

MAIZE ADOPTION AND INTENSIFICATION IN THE CENTRAL ILLINOIS RIVER VALLEY: AN ANALYSIS OF ARCHAEOBOTANICAL DATA FROM THE LATE WOODLAND TO EARLY MISSISSIPPIAN PERIODS (A.D. 600–1200)

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*We consider the causes and timing of maize (*Zea mays*) intensification in the central Illinois River valley and argue that an understanding of changes in maize production requires a consideration of changes occurring in the entire plant subsistence system. To this end, we explore trends in the collection and production of plant foods from the Late Woodland (A.D. 600–1100) to Early Mississippian periods (A.D. 1100–1200). The plant data reveal a stepwise decrease in nut collection during the Late Woodland period, and again during the transition to the Early Mississippian period. This pattern is accompanied by statistical increases in maize abundance, indicating an intensification of maize production around A.D. 1100. We consider these patterns in light of similar maize increases occurring throughout the Eastern Woodlands and evaluate several possible interpretations related to population pressure, climate change, competitive generosity, and cultural emulation, the latter which appears to have been inspired by prolonged contact between local populations and Mississippian groups in the greater Cahokia area.*

How, why, and when ancient Eastern Woodland peoples intensified maize (*Zea mays*) farming is a question that has resonated with archaeological research interests for decades. Early investigators viewed the adoption and intensification of maize as a prime mover in the development and spread of Mississippian culture. These traditional explanations of increased maize production tended to invoke subsistence stress and risk as primary causal factors (Chmurny 1973; Ford 1974; Muller and Stephens 1991; Peebles and Kus 1977), which were then tied more generally to models of population pressure (see Scarry 1993a for a summary).

However, more recent archaeobotanical analyses have revealed significant regional variation in the timing of maize adoption and intensification relative

to the rise of political complexity (Chapman and Shea 1981; Crites 1978; Gremillion and Yarnell 1986; Johannessen 1993a, 1993b; Kidder and Fritz 1993; King 1988; Scarry 1986, 1993a, 1993b; Simon and Parker 2006). Indeed, in some regions, there was a significant delay in terms of both the reliance on and intensification of maize with respect to political development (e.g., Brown 1984; Fritz 1982; Kidder and Fritz 1993); in other regions, increases in maize production occurred within the context of only weakly centralized hierarchical political institutions (Emerson et al. 2005).

Early attempts at understanding the delay between the introduction of maize (A.D. 100–500) and its elevation as a staple food (A.D. 800–1100) in the Eastern Woodlands argued for the arrival of a more productive maize variety that would have made it suitably productive as a staple crop (Coe et al. 1986; Fowler 1975; Galinat and Campbell 1967; Galinat and Gunnerson 1963; see also Fritz 1992). Fritz's (1992:28) research on the topic however, has revealed a paucity of archaeobotanical evidence to support the "introduction of a new type of maize around A.D. 800–1000 that might have been superior to previously existing types [that] thereby played a causal role in agricultural intensification and culture change." Fritz (1992:29) instead argues that increased maize productivity witnessed after A.D. 1000 is better explained by cultural and political factors, such as "individual and corporate group decision making and information sharing, field allocation policies, and responses to demands for increased surplus and trade." In addition to political development are other variables that factor into the variation regarding the timing of maize production increases, such as rainfall, temperature, and soil conditions. Such variation implies that blanket explanations of subsistence risk and population pressure are inappropriate, and that any investigation into the adoption and intensification of maize must take place on a region by region basis.

With these issues in mind, we consider the timing of maize adoption and intensification in the late

