exemplify the important contributions of geoarcheology to understanding human history. The lower Mississippi Valley (the Mississippi River alluvial valley south of the mouth of the Ohio River; henceforth, LMV) epitomizes a complex, highly dynamic landscape where human settlement and its associated behavior was intimately tied to the geologic evolution of landforms. This paper discusses the evolution of the near-surface landscape of the Upper Tensas Basin, northeast Louisiana (Fig. 1) and its influence on human settlement. The Tensas Basin is one of several named subdivisions of the LMV, where the primary geological control during the late Quaternary has been the Mississippi River and its tributaries. Basin evolution is influenced by myriad factors, including upstream (water and sediment inputs) and downstream (base-level) controls, Mississippi River fluvial processes (meander belt avulsion, delta switching, and climate-induced flooding), and local processes (sediment erosion and deposition, topographic changes due to meander belt formation and abandonment, and the development of local drainages and lakes). Although tectonic processes have an effect on the Mississippi River fluvial system (Burnett and Schumm, 1983; Schweig and Van Arsdale, 1996; Washington, 2002; Schumm, 2005, pp. 108–117), this study area contains no detectable signature of these influences.

Geological processes act at different temporal and spatial scales and have differing effects on human settlement choices. We discuss the relationship between geological and landscape history and significant cultural and behavioral events from the end of the Pleistocene to early Historic times, but focus on the period ca 7000–300 cal BP. Since the contemporary alluvial valley is either deeply buried or eroded away, data from uplands adjacent to the

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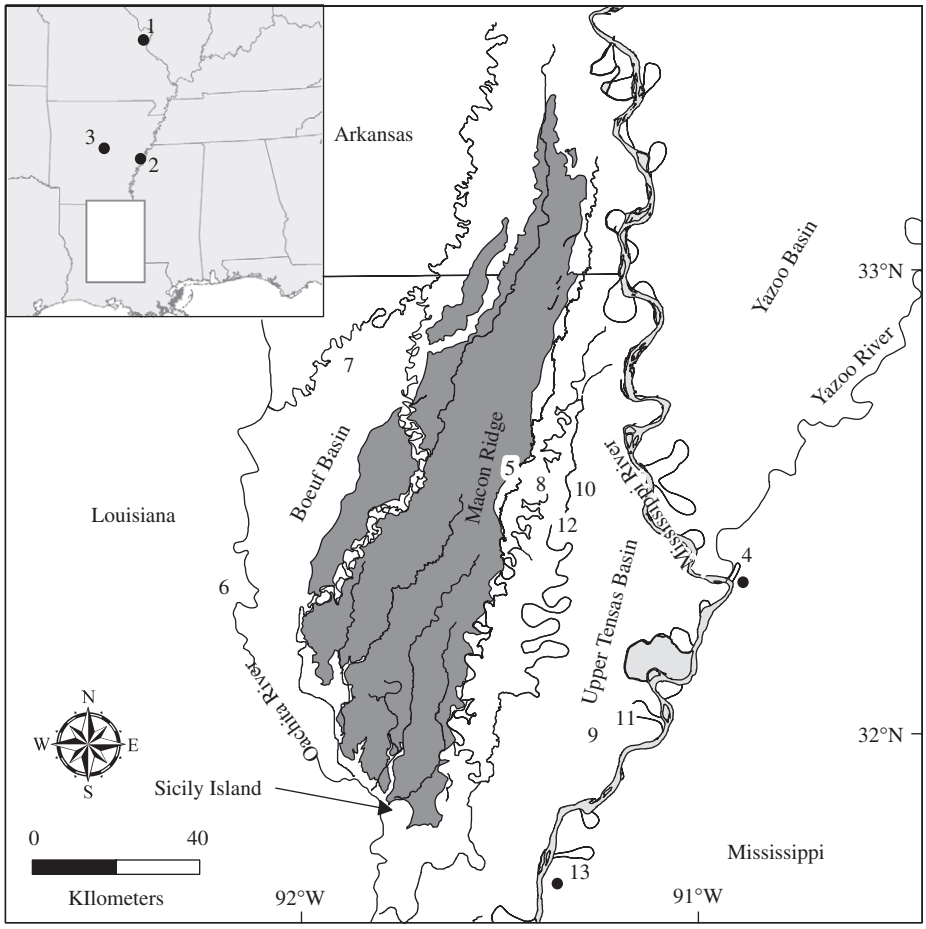


Fig. 1. Map showing the location of the Upper Tensas Basin with cities and archeological sites mentioned in the text. (1) St. Louis, Missouri (Cahokia site); (2) Helena, Arkansas; (3) Little Rock, Arkansas; (4) Vicksburg, Mississippi; (5) Poverty Point; (6) Watson Brake; (7) Caney Mounds/Bottleneck; (8) J.W. Copes; (9) Osceola; (10) Raffman; (11) Routh; (12) Nolan; and (13) Natchez, Mississippi.

floodplain must be used to provide insights into Late Pleistocene and early Holocene contexts for human settlement and behavior in the Upper Tensas Basin. Because the Mississippi is a highly dynamic river, reconstructing geological and landscape history in the alluvial floodplain of the Upper Tensas Basin is limited to the Holocene; realistically, only the last 6000–7000 years can be studied in any detail.

2. Background

The geology and geomorphology of the LMV is generally well-known (Fisk, 1944; Saucier, 1967, 1994b, 1996; Saucier and Kolb, 1967; Guccione et al., 1988; Autin et al., 1991; Blum et al., 2000); however, at increasingly smaller spatial scales, specific basin histories are not always well documented and temporal constraints for Holocene-age deposits are often unclear or poorly resolved (Saucier, 1994b, pp. 16, 18–19; Arco et al., 2006). Similarly, at the regional scale the archeology has been relatively well-studied and a well-defined Holocene chronosequence has been established (Phillips et al., 1951; Phillips, 1970; Williams and Brain, 1983; Neuman, 1984; Kidder, 2002, 2004b). Site-specific investigations conducted in the region provide important data for particular time periods or site types (Hally, 1972; Jackson, 1986; Gibson, 1991, 1996, 2000; Kidder and Fritz, 1993; Jackson and Jeter, 1994; Ryan, 2004; Weinstein, 2005).

The Upper Tensas Basin of the LMV is one of a number of geological subdivisions of the Mississippi River alluvial valley (Fisk, 1944, pp. 22–33; Saucier, 1994b, pp. 24–29). The basin is bounded on the east by the modern channel of the Mississippi River and on the west by Pleistocene-age deposits of Macon Ridge (Fig. 1). The basin is enclosed at its northern end where the modern Mississippi River meander belt impinges on Macon Ridge; the southern border of the basin, however, is marked only by a constriction of the alluvial valley between the modern meander belt at Natchez, Mississippi, and Sicily Island (Fisk, 1944, p. 28), a Pliocene–Pleistocene age outlier of the Upland Formation (Autin et al., 1991). South of this constriction to the mouth of Old River, the alluvial lowland is termed the Lower Tensas Basin, which will not be directly discussed in this paper.

While our knowledge of basic geological and archeological processes in the LMV is reasonable, we lack intermediate-scale analyses that connect regional geological and archeological interpretations to specific site and locality settings. The discussion presented here is an initial attempt to comprehend the physical environment of a river basin at a scale relevant to integrating and synthesizing human settlement and associated behaviors through time. These basin-scale investigations will be increasingly necessary to integrate geologic and archeological data in the Mississippi Valley.

3. Methods

During the summers of 2002, 2004, and 2006, 75cores 5.08 cm in diameter were obtained from various locations in the Upper

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Tensas Basin using a trailer-mounted Giddings hydraulic soil probe (Fig. 2). Core sediments were described and interpreted in the field as well as under laboratory conditions for soil texture and development, grain size, presence of organics or artifacts, and color. Geological field investigations were supplemented by archeological excavations conducted by the authors at five sites, as well as surface survey of several localities. In addition, 4–6 m deep backhoe trenches were excavated at the Nolan (16MA201) and Raffman (16MA20) sites (Kidder, 2004a; Arco et al., 2006). Sediments from archeological and trenched profiles were described and analyzed according to the same criteria applied to core sediments.

Descriptive data recorded in the field included Munsell color, field texture, and soil horizonation, as well as the presence/absence of artifacts, organics, and redox features, following guidelines employed by the Natural Resource Conservation Service and the United States Geological Survey as summarized by various authors (Soil Survey Division Staff, 1993; Birkeland, 1999; Soil Survey Staff, 1999; Schoeneberger et al., 2002; Vogel, 2002). Quantitative analysis of sediment textures employed the hydrometer method and the United States Department of Agriculture texture classification system (Soil Survey Staff, 1999; American Society for Testing and Materials, 2003). AMS radiocarbon dates of archeological and geological samples were provided by the NSF Arizona AMS Facility, USA and Beta Analytic, Inc., USA, using charcoal and organic material obtained from archeological excavations, geological cores, and trench sediments (see Arco et al., 2006, Table 1; Kidder, 2004a, Table 1, 2006a, Table 1 for published dates). For purposes of comparison, all dates have been calibrated using the program CALIB (version 5.0.2) (Stuiver and Reimer, 1986; Reimer et al., 2004) and are reported in calibrated years before present (cal BP) in this text. Locations for core extractions and trench profiles were obtained from aerial photographs of the Tensas Basin in conjunction with differential GPS data taken in the field. Core logs, soil data, maps, digital elevation models, and aerial photographs were organized and analyzed using ArcGIS 9 software as well as Adobe Illustrator.

4. Results

4.1. Geologic overview

The Mississippi alluvial valley evolved within the Mississippi Embayment, which formed as a result of uplift, erosion, and subsidence of the Mississippi Valley graben complex between the Appalachian and Ouachita Mountains during the Cretaceous (Cox and Van Arsdale, 2002; Van Arsdale and Cox, 2007). The alluvial system developed during the Tertiary; however, waxing and waning Pleistocene glacial cycles are largely responsible for the formation of the valley trench (Saucier, 1994b, pp. 67–68). During the late Pleistocene aggradation and downcutting consequent to glacial advances and retreats (coupled with the effects of changes in sea level) led to the gradual enlargement and entrenchment of the valley. The ancestral Mississippi River entered a braided stream regime ca 64–55 ka and switched to a meandering regime at the end of the Pleistocene (Saucier, 1994b; Rittenour et al., 2005). Macon Ridge, a terrace underlain by braided stream outwash, formed during the late Pleistocene (Rittenour et al., 2005, Tables 3–4). The surface of the eastern part of Macon Ridge is veneered with 1–5 m of Peoria loess deposited ca 25–14 ka (Pye and Johnson, 1988; Allen and Touchet, 1990; Autin et al., 1991; Saucier, 1994b; Rutledge et al., 1996). The collapse of the Laurentide Ice Sheet led to sea-level rise to within approximately 10 m of its present relative position by ca 7–5 ka (Balsillie and Donoghue, 2004; Törnqvist et al., 2004); changes in hydrological conditions and reductions in the sediment load and sediment coarseness of the Mississippi River caused a shift from a braided to a meandering system between 11 and 9.8 ka.

Although the Mississippi River drainage is often considered a unified hydraulic system, the lower Mississippi River is composed of flow derived from four separate watersheds, each with a unique contribution to the river's sediment and water volume (Meade, 1995). The upper Mississippi River and its tributaries extend from the headwaters in Minnesota south to the confluence of the Missouri River; while this basin composes approximately 16.5% of

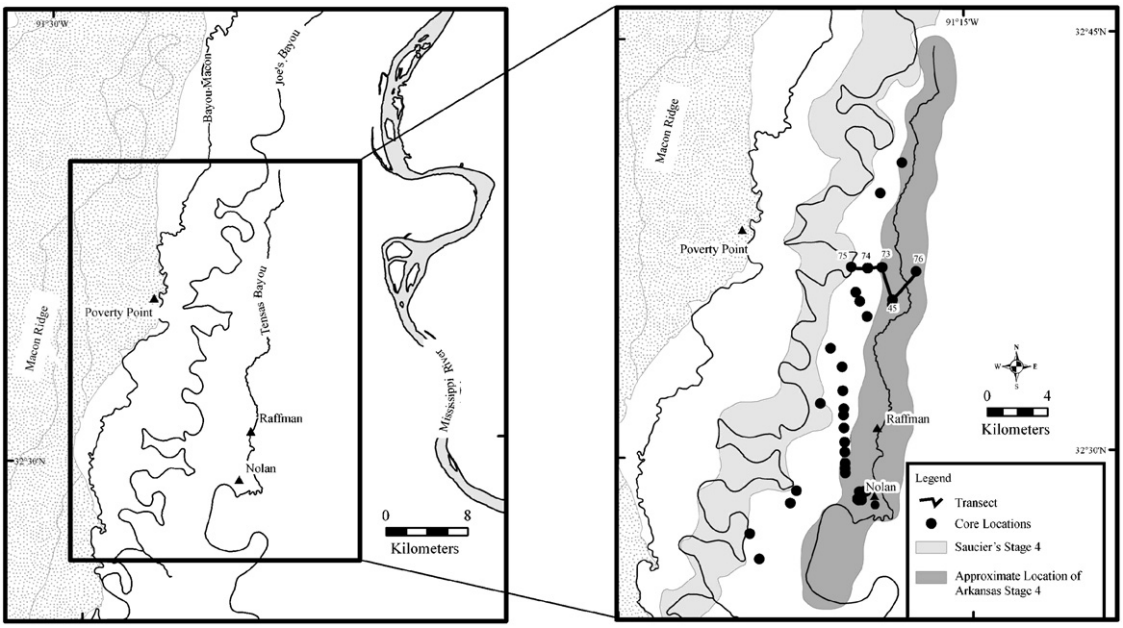


Fig. 2. Map of the Upper Tensas Basin. The trend of the Arkansas River "stage 4" channel as revealed by detailed basin-scale coring is shown on the right. Joes Bayou has historically been mapped as flowing in the channel of the Stage 4 Arkansas River (Fisk, 1944, Plate 15; Saucier, 1994b, Plate 10). Joes Bayou levee sediments overlie Arkansas River deposits and relate to an episode of Mississippi River distributary flow. The channel of the ancestral Arkansas River in this area was east of its historically mapped location as revealed by the presence of levee and point bar deposits seen in cores extracted from locations near Tensas Bayou. See Fig. 6 for details of one representative core transect.

