Town aggregation and abandonment during the era of urban transformations in the Cahokia region: Bayesian modeling of the Washausen mound-town

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Abstract

The American Bottom portion of the Central Mississippi River Valley is a region where urban transformations occurred in the pre-Columbian era. During the 11th century AD, Cahokia experienced significant population increases through immigration of non-local migrants to the site and, assumedly, the aggregation of extant local groups. This article considers the latter phenomenon and the extent to which urbanization involved demographic reorganizations on a regional scale. A suite of AMS radiocarbon dates are presented for the Washausen site, a place where residents built one of the earliest mound-and-plaza towns outside of Cahokia. Knowledge of the site from broad-scale geophysical survey, surface collections, excavations, and artifact analyses, provides information utilized for Bayesian chronological modeling. A new site

chronology places major occupations in the late 11th-early 12th centuries, and suggests the site occupations spanned a brief period of potentially 30 years or less. The data also support a scenario wherein town abandonment was rapid and begun by AD 1100 or shortly thereafter, possibly undertaken as a single event. Washausen's site chronology demonstrates that some early regional centers were abandoned as Cahokia and other large settlements were approaching their maximum population sizes. This study provides evidence for models of urban development that consider the movements of local populations and communities as part of the urbanization process.

Keywords:

Cahokia; Mississippian; Bayesian modeling; demography; aggregation; abandonment; urbanism

1. Introduction

The 11th century AD saw the growth of numerous mound-and-plaza oriented towns in eastern North America (Cobb and Butler 2016). Referred to broadly as Mississippian, the societies that built these settlements variously shared certain aspects of culture that included, among other things, a dedication to maize-dominated agriculture, certain religious themes and practices, and forms of political organization (Blitz 2010; Cobb 2003; Welch and Butler 2006). Social complexity, sedentism, and monumentality are known to predate the Mississippian era by several millennia, having histories that waxed and waned through time across the greater region (Kidder 2011; Ortmann and Kidder 2013; Russo 1994; Saunders et al. 1997; Thompson and Andrus 2011; see also Anderson and Sassaman 2012; Milner 2004; Sassaman 2004, 2010). By broad comparison, however, Mississippian settlements provide evidence of a far-reaching penchant for substantially-built domestic architecture at monumental and other sites, greater emphases upon sedentary lifestyles, and new ways of spatially anchoring corporate and domestic life to place (Barrier and Kassabaum, *in press*; Beck and Brown 2012; Cobb and Nassaney 2002).

In the American Bottom portion of the Central Mississippi River valley (Fig. 1), the constellation of features considered the core of a Mississippian culture first appeared as Cahokia was experiencing rapid population growth and major structural reorganizations around AD 1050 (Anderson 1997; Beck et al. 2007; Kelly 1990; Pauketat 2004). Within just a few centuries time, the earliest sedentary farming villages in the region gave way to an array of settlements that included mound-town centers housing large resident populations. By AD 1100, if not earlier, Cahokia reached a size and scale that were unrivaled by any other Mississippian center locally or elsewhere.

The transformational changes at Cahokia, evident in population, settlement size and layout, monumental constructions, public rituals and performances, and landscape modifications, have led archaeologists to identify the settlement's urban character and establish it as North America's first city (Kelly and Brown 2014; Iseminger 2010; Pauketat 2007, 2009; Pauketat et

al. 2015; Yoffee 2014:Table 12.1). This realization comes at a moment when scholars are giving increased attention to early cities around the globe and their variable physical, social, and institutional forms; with the recognition that many of the earliest cities emerged in the absence of the political state (Creekmore and Fisher 2014; Cowgill 2004:526; Fletcher 2012; Jennings and Earle 2016; Marcus and Sabloff 2008a; McIntosh 1991, 2005; McIntosh and McIntosh 2003;

Fig. 1. Map showing locations of American Bottom mound sites mentioned in text (adapted from Barrier and Horsley 2014:Figure 1).

Possehl 1998; M.E. Smith 2007, 2009; M.L. Smith 2003; Yoffee 2014, 2015). From a comparative perspective, the decades surrounding the Mississippian transition in the American

Bottom provide opportunities to understand the processes by which thousands of individuals relocated to create a densely populated and urban-scaled social landscape centered upon Cahokia.

Windows giving view into the nature of urban Cahokia include the size and spatial layout of the site. Cahokia surged from a village of a few thousand inhabitants or less, to a center with 10-15 thousand people within the span of a couple centuries, with the major pulse occurring in the 11th century (Milner 1998; Pauketat 2003; Pauketat and Lopinot 1997). Regional population sizes were likely growing as a result of increases in fertility related to agricultural changes and reductions in overall mobility (Buikstra et al. 1986; Bocquet-Appel 2008, 2011; Kelly 1992), but a significant portion of the increase at Cahokia would have resulted from the aggregation of existing groups as well as incorporation of migrants from farther afield (Alt 2006; Beck 2006; Cobb 2005; Emerson and Hedman 2016; Kelly 1990; Kelly and Brown 2014:303-304; Pauketat 1994, 2003). Like other ancient cities worldwide (Emberling et al. 2015:300-301; Marcus and Sabloff 2008b:324), however, centuries (in Cahokia's case) of occupations masked and altered many of the archaeological deposits that would provide opportunities to more fully understand the timing and tempo of aggregation during urban transformations.

As future and ongoing work continues to address this issue in more detail for Cahokia-proper, data from other regional sites can provide insights into the processes of urbanization in the American Bottom. As urbanization is known to operate at regional scales (McIntosh 2005; M.E. Smith 2014; M.L. Smith 2003, 2014; Yoffee 2005:54, 214), knowledge of population shifts and demographic reorganizations throughout the larger region contribute to the overall picture for the early Mississippian case. Data given here for the Washausen site provide an example of the scale and timing of residential movements during the early Mississippian transition.

A suite of AMS radiocarbon dates from Washausen are presented and modeled using Bayesian methods to date town development as well as the commencement and pace of village abandonment. Details about the dated contexts, excavated features, and prior information from the site are discussed in order to substantiate the modeling procedures utilized herein (see Bayliss

2015). These Bayesian models complement other means of dating Washausen's major occupations, while providing a more precise chronology than previously available. This new site chronology is discussed in relation to the timing of population aggregations also taking place at Cahokia and other large Mississippian centers at this time. Results show that the growth of Washausen and its subsequent depopulation should be viewed as part of the process of urbanization in the American Bottom.

2. Early Mississippian in the American Bottom: Situating the Washausen Site

The pattern of settlement variability in the American Bottom, with several mound-towns and an array of non-mound settlements, emerged by the early Mississippian period (AD 1050-1200) (Milner 1990, 1998:Figure 3.1). Although the extent to which any mounding had begun prior to AD 1050 is unknown, constructions dating to the early Mississippian era at Cahokia and numerous other centers account for the majority of monumental constructions in the region.¹ After this time, few sites show evidence for continued mound building, and regional population numbers following AD 1300 were in sharp decline, resulting in the virtual abandonment of Cahokia and the American Bottom by Mississippian groups by the mid-14th century (Emerson and Hedman 2016; Kelly 2008; Milner 1998; Pauketat and Lopinot 1997).

Work at both floodplain and nearby upland locations shows significant levels of population movements and reorganizations that begun in pre-Mississippian times and continued throughout the Mississippian period (Alt 2002; Barrier and Horsley 2014; Emerson 1997; Kelly 1990; Koldehoff and Galloy 2006; Mehrer 1995; Mehrer and Collins 1995; Milner 1990, 1998; Pauketat 2003; Quinn and Barrier 2014; Welch 2006). Just prior to AD 1050, the largest known population concentrations were present at Cahokia and possibly a few other sites in the northern American Bottom, as well as at the Pulcher site several kilometers to the south (Kelly 1993). Located 15 km south of Pulcher, the Washausen site (Fig. 1) has been a suspected location of

¹ Mound and plaza construction continued at Cahokia after AD 1200 during the Moorehead phase, and the labor-intensive construction of the site's palisades did not begin until the 13th century (Kelly and Brown 2014; Krus 2016; Milner 2007).

early mound building since its initial discovery in the 1970s (Porter & Linder 1974). Since then, Washausen has received increased attention from a handful of archaeologists only in the last several years.

Recent field investigations at the site have included the production of a topographic map, surface collections, a series of geophysical prospection surveys, and excavations (Bailey 2007; Barrier 2014; Barrier & Horsley 2014; Betzenhauser 2011; Kelly 2006; Stahlmann et al. 2004).

Evidence of occupations at Washausen extends over an area measuring at least 4.5 hectares and contains remnants of three earthen mounds, a central plaza, and numerous structures and other sub-surface features (Barrier and Horsley 2014). Although the total area excavated at the site is less than that for Cahokia and several other regional sites, the integration of extensive geophysical analyses into the research design has helped produce one of the most complete views of an early Mississippian mound-town for the region (Barrier and Horsley 2014; Horsley et al. 2014). This is most exemplified by the recognition and mapping of substantial village occupations associated with the mounds and plaza (Fig. 2).