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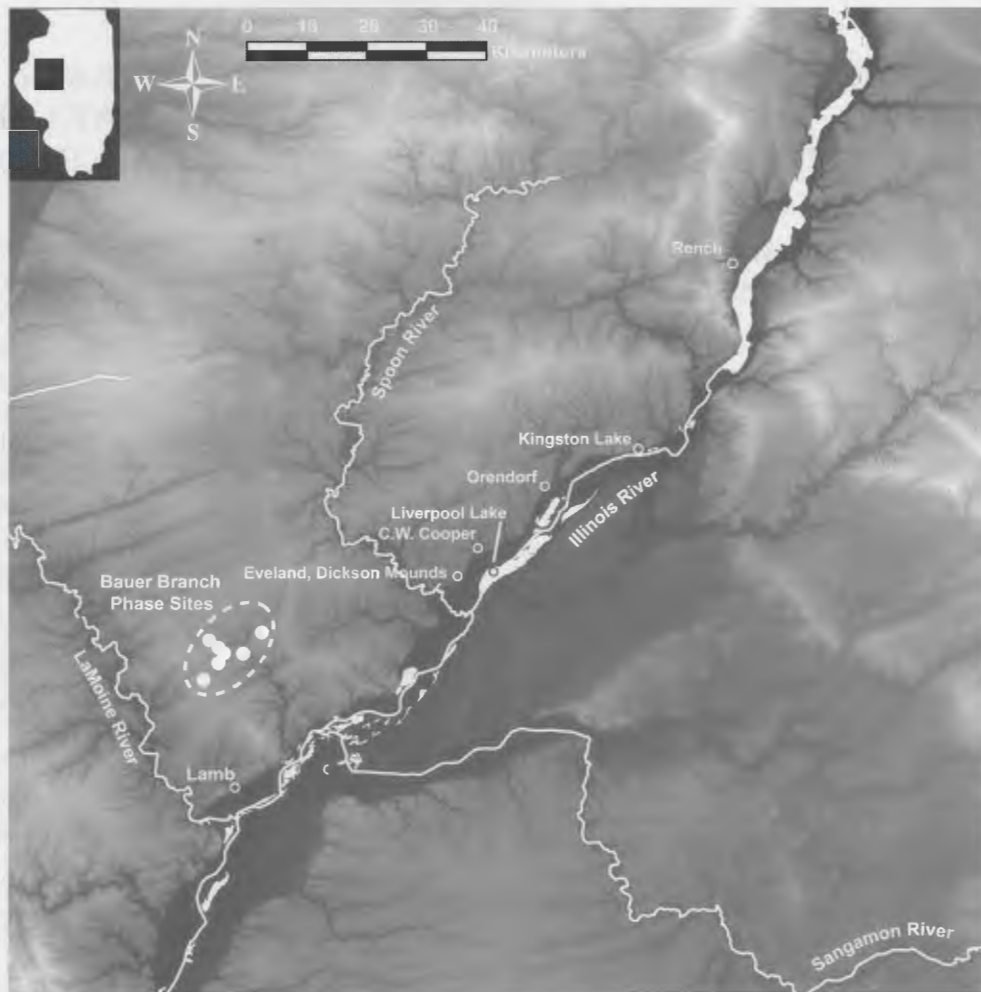


Figure 1. Map of the central Illinois River valley with relevant sites labeled.

prehistoric central Illinois River valley (CIRV) through a diachronic analysis of plant assemblages dating from A.D. 600–1200. We draw on published data from the Late Woodland period and present new data from the Early Mississippian period. In general, we argue that an understanding of changes in maize production requires a consideration of changes that occurred (or did not occur) in the entire plant subsistence system, and thus we explore trends in the collection and production of plant foods throughout this time, using all the plant data that are currently available. By contextualizing changes in maize production as embedded within broader shifts in plant subsistence, we ultimately hope to better understand why people increased food production, in addition to describing how it happened. Currently, there exist no published data on plant remains from Mississippian sites in the region, leading most regional scholars to generalize about subsistence strategies or offer comparisons to the nearby American Bottom or other regions of Mississippian occupation. In addition to presenting the extant Late Woodland plant data from the CIRV (Green 1987;

McConaughy et al. 1993; Schroeder 2000), we report our analyses of plant data from two Mississippian sites in the valley: Lamb (early Eveland phase, A.D. 1100–1150) and C. W. Cooper (late Eveland phase, A.D. 1150–1200). Although plant data from these two sequentially occupied Early Mississippian sites cannot capture all of the variation in plant subsistence that likely existed in the Early Mississippian CIRV, we use the Lamb and C. W. Cooper data to present plausible hypotheses that can be tested once plant data from additional Early Mississippian sites are available.

The Woodland-Mississippian Transition in the Central Illinois River Valley

Located between present-day Hennepin, Illinois, to the north and Meredosia, Illinois, to the south, the central Illinois River valley represents a 210-km stretch of floodplain and bluff areas approximately 177 river km north of the American Bottom and the well-known site of Cahokia (Harn 1978) (Figure 1). The region has a

deep history of occupation; as the present study focuses on the timing of maize intensification, we begin our survey of the region with the Late Woodland period in order to set the stage for assessing changes in subsistence occurring with the Mississippianization of the region that began around A.D. 1050.

Previous examination of site distribution and ceramic stylistic data indicates that two contemporaneous Late Woodland groups occupied the CIRV. These two groups are represented by the Bauer Branch phase in the southern and the Maples Mills phase in the northern part of the region. Patterns of regional settlement mobility and site distribution are not well understood for this time period. However, pedestrian surveys and excavations have documented the presence of village-sized Maples Mills and Bauer Branch phase sites on natural levees and floodplain ridges along the Illinois River (Esarey 1988, 2000). Smaller Maples Mills and Bauer Branch phase occupations have been identified in the western uplands of the CIRV as well.