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the total drainage, roughly 10–15% of the river's total latitude flow is derived from this source area. The Missouri River and its tributaries compose the second drainage region and encompass roughly 45% of the Mississippi River's catchment. This segment supplies the overwhelming bulk of the sediment discharged by the Mississippi at its mouth, but it only contributes only 12% of the total latitude flow. Nearly half of the River's total latitude flow is derived from the Ohio River and its tributaries even though this watershed segment barely encompasses approximately 16% of the total basin area. Below the mouth of the Ohio River, the river receives water from a number of western tributaries (primarily the Arkansas, White, and Red rivers) that compose the final part of the hydraulic system.

The differentiation of the Mississippi River watershed and the varying contributions to total latitude flow is critical for appreciating the landscape history of the LMV and for measuring effects of climate change on residents of the basin as a whole. For example, different segments of the Mississippi watershed can flood independent of one another and not have a notable effect on the entire watershed. This happened in 1993 when the Missouri and upper Mississippi segments suffered historically unprecedented flooding. At the same time these two segments were inundated, the Ohio and lower Mississippi rivers were only minimally affected (Drew and DuCharme, 1993; US Army Corps of Engineers, 1994). For the LMV to suffer catastrophic flooding it is necessary to involve flood conditions in all or substantially all four major drainage segments, but most especially the Ohio River and its tributaries. Basin-wide flooding by the Mississippi River in 1927, for example, was caused by unusual climatic circumstances throughout the watershed and especially in the upper Mississippi and Ohio River segments (American National Red Cross, 1929; Public Works Administration, 1934) Locally heavy rainfall within the lower Mississippi River basin exacerbated conditions but did not cause flooding.

The Holocene history of the lower Mississippi River and its tributaries is structured around the identification of six meander belts organized into a relative chronological sequence numbered in stages from 6 (oldest) to 1 (most recent/modern) (Figs. 3 and 4). There are eight recognized Arkansas River meander belt stages as well, organized in a relative sequence from 8 (oldest) to 1 (most recent/modern) (Saucier, 1994b, Fig. 50) (Figs. 4 and 5). Similarly, there are six recognized delta complexes, although these are not necessarily synchronously correlated with correspondingly numbered Mississippi River meander belts (Saucier, 1994b, Fig. 50; Törnqvist et al., 1996; Aslan et al., 2005). With the exception of Stage 1, meander belts and their associated channels cannot be traced continuously down the Mississippi Valley because of subsequent alluvial activity (erosion and burial). Meander belt segments, abandoned channels, and abandoned courses are assigned to a numbered meander belt stage using morphological, stratigraphic, archeological, or geographic inferences. The numbered meander belts are, for the most part, very poorly dated, and a good deal of the chronological data for assigning ages comes from archeological sites that are not always clearly dating the landform itself. Numeric age estimates are rare and commonly provide only bracketing ages for the meander belts (Saucier, 1994b, pp. 9–19).

4.2. Basin evolution, meander belts, and human history

Evidence for early human occupation of the LMV is confined to surface finds on Pleistocene-age braided stream surfaces such as Macon Ridge or to the east in parts of the Yazoo Basin (Brain, 1983). In the Upper Tensas Basin there is abundant evidence that the eastern edge of Macon Ridge was used by early humans; unfortunately, we do not at this time have any intact stratified sites dating to the Late Pleistocene or early Holocene. Surface finds of Clovis projectile points (>12,200 cal BP) are rare and widely scattered across Macon Ridge (Gibson, 1970, 2000; Hillman, 1990). Diagnostic Clovis projectile points are invariably made from chart of non-local origin; most of these materials point to a western and northern source area, suggesting populations were migrating from the west or north and moving southward along the axis of the Mississippi Valley (Anderson, 1990). The relatively low density of Clovis finds suggests small or transient populations were exploiting the Macon Ridge landscape. During Clovis times, the valley of the Mississippi River may have been relatively inhospitable for human occupation because of frequent flooding caused by glacial meltwater pulses, and active eolian scouring of the wide and braided surface. The river probably did not support an abundant fish population, and mammals likely spent most of their time on the adjacent hills and terraces. Thus, it is likely the distribution of Clovis finds provides a fairly accurate indication of settlement locations, although this supposition should serve as hypothesis rather than established fact (Saucier, 1994c).

In the study area, terminal Pleistocene finds are likewise confined to Macon Ridge. Late Paleoindian (ca 12,200–11,500 cal BP) diagnostic artifacts, such as San Patrice and Dalton points, are found across much of the ridge, but the distribution of these finds favors occupation on low knolls or ridges elevated above and adjacent to small streams occupying relict braided channels. Lithic tools are made predominantly from locally available Citronelle gravel chert,[1] but a small percentage of tools were crafted from non-local materials. Terminal Pleistocene sites appear to be larger, or they represent more frequent visits to the same locality. Because of the increasing use of locally available lithic sources, we infer regional and local populations were increasing and inhabitants were ranging less widely across the landscape.

As with the earlier Paleoindian occupation of the region, there is no evidence of settlement in the alluvial valley of the Upper Tensas Basin during the Terminal Pleistocene. Available evidence indicates the ancestral Mississippi was still flowing in a braided regime (Saucier, 1994b, 1994c). Thus, we infer the valley proper would have been a relatively inhospitable place for significant occupation. Furthermore, contemporary Terminal Pleistocene valley surfaces are so deeply buried or have been so heavily eroded we have no realistic opportunity to investigate the type or intensity of terminal Paleoindian land use in this part of the study area.

The Mississippi River shifted to a meandering pattern possibly as early as 12,900 cal BP (Rittenour et al., 2005) and certainly no later than 11,200 cal BP ka (Saucier, 1994a, p. 980). This shift occurred relatively rapidly and was precipitated by changes in stream flow coupled with diminished coarse-grained sediment input and increased fine-grained sediment loads associated with the collapse of the Laurentide Ice Sheet (Autin et al., 1991; Aslan and Autin, 1999, p. 801). In the Upper Tensas Basin, the two earliest Mississippi River meander belts (Stages 6 and 5) are either not present, have been destroyed by erosion, or lie too deeply buried to be recognized. The earliest identified Mississippi River meander belt in the basin is assigned to Stage 4. In the study area, there are also meander belts, meander belt segments, abandoned channels, and abandoned courses associated with the Stage 3, 2, and 1 Mississippi River meander belts (Fig. 3). A Stage 4 Arkansas River meander belt has been identified in the western Upper Tensas Basin (Figs. 2 and 5). As the following discussion reveals,

[1] Raw material for tool manufacture is non-existent on Macon Ridge and the surrounding regions. The nearest sources of the Citronelle Gravel, the so-called "local" lithic resource, lie to the east and west along the current valley walls and are anywhere from 10 to 60 km distant from points on Macon Ridge.

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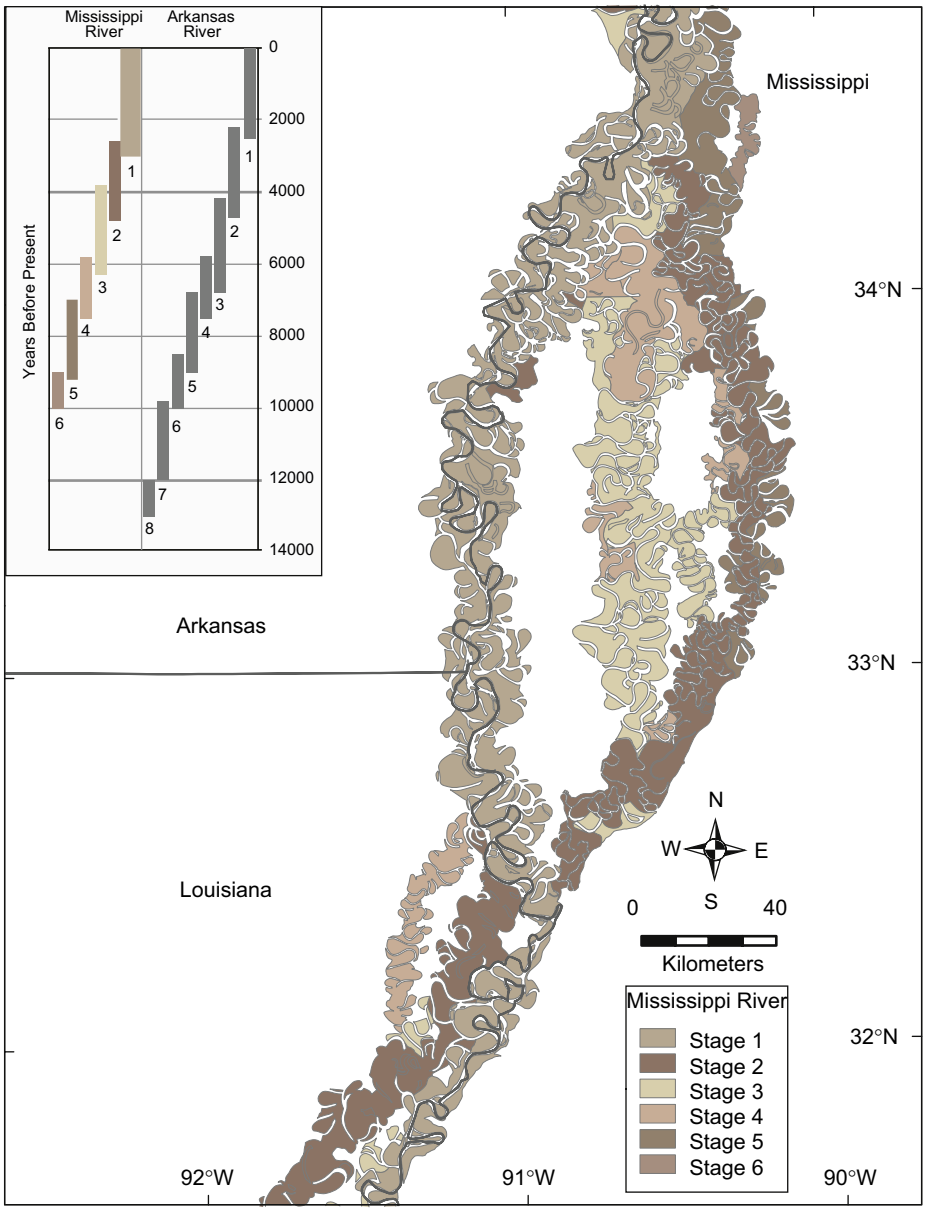


Fig. 3. Mississippi River meander belts and generalized meander belt chronology (after Saucier, 1994b, Fig. 50, Plates 7–10).

however, the relative sequences and ages of these meander belts are not actually as clear as they have been presented in valley-wide syntheses.

Many interpretations of LMV evolution infer that once a meandering regime was established, the river flowed in a single channel during each meander belt stage; over time the river avulsed, creating new meander belts associated with new stages of meander belt development. The combination of these meander belt shifts culminated in the modern alluvial floodplain (Saucier, 1974). Although it was never formally acknowledged, this concept of one active channel occurring at a time became entrenched in the literature and is currently a common generalization, especially among archeologists. However, even while publishing maps that reinforced the one channel at one time concept, Saucier acknowledged the river's flow prior to the development of the Stage 1 meander belt had, in fact, been divided among at least several channels at any given time (Saucier, 1994b, 1996, pp. 80–83). In concert with this notion of one channel at one time, the basic mode of meander belt formation was perceived to be uniform and static (Aslan and Autin, 1999). Meander belts were theorized to develop as a consequence of repeated, mostly seasonal, episodes of overbank flooding in full-flow channels, where grain size and bed thickness decreases are a property of distance from the main river channel.

Archeological theory and methods in the Mississippi Valley have been strongly influenced by geological concepts of floodplain evolution (Haag, 1996; Kidder, 1996). Taking their cues from the influential work of Fisk (1944, 1947) and later Saucier (1974, 1981, 1994b, 1994c, 1996), archeologists developed a number of (often implicit) assumptions from the gradual overbank floodplain evolution model (Phillips et al., 1951; Williams, 1956; Brain, 1970, 1971, 1978; Phillips, 1970; Weinstein et al., 1979; Weinstein, 1981; Williams and Brain, 1983; Weinstein and Kelley, 1984, 1992). First, it has generally been assumed that modes of sediment deposition have not changed significantly through time; settlement and subsistence models can therefore be the same for any one meander belt at any point in time because the basics of meander belt formation are the same. Secondly, although not specifically related to geological context, the gradualist model of meander belt formation accommodated the prevailing archeological view of

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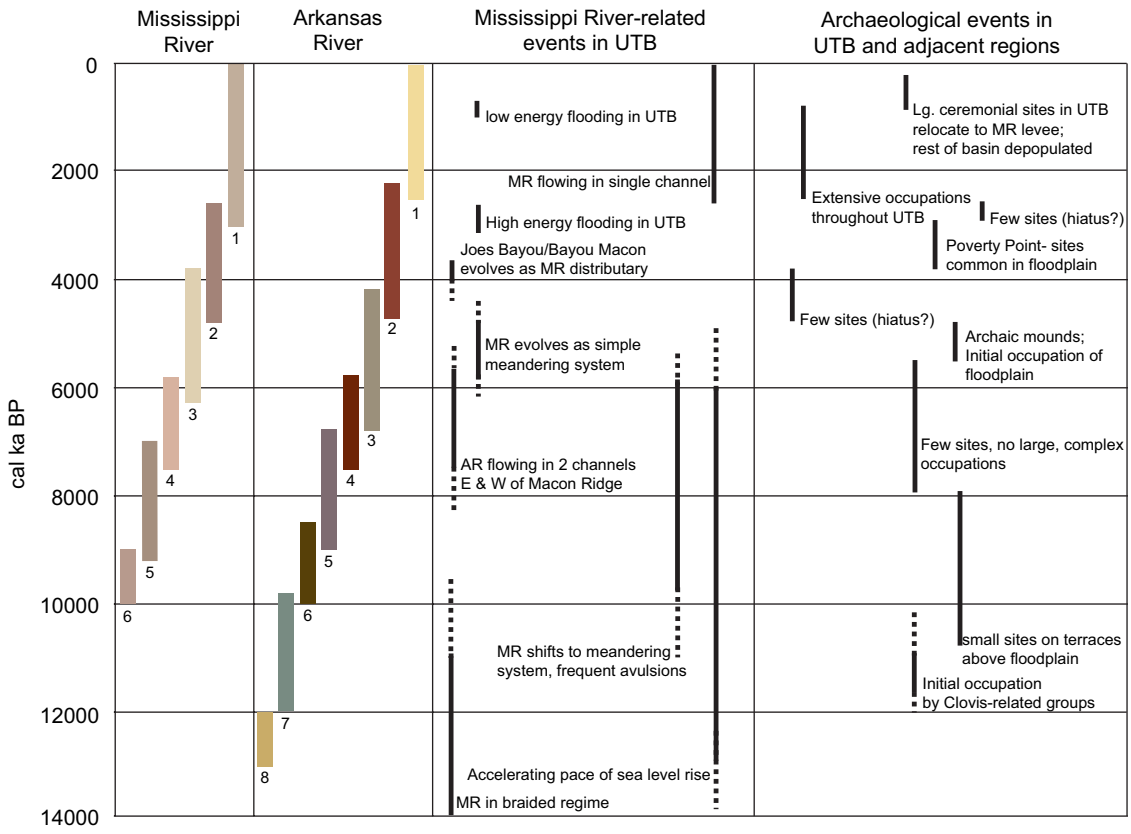


Fig. 4. Diagram showing fluvial chronologies for the Mississippi (MR) and Arkansas (AR) rivers (after Autin et al., 1991, Fig. 5; Saucier, 1994b, Fig. 50) and correlation of these chronologies with inferred Mississippi River-related geological and archeological events in the Upper Tensas Basin (UTB) and adjacent regions. Dotted lines indicate uncertainty about age estimates.

slow evolutionary progression of cultures through time, and was therefore eagerly adopted by archeologists. Finally, historical processes that act on human populations and influence their behavior, such as climate change, large-scale flooding, avulsions, and sea-level variation, have been diminished, ignored, or relegated to inconsequential status because they were not the focus of investigations of the floodplain sediment record (Kidder, 2006a).