After ground-truthing excavations, geophysical data for basin sizes suggest that Washausen was home to a peak population approaching 300 individuals (see Barrier & Horsley 2014 for a discussion of population estimates). A majority of structures are grouped around several small open spaces that together resemble what archaeologists call courtyard groups (Fig. 2). These are thought to have been the central residential spaces of corporate kin groups and are commonly seen at Mississippian sites throughout eastern North America, and were present

Fig. 2. Map of the Washausen settlement showing location of mounds A, B, and C; the central plaza; the distribution of basin structures; and the location of structures 1-5. Outer border shows extent of 2011 magnetometer survey. Dashed circle shows approximate location of Mound C (adapted from Barrier and Horsley 2014:Figure 4).

locally as early as the 10th century (Alt 2006; Barrier 2011; Barrier and Kassabaum, *in press*; Boudreaux 2013; Kelly 1990, 2000; Mehrer & Collins 1995; Nelson 2014; Pauketat 2003; Wilson 2008, 2010). At Washausen, courtyard groups surround the mound-and-plaza complex,

leaving the hallmark plan of a Mississippian town (Holley 1999; Kidder 2004; Lewis et al. 1998). Surface-collected and excavated materials depict a primary occupation dating to the local Mississippian transition of the 11th century AD (Bailey 2007; Betzenhauser 2011; Kelly 2006; Milner 1998:182; Stahlman et al. 2004).

2.1 Dating Occupations at Washausen

The American Bottom regional chronology is composed of a series of phase taxonomic units making up larger cultural-time periods (see Fortier et al. 2006; Hall 1991) (Fig. 3). Based largely on seriated ceramic assemblages and a suite of calibrated radiocarbon assays, ceramic phase designations provide a robust method for ordering late prehistoric assemblages to relatively fine stretches of time. The chronology also includes parallel phase designations for the 10th and 11th centuries based upon differences in ceramic attributes between sites in the northern (around Cahokia) and central (around Pulcher) portions of the floodplain (Kelly 1990, 2002; Pauketat 1994:55).

The ceramic assemblage from Washausen is taxonomically assigned to the Lindeman-Lindhorst phases. These phases are dated to the calendar years AD 1000-1100 and considered contemporaneous to the Edelhardt-Lohmann phases at Cahokia (Bailey 2007; Barrier 2014; Betzenhauser 2011; Kelly 2006). A majority of Washausen's assemblage is tempered with crushed limestone (>75%), a trait that dominates early Mississippian ceramic assemblages in this area (see Kelly 2002). Just over 10% of Washausen's sherds are shell-tempered, and a minority are tempered with grog, grit, or mixed materials. Surface treatments include cordmarked, plain, red-slipped, and polished/brushed varieties.

An 11th century designation for Washausen confirms the site's status as a location of early mound building dating to the Mississippian transition. However, extant data suggest a briefer pulse of activities that saw the aggregation of significant populations and their subsequent abandonment of this location (see Barrier and Horsley 2014). Based upon the surface-collected ceramics, Kelly (2006) has proposed that major occupations at the site were short-lived,

spanning perhaps 50 years or fewer, or only a generation or two. While a small population may have occupied an elevated ridge abutting the banks of Fountain Creek in the northern portion of the site for slightly longer (Betzenhauser 2011; see also Barrier 2014:53-59), multiple lines of evidence have been garnered that lend support to Kelly’s brief-occupation hypothesis (Bailey 2007; Barrier 2014; Barrier and Horsley 2014; Betzenhauser 2011). These include a paucity of overlapping or superimposed structures, consistent pottery from both surface- and excavated-assemblages, the relatively small size of the site's mounds, the low density of surface materials, and the “clear” village patterning inferred from geophysical data (i.e., in contrast to a palimpsestic image that would be indicative of multi-component occupations).

A.D.	Culture	Phase			
1400	Oneota	Vulcan			
		Sand Prairie	Groves / Bold Counselor		
1300	Mississippian	Moorehead			
1200		Stirling			
1100	Emergent Mississippian / Terminal Late Woodland	Lohmann		Lindhorst	Pulcher Tradition
1050		Edelhardt	Late Bluff Tradition	Lindeman	
1000	Merrell	George Reeves			
	Loyd	Range			
900	Collinsville	Dubois

Fig. 3. American Bottom chronology (adapted from Fortier et al. 2006:Figure 4; Kelly 2008:Figure 37).

As Washausen’s settlement history is important for understanding region-wide demographic shifts associated with the growth of much larger settlements like Cahokia and Pulcher (Barrier and Horsley 2014), more precise dating of the occupation and abandonment of the site is needed. Unfortunately, as Kelly (2002:143, 145) notes, in the Pulcher-Washausen area there is a relative “continuity of the ceramic assemblage from the Emergent Mississippian into early Mississippian.” Thus, Bayesian modeling of radiocarbon dates is used in this study to provide a method for dating the timing and tempo of major occupations at the site. These modeled AMS dates for Washausen, presented below, establish a rapid sequence of population aggregation and village abandonment early in the Mississippian period.

3. Radiocarbon Dates and their Excavated Contexts

Results of the 2011 magnetometer survey (Barrier and Horsley 2014) were used to guide an excavation strategy developed to target and sample intact subsurface features. Five basin structures were targeted as a result (Fig. 2). Two structures located east of Mound B, both from

separate courtyard groups, were sampled with test unit excavations. In addition, three structures located south of Mound B within a smaller/secondary plaza were partially excavated. Botanical remains recovered during excavations were identified by Kathryn Parker, who also consulted with the author during selection of specimens for AMS dating. A brief description of the five excavated structures and dated contexts is provided below (see Tables 1 and 2).² Calibrated dates are reported as ranges with end points rounded to the nearest five years.

Structure 1. Structure 1 is centrally located within a secondary plaza south of Mound B. Thirteen 1x1 meter units were positioned to expose three edges of the basin beneath the plowzone. A 2x6 meter trench was then excavated beneath plowzone to expose the structure's floor. Due to bioturbation and sandy subsoils at the base, no intramural features were discernable during excavations, although several possible postholes were noted.

Structure 1's basin measured approximately 3.7 meters along its long axis, with an average depth of 0.87 meters below surface (Fig. 4). Multiple fill layers were encountered within this basin. The initial major layer (Zone 3), consisting of a dark grayish brown matrix, was overlaid by a layer (Zone 2) that consisted of very dark grayish brown sediments. Between these zones in the south end of the basin were other fills with high concentrations of charcoal and burned clay.

² All radiocarbon dates (except 11WAP210) were determined from short-lived annual plant species. Sample processing and dating were conducted by two labs: the Accelerator Mass Spectrometry Laboratory, University of Arizona; and the Center for Applied Isotope Studies, University of Georgia (see Table 1). Calibration and Bayesian modeling of Washausen's radiocarbon dates were conducted using OxCal v4.2.4 (Bronk Ramsey 2013) and the IntCal13 atmospheric curve (Reimer et al. 2013).

Lab #	Sample (see Table 2)	Radioca rbon Age (BP)	$\delta^{13}\text{C}$ (‰)	Calibrated Date Range (95.4% confidence) ^{c,d}	Calibrated Median Age	Posterior Density Estimate - Model 3 (95.4% confidence) ^{c,d,e}	Modeled Median Calibrated Age - Model 3
^a AA102 733	11WAP2 01	956 ± 37	-11. 30	cal AD 1020– 1160	cal AD 1094	<i>cal AD 1040–1155</i> (A_i = 107.3)	<i>cal AD 1109</i>
^a AA102 734	11WAP2 02	963 ± 37	-9.8 0	cal AD 1015– 1160	cal AD 1092	<i>cal AD 1030–1155</i> (A_i = 105.3)	<i>cal AD 1109</i>
^a AA102 735	11WAP2 03	937 ± 38	-25. 00	cal AD 1020– 1185	cal AD 1099	<i>cal AD 1045–1160</i> (A_i = 110.5)	<i>cal AD 1109</i>
^a AA102 736	11WAP2 04	951 ± 37	-9.1 0	cal AD 1020– 1165	cal AD 1096	<i>cal AD 1040–1160</i> (A_i = 108.4)	<i>cal AD 1109</i>
^a AA102 737	11WAP2 05	909 ± 40	-25. 10	cal AD 1030– 1210	cal AD 1114	<i>cal AD 1050–1160</i> (A_i = 107.4)	<i>cal AD 1109</i>
^a AA102 738	11WAP2 06	1091 ± 76	-25. 20	cal AD 720– 1150	cal AD 993	not modeled	<i>cal AD 1109</i>
^a AA102 739	11WAP2 07	966 ± 64	-9.3 0	cal AD 970– 1220	cal AD 1087	<i>cal AD 1030–1160</i> (A_i = 119.5)	<i>cal AD 1109</i>
^a AA102 740	11WAP2 08	959 ± 57	-25. 40	cal AD 990– 1210	cal AD 1092	<i>cal AD 1035–1160</i> (A_i = 117.1)	<i>cal AD 1109</i>
^a AA102 741	11WAP2 09	952 ± 37	-9.3 0	cal AD 1020– 1165	cal AD 1095	<i>cal AD 1040–1160</i> (A_i = 108.2)	<i>cal AD 1109</i>
^a AA102 742	11WAP2 10	986 ± 39	-26. 80	cal AD 990– 1155	cal AD 1061	<i>cal AD 1020–1155</i> (A_i = 92.3)	<i>cal AD 1109</i>
^b A20856	11WAP2 11	839 ± 25	-23. 77	cal AD 1160– 1260	cal AD 1205	not modeled in Model 3	<i>cal AD 1109</i>
^b A20857	11WAP2 12	886 ± 25	-26. 40	cal AD 1045– 1220	cal AD 1158	<i>cal AD 1050–1160</i> (A_i = 66.5)	<i>cal AD 1106</i>

^a Accelerator Mass Spectrometry Laboratory, University of Arizona.