By the end of the Late Woodland period around A.D. 1050, local groups in the CIRV began to develop strong connections with Cahokians, during an era known as the Mossville phase in the northern part of the region. The impacts of this interaction have been best documented at the small late Late Woodland Rensch site, where excavations uncovered domestic architecture and ceramic assemblages that exhibit a mix of Cahokian and local stylistic influences (McConaughy et al. 1993). A contemporary phase of initial Cahokian contact and interaction has not been formally defined for the southern portion of the region. However, recent analysis of excavated materials from the Early Mississippian Lamb site in Schuyler County, Illinois, has revealed that Bauer Branch phase groups participated in a similar dynamic of contact with and emulation of American Bottom Mississippian traditions (Bardolph 2014; Wilson 2012). Throughout the region there also appears to have been a trend of settlement dispersal entailing the abandonment of riverside villages in favor of small bluff-edge and terrace occupations (Esarey 2000:398).

A second pulse of Cahokian interaction in the CIRV began around A.D. 1100 at the beginning of the Early Mississippian Eveland phase. This period witnessed a more pervasive emulation of Cahokian-inspired material culture and ritual traditions. However, recent research at both the Lamb and Eveland sites has revealed that Cahokian influence in the region did not entail major organizational changes in political and economic organization. For example, the Eveland phase settlement pattern is similar to that of the preceding Mossville phase in that it consisted of small, dispersed habitation sites connected through events occurring at small nodal ceremonial centers (e.g., Eveland and Kingston Lake sites; see Conrad [1989: 100, 106]). And while the Eveland phase occupants of

the CIRV adopted Cahokian pottery styles and construction methods, they continued to use these pots in ways that corresponded with Late Woodland organizational conventions (Bardolph 2014; Wilson 2012). Moreover, communal methods of food preparation and consumption persisted well into the Early Mississippian CIRV long after more individualized and hierarchically structured foodways developed in the greater Cahokian area (Bardolph 2014; Mehrer 1995).

Plant Subsistence in the Central Illinois River Valley

We consider changes in subsistence through a diachronic analysis of plant remains (recovered via flotation) from several sites in the CIRV, discussed here in temporal order. We begin by synthesizing the available plant data that date to the last 500 years of the Late Woodland period; this synthesis allows us to set the baseline against which to measure changes occurring with the transition to the Mississippian period as seen at the Lamb and C. W. Cooper sites (see Figure 1 for site locations). The earliest plant assemblages we consider were reported by William Green (1987) in his dissertation on Late Woodland economy, technology, and history; these data come from 151 features from a total of eight sites located in the southwestern uplands of the CIRV, collectively dating between A.D. 600 and 1100 (Table 1). We also include plant data from the Liverpool Lake site, a Maples Mills phase (A.D. 750–1000) village located on a natural levee on the southern banks of the Illinois River valley near its confluence with Buckheart Creek. The Liverpool Lake botanical sample comes from 15 flotation samples taken from 13 features; these data were analyzed and reported by Marjorie Schroeder (2000). The final set of late Late Woodland plant data comes from the Mossville phase (A.D. 1000–1100) Rensch site, a small farmstead located on a floodplain terrace along the bluff edge in the northeastern part of the valley. This site is important as it straddles the transition from the Late Woodland to the Mississippian period. The Rensch site botanical sample comes from two structures and nine pit features; analyzed by Frances King, these data were reported in McConaughy et al. (1993).

In addition to the existing Late Woodland plant data, we report new data from two consecutively occupied Early Mississippian sites, Lamb and C. W. Cooper, located in the southern and central portions of the valley, respectively. The Lamb site is an Early Mississippian, Eveland phase (A.D. 1100–1150) farmstead or hamlet dating to the period of culture contact with Cahokia to the south. Salvage excavations conducted at the site in 1990 exposed 33 pit features (Figure 2); no structures were documented. The materials excavated from these features all represent secondary refuse in their final context. The C. W.

Table 1. Dates of occupation and months of plant collection/production at Late Woodland sites (A.D. 600–1100) from the CIRV.

Site	Dates (A.D.)	Temporal Group	Season of Bloom for Identified Plants	Citation	Maize?
11SC268	600–700	1	May–November	Green 1987	No
11SC360	600–1000	1	April–November	Green 1987	No
11SC87 ^a	700–900	2	April–November	Green 1987	No
11SC347	800–950	2	April–November	Green 1987	No
11SC348	800–1050	2	April–November	Green 1987	No
11SC359	800–1100	2	April–November	Green 1987	No
11SC264	900–1050	2	May–November	Green 1987	No
11SC357	950–1100	3	April–November	Green 1987	Yes
Liverpool Lake	750–1000	3	April–November	Schroeder 2000; Esarey et al. 2000	Yes
Rench	1000–1100	3	April–November	McConaughy et al. 1993	Yes

^aSC87 is not included in any of the density comparisons, as the volume of soil floated is uncertain for this site.