Recently, one channel at a time and gradual accumulation models have been revised and supplanted by a more dynamic scheme that incorporates change through time as well as multiple sedimentary and depositional processes (Aslan and Autin, 1999; Aslan et al., 2005). While these new ideas have an important influence on our comprehension of the dynamics of floodplain formation in fine-grained depositional river systems, they also force a considerable reevaluation of our understanding of human social, settlement, and subsistence systems in these environments. In the Upper Tensas Basin, recent work by Aslan and Autin (Aslan and Autin, 1998, 1999; Autin and Aslan, 2001; Aslan et al., 2005) demonstrated two phases of floodplain development marked by different modes of sediment deposition and landscape formation processes as well as different types and patterns of meander belt and channel formation.

According to their work, before ca 5900 cal BP the LMV was undergoing "rapid floodplain aggradation during which crevassing, lacustrine sedimentation, and avulsion-dominated floodplain construction" (Aslan and Autin, 1999, p. 800). Rapid floodplain aggradation in the study area (~300–400 km from the coast) was significantly influenced by sea-level rise, which accelerated dramatically between 12 and 7 cal BP (Balsillie and Donoghue, 2004, Fig. 8; Törnqvist et al., 2004, p. 1036). Fast accumulation of clays and silts in poorly drained lakes and backswamp depressions inhibited lateral channel migration and fostered the development of multichannel streams. Thus, Aslan and Autin argue the Mississippi River was conveyed not by a single channel but by multiple, small floodplain streams. Lateral variability in sediment grain sizes documented in the southern part of the present study area is consistent with deposition during episodes of crevassing and avulsion. Based on analysis of historic sedimentation in the Atchafalaya Basin of southern Louisiana, it is likely these sediments were deposited at all stages of Mississippi River flow and not solely during seasonal or sporadic overbank events (Aslan and Autin, 1999, pp. 809–812, Fig. 10a and b).

The implications of these findings for models of human settlement in the Mississippi Valley are considerable. Explanations for social change in the Middle Archaic often focus on human response to climatic fluctuations (Smith, 1986, pp. 21–24; Steponaitis, 1986, p. 370; Anderson and Sassaman, 2004; Brookes, 2004; Anderson et al., 2007). Climate changes are inferred to have several effects on the Middle Archaic populations of the Southeast. Middle Holocene climates were certainly dryer in some parts of the Mississippi Basin. Increased aridity may have forced populations into resource-rich areas such as river valleys and coastal zones placing increasing pressure on resources in these localities. Human groups, their mobility already restricted by rising population pressure resulting from natural demographic increase, would encounter greater competition for restricted or scarce resources.

The emergence of spatially extensive deeply stratified and in some cases sedentary, settlements on floodplains of the Upper Mississippi and Ohio rivers are often tied to patterns of environmental change that simultaneously pushed people out of

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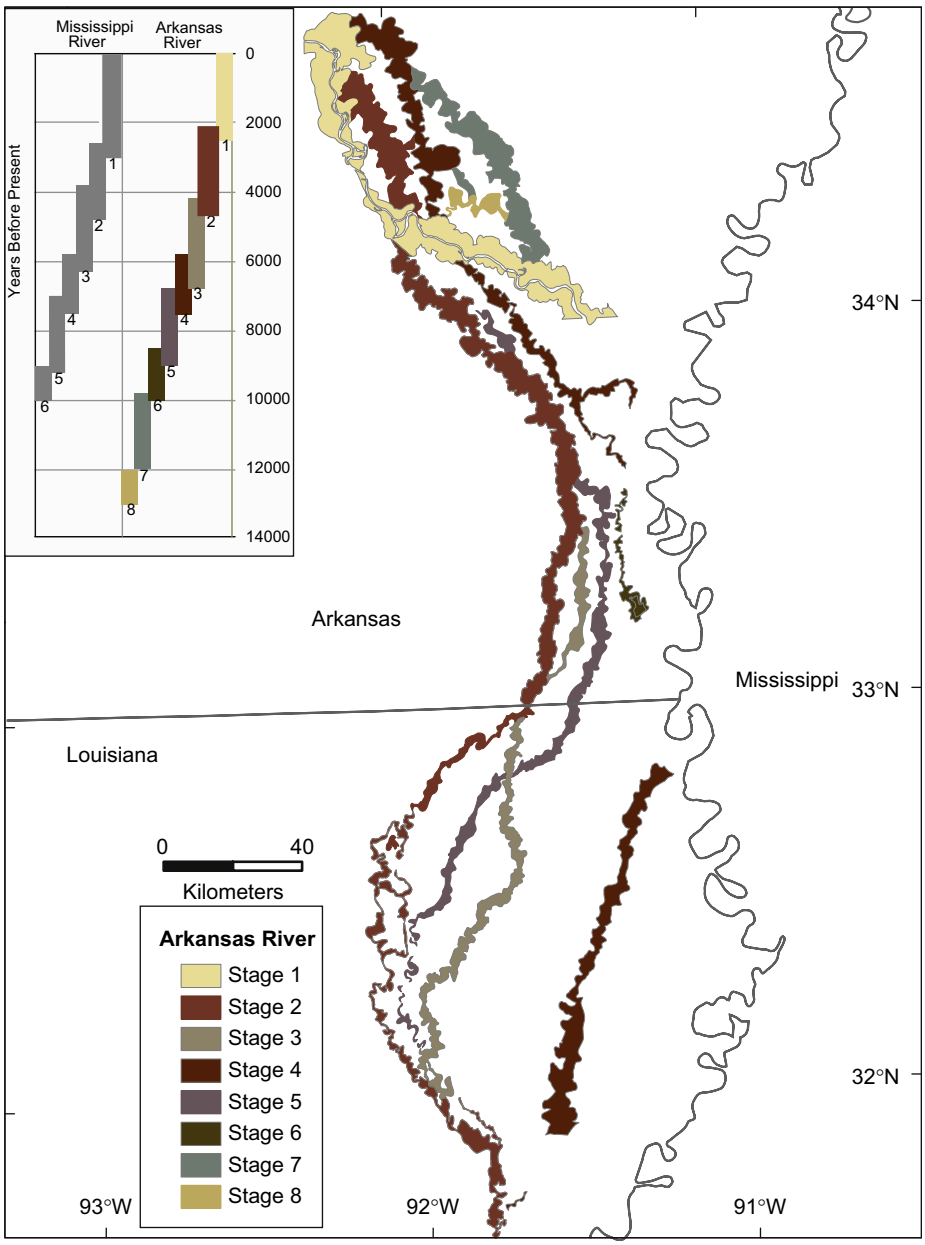


Fig. 5. Arkansas River meander belts and generalized meander belt chronology (after Saucier, 1994b, Fig. 50, Plates 7–10).

uplands and pulled them into nearby and resource-rich alluvial lowlands (Brown and Vierra, 1983; Brown, 1985; Stafford, 1994; Stafford et al., 2000). Mid-Holocene warming is also suggested to be the impetus for the emergence of long-distance trade and exchange relations that spanned hundreds of kilometers and which moved prized commodities (e.g., shell from the Gulf Coast, certain types of stone in the form of raw material and finished objects, and copper) over very long distances (Brookes, 2004). In this argument, the exchange of trade goods represent long-distance and localized exchange of information and bound communities in a web of reciprocal interest and aid, which was critical in times of environmental uncertainty and potential resource shortfalls.

Although large, deeply stratified and possibly sedentary sites are found farther upriver in the Illinois, Upper Mississippi and Ohio River floodplains, in the Upper Tensas Basin, Early Holocene and early Middle Holocene (ca 11,500–6000 cal BP; generally the same chronology as Early Archaic and early Middle Archaic) archeological sites are rare, and when found they are confined to uplands adjacent to the alluvial valley. Settlements at this time are small with shallow deposits and likely mark short-term or seasonal occupations. The distribution of sites suggests regional populations are dispersed across the landscape; there are no large, deeply stratified settlements that could have served as centers of population aggregation. Elsewhere in the LMV, Early Holocene and early Middle Holocene occupations are also infrequent and are mostly found on the Late Pleistocene braided stream surfaces in the Yazoo Basin of western Mississippi (Brain, 1970, 1983; Yarborough, 1981; McGahey, 1987, 1996), and in the uplands and tributary stream valleys of the Ozark Escarpment in Arkansas and Missouri (Morse and Morse, 1983, p. 111).

For eastern Arkansas, Morse and Morse (1983, pp. 99–101, 111–112) invoke Hypsithermal warm, dry conditions to explain the apparent depopulation of the alluvial valley and immediately adjacent regions. They suggest the alluvial lowlands witnessed a shift from bottomland hardwood-dominated forests

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to increasingly open, grass- and non-arboreal-species-dominated ecosystems. Human response, they argue, was to de-emphasize the use of the alluvial lowlands and to shift settlement to the west. Farther north in the Illinois River Valley, mid-Holocene climatic and environmental changes are cited to suggest a completely opposite response. Carmichael (1977) argued that increased aridity and associated habitat changes in the uplands adjacent to the Illinois and upper Mississippi Valley pushed human occupation into the relatively stable and increasingly resource-rich alluvial bottomlands. In contrast, Brown and Vierra (1983, p. 190) contend the key variable leading to Middle and early Late Holocene population increases and associated trends towards greater sedentism was the "growth of the food-rich slack-water environment" found in river valleys that "pulled hunter–gatherer subsistence and settlement strategies predominantly toward this area to the exclusion of alternatives".

The low incidence of Early Archaic and early Middle Archaic sites and finds within the Upper Tensas Basin might be attributed to the burial or erosion of Mississippi and Arkansas River meander belts 6, 5, and 4. However, the Aslan and Autin model of Mississippi River floodplain development in the era before ca 5900 Cal BP suggests this area may have been neither environmentally stable nor necessarily desirable as a locus for long-term permanent habitation. Many of the resources that would have attracted people to the floodplain, such as fish, game animals, birds, and nut trees, would have been spatially patchy and their distribution temporally incongruent. At multi-year temporal scales, resource availability was likely very high but predictability very low. At shorter, annual to seasonal temporal scales, however, resource abundance may have been relatively high, as many of the ecological zones, such as backswamp and floodplain lake environments, have significant productive potential. Over both long and short time scales, landscape stability would have been limited because of rapid sediment accumulation and frequent avulsion and crevassing of small floodplain streams. Over time scales longer than a single year, populations living in the alluvial valley would have had to emphasize settlement mobility coupled with very flexible subsistence and technological adaptations. In short, contrary to expectations for smaller post-Pleistocene riverine systems upstream or elsewhere in the southeastern United States (Brown and Vierra, 1983; Brown, 1985; Smith, 1986, pp. 21–24), lower Mississippi alluvial valley environments may not have encouraged the influx of increased populations enticed by stable resources. In fact, the LMV may have been avoided or only visited at certain seasons of the year during this period. We infer that, where present, sites would have generally been small and, at least in the valley proper, multi-year sedentism may not have been a realistic possibility (cf. Saucier, 1994c, p. 143).

The interval ca 6000–5000 cal BP represents an era of significant transformation in the Upper Tensas Basin. During this period we have evidence for the establishment of an increasingly stable landscape, dominated by the formation of simple meander belts associated with the Mississippi and Arkansas rivers. Aslan and Autin (1999, pp. 800, 812) argue for a "dramatic change" in Mississippi River floodplain evolution ca 5900 cal BP; in their model, the deceleration of rising sea levels in the mid-Holocene (<7000 cal BP) coupled with decreased sediment storage capacity in the floodplain led to slower, more gradual sediment accumulation, accompanied by extensive lateral channel migration, overbank deposition, and soil formation. While it is possible, the formation of simple meander belts was a consequence of reduced river discharges associated with mid-Holocene warming and drying, it is more likely these simple meander belts reflect the existence of multiple contemporary channels indicating divided flow (Saucier, 1994b, 1996; Aslan and Autin, 1999).