^b Accelerator Mass Spectrometer Facility, Center for Applied Isotope Studies, University of Georgia.

^c Calibrated using OxCal v4.2.4 (Bronk Ramsey 2013) and the IntCal13 atmospheric curve (Reimer et al. 2013); displaying entire 95.4% confidence range.

^d End points rounded to the nearest five years.

^e Model 3 individual date agreement index (A_i) shown in parentheses.

Table 1. AMS radiocarbon dates from Washausen and Bayesian model (Model 3) results.

Sample (see Table 1)	Sample Details
11WAP201	Carbonized thatch/grass stems recovered from thin, organic-rich lens at base of Structure 1 basin. Piece-plotted in-situ and hand excavated.
11WAP202	Carbonized thatch/grass stems recovered at contact between zones 2 and 3 in Structure 1 basin fills. Piece-plotted in-situ and hand excavated.
11WAP203	Carbonized erect knotweed seeds (<i>Polygonum erectum</i>) recovered from Zone 5 of Structure 2 basin fills. Seeds selected from flotation sample heavy fraction.
11WAP204	Carbonized maize fragment (<i>Zea mays</i>) recovered from Zone 8 of Structure 2 basin fills. Fragment selected from flotation sample heavy fraction.
11WAP205	Carbonized Eastern Agricultural Complex (EAC) seeds (<i>P. erectum</i> , <i>Chenopodium berlandieri</i>) recovered from thin lens lining base of hearth in floor of Structure 3. Seeds selected from flotation sample heavy fraction.
11WAP206	Carbonized EAC seeds (<i>Iva annua</i> , <i>C. berlandieri</i>) recovered from pit feature fills inside Structure 3. Seeds selected from flotation sample heavy fraction.
11WAP207	Carbonized maize fragment (<i>Z. mays</i>) recovered from Zone 2 of Structure 4 basin fills. Fragment selected from flotation sample heavy fraction.
11WAP208	Carbonized maize fragment (<i>Z. mays</i>) recovered from Zone 2 of Structure 4 basin fills. Fragment selected from flotation sample heavy fraction.
11WAP209	Carbonized maize fragment (<i>Z. mays</i>) recovered from Zone 1 of Structure 5 basin fills. Fragment selected from flotation sample heavy fraction.
11WAP210	Oak charcoal fragment (<i>Quercus</i> sp.) recovered from single-set post feature in floor of Structure 5. Fragment selected from flotation sample heavy fraction.
11WAP211	Carbonized EAC (<i>C. berlandieri</i>) seeds recovered from Zone 8 of Structure 1 basin fills. Fragment selected from flotation sample heavy fraction.
11WAP212	Carbonized EAC (<i>C. berlandieri</i>) seeds recovered from Structure 3 basin fills. Seeds selected from flotation sample heavy fraction.

Table 2. Details of organic samples from Washausen submitted for AMS radiocarbon dating.

Fig. 4. Structure 1 west profile, showing major zones of basin fill and stratigraphic context of radiocarbon samples (“rr” = rodent run/bioturbation).

Two AMS dates were run from Structure 1 fills. Clumps of thatch/grass stems were encountered in a thin, organic-rich lens directly beneath Zone 3 at the basin's floor. A sample from this context (11WAP201) dated to cal AD 1025-1150 (at the 1-sigma level; 956 ±37 BP). A second sample of thatch/grass stems (11WAP202) encountered from the contact between zones 2 and 3 dated to cal AD 1020-1150 (at the 1-sigma level; 963±37 BP).

Structure 2. Structure 2 lies on the eastern edge of the secondary plaza at Washausen. Twelve 1x1 meter units were placed to expose all four basin edges beneath the plowzone. A 1x5 meter north-south trench was then excavated to its base. Like Structure 1, this basin terminated in sandy subsoils, and the effects of bioturbation limited the ability to delineate intramural features. However, three potential postholes were noted along the northern edge of the basin that may reflect a line of single-set wall posts.

Structure 2 measured approximately 5 meters long and 3.4 meters wide. Average basin depth was 0.95 meters below surface (Fig. 5). Numerous fill layers were encountered with some containing high concentrations of charcoal and other organic remains. Large fragments of broken pottery, chunks of limestone, and animal bones were present in some fills, especially in layers underlying Zone 1. The bottom layers (zones 7 and 8) were composed of dark brown fills. A maize (*Zea mays*) fragment from Zone 8 (11WAP204) dated to cal AD 1030-1150 (at the 1-sigma level; 951±37 BP). Overlying zones 7 and 8 were several layers consisting of mixed dark fills. Zone 5 matrix had an especially high organic material content. From this zone, erect knotweed (*Polygonum erectum*) seeds (11WAP203) dated to cal AD 1035-1055 (at the 1-sigma level; 937±38 BP). The upper fill layer (Zone 1) was less organically-rich and lacked the abundance of large artifact fragments that were present in some of the underlying fills, and appears to have backfilled via natural erosion. Chenopod (*Chenopodium berlandieri*) seeds (11WAP211) from Zone 1 dated to cal AD 1170-1225 (at the 1-sigma level; 839±25 BP).

Structure 3. Structure 3 is located on the western edge of Washausen's secondary plaza. A total of eleven 1x1 meter units were situated to expose multiple edges of this basin beneath the plowzone. An east-west running 1x3 meter trench was then excavated to the base of this

structure. This excavation strategy was successful in confirming the structure's T-shaped morphology (Fig. 6), a form originally suspected from the magnetometer data (Barrier and Horsley 2014). At Cahokia and a handful of other regional sites, T-shaped structures, although

Fig. 5. Structure 2 west profile, showing major zones of basin fill and stratigraphic context of radiocarbon samples (“rr” = rodent run/bioturbation).

Fig. 6. Structure 3 excavation locus; planview showing morphology of T-shaped structure, with east-west 1x3 meter trench excavated to structure floor and showing location of intramural features (right); combined north and west profiles of pit feature, showing pit fill zones and stratigraphic context of radiocarbon sample (top-left); north profile of hearth, showing thin lens (drawn thicker here for visualization) of carbonized remains and context of radiocarbon sample, and overlaying

yellow clay cap (bottom-left); note: radiocarbon sample 11WAP212 recovered from basin fills is not shown.

rare, are known from AD 1050-1200 and are thought to have served specialized, ritual functions (Baltus and Baires 2012; Pauketat 2012:123-130, Table 6.6; Pauketat et al. 2012).

Structure 3's basin measured approximately 7.5 meters along its long axis, and had an average depth of 0.80 meters below surface. Its T-extension stretched roughly 1.55 meters beyond the western edge of the structure. Fills within the basin consisted of a homogenous and very dark grayish brown matrix, likely backfilled through natural erosion.

Unlike structures 1 and 2, the base of Structure 3 terminated in clayey subsoils leaving intramural features easily discernable. A series of five postholes were identified along the far western wall of the T-extension, with at least two of these showing signs of repair or replacement. T-shaped structures with individually-set posts (instead of wall trenches) are rare or unknown from the American Bottom. However, the use of single-set posts is known to have continued in the Pulcher-Washausen region into the Mississippian period.

Three AMS dates were submitted from Structure 3, two resulting from intramural features and one from overlying fills. Just inside the line of postholes in the building's T-extension was a circular pit that measured 62 cm in diameter and approximately 67 cm deep. Marshelder (*Iva annua*) seeds recovered from a lens of dark organic materials near the base of the pit (11WAP206) dated to cal AD 780-1025 (at the 1-sigma level; 1091 ± 76 BP). An interior hearth encountered directly east of the pit produced a sample (11WAP205) that dated to cal AD 1045-1165 (at the 1-sigma level; 909 ± 40 BP). This date was derived from erect knotweed (*Polygonum erectum*) and chenopod (*C. berlandieri*) seeds recovered from a 1-2 cm thick lens of carbonized organic remains that lined the hearth's bowl-shaped base. This basal lens was subsequently capped with yellow clay and likely marks the final use of this hearth and potentially the T-shaped structure. A third AMS sample was run from chenopod (*C. berlandieri*) seeds (11WAP212) taken from overlying basin fills, and dated to cal AD 1055-1210 (at the 1-sigma level; 886 ± 25 BP).