Cooper site is a small, nucleated village located on the western bluff near the intersection of the Sister Creeks and the Illinois River valley floodplains (Conrad 1991). We analyzed flotation samples from nine pit features, three postmolds, and one wall-trench structure that were uncovered during excavations in 2011 (Figure 3). The contexts of all the C. W. Cooper flotation samples taken from these features are that of secondary or tertiary refuse, contexts that are comparable to the Lamb site. The one exception is

an earth oven from C. W. Cooper that represents intact abandonment refuse of a failed corn roast, including an estimated 90 ears of maize; we exclude this context from the present study.

Late Woodland Plant Subsistence

Before we can understand changes occurring in plant subsistence concurrent with the beginning of the Mississippian period, it is important to synthesize the

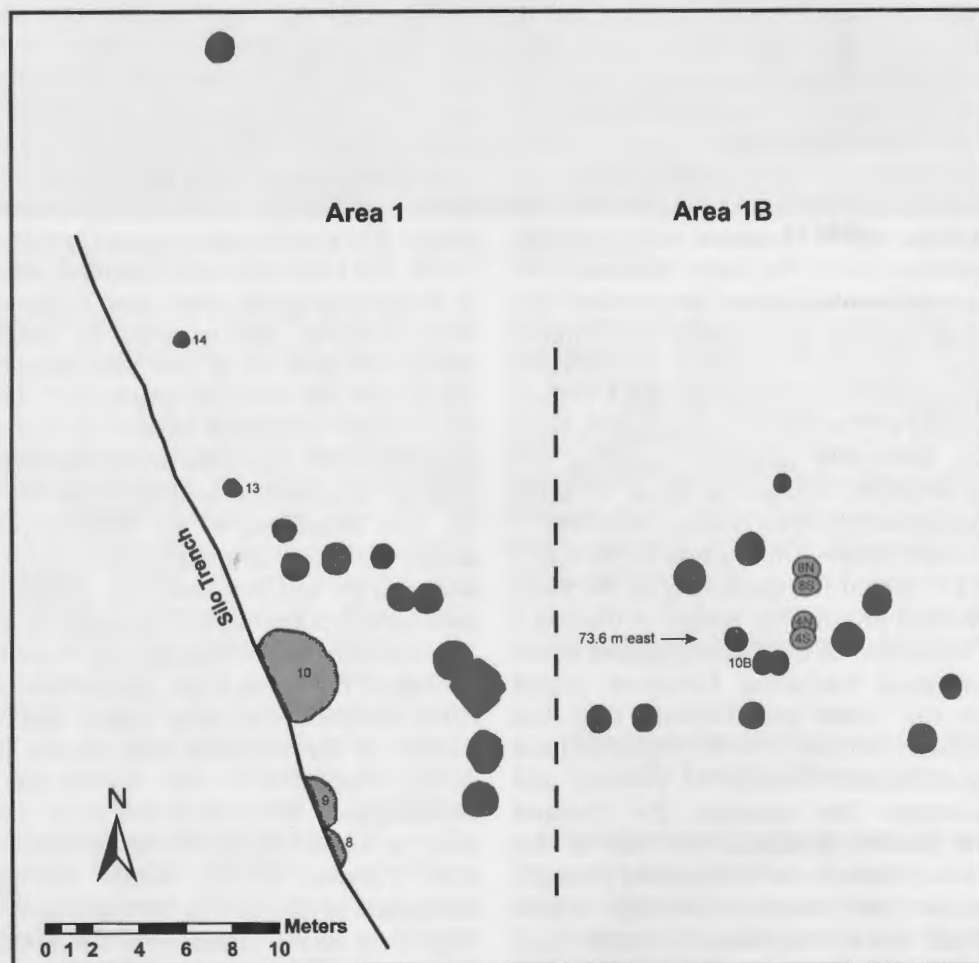


Figure 2. Plan map of the Lamb site excavations.