Recent archeological and geological research has revealed the most secure evidence yet to support Aslan and Autin's assertion for change in river regime in the period ca 5900 cal BP. Coring and limited excavation at the Nolan site (Fig. 2) demonstrate the existence of a substantial mound complex (four mounds and a human-built earthen ridge) situated on the crest of a levee of an Arkansas River meander belt attributed by Saucier to Stage 4 of the Arkansas River chronology (Arco et al., 2006). Today, the site is buried beneath 3–5 m of Holocene alluvium. This levee is part of a stable meander belt, exhibiting point bar development and oxbow cutoffs; lateral sediment facies that shift from course-grained levees to fine-grained backswamp deposits indicate overbank flooding was the dominant mode of sedimentary deposition. Work at Nolan places the site occupation in the interval ca 5200–4800 cal BP (Arco et al., 2006, Table 1). The site was constructed after active Arkansas River sedimentation had ceased in the region and a thin soil had formed on the surface of the levee, suggesting the channel adjacent to the site had been abandoned well before the initial occupation ca 5200 cal BP.

Because of their distinctive red color, sediments deposited in this Arkansas River meander belt are easily distinguished. Within cores extracted from the Tensas Basin there is no evidence for Arkansas River sediments interfingered with those of contemporary Mississippi River origin. We interpret these data to indicate the Mississippi River was located a considerable distance to the east of the Arkansas channel (the Mississippi at this time probably flowed in the same general location as it does today) and we believe a substantial interdistributary basin existed between the Mississippi and the Arkansas rivers. An important conclusion to be drawn from these inferences is the "Stage 4" Mississippi River channel adjacent to Nolan and said to be contemporary with the "Stage 4" Arkansas River channel (Saucier, 1967, 1994b, Fig. 50) obviously is not, in fact, contemporary, or else the chronology of this channel has been significantly misinterpreted. We return to this matter below.

The discovery of a relict Arkansas River meander belt in the Tensas Basin is not surprising, as this feature has been mapped beginning with Fisk (Fisk, 1944, Plate 15). Following Fisk, Saucier (1967, 1974, Fig. 1, 1994b1, 1994, Plate 10) mapped this relict meander belt and identified it with the channels of modern-day Joes Bayou and Bayou Macon (Fig. 2). Recent coring, however, indicates Joes Bayou/Bayou Macon sediments accumulated after the deposition of Arkansas River overbank deposits. The Arkansas meander belt formed east of the modern Joes Bayou/Bayou Macon channel (Figs. 2 and 5). When the Arkansas meander belt formed in this region, there was a relatively narrow elongated basin between the meander belt and the edge of Macon Ridge. Thus, these data suggest the Arkansas meander belt existed as a narrow ridge of high ground surrounded to the east and west by extensive backswamp basins. This situation made the Arkansas meander belt a prime location for human settlement, because the levee surfaces of the meander belt were elevated above flood levels and there were productive backswamp forests, swamps, and probably lakes on both sides. This Arkansas River meander belt is now buried three (at the levee crests) to ten or more meters (in backswamp locations) below the modern ground surface.

The era of landscape stability indicated by the occupation of the Nolan site coincides with a period of extensive cultural development marked by the construction and use of many mound sites throughout northeast Louisiana. These mounds are the earliest monumental constructions in North America, dated ca 5400–4800 cal BP (Saunders, 1994; Saunders et al., 1994; Saunders et al., 2001; Saunders et al., 2005). At Watson Brake (Fig. 1), archeological evidence indicates populations were present at or at least visiting the site during all seasons of the year (Saunders et al., 2005). In northeast Louisiana, these mound sites,

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as well as contemporary village settlements, are usually found on Pleistocene terraces overlooking relict channels assigned by Saucier to the Arkansas River meander belt sequence (Figs. 1 and 5). Only two sites dating to this time period have been located in the alluvial valley proper, and one of these, the Denton site in western Mississippi, is situated on a relict Pleistocene surface. The delineation of a buried Arkansas River meander belt in the Upper Tensas Basin suggests more contemporary sites were located off of the Pleistocene terrace but have yet to be discovered because they are obscured by later sedimentation (Arco et al., 2006).

The presence of contemporary sites situated on or adjacent to channels assigned to the Arkansas River but on opposite sides of Macon Ridge suggests the Arkansas River was flowing in multiple channels with its flow divided just south of Little Rock, Arkansas (Figs. 1 and 4). Although Saucier identified a "Stage 2" Arkansas River channel flowing along the western edge of the Arkansas River valley south into the Ouachita River valley (Fig. 5), we suspect this channel was reoccupying an earlier Arkansas River course. Middle Archaic sites contemporary with the Nolan site have been found adjacent to or overlooking the "Stage 2" Arkansas channel west of Macon Ridge, which would be hard to reconcile with Saucier's dating of the "Stage 2" channel (Fig. 4). While it is possible that some Middle Archaic sites may have been associated with local streams or drainages (such as the Ouachita River itself), sites such as Frenchmans Bend and the Caney Bayou/Bottleneck site group (Fig. 1) must have been situated on an Arkansas River channel at the time of their occupation because there are no alternative drainages with which they could have been associated.

After abandonment, the Nolan area was blanketed by massive, fine-grained Mississippi River overbank deposits of varying thickness relative to the underlying landform. These sediments post-date the site occupation and thus are more recent than ca 4800 cal BP; however, they stratigraphically underlie crevasse deposits (discussed below), radiocarbon dated after ca 3900 cal BP. The nearest sources for these Mississippi River sediments are abandoned channels associated with a mapped Mississippi River Stage 4 meander belt immediately east and south of the site (Saucier, 1994b, Plate 9; Arco et al., 2006, Fig. 4).

These chronostratigraphic data are perplexing in light of existing age estimates for Mississippi River meander belts. What is mapped as the Mississippi River Stage 4 meander belt in the Nolan site area is apparently considerably younger than its estimated age (ca 7500–4800 cal BP) and may be equivalent to the age assigned to Mississippi River meander belt 2 (Saucier, 1994b, pp. 257–260, Fig. 50) (Fig. 3). Saucier (1994b, p. 257) notes the paleogeography of this meander belt is "especially confusing and uncertain." The total discharge of the Stage 4 channel south of modern Helena, Arkansas, was divided and the Tensas Meander Belt segment shows characteristics of a major distributary rather than a full-flow channel (Saucier, 1994b, p. 258). We believe the most likely explanation is the deposits overlying Nolan relate to a relatively late reoccupation of a relict Stage 4 channel, which would account for an age estimate considerably younger than the date of the avulsion that originally formed this meander belt. In this scenario, the Arkansas River "Stage 4" meander belt formed after the Mississippi River "Stage 4" meander belt. The fine-grained sediments of Mississippi River origin that bury the Arkansas River meander belt were most likely deposited when the then-contemporary Mississippi River channel was at some distance, suggesting the source is one of the channels associated with the mapped Stage 3 Mississippi River meander belt. This interpretation indicates the challenges of using mapped channel ages as a guide to the geochronology of this complex fluvial environment. Although it is possible that some of Saucier's mapped meander belt segments may be incorrectly identified or misdated, it is certain these meander belts have a more complex history than is generally appreciated.

After 4800 cal BP, there was a rapid transformation of the regional landscape. An upstream avulsion diverted one of the Mississippi River channels westward, leading to a period of rapid fine-grained sediment deposition in the Upper Tensas Basin. We have documented nearly 4 m of fine-grained Mississippi River overbank deposits sandwiched between underlying Arkansas River overbank clays and later Joes Bayou/Bayou Macon levee sediments, suggesting a rapid influx of sediment (Fig. 6). These fine-grained sediments are distinguished by the presence of clay-rich vertisols with common mottling and slickensides. The preservation of organic material and grayish colors with dark brown mottling and iron oxide and manganese concretions provide evidence of seasonal drying episodes in a poorly drained environment (Aslan and Autin, 1998). These fine-grained deposits must have formed rapidly as the result of repeated overbank flood episodes that cannot be individually identified in cores. The most recent date on archeological remains at the Nolan site is ca 4800 cal BP, whereas radiocarbon ages associated with the upper portion of these Mississippi River overbank deposits are ca 4400–3800 cal BP (Arco et al., 2006, Table 1). The exceptional thickness and rapid deposition of these overbank deposits indicate a period of landscape instability in the Upper Tensas Basin.

The period of landscape transformation and instability ca 4800–3800 cal BP coincides with what appears to be a nearly complete abandonment of the Upper Tensas Basin and adjacent uplands. Mound building, which had been a cultural hallmark before this time, ceases completely and there are no radiocarbon dated sites in the region that fall within this time period. To some degree this hiatus may be more apparent than real, as the archeological data are by no means complete and there are hints of occupation at this time in other parts of the LMV (Ramenofsky, 1991; Thomas et al., 2004; Kidder, 2006a). However, available data suggest a dramatic depopulation. This pattern does not reflect population reorganization or a shift in settlement to the lowlands. Although archeological survey is not complete either in the uplands or the alluvial lowlands, there are simply no known sites in the Upper Tensas Basin dating to this period. Similarly, the Yazoo Basin is depopulated at this time (McNutt, 1996). In the alluvial lowlands, this is a time of considerable landscape change, including massive flooding and rapid sediment deposition. It seems unlikely that populations would have been drawn to the alluvial lowlands at precisely the time when this environment would have been inhospitable for any significant occupation.

At some point toward the end of this episode of massive fine-grained sediment deposition, a Mississippi River distributary formed west of the relict Stage 4 Arkansas meander belt. This distributary, identified as Joes Bayou/Bayou Macon (Fig. 2), prograded southward from an unknown point near the head of the Upper Tensas Basin. Sediments associated with this channel are stratigraphically superimposed on Mississippi River fine-grained deposits, which in turn overlie the Arkansas River meander belt (Fig. 6). The Joes Bayou/Bayou Macon progradation was rapid and is constrained within the period ca 4000–3800 cal BP. This chronology is based on radiocarbon dates from the Mississippi fine-grained sediments and from archeological sites located on the surface of Joes Bayou/Bayou Macon. Rapid levee formation is indicated by massive fining upward deposits ranging from very fine sand to silty clay.

The formation and stabilization of the Joes Bayou/Bayou Macon system marked the end of a period of pronounced landscape transformation and instability. The chronology of this episode (or, more likely, these episodes) of instability is poorly defined, but it falls within a span of roughly a thousand years,

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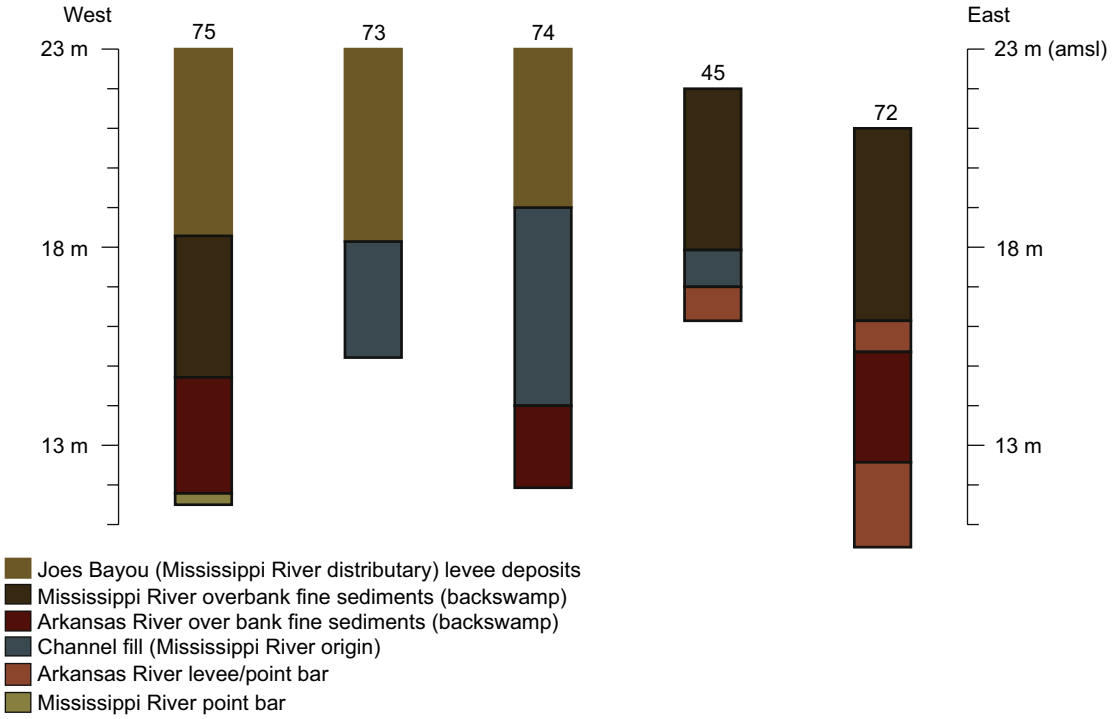


Fig. 6. Cross-section of cores in the Upper Tensas Basin showing the stratigraphic relationship between ancestral Arkansas River deposits and later Holocene Mississippi River and Mississippi River distributary sediments. Arkansas River point bar/levee sediments in cores 72 and 45 indicate this is the approximate location of the "Stage 4" Arkansas River meander belt; this conclusion is strengthened by the finding of similar point bar/levee deposits of the Arkansas River in the Nolan site area (Arco et al., 2006). These cores also demonstrate Joes Bayou prograded after the Arkansas has ceased flowing in the area. See Fig. 2 for location of cores.

from ca 4800–3800 cal BP. Toward the end of this period, lateral channel migration or perhaps an upstream avulsion associated with the formation of the Mississippi River Stage 2 meander belt moved the Mississippi River eastward. As a consequence, the western parts of the Upper Tensas Basin were insulated from significant fluvial activity associated with Mississippi River flooding.

With the eastward movement of the Mississippi, the Joes Bayou/Bayou Macon system was no longer conveying the discharge of the main channel of the river and it became an underfit stream. The stabilization of the Joes Bayou/Bayou Macon system coincided with a valley-wide episode of landscape stability that lasted for nearly a thousand years. Across much of the LMV, and in the Upper Tensas Basin specifically, people associated with the Late Archaic Poverty Point culture rapidly colonized topographically elevated, well-drained natural levees (Webb, 1982). The best-preserved examples of this era of stability are found on the levees of the Joes Bayou/Bayou Macon system. The earliest radiocarbon dated settlements on this system are ca 3900–3400 cal BP; in western Mississippi contemporary occupation of the Yazoo Basin floodplain is slightly earlier at ca 4100–3700 cal BP (Sims and Connoway, 2000; McGimsey and van der Koogh, 2001; Kidder, 2006a). Farther north, in southeast Missouri opposite the mouth of the Ohio, and in the Ohio and Tennessee River valleys, as well as in the Upper Mississippi River watershed, humans had populated the alluvial valley at earlier dates. The disruptions ca 4800–3800 cal BP that occurred in the Upper Tensas Basin and elsewhere in the LMV were not equally felt in the upper reaches of the river and in its tributaries.