Structure 4. Structure 4 is located east of Mound B in a village area that contains dozens of basin structures arranged into courtyard groupings. A 1x2 meter trench was placed to clip the northern wall along its long axis and to sample basin fills. Five individually-set wall posts arranged in an east-west line were encountered at the structure's floor (see Barrier and Horsley 2014:Figure 5).

The average depth of Structure 4's basin was measured at 0.66 meters below surface (Fig. 7). Two major fills zones were documented. The bottom fills (Zone 2) consisted of an organically-rich and very dark brown matrix that averaged 15 cm in thickness. Two AMS dates were run on maize (*Z. mays*) fragments selected from different areas within Zone 2. One sample (11WAP207) dated to cal AD 1020-1155 (at the 1-sigma level; 966±64 BP), and another (11WAP208) dated to cal AD 1020-1155 (at the 1-sigma level; 959±57 BP). Overlying Zone 2 were fills (Zone 1) that consisted of a homogenous and very dark grayish brown matrix.

Fig. 7. Structure 4 east profile, showing major zones of basin fill and stratigraphic contexts of radiocarbon samples.

Structure 5. Structure 5 is located in the far southeastern portion of the site. A 1x2 meter trench was placed to locate the western wall of the basin along its long axis and to sample fill materials. The average depth of Structure 5 measured 0.86 meters below surface (Fig. 8). Six individually-set posts were visible that mark the location of the structure's western wall, with at least one showing signs of repair or replacement. Additionally, 3-4 internal posthole features were encountered.

Two AMS dates were run from Structure 5, one from an interior posthole and another from basin fills. The posthole, which extended 34 cm below the basin floor, was backfilled with the same sediments that composed the overlying fills and contained small amounts of ceramic fragments, limestone, and wood charcoal. A sample of oak charcoal (11WAP210) dated to cal

Fig. 8. Structure 5 excavation locus; planview showing intramural features at structure floor (dashed line shows western edge of basin) (left); south profile of post feature, showing context of radiocarbon sample (top-right); Structure 5 south profile, showing major zones of basin fill and stratigraphic context of radiocarbon sample (bottom-right).

AD 1000-1150 (at the 1-sigma level; 986 ± 39 BP). A second date was run from maize (*Z. mays*) fragments collected from overlying basin fills that consisted of a very dark grayish brown matrix with yellow clay mottling throughout. This sample (11WAP 209) dated to cal AD 1030-1150 (at the 1-sigma level; 952 ± 37 BP).

4. Results: Chronological Modeling of Washausen's Radiocarbon Dates

Bayesian modeling of radiocarbon dates provides a means to build robust and precise chronologies for dating (pre)historic events and for comparing them at regional and larger scales (Bayliss 2009; Bronk Ramsey 2009a). Bayesian procedures were first adopted by archaeologists in England and have increasingly been used by researchers for other world regions (Bayliss 2015), including archaeologists working in the southeastern and midwestern United States (e.g., see Cobb et al. 2015; Herrmann et al. 2014; Kennett and Culleton 2010; Krus 2016; Krus, Cook, and Hamilton 2015; Krus, Schilling, and Monaghan 2013; Pluckhahn et al. 2015; Schilling 2010, 2013; Smith 2009; Wallis et al. 2015). These methods can produce sequences with greater chronological precision as statistical modeling of calibrated dates is informed by other kinds of archaeological information (for detailed treatments of Bayesian methods see Bayliss et al. 2007; Bayliss and O'Sullivan 2013; Bronk Ramsey 1995, 2009a; Buck et al. 1996). Importantly, the Bayesian approach goes beyond estimating periods of site use based upon visual inspection of dated samples and their error ranges, to statistical modeling of the timing and span of groups of events and their associated archaeological contexts (Bayliss et al. 2007:5).

In the Washausen case study it is important to consider the contexts from which the dated organic samples were obtained, as this information should influence how modeling is done and how results are interpreted (Tables 1 and 2). Except for one carbonized oak charcoal fragment, all samples were carbonized specimens of short-lived plant species including thatch/grass stems, maize fragments, or non-fragmented Eastern Agricultural Complex seeds³. The benefit of dating short-lived botanical samples is that they do not present the potential of being from old wood or slowly maturing species.

As all samples were recovered from structures, including intramural features and basin fills, the models describe events associated with building use and post-depositional processes.

³ "Eastern Agricultural Complex" (EAC) refers to a suite of seed plants domesticated and/or cultivated in pre-Columbian eastern North America. EAC crops include a type of squash (*Cucurbita pepo* ssp. *ovifera*), sunflower (*Helianthus annuus*), marshelder (*Iva annua*), chenopod (*Chenopodium berlandieri*), erect knotweed (*Polygonum erectum*), maygrass (*Phalaris caroliniana*), and little barley (*Hordeum pusillum*) (Fritz 1990; Smith 2011).

Sample 11WAP206, obtained from a pit in Structure 3, produced the oldest date for the site. Since pole-and-thatch buildings were short-lived constructions (Milner; 1998:122-123; Pauketat 2003; Pauketat and Lopinot 1997), sample 11WAP206 is treated as an outlier and has been removed from the analyses (see Bronk Ramsey 2009b:3). Sample 11WAP205 was recovered from a hearth also within Structure 3. This sample is associated with the hearth's final use and considered a good context for dating terminal occupation of the building itself.

All other samples were obtained from basin fills. Unless intentionally backfilled with debris brought from other locations, abandoned basins would have accumulated eroding sediments containing refuse from activities that took place in their immediate vicinity (Mehrer 1995; Milner 1998:91-98; Pauketat 1989, 2003). Thus, these samples (especially those stratigraphically lowest) are assumed to date activities associated with structure use and, by extension, the age of occupation. Dated thatch from Structure 1 (especially Sample 11WAP201) likely originated from its dismantling/collapse. Structure 2 samples 11WAP203 and 11WAP204 date apparent anthropogenic deposits that were in place before significant amounts of eroded fills could accumulate, and provide a measure for the age of Structure 2's abandonment.

Three models were developed that treat the dated events as single phases, bounded by undated start and end boundaries that provide an estimated length for each phase. Posterior density estimates are presented as ranges with endpoints rounded to the nearest five years. The models' posterior estimates are interpretive, rather than absolute, and employ radiocarbon dates from five excavated structures. As such, the estimates are subject to change as new excavations are carried out and additional contexts are dated (Bayliss et al. 2007:5).

Models 1 and 2 apply uniform boundaries with the assumption that all events were equally likely to have occurred at any time between the start and the end of the phase. A good fit exists between Model 1 and the radiocarbon data ($A_{\text{model}} = 93.2$).⁴ According to this model, however, the estimated duration of Washausen's major occupations is longer than expected based

⁴ The agreement index presents a measure of fit between a model and data, and models with A_{model} values greater than 60 are considered valid (Bronk Ramsey 1995:427-428).

upon extant archaeological information about the site, up to a maximum of 239 (95% probability) or 170 years (68% probability). The median length of the phase obtained from Model 1 is 110 years.

Additional scrutiny of the dated samples can help determine which dates, if any, are erroneous and affecting the posterior estimates, causing Model 1 to be importantly wrong (see Bayliss et al. 2007:6-7; Bronk Ramsey 2009b). One sample, 11WAP211, is a candidate for removal as it results from a stratigraphic layer overlying and assumed to postdate two dated contexts that provide better measures of the use and abandonment of Structure 2. This sample, obtained from the upper fill zone, and potentially resulting from some reuse activity at the site, produced a calibrated median age that is more than a full century younger than the median ages of the two underlying samples (Table 1). Thus, it likely provides a poor estimate for dating the use and abandonment of Structure 2 (see Bronk-Ramsey 2009b:2).

With 11WAP211 removed, Model 2 ($A_{\text{model}} = 107.9$) suggests that major occupations at Washausen began in *cal AD 1000-1145* (95% probability), and probably in *cal AD 1020-1050* (29% probability) or *cal AD 1060-1110* (39% probability). Examination of the probability curve for the start of the phase shows a multi-modal distribution, with one mode in the first half of the 11th century and another around *cal AD 1080* (with a median age of *cal AD 1068*). Based on other information like the presence of a T-shaped building (Structure 3), which are not known to pre-date AD 1050 elsewhere in the region, a mid- to late-11th century start date for the phase is likely (and Model 3, discussed below, corroborates this scenario). Occupations are estimated to have ended in *cal AD 1045-1190* (95% probability), and probably in *cal AD 1100-1165* (68% probability). The phase is estimated to have lasted *0-156 years* (95% probability), and probably *0-80 years* (68% probability). The median value for the length of the phase is 53 years, although the probability distribution's major modal value (approximately 10 years) could suggest a much shorter phase.