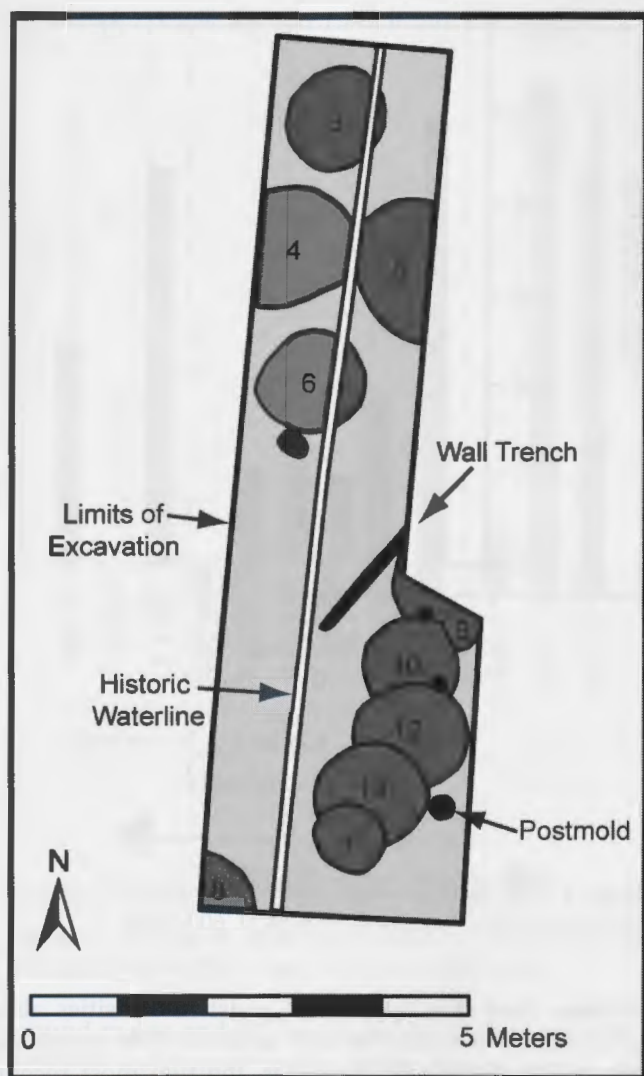


Figure 3. Plan map of the C. W. Cooper site excavations.

available data from earlier occupations in the CIRV. We focus on the Late Woodland period, presenting plant data from all sites for which data are currently available. Fortunately, with one exception, soil volume was available for all samples from the study sites. Plant data were processed and sorted comparably, but there was variation in how the data were recorded. For example, nutshell and maize remains from the Bauer Branch sites and the Rench site were weighed but not counted, whereas these same data were counted but not weighed in the Liverpool Lake report. In order to make these data comparable, we used the count/weight ratios from the Lamb and Roskamp sites¹ to estimate counts of nutshell and maize at the Bauer Branch and Rench sites. We chose to estimate counts instead of weights as count data are necessary to calculate proportions, which are used for comparison with the Early Mississippian sites (see below). This method of count estimation is common in paleoethnobotany and has been used in comparative

plant analyses throughout the southeastern United States (e.g., Scarry 2003; VanDerwarker et al. 2007; VanDerwarker and Idol 2008; VanDerwarker et al. 2013).

Before presenting the analysis of plant data, it is important to first discuss these sites in more depth. Table 1 lists the Late Woodland sites in chronological order, including both dates and phase names in addition to plant seasonal profiles and the presence/absence of maize (Esarey et al. 2000; Green 1987; McConaughy et al. 1993; Schroeder 2000). We divide these sites into three temporal groupings in order to consider changes through time in the plant data. These temporal groupings are somewhat fluid, as there is overlap in occupational duration at several sites. For example, there is a great deal of overlap between Group 2 and Group 3, and an argument could be made to combine them into a single group. However, the sites in the third group have slightly later terminal dates and are the only Late Woodland sites at which maize was identified; for these reasons, we distinguish a third temporal occupation.

In order to summarize the data from the 10 sites from which Late Woodland plant data have been reported, we aggregate the data into five main categories: fruits, maize, nuts, oily seeds, and starchy seeds² (Table 2). Densities were calculated as total counts of taxa within each category divided by the total volume of soil floated for each site. Site 11SC87 is not included in this density comparison, as the volume of soil floated was not certain. These density values are listed in Table 2 and are presented in a series of bar graphs for better visual display (Figures 4–8). There is a great deal of variability in the densities of the different plant groups that does not appear to be related to seasonality of occupation. Indeed, we ran a principal components analysis on all taxa from these sites, and the resulting groupings could not be explained by season of occupation, time, or space (e.g., upland versus lowland setting).³ Some of this variability likely relates to differences between the site locations in terms of slope, soil type, or variation in local plant communities. Given this variability with respect to individual plant species, we rely on broader plant groups in order to tease out temporal changes.

A consideration of fruit densities reveals a high level of variability across the sites (see Figure 4). Fruits fluctuate in abundance throughout the sequence, with no clear temporal pattern. As a whole, fruits represent a minimal addition to the archaeobotanical plant assemblages, and any fluctuations in their representation should be considered fairly minor. In terms of nutshell, 11SC359 was a far outlier, yielding significantly more nutshell than any other Late Woodland site considered (see Table 2); we removed this outlier from the bar graph in order to better visualize the patterning among the remaining sites. Upon removal of the outlier, it

Table 2. Density (counts/soil volume), counts, and proportions (counts per category/total plant count) for selected plant groups^a from Late Woodland sites in the CIRV.