For the first time in over a thousand years, relatively large communities emerged on the levee systems in the Upper Tensas Basin and elsewhere in the region; in numerous instances occupation intensity was considerable and thick middens formed in cumulic soil profiles (Gibson, 1996). Archeological sites developed on the modern land surface, making it possible for current investigators to readily find settlements and reconstruct a valid approximation of the settlement system. Data from the Copes site, situated on the Joes Bayou levee, indicate occupation was year-round (Jackson, 1986, 1989, 1991) and settlement survey data suggest sedentary communities were relatively evenly spaced up and down the bayou system (Webb, 1982; Gibson, 2000). This was a period of widespread cultural interaction, with extensive trade routes allowing the people living in the Upper Tensas Basin to receive goods from the Great Lakes and southern Appalachian regions, from the Ohio, Tennessee, and Missouri valleys, and from the Gulf Coast (Gibson, 2000).

This era of valley-wide cultural and geological stability was abruptly interrupted in the period ca 3000–2500 cal BP by a widespread episode of massive flooding, landscape transformation, and cultural change and reorganization (Kidder, 2006a; Adelsberger and Kidder, 2007). During this interval, the modern Stage 1 meander belt evolved in the LMV. One of the most important geological events was an avulsion north of Vicksburg, Mississippi, which diverted the Mississippi River to the eastern side of the basin (Fig. 3) (Saucier, 1994b). As the Stage 1 meander belt developed, one or more river channels migrated westward to intersect the headwaters of Joes Bayou/Bayou Macon somewhere in the vicinity of the modern Arkansas-Louisiana border, temporarily reactivating it as a major distributary.

As a consequence of this reactivation, the Joes Bayou/Bayou Macon channel and adjacent areas were significantly transformed by massive flooding. First, the Joes Bayou channel shifted in a number of places; relict channel segments and oxbow lakes were formed as a consequence. Poverty Point sites once located adjacent to the bayou were now isolated from the channel. Second, from the modern headwaters to its junction with Bayou Macon, eight crevasse splays developed on east side cutbanks of the bayou (Adelsberger and Kidder, 2007, Fig. 2). These are fan-shaped silt and fine sand deposits that emanate from Joes Bayou and extend into the basin between the bayou and the modern

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channel of the Mississippi River. Mapping and coring of these splays demonstrate they all share the same stratification and have similar soil profiles and surface morphologies. Common lithology, massive fining-upward bedding, and the absence of soil development indicate these splays formed nearly simultaneously as a consequence of a sudden high energy flood or series of floods (Adelsberger and Kidder, 2007).

Radiocarbon ages for organic remains found at the interface between underlying backswamp clay and the splays at two separate locations indicate these flood deposits must be younger than 3580±40 and 3469±59 cal BP (Arco et al., 2006, Table 1). There are no Poverty Point sites on Joes Bayou/Bayou Macon younger than 3100 cal BP, and the oldest sites on the splay surfaces date to the Early Woodland ca 2600–2200 cal BP (Kidder, 2006a, Table 1). Although the desired temporal precision is lacking, this evidence indicates the splays formed in the period ca 3000–2600 cal BP. Changes in the course of Joes Bayou, development of large sediment splays on Joes Bayou, and Mississippi River meander belt shifts coincide with the end of Poverty Point occupation in the Upper Tensas Basin. These events have been correlated with an episode of rapid global climate change hypothesized to be the cause of increased flooding documented the Mississippi River watershed (Mayewski et al., 2004; Kidder, 2006a). Locally, flooding was calamitous and rendered much of the alluvial valley uninhabitable for prolonged periods.

An important outcome of the reorganization of the Mississippi River fluvial system after ca 2500 cal BP. was the shift in the Stage 1 Mississippi channel configuration, as it now flowed in a single channel. Coupled with a period of long-term climatic stability, the river's confinement within the Stage 1 meander belt provided human occupants of the alluvial valley a period of landscape predictability that encouraged permanent settlement and allowed for considerable cultural elaboration. Archeological cultures flourished and settlement occupations were intensive and long-lasting. Many sites throughout the LMV show evidence of repeated, if not continuous, occupation, with the formation of thick cumulic middens marking preferred settlement locations. These occur most often on elevated, well-drained relict levee systems adjacent to water courses such as abandoned channels or oxbow lakes. Settlements in the basin favored settings away from the modern Mississippi meander belt and emphasized positions on lower order streams, slow, sluggish bayous, and locations where there are strong ecological boundaries (e.g., along the Pleistocene terrace of Macon Ridge).

Because these sites are preserved on the modern landscape and can be readily identified by surface survey, the appearance of stability is enhanced relative to earlier periods. Although some preferred locations were occupied nearly continuously for over a thousand years (Phillips, 1970; Williams and Brain, 1983), in many instances there is evidence of short-term settlement interruptions and localized movement. These patterns of variability, however, are overprinted on the canvass of landscape stability wherein gradual in situ evolution was the dominant mode of explanation for cultural change in the period after ca 2500 cal BP (Kidder, 2004b). This pattern of stability is also true for the entire Mississippi Valley and most of its tributaries, suggesting these benign landscape conditions are the result of continental-scale geological stability and global-scale climate processes.

The period ca 1000–800 cal BP is the only time when fluvial circumstances depart from the long-term pattern of stability begun with the establishment of a single Mississippi River channel. In this interval, several changes in the regional fluvial record contributed to shifts in settlement patterns. Throughout the Upper Tensas Basin, a massive influx of fine-grained sediment blanketed much of the alluvial lowlands west of the modern Mississippi River meander belt. At the Osceola and Raffman sites these deposits rest on and up along the edges of mound flanks and cap occupation surfaces (Kidder, 1996, 2004a). In both instances, and elsewhere in the basin, these fine-grained deposits terminate sustained human occupation. Locally, the flooding must have been substantial. The Raffman site is located on a terrace elevated ca 5 m above the modern floodplain; the fine-grained deposits rest across the terrace surface and on-lap mound flanks forming deposits 70–35 cm thick. The absence of coarse-grained sediments within these overbank deposits suggests this process was the result of extensive overbank flooding throughout the region.

The immediate cultural effect of these floods was to shift settlement to the east and concentrate it on, and adjacent to, the modern Mississippi River and its meander belt. In many instances, this was a settlement shift of relatively minor consequence. At Osceola, for example, the population is thought to have moved about 15 km north and east to the Routh site (Kidder, 1996, Fig. 7). Elsewhere, there was likely greater consequence, especially at smaller sites or settlements in lower lying areas. Although the movement of peoples appears to have been geographically limited, it was accompanied by or contemporary with relatively significant cultural transformations associated with the shift from Late Woodland to Mississippian culture (Kidder, 2002, 2004b, 2006b; Pauketat, 2004).

Regional-scale fluvial events in the Upper Tensas Basin coincide with the end of the successful fishing/hunting and gathering subsistence practices that had supported the elaborate cultural expression for the previous 3000 years and their replacement with plant-food diets increasingly reliant on domesticated crops. In this area, as with elsewhere, the transformation to agricultural lifestyles signals a substantial realignment of the ways humans relate to the natural world and to each other (Cobb and Nassaney, 2002; Kennett and Winterhalder, 2006). The emergence of sustained maize-based agriculture at this time may have provided further impetus for populations to move eastward to the well-drained modern Mississippi River meander belt (Fritz and Kidder, 1993; Kidder and Fritz, 1993; Roberts, 2005). The concentration of settlements, including large mound complexes, along the Mississippi River was facilitated by increasing trade and exchange in early Mississippian times (ca 1000–800 cal BP); we have direct evidence at sites in the Upper Tensas Basin and in the Yazoo Basin of trade from sites such as Cahokia, located near modern-day St. Louis, 700 km upstream (Brain, 1989, 1991; Weinstein, 2005; Kidder, 2006b). However, elsewhere in the Mississippi Valley, there is no evidence of flooding causing similar settlement displacement; for example, in the Yazoo Basin the contemporary settlement shift appears to be in exactly the opposite direction, with major settlements located on the modern Mississippi River meander belt being displaced towards the interior (Brain, 1978; Brown and Brain, 1983; Kidder, 2004b). In the LMV, the shift from Late Woodland to Mississippian was a significant cultural change, and the evidence suggests it was accompanied by and possibly causally related to environmental changes in the Mississippi River fluvial system.

It is important to note, however, in contrast to the fluvial disruptions documented in earlier times, what we see in later prehistory is very different. The ca 1000–800 cal BP flooding was geographically limited and appears to have had far less momentous regional cultural consequences. These floods are not, for example, associated with changes in Mississippi River meander belt configurations and we have no evidence of significant high-energy processes; these events were the result of high-frequency, low-amplitude developments typical of historically documented LMV flooding. Some settlements were displaced but there is no evidence of region-wide abandonment. At both Raffman and Osceola the flooding may have been the result of lateral channel

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movement within the modern meander belt; as the meander belt accreted and channels migrated locally they appear to have impinged on lower areas to the west. Through a combination of overbank flooding and upstream crevassing during high water, fine-grained sediments were introduced into these contained backswamp depressions, resulting in localized but calamitous flooding. A similar pattern is documented in the Upper Mississippi Valley in Wisconsin, where Knox has documented multiple floods during the same interval. Here too, cultural response appears to be localized and consists of movement of populations from floodplain to terrace locations or the abandonment of some floodplain localities and surrounding regions (Knox, 1985, 1987, 1988, 1996, 1999, 2003; Stoltman and Christiansen, 2000; Knox and Daniels, 2002; Stoltman, 2005). Although these processes were important at the local scale they were not part of a larger regional population re-organization in the wake of climate-induced flooding.

After ca 800 cal BP the LMV floodplain reverted to a relatively stable mode. Archeological sites associated with the latest prehistoric and initial contact period (ca 800–300 cal BP) are mostly found along the modern Mississippi River meander belt. Interior locations on relict drainages and in backswamp areas were rarely settled; however, these areas were visited periodically by small hunting/fishing parties. Evidence from the earliest European explorers indicates flooding was a factor in Indian settlement organization in the mid-sixteenth century (Clayton et al., 1993, I: pp. 151–154, II: 489–490). Later European explorers, traders, and settlers record Mississippi River floods as a regular occurrence but there is no suggestion there were periods of sustained flooding that disrupted farming or commerce for more than several years at a time. By the later eighteenth century, settlers and local governments were erecting levees to control flooding and historical records indicate high frequency/low-amplitude floods were an accepted risk for occupants of the alluvial valley. Still, floods of exceptional size are documented in 1782, 1809, 1811, 1813, 1815, 1828, 1844, 1849, 1850, 1858, 1859, 1882, 1890, 1912, 1913, 1927, and 1937 (Humphreys and Abbot, 1861, pp. 167–183; United States Congress Senate Committee on Commerce, 1898; US Army Corps of Engineers, 1994; Barry, 1997). In 1828, 1844, 1850, 1882, and 1927 the Upper Tensas Basin was completely inundated (Humphreys and Abbot, 1861, pp. 167–183; American National Red Cross, 1929). These floods cannot be quantitatively assessed because instrumental data are not consistently available, but they had sufficient impact to be recorded and are thus important at a human scale even if they did not leave a basin-wide geological signature. By the time of the 1937 flood much of the LMV had been transformed by flood control works such as levees, cutoffs, and diversions (Winkley, 1977). More recently, floods have been recorded in 1945, 1950, 1973, 1975, 1979, and 1983. These data reflect the regularity and thus the human consequences of high frequency, low-amplitude basin-wide flooding in the LMV.

4.3. Climate change and basin-scale evolution in the LMV

Large river valleys integrate hydroclimatic change differently than smaller ones (Knox and Daniels, 2002). Large valleys are relatively insensitive to changes over small intervals of time, whereas sedimentary deposits in smaller valleys often serve to record temporally short-lived and/or low-amplitude hydrological and geomorphic responses. However, because of their size, larger valleys usually archive sedimentary records of longer-term, geographically extensive flooding and climate-related landscape evolution (Gladfelter, 1985, 2001). Once the Mississippi River basin stabilized following glacial retreat and deceleration of sea-level rise, the history of the river south of the Ohio and its inhabitants was dominated by long periods of landscape stability punctuated by episodes of dramatic landform alteration.

In the LMV, periods of significant landscape instability and fluvial re-adjustment are recorded for the periods ca 4800–3800 cal BP, 3000–2500 cal BP, and 1000–800 cal BP. Furthermore, in contrast to tributaries upstream from the Ohio confluence, the LMV may not have been conducive to human occupation during the Early and Middle Holocene. These punctuations in the environmental history of the LMV are related to periods of major cultural transformation and suggest climate change has a causal role in the long-term history of human occupation in this river valley. Variations in cultural responses between locations upstream of the Ohio-Mississippi River confluence and those downstream in the LMV indicate we cannot model human or natural processes uniformly throughout the length of the river. Because the Mississippi River south of the Ohio is composed of inputs from four watersheds with distinctive hydroclimatic conditions, we should not expect consistent patterns of landscape evolution and response to climatic changes. The sedimentary archives of the LMV record basin-wide fluvial responses to changes in climate, which is not always the case in upstream watersheds. Similarly, in thinking about the relationship between human behavior and geological/landscape evolution, differences between tributary and upstream river segments and downstream main stem river processes must be disentangled. As we can see from human responses to mid-Holocene climate changes, models that account for settlement behavior and organization in regions upstream from the Ohio confluence do not work in the LMV.