The dates were modeled a third time using a Tau boundary to account for the fact that the samples are more likely associated with the final use of structures and/or their abandonment and

infilling, rather than the initial construction of buildings or their earliest period of use. That is, the samples recovered from structure basin fills, or those associated with the final use of a hearth (as is the case for Sample 11WAP205), are assumed to relate behaviorally to activities that took place within or nearby each structure during or just after terminal occupations. This is especially the case for short-lived plant species as radiocarbon measurements for these materials date the harvest event, which should not pre-date their use/loss by more than 1-2 years (Schilling 2010:249-250). As a consequence, the dates are expected to cluster at the end of Washausen's occupations with some perhaps being slightly older. To control for the expectation of a non-uniform phase or a non-normal distribution, Model 3 uses a Tau boundary with a rising exponential distribution (see Bronk Ramsey 2008, 2009a:345-347, Figure 5), and produces a strong fit with the data ($A_{\text{model}} = 108.7$) (Fig. 9).

By many measures Models 2 and 3 are not importantly different, although Model 3 is probably most correct when the dated contexts and site formation processes are taken into account. According to Model 3, terminal occupations were ongoing between *cal AD 1050-1150*

Fig. 9. Probability distributions (for Bayesian Model 3) of calibrated AMS radiocarbon dates from Washausen (+ = median; $\bigcirc$ = mean).

(95% probability), and probably between *cal AD 1075-1130* (68% probability) (Fig. 10). Both the mean and median of the Tau boundary's distribution, approximately *cal AD 1100*, provide good statistical estimate of a *terminus post quem* for the average age of the dated materials (i.e., the beginning of the terminal phase of plant harvest). The interval of time between this date (Tau boundary) and the end of the phase (complete abandonment) was apparently brief. The mean and median ages for the end of the phase lie around *cal AD 1130* (Fig. 11). The phase may have lasted for a much shorter stretch of time however, as the time constant's posterior has a modal value around *15 years* with a right-skewed distribution (Fig. 12).⁵

5. Discussion

Bayesian modeling of Washausen's radiocarbon dates provides a robust method for dating the occupation of this mound-town. Ceramic data suggest that major occupations of the site spanned a period of potentially 50 years or less, sometime in the 11th century AD. Other extant archaeological information about the site supports a brief-occupation hypothesis (see Section 2.1). Difficulties arise, however, if trying to pinpoint exactly when during the 11th century Washausen rose to prominence. A precise chronology for the construction and abandonment of this early mound-town is critical for understanding the demographic histories of regional populations during a time of urban transitions in the American Bottom. Bayesian modeling of Washausen's radiocarbon dates provides an additional means for dating the site's occupations, and serves as an independent test of the brief occupation hypothesis. Additionally, it gives the site's chronology real calendar dates and charts a history of events according to it.

Multiple models have been produced that confirm the site's status as the location of an early Mississippian mound-town. Models 2 and 3 support the hypothesis that major occupations

⁵ When sample 11WAP212 is removed from Model 3, the posterior density's mode for this timescale shifts to a value of less than *five years* with a right-skewed distribution, and supports a hypothesis that Washausen was abandoned rapidly, possibly as a single event. Sample 11WAP212 was recovered from homogenous brown fills within Structure 3's basin, which appear to have accumulated slowly through natural erosion. The best measure of final use of Structure 3 is provided by sample 11WAP205, determined from EAC annuals recovered from a thin lens of carbonized organic remains lining the base of a hearth that was capped with yellow clay. Sample 11WAP212's calibrated median age is approximately a half-century younger (44 years) than the median age of seeds burned during the hearth's final use-event.

at Washausen started during the late 11th century, or during the local Lindhorst phase (or the Lohmann phase at Cahokia). The modeled data also suggest that abandonment of the settlement took place no later than the early Stirling phase. Model 3, probably the best model for assessing

Fig. 10. Probability distribution for the Tau boundary, Model 3; underlying brackets display the 68.2 % and 95.4% confidence ranges (+ = median; ○ = mean). Date ranges rounded to nearest five years.

Fig. 11. Probability distribution for the End boundary, Model 3; underlying brackets display the 68.2 % and 95.4% confidence ranges (+ = median; $\bigcirc$ = mean). Date ranges rounded to nearest five years.

Fig. 12. Probability distribution of the Tau distribution's time constant, Model 3; underlying brackets display the 68.2 % and 95.4% confidence ranges (+ = median; = mean). Date ranges rounded to nearest five years.

the real timing of events, estimates that terminal occupations were ongoing by AD 1100. It also suggests that final events at the site ended soon after this date.

Estimating the initiation of major occupations is possible by tracking back from the dates produced by Model 3. As discussed above (see Section 2.1), some evidence exists that suggest a small (Lindeman phase) population may have resided near the banks of a creek during the early 11th century (see Betzenhauser 2011). This would not be unexpected, as the initial occupants at late prehistoric sites throughout the region often built upon high ground near streams and productive wetlands (see Dalan et al. 2003; Milner and Oliver 1999; Pauketat 2004; Schroeder 1997, 2004).

From a site-wide perspective, however, the preponderance of evidence reveals few signs that buildings were reconstructed atop (or superimposed upon) earlier structures (Barrier and Horsley 2014), a practice common at American Bottom sites where residence was sustained over longer stretches of time (Pauketat 1989, 2003, 2012:148). Pole-and-thatch buildings in the region are thought to have had use-lives shorter than 20 years before they would have succumbed to rot requiring substantial reconstructions or abandonment. Milner (1986, 1998:122-123) has used structure longevity estimates as low as five and 10 years to estimate regional population sizes. Pauketat (1989, 2003; Pauketat and Lopinot 1997) has considered longevity estimates between 10 and 17 years for similar calculations for village sites, and Barrier and Horsley (2014) have used 10- and 15-year estimates for Washausen. Since it appears that buildings at Washausen were rarely reconstructed in their original locations, resident courtyard group tenure likely did not extend beyond the maximum use-life of pole-and-thatch buildings, or approximately 15 years. If

residents rebuilt their homes adjacent to abandoned basins, then group residency could have extended for roughly twice this duration. A scenario of multiple rebuilding episodes much beyond this is not congruent with other information for the site, including the spatial patterning of basin structures, the site's ceramic assemblage, or the modeled radiocarbon dates.

If the structure longevity figures are taken into account with the radiocarbon data, then a chronology for major occupations at Washausen that begins sometime in the second half of the 11th century, or during the early Mississippian Lindhorst phase, is supported. Additionally, there is reason to suspect that occupations lasted for as short a span as 30 years or less. The modeled radiocarbon data also suggest that site abandonment began sometime around or shortly following the year AD 1100. Although it cannot be ruled out that emigration from the site was drawn out over a period lasting a couple of decades, both models 2 and 3 can be used to support the hypothesis that Washausen was abandoned in rapid fashion within a few years' time, or potentially as a single event. As the ceramic assemblage lacks pottery diagnostic of the 12th century Stirling phase (Bailey 2007; Barrier 2014; Betzenhauser 2011; Kelly 2006), a rapid abandonment scenario is likely.

In light of this, data from Washausen provide information about town formation and abandonment during the early Mississippian transition. As Washausen formed through a fission-fusion aggregation process (see Barrier and Horsley 2014), the decision of individuals to leave their village – as multiple corporate entities or *in toto* – demonstrates the continued use of residential movements within a broader sedentary tradition, a process known for village sequences in the US Southwest and elsewhere (see Bernardini 2005; Birch 2012; Birch and Williamson 2015; Fowles 2013; Schachner 2010). The Washausen case is informative for scholars of early ancient cities, however, as this demographic pattern is shown here to have been active within a social landscape that now included urbanizing places like Cahokia and the expanding Pulcher settlement, which likely experienced growth until around AD 1150 (Kelly 1993, 2002, 2014). Although the means are not currently available to definitively track the subsequent movements of residents leaving Washausen, one intriguing scenario is that this community (or subsets of it) joined others at these larger settlements. The expansion of Cahokia

through means of population aggregation has been discussed by others (see Beck 2003, 2006; Beck et al. 2007; Brown and Kelly 2015; Kelly and Brown 2014; Pauketat 2004:155).

6. Conclusions

Knowledge of Washausen results from broad-scale geophysical survey, surface collections, excavations, and artifact analyses. These lines of evidence produce information that was utilized for Bayesian chronological modeling of radiocarbon dates from the site. The new site chronology supports the view that major occupations were brief. However, modeling provides greater dating precision than what has previously been available through use of ceramic remains alone, and places the start of major occupations within the late 11th century AD. The modeling procedures also give opportunity to consider the commencement and tempo of village abandonment – modeled results suggest that the settlement was abandoned by early in the 12th century. Together, the current evidence situates the history of events at the Washausen mound-town within a time of regional urbanization.

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References

Alt, Susan M.