Site	Soil Volume		Fleshy Fruits		Maize		Nuts		Oily Seeds		Starchy Seeds	
	Liters	Density	Count/Proportion	Density	Count/Proportion	Density	Count/Proportion	Density	Count/Proportion	Density	Count/Proportion	Density
11SC268	79.80	0.050	4/0.03	0	0	0.965	77/0.517	0	0	0.852	68/0.456	0.852
11SC360	116.40	0	0	0	0	3.299	384/0.808	0	0	0.782	91/0.192	0.782
11SC367 ^b	?	-	12/0.004	-	0	-	2,011/0.624	-	8/0.002	-	1,190/0.369	-
11SC347	101.40	0.010	1/0.005	0	0	1.262	128/0.680	0	0	0.582	59/0.314	0.582
11SC348	86.20	0.023	2/0.004	0	0	5.197	448/0.867	0.070	6/0.012	0.708	61/0.118	0.708
11SC359	240.40	0.004	1/0.000	0	0	205.383	49,374/0.997	0.012	3/0.000	0.686	165/0.003	0.686
11SC264	14.60	0	0	0	0	10.548	154/0.703	0.137	2/0.009	4.315	63/0.288	4.315
11SC357	12.30	0	0	8.293	102/0.337	13.577	167/0.551	0	0	2.764	34/0.112	2.764
Liverpool Lake	90.75	0.044	4/0.008	2.347	213/0.471	1.807	164/0.363	0	0	0.782	71/0.157	0.782
Rench	768.00	0.025	19/0.002	0.595	457/0.048	11.391	8,784/0.929	0.001	1/0.000	0.254	195/0.021	0.254

^a Fleshy fruits include sumac, nightshade, blueberry, blackberry/raspberry, hawthorn, strawberry, elderberry, grape, and persimmon. Nutshell includes hickory, walnut, acorn, and hazel. Oily seeds include sunflower and sunflower, as well as any specimens grouped into a sunflower category. Starchy seeds include chenopod, knotweed/smartweed, maygrass, and little barley. Although the chenopod and knotweed specimens are not clear domesticates, we nevertheless include them in the starchy seed category as they were likely processed similarly to their domesticated counterparts.

^b SC367 is not included in any of the density comparisons, as the volume of soil floated is uncertain for this site.

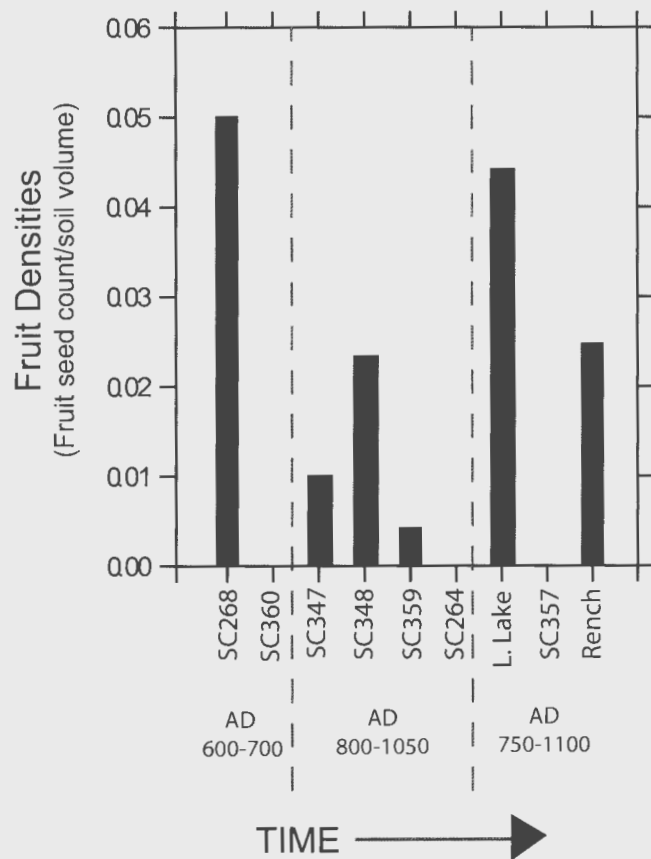


Figure 4. Bar chart showing densities of fruits (count/soil volume) for Late Woodland sites (A.D. 600–1100).

becomes clear that, like fruits, nutshell densities also vary greatly from site to site, with no clear temporal pattern (see Figure 5). However, the two most recent Late Woodland sites (11SC357 and Rench) yielded fairly high densities of nutshell.