Climate and landscape changes, however, are modulated by social, political, economic, and technological developments that must be considered before we ascribe changes in culture to climatic causes. Data from upper Mississippi River Valley, the Missouri River Valley, the Great Plains, and Gulf of Mexico provide information for assessing climate changes through time and flood magnitude and frequency in the past (Chumbley et al., 1990; Baker et al., 1992; Anderson, 1993; Anderson et al., 1993; Bradbury and Dean, 1993; Brown et al., 1999; Baker et al., 2000; Baker et al., 2001; Baker et al., 2002; Bettis, 2003; Mason et al., 2003; Wright et al., 2004; Miao et al., 2005; Mason and Kuzila, 2007; Miao et al., 2007a, 2007b), which can in turn be used to inform models of societal development and change. Because the LMV is so affected by the dominance of drainages from the Upper Mississippi and Missouri River tributaries, these data allow us to couple Holocene climate changes over a large area with regional-scale human response. The available data lack the desired resolution necessary for detailed archeological correlations, but they do offer the best evidence available at present. In Figs. 4 and 7 we provide an outline of a model of Upper Tensas Basin landscape stability based on current data and interpretations. In Fig. 7 we superimpose on this model the extant Mississippi Valley paleoclimatic and paleoflood data to explore the degree of fit between climate change, flooding, and cultural processes. On this model we also overlay globally generalized data for episodes of Holocene rapid climate change (RCC) as synthesized by Mayewski et al. (2004). Because we are analyzing the LMV sedimentary archive, our results do not adequately reflect the effects of prolonged or severe drought, which leave no clear signature in our data. Data amassed from tree-ring studies indicate droughts may have played an important role in the relatively recent past and they are likely to have been an important factor in human–landscape dynamics over the Holocene (Stahle et al., 1985; Stahle and Cleaveland, 1994; Clark et al., 2002; Benson et al., 2007; Seager et al., 2007; Stahle et al., 2007).

Fig. 7 demonstrates there is no simple or uniform correlation between known global or regional climate events and the pattern of landscape stability documented in the Upper Tensas Basin.

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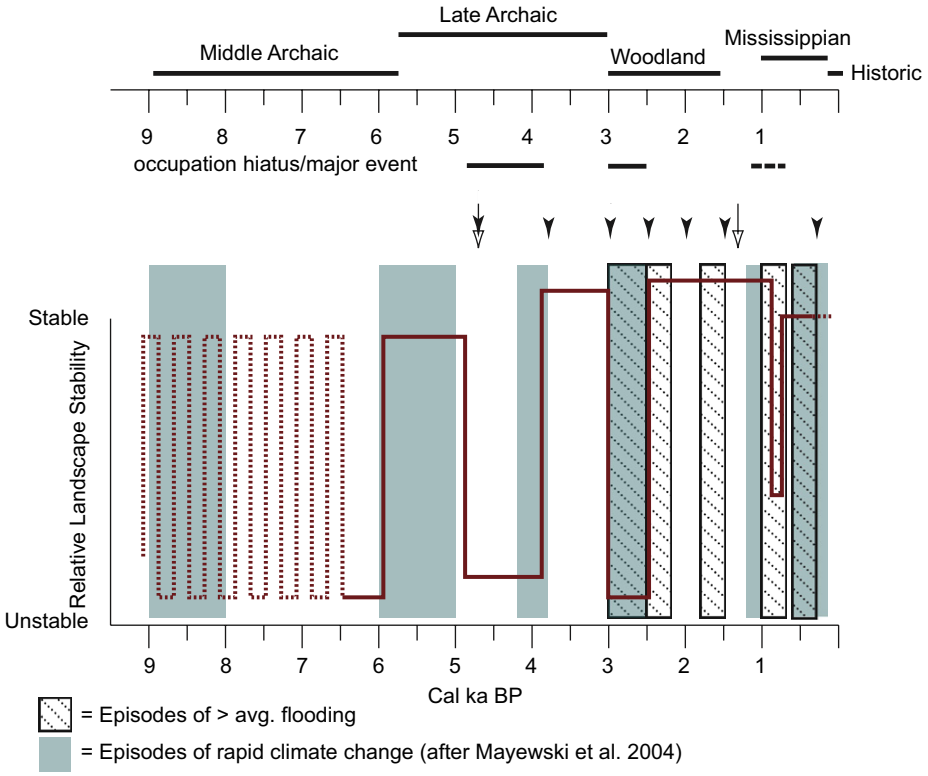


Fig. 7. Schematic diagram of Upper Tensas Basin paleolandscape history showing cultural chronology (top), global episodes of rapid climate change (shaded rectangles; after Mayewski et al., 2004), and periods of Upper Mississippi River flooding (hatched rectangles; after Knox, 1996, 1999, 2000, 2003). Open arrows on the top of the diagram show dates of specific paleofloods recognized in the Upper Mississippi River (after Knox, 2003); the filled triangles show dates of Mississippi River "megafloods" documented in the Gulf of Mexico (Brown et al., 1999). Three cultural occupation hiatuses or periods of major change are shown; the one dating ca 1000–800 cal BP is dashed because this episode appears to be confined to the Upper Tensas Basin and is not a regional phenomenon. The solid line shows relative landscape stability (Y axis) based on data presented in Section 4.2. The line is dashed up to ca 6500 cal BP to show hypothesized rapid fluctuation between stable and unstable landscape modes because of "rapid floodplain aggradation during which crevassing, lacustrine sedimentation, and avulsion-dominated floodplain construction" (after Aslan and Autin, 1998, p. 800, 1999); following ca 300 cal B.P the curve is again dashed and lies flat because after this period human intervention in the region and throughout the LMV constrained landscape evolution.

Examining the period from ca 6000 cal BP to the present, there are four RCC episodes. Two of these episodes (ca 4200–3800 cal BP and ca 3000–2500 cal BP) correlate with periods of landscape instability in the LMV; these are also intervals when the study area was abandoned or the local populations experienced a dramatic change (or both). Two of the RCC episodes (ca 6000–5000 cal BP and 1200–1000 cal BP) do not clearly correlate with intervals of documented landscape instability. In fact, the interval ca 6000–5000 cal BP appears to be a time of landscape stability in our study area as marked by the development of simple meander belts and the formation of a paleosol on the surface of an Arkansas River levee at the Nolan site. The occupation of the Nolan site ca 5200–4800 cal BP suggests climate change in this period (or at least the end of it) did not lead to dramatic negative culture change. Fig. 7 also documents specific flood events and intervals in the LMV where flood frequency and amplitude exceed the historical norm. These events only loosely correlate with episodes of RCC (the most notable correlation being the period ca 3000–2500 cal BP). Flooding in the Mississippi Valley ca 1000–800 cal BP has a regional signal but cannot be connected to global-scale processes. These data indicate landscape stability, climate change, and human response are complex variables that are linked, in some instances, by the dynamic fluvial environment of the Mississippi River. At some times and under certain climatic conditions, the Mississippi River can be understood to have a causal role in local and regional alluvial floodplain stability and thus how humans occupy and exploit these environments. At other times and under different circumstances climatic change and floodplain response are either decoupled, or their effects are moderated leaving no clear signature in the landscape or in the human historical record. Further work and higher-resolution data sets are likely the most promising means of generating better linkages (or evidence for a lack thereof) between climate, landscapes, and people.

5. Conclusion

A primary goal of archeological research is to explain cultural transformations and investigate the sources and roles of change within social, political, economic, and cultural systems. Because of the inextricable link and reciprocal relationship between humans and the landscape they occupy, understanding the regional geologic and landscape history is central to any study of past human societies. Recent work in the Upper Tensas Basin of the LMV has refined accepted chronologies for Arkansas and Mississippi River meander belt formation, providing more detailed descriptions of regional landscape development as well as geologic data sets on a scale that can be utilized for archeology. The archeological and geomorphological records from this region of the LMV reveal the complexity and dynamism of social and environmental landscapes over the past 10,000 years. The complex relationship between landscape stability, climate change, and associated human responses in the Mississippi Valley elucidates the intricate interplay between changes in the physical environment and resultant effects on human behavior. Times of environmental perturbations are often but not always associated with periods of major cultural transformations, suggesting climate

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change is a causal force affecting human occupation in this region. However, the intervals of climate change that do not correspond to any archeologically visible human responses highlight the inadequacy of blanket and indiscriminate environmental explanations.

Linking local-scale archeological data to global- or continental-scale models of climate-induced flooding and associated meander belt shifts requires an intermediate level of investigation. The climatic, environmental, and geological controls within this intermediate-scale analysis are specific to our particular frame of reference, indicating significant additional work will be needed before we can realistically gauge the impacts of large-scale geological processes on past societies. Any hope we have of understanding controls on archeological populations within regional study areas will have to come from detailed, sub-basin-scale investigations of meander belt shifts using the larger Mississippi system as a guide. The physical environment provides an important context for human behavior; however, simple deterministic explanations for social and cultural change often fail to accurately depict the true nature and trajectory of prehistoric human–landscape interactions. Recent investigations have made large strides toward closing the gaps between regional geologic investigations and small-scale archeological studies, and modern field methods and theories promise a more interdisciplinary interaction within both fields. By providing information on recursive human–environmental relationships and long-term landscape histories, geoarcheological research at relevant temporal and spatial scales will continue to elucidate the intricacies of these interconnections.

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References

Adelsberger, K.A., Kidder, T.R., 2007. Climate change, landscape evolution, and human settlement in the lower Mississippi Valley, 5500–2400 cal B.P. In: Wilson, L., Dickinson, P., Jeandron, J. (Eds.), Reconstructing Human–Landscape Interactions. Cambridge Scholars Publishing, Newcastle upon Tyne, pp. 84–108.

Allen, T.E., Touchet, B.A., 1990. Geomorphic evolution and soils. In: Gibson, J.L. (Ed.), Search for the Lost Sixth Ridge: The 1989 Excavations at Poverty Point. Report No. 9, Center for Archaeological Studies. University of Southwestern Louisiana, Lafayette, LA, pp. 21–25.

American National Red Cross, 1929. The Mississippi valley flood disaster of 1927: official report of the relief operations. The American National Red Cross, Washington, DC.

American Society for Testing and Materials, 2003. Standard test for particle-size analysis of soils. ASTM D422-63 (reapproved 2002). ASTM International, West Conshohocken, Pennsylvania.

Anderson, D.G., 1990. The Paleoindian colonization of Eastern North America: a view from the southeastern United States. In: Tankersley, K.B., Isaac, B.L. (Eds.), Early Paleoindian Economics of Eastern North America. Research in Economic Anthropology, Supplement 5. JAI Press, Greenwich, CT, pp. 163–216.

Anderson, D.G., Sassaman, K.E., 2004. Early and middle Holocene periods, 9500–3750 B.C. In: Fogelson, R.D. (Ed.), Southeast. Handbook of North American Indians, vol. 14. Smithsonian Institution Press, Washington, DC, pp. 87–100.

Anderson, D.G., Russo, M., Sassaman, K.E., 2007. Mid-Holocene cultural dynamics in southeastern North America. In: Anderson, D.G., Maasch, K.A., Sandweiss, D.H. (Eds.), Climate Change and Cultural Dynamics: A Global Perspective on Mid-Holocene Transitions. Academic Press, London, pp. 457–489.

Anderson, R.Y., 1993. The Varve chronometer in Elk Lake: record of climatic variability and evidence for solar/geomagnetic-^{14}C-climatic connection. In: Bradbury, J.P., Dean, W.E. (Eds.), Elk Lake Minnesota: Evidence for Rapid Climatic Change in the North-Central United States. Geological Society of America, Boulder, Special Paper, vol. 276, pp. 45–67.

Anderson, R.Y., Dean, W.E., Bradbury, J.P., 1993. Elk Lake in perspective. In: Bradbury, J.P., Dean, W.E. (Eds.), Elk Lake Minnesota: Evidence for Rapid Climatic Change in the North-Central United States. Geological Society of America, Boulder, Special Paper, vol. 276, pp. 1–6.

Arco, L.J., Adelsberger, K.A., Hung, L.-y., Kidder, T.R., 2006. Alluvial geoarchaeology of a Middle Archaic mound complex in the lower Mississippi Valley. USA Geoarchaeology 21, 591–614.

Aslan, A., Autin, W., 1998. Holocene flood-plain soil formation in the southern lower Mississippi Valley: implications for interpreting alluvial paleosols. Bulletin of the Geological Society of America 110, 433–449.

Aslan, A., Autin, W.J., 1999. Evolution of the Holocene Mississippi River floodplain, Ferriday, Louisiana; insights on the origin of fine-grained floodplains. Journal of Sedimentary Research 69, 800–815.

Aslan, A., Autin, W.J., Blum, M.D., 2005. Causes of river avulsion: insights from the late Holocene avulsion history of the Mississippi River. USA Journal of Sedimentary Research 75, 650–664.

Autin, W.J., Aslan, A., 2001. Alluvial pedogenesis in Pleistocene and Holocene Mississippi River deposits: effects of relative sea-level change. Bulletin of the Geological Society of America 113, 1456–1466.

Autin, W.J., Burns, S.F., Miller, B.J., Saucier, R.T., Snead, J.I., 1991. Quaternary geology of the lower Mississippi Valley. In: Morrison, R.B. (Ed.), The Geology of North America, vol. K-2, Quaternary Nonglacial Geology, Geological Society of America, Boulder; Coterminous United States, pp. 547–582.

Baker, R.G., Maher, L.J., Chumbley, C.A., Van Zant, K.L., 1992. Patterns of Holocene environmental change in the midwestern United States. Quaternary Research 37, 379–389.

Baker, R.G., Fredlund, G.G., Mandel, R.D., Bettis III, E.A., 2000. Holocene environments of the central Great Plains: multi-proxy evidence from alluvial sequences, southeastern Nebraska. Quaternary International 67, 75–88.

Baker, R.G., Bettis, E.A.III., Denniston, R.F., Gonzalez, L.A., 2001. Plant remains, alluvial chronology, and cave speleothem isotopes indicate abrupt Holocene climate change at 6 KA in midwestern USA. Global and Planetary Change 28, 285–291.

Baker, R.G., Bettis III, E.A., Denniston, R.F., Gonzalez, L.A., Strickland, L.E., Krieg, J.R., 2002. Holocene paleoenvironments in southeastern Minnesota—chasing the prairie-forest ecotone. Palaeogeography, Palaeoclimatology, Palaeoecology 177, 103–122.

Balsillie, J.H., Donoghue, J.F., 2004. High-resolution sea-level history for the Gulf of Mexico since the last glacial maximum. Report of Investigations 103, Florida Geological Survey, Tallahassee.