2002 Identities, Traditions, and Diversity in Cahokia's Uplands. *Midcontinental Journal of Archaeology* 27:217-235.

2006 The Power of Diversity: The Roles of Migration and Hybridity in Culture Change. In *Leadership and Polity in Mississippian Society*, edited by Brian M. Butler and Paul D. Welch, pp. 289-308. Occasional Paper No. 33. Center for Archaeological Investigations, Southern Illinois University, Carbondale.

Anderson, David G.

1997 The Role of Cahokia in the Evolution of Southeastern Mississippian Society. In *Cahokia: Domination and Ideology in the Mississippian World*, edited by Timothy R. Pauketat and Thomas E. Emerson, pp. 248-268. University of Nebraska Press, Lincoln.

Anderson, David G, and Kenneth E. Sassaman

2012 *Recent Developments in Southeastern Archaeology: From Colonization to Complexity*. Society for American Archaeology Press, Washington, D.C.

Bailey, Katri Susanna

2007 Washausen Mound Center (11MO305) Ceramic Assemblage: Broken Pots from the Plaza. Unpublished Master's thesis, Department of Anthropology, Washington University, Saint Louis, Missouri.

Baltus, Melissa R., and Sarah E. Baires

2012 Elements of Ancient Power in the Cahokian World. *Journal of Social Archaeology* 12:167-192.

Barrier, Casey R.

2011 Storage and Relative Surplus at the Mississippian Site of Moundville. *Journal of Anthropological Archaeology* 30:206-219.

2014 The Mississippian Transition at the Washausen Site: Demography and Community at a Tenth-Eleventh Century A.D. Mound Town in the American Bottom, Illinois. Unpublished Ph.D. dissertation, Department of Anthropology, University of Michigan, Ann Arbor.

Barrier, Casey R., and Timothy J. Horsley

2014 Shifting Communities: Demographic Profiles of Early Village Population Growth and Decline in the Central American Bottom. *American Antiquity* 79:295-313.

Barrier, Casey R., and Megan C. Kassabaum

In press. Gathering in the Late Woodland: Plazas and Gathering Places as Performative Space at Two Sites from the Greater Southeastern US, A.D. 750-1000. In *The Archaeology of Everyday Matters*, edited by Sarah E. Price and Philip J. Carr. University Press of Florida, Gainesville.

Bayliss, Alex

2009 Rolling out Revolution: Using Radiocarbon Dating in Archaeology. *Radiocarbon* 51:123-147.

2015 Quality in Bayesian Chronological Models in Archaeology. *World Archaeology* 47:677-700.

Bayliss, Alex, Christopher Bronk Ramsey, Johannes van der Plicht, and Alasair Whittle

2007 Bradshaw and Bayes: Towards a Timetable for the Neolithic. *Cambridge Archaeological Journal* 17:1-28.

Bayliss, Alex, and Muiris O'Sullivan

2013 Interpreting Chronologies for the Mound of the Hostages and its Contemporary Irish Contexts. In *Tara: From the Past to the Future*, edited by Muiris O'Sullivan, pp. 26-104. Wordell and UCD School of Archaeology, Bray, Ireland.

Beck, Robin A., Jr.

2003 Consolidation and Hierarchy: Chiefdom Variability in the Mississippian Southeast.

American Antiquity 68:641-661.

2006 Persuasive Politics and Domination at Cahokia and Moundville. In *Leadership and Polity in Mississippian Society*, edited by Brian M. Butler and Paul D. Welch, pp. 19-42. Occasional Paper No. 33. Center for Archaeological Investigations, Southern Illinois University, Carbondale.

Beck, Robin A., Jr., Douglas J. Bolender, James A. Brown, and Timothy K. Earle

2007 Eventful Archaeology: The Place of Space in Structural Transformation. *Current*

Anthropology 48:833-860.

Beck, Robin A., Jr., and James A. Brown

2012 Political Economy and the Routinization of Religious Movements: A View from the Eastern Woodlands. *Archaeological Papers of the American Anthropological Association* 21:72-88.

Bernardini, Wesley

2005 *Hopi Oral Tradition and the Archaeology of Identity*. University of Arizona Press, Tucson.

Betzenhauser, Alleen

2011 Creating the Cahokian Community: The Power of Place in Early Mississippian Political Dynamics. Unpublished Ph.D. dissertation, Department of Anthropology, University of Illinois, Urbana.

Blitz, John H.

2010 New Perspectives in Mississippian Archaeology. *Journal of Archaeological Research* 18:1-39.

Birch, Jennifer

2012 Coalescent Communities: Settlement Aggregation and Social Integration in Iroquoian Ontario. *American Antiquity* 77:646-670.

Birch, Jennifer, and Ronald F. Williamson

2015 Navigating Ancestral Landscapes in the Northern Iroquoian World. *Journal of Anthropological Archaeology* 39:139-150.

Bocquet-Appel, Jean-Pierre

2008 Explaining the Neolithic Demographic Transition. In *The Neolithic Demographic Transition and its Consequences*, edited by Jean-Pierre Bocquet-Appel and Ofer Bar-Yosef, pp. 35-56. Springer, Dordrecht.

2011 The Agricultural Demographic Transition During and After the Agriculture Inventions.

Current Anthropology 52(S):S497-S510.

Boudreaux, Edmond A., III

2013 Community and Ritual within the Mississippian Center at Town Creek. *American*

Antiquity 78:483–501.

Bronk Ramsey, Christopher

1995 Radiocarbon Calibration and Analysis of Stratigraphy: The OxCal Program.

Radiocarbon 37:425-430.

2008 Deposition Models for Chronological Records. *Quaternary Science Reviews* 27(1-2):42-

60.

2009a Bayesian Analysis of Radiocarbon Dates. *Radiocarbon* 51:337-360.

2009b Dealing with Outliers and Offsets in Radiocarbon Dating. *Radiocarbon* 51:1023-1045.

2013 Oxcal 4.2 Manual. http://c14.arch.ox.ac.uk/oxcalhelp/hlp_contents.html (accessed August

2016).

Brown, James A., and John E. Kelly

2015 Surplus Labor, Ceremonial Feasting, and Social Inequality at Cahokia. In *Surplus: The Politics of Production and the Strategies of Everyday Life*, edited by Christopher T. Morehart and Kristin De Lucia, pp. 221-244. University Press of Colorado, Boulder.

Buck, C.E., W.G., Cavanagh, and C.D. Litton

1996 *Bayesian Approach to Interpreting Archaeological Data*. Wiley, Chichester.

Buikstra, Jane E., Lyle W. Konigsberg, and Jill Bullington

1986 Fertility and the Development of Agriculture in the Prehistoric Midwest. *American Antiquity* 51:528-546.

Cobb, Charles R.

2003 Mississippian Chiefdoms: How Complex? *Annual Review of Anthropology* 32:63-84.

2005 Archaeology and the “Savage Slot”: Displacement and Emplacement in the Premodern World. *American Anthropologist* 107:563-574.

Cobb, Charles R., and Brian M. Butler

2016 Mississippian Plazas, Performances, and Portable Histories. *Journal of Archaeological*

Method and Theory published online 08 March 2016.

Cobb, Charles R., Anthony M. Krus, and Dawnie W. Steadman

2015 Bayesian Modeling of the Occupation Span of the Averbuch Site in the Middle Cumberland Drainage, Tennessee. *Southeastern Archaeology* 34:46-56.

Cobb, Charles R., and Michael S. Nassaney

2002 Domesticating Self and Society in the Woodland Southeast. In *The Woodland Southeast*, edited by David G. Anderson and Robert C. Mainfort, Jr., pp. 525-539. University of Alabama Press, Tuscaloosa.

Cowgill, George L.

2004 Origins and Development of Urbanism: Archaeological Perspectives. *Annual Review of Anthropology* 33:525-549.

Creekmore, Andrew T, III, and Kevin D. Fisher [editors]

2014 *Making Ancient Cities: Space and Place in Early Urban Societies*. Cambridge University Press, Cambridge.

Dalan, Rinita A., George R. Holley, William I. Woods, Harold W. Watters, Jr., and John A. Koepke

2003 *Envisioning Cahokia: A Landscape Perspective*. Northern Illinois University Press, DeKalb.

Emberling, Geoff, Sarah C. Clayton, and John W. Janusek

2015 Urban Landscapes: Transforming Spaces and Reshaping Communities. In *Early Cities in Comparative Perspective, 4000 BCE-1200 CE*, edited by Norman Yoffee, pp. 300-316. The Cambridge World History, Vol III. Cambridge University Press, Cambridge.

Emerson, Thomas E.

1997 *Cahokia and the Archaeology of Power*. University of Alabama Press, Tuscaloosa.

Emerson, Thomas E., and Kristin M. Hedman

2016 The Dangers of Diversity: The Consolidation and Dissolution of Cahokia, Native North America's First Urban Polity. In *Beyond Collapse: Archaeological Perspectives on Resilience, Revitalization, and Transformation in Complex Societies*, edited by Ronald K. Faulseit, pp. 147-175. Occasional Paper No. 42. Center for Archaeological Investigations, Southern Illinois University, Carbondale.