The distribution of oily seed and starchy seed densities reveals some interesting patterning. Starchy seeds are present throughout the Late Woodland sequence but occur in higher densities after A.D. 900 (see Figure 6). In contrast, oily seeds do not appear in the sequence until after A.D. 800, but not at 11SC357 and only minimally at Rench (see Figure 7). It appears that the late Late Woodland inhabitants of the CIRV expanded their system of low-level food production around A.D. 800, with plant cultivation increasingly supplementing the collection of wild nuts, fruits, and greens. This interpretation is further bolstered by the maize data, which are only present at Liverpool Lake, 11SC357, and Rench; the density values among these three sites are variable, indicating differing levels of cultivation of and reliance on maize (see Figure 8). The variability that is most interesting, however, is how the inhabitants of each of these three late Late Woodland sites combined different productive activities. Residents of Liverpool Lake focused plant cultivation

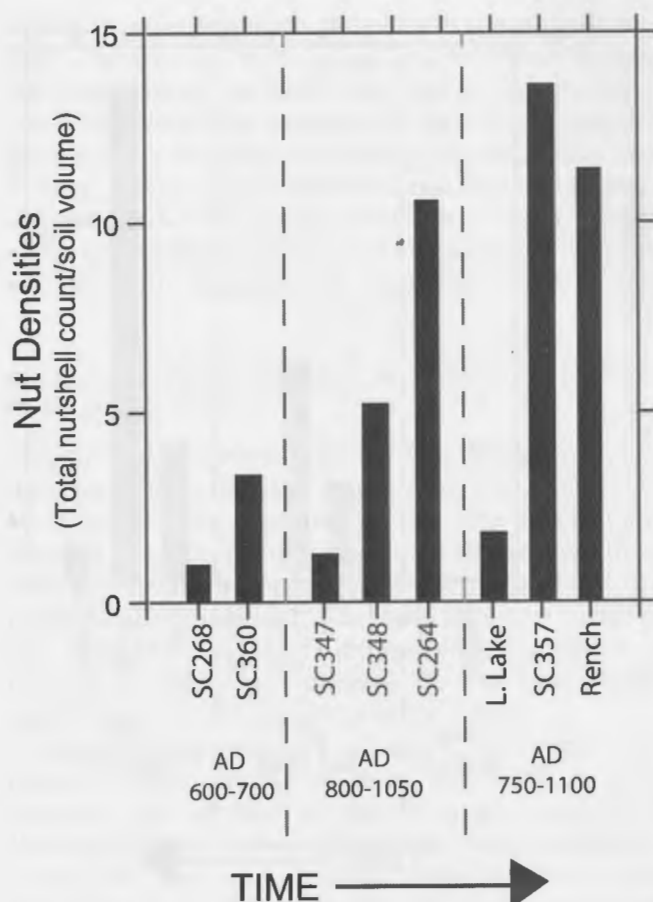


Figure 5. Bar chart showing densities of nuts (count/soil volume) for Late Woodland sites (A.D. 600-1100).

around maize and oily seeds, whereas the residents of 11SC357 cultivated maize and starchy seeds. The higher level of nutshell at 11SC357 (dominated by hickories [*Carya* spp.], used to produce hickory oil) in comparison to Liverpool Lake likely offset the need for oily seed production. In contrast, people living at Rensch combined the cultivation of maize, starchy seeds, and oily seeds, but at a lower level of intensity than at 11SC357 or Liverpool Lake.

In terms of settlement mobility, the Late Woodland CIRV has been interpreted as possessing a combination of year-round and seasonal occupations (Esarey et al. 2000; Green 1987; Schroeder 2000; McConaughy et al. 1993). In evaluating these inferences it is important to note that CIRV researchers have varied in the kinds of data they use to assess settlement mobility. In some cases, arguments about occupational seasonality have been based on the analysis of macrobotanical remains (see Hally 1981; King and McMillan 1975; Miller 1988; Watson and Yarnell 1989); however, season of procurement does not necessarily correlate with season of occupation at a given site, and seasonal arguments based on macrobotanical data become more complicated if a community stores food (Wagner 1996:255). Thus