Barry, J., 1997. Rising Tide: The Great Mississippi Flood of 1927 and How it Changed America. Simon and Schuster, New York.

Benson, L.V., Berry, M.S., Jolie, E.A., Spangler, J.D., Stahle, D.W., Hattori, E.M., 2007. Possible impacts of early-11th-, middle-12th-, and late 13th-century droughts on western Native Americans and Mississippian Cahokians. Quaternary Science Reviews 26, 336–350.

Bettis III, E.A., 2003. Patterns in Holocene colluvium and alluvial fans across the prairie-forest transition in the midcontinent USA. Geoarchaeology 18, 779–797.

Birkeland, P.W., 1999. Soils and Geomorphology, third ed. Oxford University Press, New York.

Blum, M.D., Guccione, M.J., Wysocki, D.A., Robnett, P.C., Rutledge, E.M., 2000. Late pleistocene evolution of the lower Mississippi River Valley, southern Missouri to Arkansas. Geological Society of America Bulletin 112, 221–235.

Bradbury, J.P., Dean, W.E. (Eds.), 1993. Elk Lake Minnesota: Evidence for Rapid Climatic Change in the North-central United States, Geological Society of America, Boulder.

Brain, J.P., 1970. Early Archaic in the lower Mississippi alluvial valley. American Antiquity 35, 104–106.

Brain, J.P., 1971. The Lower Mississippi Valley in North American Prehistory. National Park Service and Arkansas Archeological Survey, Fayetteville.

Brain, J.P., 1978. Late Prehistoric settlement patterning in the Yazoo Basin and Natchez Bluffs regions of the lower Mississippi Valley. In: Smith, B. (Ed.), Mississippian Settlement Patterns. Academic Press, New York, pp. 331–368.

Brain, J.P., 1983. Paleo-Indian in the lower Mississippi Valley. Southeastern Archaeological Conference Bulletin 20, 22–37.

Brain, J.P., 1989. Winterville: Late Prehistoric Culture Contact in the Lower Mississippi Valley. Archaeological Report 23. Mississippi Department of Archives and History, Jackson.

Brain, J.P., 1991. Cahokia from the southern periphery. In: Stoltman, J.B. (Ed.), New Perspectives on Cahokia: Views from the Periphery. Monographs in World Archaeology 2. Prehistory Press, Madison, pp. 93–100.

Brookes, S.O., 2004. Cultural complexity in the middle Archaic of Mississippi. In: Gibson, J.L., Carr, P.J. (Eds.), Signs of Power: The Rise of Complexity in the Southeast. University of Alabama Press, Tuscaloosa, Alabama, pp. 97–113.

Brown, J.A., 1985. Long-term trends to sedentism and the emergence of complexity in the American midwest. In: Price, T.D., Brown, J.A. (Eds.), Prehistoric Hunter-Gatherers: The Emergence of Cultural Complexity. Academic Press, New York, pp. 201–231.

Author's personal copy

Brown, I.W., Brain, J.P., 1983. Archaeology of the Natchez Bluffs region, Mississippi: hypothesized cultural and environmental factors influencing local population movements. Southeastern Archaeological Conference Bulletin 20, 38–49.
Brown, J.A., Vierra, R.K., 1983. what happened in the Middle Archaic? introduction to an ecological approach to Koster site archaeology. In: Phillips, J.L., Brown, J.A. (Eds.), Archaic Hunters and Gatherers in the American Midwest. Academic Press, New York, pp. 165–195.
Brown, P., Kennett, J.P., Ingram, B.L., 1999. Marine evidence for episodic Holocene megafloods in North America and the northern Gulf of Mexico. Paleoceanography 14, 498–510.
Burnett, A.W., Schumm, S.A., 1983. Alluvial-river response to neotectonic deformation in Louisiana and Mississippi. Science 222, 49–50.
Carmichael, D.L., 1977. Preliminary archaeological survey of Illinois uplands and some behavioral considerations. Midcontinental Journal of Archaeology 2, 210–251.
Chumbley, C.A., Baker, R.G., Bettis, E.A.III., 1990. Midwestern Holocene paleoenvironments revealed by floodplain deposits in northeastern Iowa. Science 249, 272–273.
Clark, J.S., Grimm, E.C., Donovan, J.J., Fritz, C.S., Engstrom, D.R., Almendinger, J.E., 2002. Drought cycles and landscape responses to past aridity on prairies of the northern Great Plains, USA. Ecology 83, 595–601.
Clayton, L.A., Knight, Jr., V.J., Moore, E.C. (Eds.), 1993. The De Soto Chronicles: The Expedition of Hernando de Soto to North America in 1539–1543. University of Alabama Press, Tuscaloosa.
Cobb, C. R., Nassaney, M.S., 2002. Domesticating Self and Society in the Woodland Southeast. In: Anderson, D. G., and Mainfort, R. C., Jr. (Eds.), The Woodland Southeast. University of Alabama Press, Tuscaloosa, pp. 525–539.
Cox, R.T., Van Arsdale, R.B., 2002. The Mississippi Embayment, North America: a first order continental structure generated by the Cretaceous superplume mantle event. Journal of Geodynamics 34, 163–176.
Drew, J., DuCharme, C., 1993. The record flood of 1993. Open File Report 93-95-WR, Missouri Department of Natural Resources, Division of Geology and Land Survey, Rolla, MO.
Fisk, H.N., 1944. Geological Investigation of the Alluvial Valley of the Lower Mississippi River. US Army Corps of Engineers, Mississippi River Commission, Vicksburg.
Fisk, H.N., 1947. Fine-grained alluvial deposits and their effects on Mississippi river activity. Waterways Experiment Station, Mississippi River Commission, Corps of Engineers, Vicksburg.
Fritz, G.J., Kidder, T.R., 1993. Recent investigations into prehistoric agriculture in the lower Mississippi Valley. Southeastern Archaeology 12, 1–14.
Gibson, J.L., 1970. The Paleo-Indian era in Louisiana. Louisiana Heritage 2, 18–19, 38.
Gibson, J.L., 1991. Islands in the past: archaeological excavations at the Francis Thompson site, Madison Parish, Louisiana. Louisiana Archaeology 14, 1–155.
Gibson, J.L., 1996. The Orvis Scott site: a Poverty Point component on Joes Bayou, East Carroll Parish, Louisiana. Midcontinental Journal of Archaeology 21, 1–48.
Gibson, J.L., 2000. The Ancient Mounds of Poverty Point: Place of Rings. University Press of Florida, Gainesville.
Gladfelter, B.G., 1985. On the interpretation of archaeological sites in alluvial settings. In: Stein, J.K., Farrand, W.R. (Eds.), Archaeological Sediments in Context. Peopling of the Americas Edited Volume Series: vol. 1. Center for the Study of Early Man, Institute for Quaternary Studies, University of Maine at Orono, Orono, ME, pp. 41–52.
Gladfelter, B.G., 2001. Archaeological sediments in humid alluvial environments. In: Stein, J.K., Farrand, W.R. (Eds.), Sediments in Archaeological Context. University of Utah Press, Salt Lake City, pp. 93–125.
Guccione, M.J., Lafferty III, R.H., Cummings, L.S., 1988. Environmental constraints of human settlement in an evolving Holocene alluvial system, the lower Mississippi Valley. Geoarchaeology 3, 65–84.
Haag, W.G., 1996. Geoarchaeology of the lower Mississippi Valley. Engineering Geology 45, 59–64.
Hally, D.J., 1972. The Plaquemine and Mississippian occupations of the Upper Tensas Basin, Louisiana. Unpublished Ph.D. Thesis, Department of Anthropology, Harvard University, Cambridge, MA.
Hillman, M., 1990. Paleoindian settlement on the Macon Ridge, northeastern Louisiana. Louisiana Archaeology 12, 203–218.
Humphreys, A.A., Abbot, H.L., 1861. Report on the Physics and Hydraulics of the Mississippi River. Professional Papers of the Corps of Topographical Engineers No. 4, United States Army, J.B. Lippincott, Philadelphia.
Jackson, H.E., 1986. Sedentism and hunter–gatherer adaptations in the lower Mississippi Valley: subsistence strategies during the Poverty Point period. Unpublished Ph.D. Dissertation, Department of Anthropology, University of Michigan, Ann Arbor, MI.
Jackson, H.E., 1989. Poverty Point adaptive systems in the lower Mississippi Valley: subsistence remains from the J.W. Copes site. North American Archaeologist 10, 173–204.
Jackson, H.E., 1991. Bottomland resources and exploitation strategies during the Poverty Point period: implications of the archaeobiological record from the J.W. Copes site. In: Byrd, K.M. (Ed.), The Poverty Point Culture: Local Manifestations, Subsistence Practices, and Trade Networks. Geoscience and Man 29. Louisiana State University, Baton Rouge, pp. 131–157.
Jackson, H.E., Jeter, M.D., 1994. Preceramic earthworks in Arkansas: a report on the Poverty Point period Lake Enterprise mound (3AS379). Southeastern Archaeology 13, 153–162.
Kennett, D.J., Winterhalder, B., 2006. Behavioral ecology and the transition from hunting and gathering to agriculture. In: Winterhalder, B., Kennett, D.J. (Eds.), Behavioral Ecology and the Transition to Agriculture. University of California Press, Berkeley, pp. 1–21.
Kidder, T.R., 1996. Perspectives on the geoarchaeology of the lower Mississippi Valley. Engineering Geology 45, 305–323.
Kidder, T.R., 2002. Woodland period archaeology of the lower Mississippi Valley. In: Anderson, D.G., Mainfort, Jr., R.C. (Eds.), The Woodland Southeast. University of Alabama Press, Tuscaloosa, pp. 66–90.
Kidder, T.R., 2004a. Plazas as architecture: an example from the Raffman site, Northeast Louisiana. American Antiquity 69, 514–532.
Kidder, T.R., 2004b. Prehistory of the lower Mississippi Valley after 800 B.C. In: Fogelson, R.D. (Ed.), Southeast. Handbook of North American Indians, vol. 14. Smithsonian Institution Press, Washington, DC, pp. 545–559.
Kidder, T.R., 2006a. Climate change and the Archaic to Woodland transition (3000–2600 cal B.P.) in the Mississippi River Basin. American Antiquity 71, 195–231.
Kidder, T.R., 2006b. Contemplating plaquemine culture. In: Reese, M., Livingood, P. (Eds.), Plaquemine Archaeology. University of Alabama Press, Tuscaloosa, pp. 196–205.
Kidder, T.R., Fritz, G.J., 1993. Subsistence and social change in the lower Mississippi Valley: the Reno Brake and Osceola sites, Louisiana. Journal of Field Archaeology 20, 281–297.
Knox, J.C., 1985. Responses of floods to Holocene climatic change in the upper Mississippi Valley. Quaternary Research 23, 287–300.
Knox, J.C., 1987. Stratigraphic evidence of large floods in the upper Mississippi Valley. In: Mayer, L., Nash, D. (Eds.), Catastrophic Flooding. Allen and Unwin, Boston, pp. 155–180.
Knox, J.C., 1988. Climate influence on upper Mississippi Valley floods. In: Baker, V.R., Kochel, R.C., Patton, P.C. (Eds.), Flood Geomorphology. Wiley, New York, pp. 279–299.
Knox, J.C., 1996. Late Quaternary upper Mississippi River alluvial episodes and their significance to the lower Mississippi River system. Engineering Geology 45, 263–285.
Knox, J.C., 1999. Long-term episodic changes in magnitudes and frequencies of floods in the upper Mississippi River Valley. In: Brown, A.G., Quine, T.A. (Eds.), Fluvial Processes and Environmental Change. Wiley, Chichester, pp. 255–282.
Knox, J.C., 2000. Sensitivity of modern and Holocene floods to climate change. Quaternary Science Reviews 19, 439–457.
Knox, J.C., 2003. North American paleofloods and future floods: responses to climatic change. In: Gregory, K.J., Benito, G. (Eds.), Palaeohydrology: Understanding Global Change. Wiley, New York, pp. 143–164.
Knox, J.C., Daniels, J.M., 2002. Watershed scale and the stratigraphic record of large floods. In: House, P.K., Webb, R.H., Baker, V.R., Levish, D.R. (Eds.), Ancient Floods, Modern Hazards: Principles and Applications of Paleoflood Hydrology. Water Science and Application, vol. 5. American Geophysical Union, Washington, DC, pp. 237–255.
Mason, J.A., Kuzila, M.S., 2007. Episodic Holocene loess deposition in central Nebraska. Quaternary International 67, 119–131.
Mason, J.A., Jacobs, P.M., Hanson, P.R., Miao, X., Goble, R.J., 2003. Sources and paleoclimatic significance of Holocene Bignell loess, Central Great Plains, USA. Quaternary Research 60, 330–339.
Mayewski, P.A., Rohling, E.E., Stager, J.C., Karlén, W., Maasch, K.A., Meeker, L.D., Meyerson, E.A., Gasse, F., van Kreveld, S., Holmgren, K., Lee-Thorp, J., Rosqvist, G., Rack, F., Staubwasser, M., Schneider, R.R., Steig, E.J., 2004. Holocene climate variability. Quaternary Research 62, 243–255.
McGahey, S.O., 1987. Paleo-Indian lithic material: implications of distributions in Mississippi. Mississippi Archaeology 22, 1–13.
McGahey, S.O., 1996. Paleo-Indian and Early Archaic data from Mississippi. In: Anderson, D.G., Sassaman, K.E. (Eds.), The Paleoindian and Early Archaic Southeast. University of Alabama Press, Tuscaloosa, AL, pp. 354–384.
McGimsey, C.R., van der Koogh, J., 2001. Louisiana's Archaeological Radiometric Database. Special Publication 3. Louisiana Archaeological Society, Baton Rouge.
McNutt, C.H., 1996. The upper Yazoo Basin in northwest Mississippi. In: McNutt, C.H. (Ed.), Prehistory of the Central Mississippi Valley. University of Alabama Press, Tuscaloosa, pp. 155–185.
Meade, R.H., 1995. Setting: geology, hydrology, sediments, and engineering of the Mississippi River. In: Meade, R.H. (Ed.), Contaminants in the Mississippi River, 1987–92. US Geological Survey Circular 1133, US Geological Survey, Reston, VA, pp. 13–30.
Miao, X., Mason, J.A., Goble, R.J., Hanson, P.R., 2005. Loess record of dry climate and aeolian activity in the early- to mid-Holocene, central Great Plains, North America. The Holocene 15, 339–346.
Miao, X., Mason, J.A., Johnson, W.C., Wang, H., 2007a. High-resolution proxy record of Holocene climate from a loess section in southwestern Nebraska, USA. Palaeogeography, Palaeoclimatology, Palaeoecology 245, 368–381.
Miao, X., Mason, J.A., Swinehart, J.B., Loope, D.B., Hanson, P.R., Goble, R.J., Liu, X., 2007b. A 10,000 year record of dune activity, dust storms, and severe drought in the central Great Plains. Geology 35, 119–122.
Morse, D.F., Morse, P.A., 1983. Archaeology of the Central Mississippi Valley. Academic Press, New York.
Neuman, R.W., 1984. An Introduction to Louisiana Archaeology. Louisiana State University Press, Baton Rouge.
Pauketat, T.R., 2004. Ancient Cahokia and the Mississippians. Cambridge University Press, Cambridge.