Fletcher, Roland

2012 Low-Density, Agrarian-Based Urbanism: Scale, Power, and Ecology. In *The Comparative Archaeology of Complex Societies*, edited by Michael E. Smith, pp. 285-320.

Cambridge University Press, Cambridge.

Fortier, A.C., Thomas E. Emerson, and D. L. McElrath

2006 Calibrating and Reassessing American Bottom Culture History. *Southeastern Archaeology* 25:170-211.

Fowles, Severin M.

2011 Movement and the Unsettling of the Pueblos. In *Rethinking Anthropological Perspectives on Migration*, edited by Graciela Cabana and Jeffery Clark, pp. 45-67. University Press of Florida, Gainesville.

Fritz, Gayle J.

1990 Multiple Pathways to Farming in Precontact Eastern North America. *Journal of World Prehistory* 4:387-435.

Hall, Robert L.

1991 Cahokia Identity and Interaction Models of Cahokia Mississippian. In *Cahokia and the Hinterlands: Middle Mississippian Cultures of the Midwest*, edited by Thomas E. Emerson and R. Barry Lewis, pp. 3-34. University of Illinois Press, Urbana.

Herrmann, Edward W., G. William Monaghan, William F. Romain, Timothy M. Schilling, Jarrod Burks, Karen L. Leone, Matthew P. Purtill, and Alan C. Tonetti

2014 A New Multistage Construction Chronology for the Great Serpent Mound, USA. *Journal of Archaeological Science* 50:117-125.

Holley, George R.

1999 Late Prehistoric Towns in the Southeast. In *Great Towns and Regional Polities in the Prehistoric American Southwest and Southeast*, edited by Jill E. Neitzel, pp. 23-38. Amerind Foundation New World Studies Series No. 3. University of New Mexico Press, Albuquerque.

Horsley, Timothy, Alice Wright, and Casey Barrier

2014 Prospecting for New Questions: Integrating Geophysics to Define Anthropological Research Objectives and Inform Excavation Strategies at Monumental Sites. *Archaeological Prospection* 21:75-86.

Iseminger, William R.

2010 *Cahokia Mounds: America's First City*. History Press, London.

Jennings, Justin, and Timothy Earle

2016 Urbanization, State Formation, and Cooperation. *Current Anthropology* 57:474-493.

Kelly, John E.

1990 The Emergence of Mississippian Culture in the American Bottom Region. In *The Mississippian Emergence*, edited by Bruce D. Smith, pp. 113-152. Smithsonian Institution Press,

Washington D.C.

1992 The Impact of Maize on the Development of Nucleated Settlements: An American Bottom Example. In *Late Prehistoric Agriculture: Observations from the Midwest*, edited by William I. Woods, pp. 167-197. Studies in Illinois Archaeology 8. Illinois Historic Preservation Agency, Springfield.

1993 The Pulcher Site: An Archaeological and Historical Overview. *Illinois Archaeology* 5:434-451.

2000 The Nature and Context of Emergent Mississippian Cultural Dynamics in the Greater American Bottom. In *Late Woodland Societies: Tradition and Transformation across the Midcontinent*, edited by Thomas E. Emerson, Dale L. McElrath, and Andrew C. Fortier, pp. 163-175. University of Nebraska Press, Lincoln.

2002 The Pulcher Tradition and the Ritualization of Cahokia: A Perspective from Cahokia's Southern Neighbor. *Southeastern Archaeology* 21:136-148.

2006 Washausen and the "Big Bang": Understanding the Context of the Ripple Effect. Paper presented at the 63rd Annual Meeting of the Southeastern Archaeological Conference, Little Rock, Arkansas.

2008 Contemplating Cahokia's Collapse. In *Global Perspectives on the Collapse of Complex Systems*, edited by James A. Railey and Richard Martin Reycraft, pp. 147-168. Maxwell Museum of Anthropology, Albuquerque, New Mexico.

2014 Defining the Occupational Limits of the Pulcher Mound Group. Report submitted to the Heartlands Conservancy, Mascoutah, IL.

Kelly, John E., and James A. Brown.

2014 Cahokia: The Processes and Principles of the Creation of an Early Mississippian City. In *Making Ancient Cities: Space and Place in Early Urban Societies*, edited by Creekmore, Andrew T, III, and Kevin D. Fisher, pp. 292-336. Cambridge University Press, Cambridge.

Kennett, Douglas J., and Brendan J. Culleton

2010 A Bayesian Chronological Framework for Determining Site Seasonality and

Contemporaneity. In *Seasonality and Human Mobility along the Georgia Bight*, edited by Elizabeth J. Reitz, Irvy R. Quitmyer, and David Hurst Thomas, pp. 38-49. American Museum of Natural History Anthropological Papers, Number 97. American Museum of Natural History, New York.

Kidder, Tristram R.

2004 Plazas as Architecture: An Example from the Raffman Site, Northeast Louisiana.

American Antiquity 69:514-532.

2011 Transforming Hunter-Gatherer History at Poverty Point. In *Hunter-Gatherer Archaeology as Historical Process*, edited by Kenneth E. Sassaman and Donald H. Holly, Jr., pp. 95-119.

University of Arizona Press, Tucson.

Koldehoff, Brad, and Joseph M. Galloy

2006 Late Woodland Frontiers in the American Bottom Region. *Southeastern Archaeology* 25:275-300.

Krus, Anthony M.

2016 The Timing of Precolumbian Militarization in the U.S. Midwest and Southeast. *American*

Antiquity 81:375-388.

Krus, Anthony M., Robert Cook, and Derek Hamilton

2015 Bayesian Chronological Modeling of Sunwatch, a Fort Ancient Village in Dayton, Ohio.

Radiocarbon 57:965-977.

Krus, Anthony Michal, Timothy Schilling, and G. William Monaghan

2013 The Timing of Angel Mounds Palisade Construction: A Search for the Best Chronological Model. *Midcontinental Journal of Archaeology* 38:171-182.

Lewis, R. Barry, Charles Stout, and Cameron B. Wesson

1998 The Design of Mississippian Towns. In *Mississippian Towns and Sacred Spaces*, edited by R. Barry Lewis and Charles Stout, pp. 1-21. University of Alabama Press, Tuscaloosa.

Marcus, Joyce, and Jeremy A. Sabloff

2008a Introduction. In *The Ancient: New Perspectives on Urbanism in the Old and New World*, edited by Joyce Marcus and Jeremy A. Sabloff, pp. 3-26. School of American Research, Santa Fe, NM.

2008b Cities and Urbanism: Central Themes and Future Directions. *The Ancient: New Perspectives on Urbanism in the Old and New World*, edited by Joyce Marcus and Jeremy A. Sabloff, pp. 323-336. School of American Research, Santa Fe, NM.

McIntosh, Roderick J.

1991 Early Urban Clusters in China and Africa: The Arbitration of Social Ambiguity. *Journal of Field Archaeology* 18:199-212.

2005 *Ancient Middle Niger: Urbanism and the Self-Organizing Landscape*. Cambridge University Press, Cambridge.

McIntosh, Roderick J., and Susan Keech McIntosh

2003 Early Urban Configurations on the Middle Niger: Clustered Cities and Landscapes of Power. In *The Social Construction of Ancient Cities*, edited by Monica L. Smith, pp. 103-120. Smithsonian Institution Press, Washington, D.C.

Mehrer, Mark W.

1995 *Cahokia's Countryside*. Northern Illinois University Press, DeKalb.

Mehrer, Mark W., and James M. Collins

1995 Household Archaeology at Cahokia and its Hinterlands. In *Mississippian Communities and Households*, edited by J. Daniel Rogers and Bruce D. Smith, pp. 32-57. University of Alabama Press, Tuscaloosa.

Milner, George R.

1986 Mississippian Period Population Density in a Segment of the Central Mississippi River Valley. *American Antiquity* 51:227-238.

1990 The Late Prehistoric Cahokia Cultural System of the Mississippi River Valley: Foundations, Florescence, and Fragmentation. *Journal of World Prehistory* 4:1-43.

1998 *The Cahokia Chiefdom: The Archaeology of a Mississippian Society*. Smithsonian Institution Press, Washington D.C.

2004 *The Moundbuilders: Ancient Peoples of Eastern North America*. Thames and Hudson, New York.

2007 Warfare, Population, and Food Production in Prehistoric Eastern North America. In *North American Indigenous Warfare and Ritual*, edited by Richard J. Chacon and Rubén G. Mendoza, pp. 182-201. University of Arizona Press, Tucson.

Milner, George R., and James S. Oliver

1999 Late Prehistoric Settlements and Wetlands in the Central Mississippi Valley. In *Settlement Pattern Studies in the Americas: Fifty Years since Virú*, edited by Brian R. Billman and Gary M. Feinman, pp. 79-95. Smithsonian Institution Press, Washington D.C.

Nelson, Erin S.

2014 Intimate Landscapes: the Social Nature of the Spaces Between. *Archaeological Prospection* 21:49–57.

Ortmann, Anthony L., and Tristram R. Kidder

2013 Building Mound A at Poverty Point, Louisiana: Monumental Public Architecture, Ritual Practice, and Implications for Hunter-Gatherer Complexity. *Geoarchaeology* 28:66-86.

Pauketat, Timothy R.

1989 Monitoring Mississippian Homestead Occupation Span and Economy Using Ceramic Refuse. *American Antiquity* 54:288-310.

1994 *The Ascent of Chiefs: Cahokia and Mississippian Politics in Native North America*.

University of Alabama Press, Tuscaloosa.

2003 Resettled Farmers and the Making of a Mississippian Polity. *American Antiquity* 68:39-66.

2004 *Ancient Cahokia and the Mississippians*. Cambridge University Press.

2007 *Chiefdoms and Other Archaeological Delusions*. AltaMira, Lanham, Maryland.

2009 *Cahokia: Ancient America's Great City on the Mississippi*. Viking-Penguin Press, New York.

2012 *The Archaeology of the Cosmos: Rethinking Agency and Religion in Ancient America*.

Routledge, London.

Pauketat, Timothy R., Susan M. Alt, and Jeffery D. Kruchten

2015 City of Earth and Wood: New Cahokia and its Material-Historical Implications. In *Early Cities in Comparative Perspective, 4000 BCE-1200 CE*, edited by Norman Yoffee, pp. 437-454.

The Cambridge World History, Vol III. Cambridge University Press, Cambridge.

Pauketat, Timothy R., Jeffery D. Kruchten, Melissa R. Baltus, Kathryn E. Parker, and Elizabeth Kassly

2012 An Ancient Medicine Lodge in the Richland Complex. *Illinois Archaeology* 24:159-183.

Pauketat, Timothy R., and Neil H. Lopinot

1997 Cahokian Population Dynamics. In *Cahokia: Domination and Ideology in the Mississippian World*, edited by Timothy R. Pauketat and Thomas E. Emerson, pp. 103-123.

University of Nebraska Press, Lincoln.

Pluckhahn, Thomas J., Victor D. Thompson, and Alexander Cherkinsky

2015 The Temporality of Shell-Bearing Landscapes at Crystal River, Florida. *Journal of Anthropological Archaeology* 37:19-36.

Porter, James W., and Jean Linder

1974 An Archaeological Survey of the Mississippi Valley in St. Clair, Monroe, and Randolph Counties. In *Preliminary Report of the 1973 Historic Sites Survey Archaeological Reconnaissance of Selected Areas in the State of Illinois*, p. 28-34. Illinois Archaeological Survey, Urbana.

Possehl, Gregory L.

1998 Sociocultural Complexity without the State: The Indus Civilization. In *Archaic States*, edited by Gary M. Feinman and Joyce Marcus, pp. 261-291. School of American Research, Santa Fe, NM.

Quinn, Colin P., and Casey R. Barrier

2014 Early Regional Centers: Evolution and Organization. In *Encyclopedia of Global Archaeology*, edited by Claire Smith, pp. 2248-2260. Springer, New York.

Reimer, Paula J., Edouard Bard, Alex Bayliss, J. Warren Beck, Paul G. Blackwell, Christopher Bronk Ramsey, Caitlin E. Buck, Hai Cheng, R. Lawrence Edwards, Michael Friedrich, Pieter M. Grootes, Thomas P. Guilderson, Haflidi Haflidason, Irka Hajdas, Christine Hatté, Timothy J. Heaton, Dirk L. Hoffmann, Alan G. Hogg, Konrad A. Hughen, K. Felix Kaiser, Bernd Kromer, Sturt W. Manning, Mu Niu, Ron W. Reimer, David A. Richards, E. Marian Scott, John R. Southon, Richard A. Staff, Christian S. M. Turney, and Johannes van der Plicht

2013 IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0-50,000 Years cal BP. *Radiocarbon* 55(4):1869-1887.

Russo, Michael

1994 Why We Don't Believe in Archaic Ceremonial Mounds and Why We Should: The Case from Florida. *Southeastern Archaeology* 13:93-108.

Saunders, Joe, Rolfe D. Mandel, Roger T. Saucier, E. Thurman Allen, C.T. Hallmark, Jay K. Johnson, Edwin H. Jackson, Charles M. Allen, Gary L. Stringer, Douglas S. Frink, James K. Feathers, Stephen Williams, Kristen J. Gremillion, Malcolm F. Vidrine, and Reza Jones

1997 A Mound Complex in Louisiana at 5400-5000 Years B.P. *Science* 277(5333):1796-1799.

Sassaman, Kenneth E.

2004 Complex Hunter-Gatherers in Evolution and History: A North American Perspective.

Journal of Archaeological Research 12:227-280.

2010 *The Eastern Archaic, Historicized*. AltaMira Press, New York.

Schachner, Gregson

2010 *Population Circulation and the Transformation of Ancient Zuni Communities*. University of Arizona Press, Tucson.

Schilling, Timothy

2010 An Archaeological Model of the Construction of Monks Mound and Implications for the Development of Cahokian Society (800-1400 A.D.). Unpublished Ph.D. dissertation,

Department of Anthropology, Washington University, Saint Louis, Missouri.

2013 The Chronology of Monks Mound. *Southeastern Archaeology* 32:14-28.

Schroeder, Sissel

1997 Place, Productivity, and Politics: The Evolution of Cultural Complexity in the Cahokia Area. Unpublished Ph.D. dissertation, Department of Anthropology, The Pennsylvania State University, University Park.

2004 Power and Place: Agency, Ecology, and History in the American Bottom, Illinois. *Antiquity* 78:812-827.

Smith, Bruce D.

2011 The Cultural Context of Plant Domestication in Eastern North America. *Current Anthropology* 52:S471-S484.

Smith, Karen Y.

2009 Middle and Late Woodland Period Cultural Transmission, Residential Mobility, and Aggregation in the Deep South. Unpublished Ph.D. dissertation, Department of Anthropology, University of Missouri, Columbia.

Smith, Michael E.

2007 Form and Meaning in the Earliest Cities: A New Approach to Ancient Urban Planning.

Journal of Planning History 6:3-47.

2009 Gordon Childe and the Urban Revolution: An Historical Perspective on a Revolution in Urban Studies. *Town Planning Review* 80:3-29.

2014 Peasant Mobility, Local Migration, and Premodern Urbanization. *World Archaeology* 46:516-533.

Smith, Monica L.

2003 Introduction: The Social Construction of Ancient Cities. In *The Social Construction of Ancient Cities*, edited by Monica L. Smith, pp. 1-36. Smithsonian Institution Press, Washington, D. C.

2014 The Archaeology of Urban Landscapes. *Annual Review of Anthropology* 43:307-323.

Stahlman, Kathleen, Jarrod Burks, John E. Kelly, Jim Mertz, and Toi Haaker

2004 Washausen: Recent Investigations at a Small Pulcher Tradition Mound Center and its Implications on the Emergence of the Mississippian Tradition. Paper presented at the 61st Annual Meeting of the Southeastern Archaeological Conference, Saint Louis, Missouri.

Thompson, Victor D., and C. Fred T. Andrus

2011 Evaluating Mobility, Monumentality, and Feasting at the Sapelo Island Shell Ring Complex. *American Antiquity* 76:315-343.

Wallis, Neill J., Paulette S. McFadden, Hayley M. Singleton

2015 Radiocarbon Dating the Pace of Monument Construction and Village Aggregation at Garden Patch: A Ceremonial Center on the Florida Gulf Coast. *Journal of Archaeological Science: Reports* 2:507-516.

Welch, Paul D.

2006 Interpreting Anomalous Rural Mississippian Settlements: Leadership from Below. In *Leadership and Polity in Mississippian Society*, edited by Brian M Butler and Paul D. Welch, pp. 214-235. Occasional Paper No. 33. Center for Archaeological Investigations, Southern Illinois University, Carbondale.

Welch, Paul D., and Brian M. Butler

2006 Borne on a Litter with Much Prestige. In *Leadership and Polity in Mississippian Society*, edited by Paul D. Welch and Brian M. Butler, pp. 1-15. Occasional Paper No. 33. Center for Archaeological Investigations, Southern Illinois University, Carbondale.

Wilson, Gregory D.

2008 *The Archaeology of Everyday Life at Early Moundville*. University of Alabama Press,

Tuscaloosa.

2010 Community, Identity, and Social Memory at Moundville. *American Antiquity*, 75:3-18.

Yoffee, Norman

2005 *Myths of the Archaic State: Evolution of the Earliest Cities, States, and Civilizations*.

Cambridge University Press, Cambridge.

2014 Different Cities. In *Making Ancient Cities: Space and Place in Early Urban Societies*, edited by Creekmore, Andrew T, III, and Kevin D. Fisher, pp. 407-414. Cambridge University Press, Cambridge.

Yoffee, Norman [editor]

2015 *Early Cities in Comparative Perspective, 4000 BCE-1200 CE*. The Cambridge World History, Vol III. Cambridge University Press, Cambridge.