Author's personal copy

Phillips, P., 1970. Archaeological survey in the lower Yazoo Basin, Mississippi, 1949–1955. Papers of the Peabody Museum of Archaeology and Ethnology, vol. 60. Harvard University, Cambridge.

Phillips, P., Ford, J.A., Griffin, J.B., 1951. Archaeological survey in the lower Mississippi Alluvial Valley, 1940–1947. Papers of the Peabody Museum of Archaeology and Ethnology, vol. 25. Harvard University, Cambridge.

Public Works Administration, 1934. Report of the Mississippi Valley committee of the Public Works Administration. Submitted October 1, 1934 to Harold L. Ickes, Administrator, Federal Emergency Administration of Public Works, US Government Printing Office, Washington, DC.

Pye, K., Johnson, R., 1988. Stratigraphy, geochemistry, and thermoluminesence ages of lower Mississippi Valley loess. Earth Surface Processes and Landforms 13, 103–124.

Ramenofsky, A.F., 1991. Investigating settlement strategies at Cowpen Slough, a late Archaic-Poverty Point site in Louisiana. In: Byrd, K.M. (Ed.), The Poverty Point Culture: Local Manifestations, Subsistence Practices, and Trade Networks. Geoscience and Man 29. Louisiana State University, Baton Rouge, pp. 159–172.

Reimer, P.J., Baillie, M.G.L., Bard, E., Bayliss, A., Beck, J.W., Bertrand, C.J.H., Blackwell, P.G., Buck, C.E., Burr, G.S., Cutler, K.B., Damon, P.E., Edwards, R.L., Fairbanks, R.G., Friedrich, M., Guilderson, T.P., Hogg, A.G., Hughen, K.A., Kromer, B., McCormac, F.G., Manning, S.W., Bronk Ramsey, C., Reimer, R.W., Remmele, S., Southon, J.R., Stuiver, M., Talamo, S., Taylor, F.W., van der Plicht, J., Weyhenmeyer, C.E., 2004. IntCal04 terrestrial radiocarbon age calibration, 0–26 Cal Kyr BP. Radiocarbon 46, 1029–1058.

Rittenour, T.M., Goble, R.J., Blum, M.D., 2005. Development of an OSL chronology for late Pleistocene channel belts in the lower Mississippi Valley, USA. Quaternary Science Reviews 24, 2539–2554.

Roberts, K.M., 2005. Seasonality, optimal foraging, and prehistoric plant food production in the lower Mississippi in the Tensas Basin, northeast Louisiana. Unpublished Ph.D. Thesis, Department of Anthropology, Washington University in St. Louis, St. Louis, MO.

Rutledge, E.M., Guccione, M.J., Markewich, H.W., Wysocki, D.A., Ward, L.B., 1996. Loess stratigraphy of the lower Mississippi Valley. Engineering Geology 45, 167–183.

Ryan, J. (Ed.), 2004. Data recovery excavations at the Hedgeland Site (16CT19), Catahoula Parish, Louisiana. Submitted to Vicksburg District, US Army Corps of Engineers (Contract No. DACW 38-91-D-0014, Delivery Order No. 0025). Coastal Environments, Inc., Baton Rouge.

Saucier, R.T., 1967. Geological investigation of the Boeuf–Tensas Basin, lower Mississippi Valley. Technical Report 3-757, US Army Corps of Engineers, Waterways Experiment Station, Vicksburg

Saucier, R.T., 1974. Quaternary geology of the lower Mississippi Valley. Research Series 6, Arkansas Archeological Survey, Fayetteville.

Saucier, R.T., 1981. Current thinking on riverine processes and geological history as related to human settlement in the Southeast. In: West, F.H., Neuman, R.W. (Eds.), Traces of Prehistory: Papers in Honor of William G. Haag. Geoscience and Man 22. Geoscience Publications, Department of Geography and Anthropology. Louisiana State University, Baton Rouge, pp. 7–18.

Saucier, R.T., 1994a. Evidence of late-glacial runoff in the lower Mississippi Valley. Quaternary Science Reviews 13, 973–981.

Saucier, R.T., 1994b. Geomorphology and Quaternary geologic history of the lower Mississippi Valley, 2 volumes. Mississippi River Commission, US Army Corps of Engineers, Vicksburg.

Saucier, R.T., 1994c. The Paleoenvironmental setting of northeast Louisiana during the Paleo-Indian period. Louisiana Archaeology 16, 129–146.

Saucier, R.T., 1996. A contemporary appraisal of some key Fiskian concepts with emphasis on Holocene meander belt formation and morphology. Engineering Geology 45, 67–86.

Saucier, R.T., Kolb, C.R., 1967. Alluvial geology of the Yazoo Basin, lower Mississippi Valley. Technical Report 3-480, Waterways Experiment Station, Vicksburg.

Saunders, J.W., Allen, T., Saucier, R.T., 1994. Four Archaic? mound complexes in northeast Louisiana. Southeastern Archaeology 13, 134–153.

Saunders, J.W., Allen, T., LaBatt, D., Jones, R., Griffing, D., 2001. An assessment of the antiquity of the Lower Jackson Mound. Southeastern Archaeology 20, 67–77.

Saunders, J.W., Mandel, R.D., Sampson, C.G., Allen, C.M., Allen, E.T., Bush, D.A., Feathers, J.K., Gremillion, K.J., Hallmark, C.T., Jackson, H.E., Johnson, J.K., Jones, R., Saucier, R.T., Stringer, G.L., Vidrine, M.F., 2005. Watson Brake, a middle Archaic mound complex in northeast Louisiana. American Antiquity 70, 631–668.

Saunders, R., 1994. The case for Archaic period mounds in southeastern Louisiana. Southeastern Archaeology 13, 118–134.

Schoeneberger, P.J., Wysocki, D.A., Benham, E.C., Broderson, W.D. (Eds.), 2002. Field Book for Describing and Sampling Soils, Version 2.0. Natural Resources Conservation Service, Lincoln, NE.

Schumm, S.A., 2005. River Variability and Complexity. Cambridge University Press, Cambridge.

Schweig, E.S., Van Arsdale, R.B., 1996. Neotectonics of the upper Mississippi Embayment. Engineering Geology 45, 185–203.

Seager, R., Graham, N., Herweijer, C., Gordon, A.L., Kushnir, Y., Cook, E., 2007. Blueprints for Medieval hydroclimate. Quaternary Science Reviews 26, 2322–2336.

Sims, D.C., Connoway, J.M., 2000. Updated chronometric database for Mississippi. Mississippi Archaeology 35, 208–269.

Smith, B.D., 1986. The archaeology of the southeastern United States: from Dalton to De Soto, 10,500 B.P.–500 B.P. In: Wendorf, F., Close, A. (Eds.), Advances in World Archaeology, vol. 5. Academic Press, Orlando, FL, pp. 1–92.

Soil Survey Division Staff, 1993. Soil Survey Manual. Government Printing Office, Washington, DC.

Soil Survey Staff, 1999. Soil taxonomy. Natural Resource Conservation Service. US Department of Agriculture, Washington, DC.

Stafford, C.R., 1994. Structural changes in Archaic landscape use in the dissected uplands of southwestern Indiana. American Antiquity 59, 219–237.

Stafford, C.R., Richards, R.L., Anslinger, M.C., 2000. The Bluegrass fauna and changes in middle Holocene hunter–gatherer foraging in the southern midwest. American Antiquity 65, 317–336.

Stahle, D.W., Cleaveland, M.K., 1994. Tree-ring reconstructed rainfall over the southeastern USA during the Medieval Warm Period and Little Ice Age. Climatic Change 26, 199–212.

Stahle, D.W., Cleaveland, M.K., Hehr, J.G., 1985. A 450-year drought reconstruction for Arkansas, United States. Nature 316, 530–532.

Stahle, D.W., Fye, F.K., Cook, E.R., Griffin, R.D., 2007. Tree-ring reconstructed megadroughts over North America since A.D. 1300. Climatic Change 83, 133–149.

Steponaitis, V.P., 1986. Prehistoric archaeology in the southeastern United States, 1970–1985. Annual Review of Anthropology 15, 363–404.

Stoltman, J.B., 2005. Tillmont (47CR460), a stratified prehistoric site in the upper Mississippi River Valley. The Wisconsin Archeologist 86, 1–126.

Stoltman, J.B., Christiansen, G.W., 2000. The late Woodland stage in the Driftless Area of the upper Mississippi Valley. In: Emerson, T.E., McElrath, D.L., Fortier, A.C. (Eds.), Late Woodland Societies: Tradition and Transformation Across the Midcontinent. University of Nebraska Press, Lincoln, pp. 497–524.

Stuiver, M., Reimer, P.J., 1986. A computer program for radiocarbon age calibration. Radiocarbon 28, 1022–1030.

Thomas Jr., P.M., Campbell, L.J., Morehead, J.R., 2004. The Burkett site (23MI20): implications for cultural complexity and origins. In: Gibson, J.L., Carr, P.J. (Eds.), Signs of Power: The Rise of Complexity in the Southeast. University of Alabama Press, Tuscaloosa, Alabama, pp. 114–128.

Törnqvist, T.E., Kidder, T.R., Autin, W.J., van der Borg, K., de Jong, A.F.M., Klerks, C.J.W., Snijders, E.M.A., Storms, J.E.A., van Dam, R.L., Wiemann, M.C., 1996. A revised chronology for Mississippi River subdeltas. Science 273, 1693–1696.

Törnqvist, T.E., Jong, A.F.M.d., Kurnik, C.W., González, J.L., Newsom, L.A., van der Borg, K., 2004. Deciphering Holocene sea-level history on the US Gulf Coast: a high-resolution record from the Mississippi Delta. Bulletin of the Geological Society of America 116, 1026–1039.

United States Congress Senate Committee on Commerce, 1898. Floods of the Mississippi River. 54th Congress, 3d Session, Senate Report 1433, US Government Printing Office, Washington, DC.

US Army Corps of Engineers, 1994. The great flood of 1993 post-flood report: upper Mississippi River and lower Missouri River basins. US Army Corps of Engineers, North Central Division, Chicago.

Van Arsdale, R.B., Cox, R.T., 2007. The Mississippi's curious origins. Scientific American 296, 76–82, 82B.

Vogel, G., 2002. A handbook of soil description for archeologists. Technical Paper 11, Arkansas Archeological Survey, Fayetteville.

Washington, P.A., 2002. Neotectonic deformation of alluvial valleys in southern Arkansas and northern Louisiana. Gulf Coast Association of Geological Societies Transactions 52, 991–1002.

Webb, C.H., 1982. The Poverty Point Culture. Geoscience and Man 17, 2nd ed., revised. Geoscience Publications, Department of Geography and Anthropology, Louisiana State University, Baton Rouge.

Weinstein, R.A., 1981. Meandering rivers and shifting villages: a prehistoric settlement model in the upper Steele Bayou Basin, Mississippi. Southeastern Archaeological Conference Bulletin 24, 37–41.

Weinstein, R.A. (Ed.), 2005. Lake Providence: A Terminal Coles Creek Culture Mound Center, East Carroll Parish, Louisiana. US Army Corps of Engineers, Vicksburg District, Contract No. DACW38-91-D-0014, Coastal Environments, Inc., Baton Rouge.

Weinstein, R.A., Kelley, D.B., 1984. Archaeology and Paleogeography of the Upper Felsenthal Region: Cultural Resources Investigations in the Calion Navigation Pool, South-Central Arkansas. Coastal Environments, Inc., Baton Rouge.

Weinstein, R.A., Kelley, D.B., 1992. Cultural resources investigations in the Terrebonne Marsh, South-Central Louisiana. Cultural Resources Series Report No. COELMN/PD-89/06, Coastal Environments, Inc., Baton Rouge.

Weinstein, R.A., Glander, W.P., Gagliano, S.M., Burden, E.K., McCloskey, K.G., 1979. Cultural Resources Survey of the Upper Steele Bayou Basin, West-Central Mississippi. Coastal Environments, Inc., Baton Rouge.

Williams, S., 1956. Settlement patterns in the lower Mississippi Valley. In: Willey, G.R. (Ed.), Prehistoric Settlement Patterns in the New World. Publications in Anthropology 23. Viking Fund, New York, pp. 52–62.

Williams, S., Brain, J.P., 1983. Excavations at the Lake George site, Yazoo County, Mississippi, 1958–1960. Papers of the Peabody Museum of Archaeology and Ethnology, vol. 74. Harvard University, Cambridge.

Winkley, B.B., 1977. Man-made cutoffs on the Lower Mississippi River: conception, construction, and river response. Potomology Investigations 300–2, Corps of Engineers, Vicksburg District, Vicksburg, MS.

Wright Jr., H.E., Stefanova, I., Tian, J., Brown, T.A., Hu, F.S., 2004. A chronological framework for the Holocene vegetational history of central Minnesota: the Steel Lake pollen record. Quaternary Science Reviews 23, 611–626.

Yarborough, K., 1981. A preliminary report of the Hebe Plantation site: chronology and function. Mississippi Archaeology 16, 30–38.