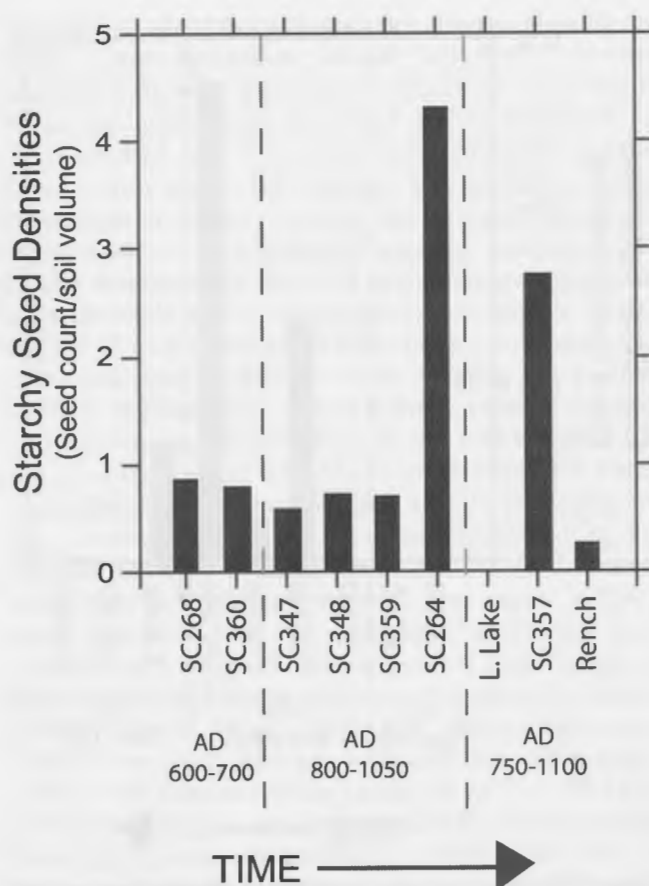


Figure 6. Bar chart showing densities of starchy seeds (count/soil volume) for Late Woodland sites (A.D. 600-1100).

multiple lines of evidence, including structure and feature data, can be used to strengthen arguments regarding the nature of settlement mobility and occupation span (Kent 1992).

Green's (1987) argument for the presence of year-round Bauer Branch phase settlements in the Sugar Creek locality is based on an analysis of archaeobotanical and architectural data. He interpreted "keyhole structures" similar to those excavated in southern and southwestern Illinois from Late Woodland LaMotte and Patrick Phase contexts as winter dwellings (Green 1987:133), where he identified structures lacking semi-subterranean basins as warm season domestic structures (Green 1987:251). In this model, sites with both cold and warm weather structures are interpreted as year-round habitation sites; however, Green (1987:246) submits that in the absence of detailed excavation data, it is difficult to determine whether or not these structures were contemporaneous at some of the Bauer Branch sites (e.g., 11SC268). A consideration of the macrobotanical data from the Bauer Branch sites reveals that the seasonality of plant collection/harvest encompasses April through November for all but two sites; the exceptions are 11SC268 and 11SC264, which yielded plant assemblages that bloom from May

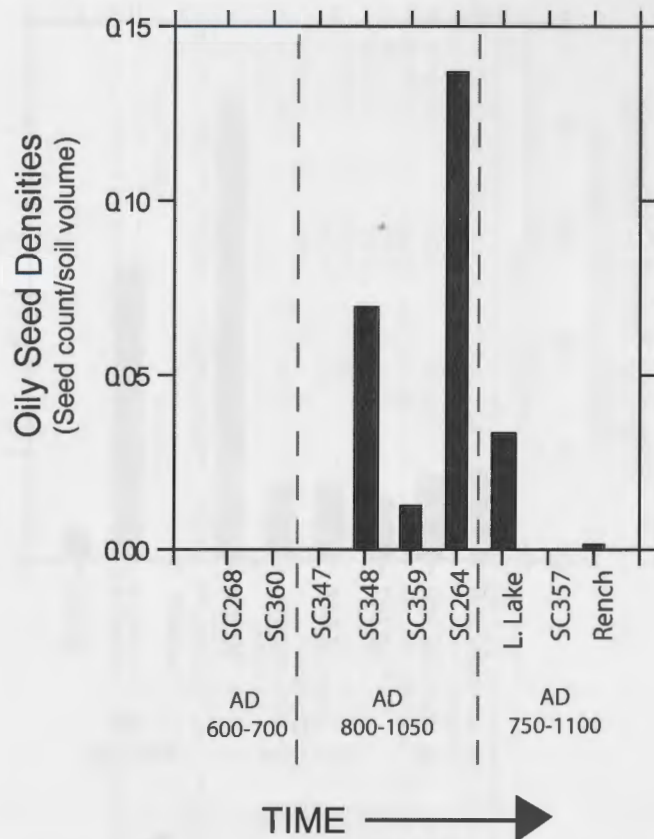


Figure 7. Bar chart showing densities of oily seeds (count/soil volume) for Late Woodland sites (A.D. 600–1100).

through November. Thus all but two of the Bauer Branch sites yield seasonal plant profiles that would be expected for year-round occupations, especially when one considers that plants do not typically bloom from December through March. Given that other datasets from these sites may not fully support interpretations of permanent year-round settlement, it becomes clear that plant data alone are insufficient to determine season of occupation.

The presence of Maples Mills and Bauer Branch phase villages on the flood-prone natural levees and floodplain ridges of the Illinois River suggests that these occupations were seasonal as opposed to year-round settlements (Esarey 2000:392). However, this assumption remains untested; no structures were uncovered at the Liverpool Lake site, and plant seasonal indicators were inconclusive (Schroeder 2000:198), complicating interpretations regarding settlement permanence at this site. Indeed, the plant data from the Liverpool Lake site also yield a seasonal profile that spans April to November, all of the months during which plants bloom in the region (see Table 1).

The late Late Woodland (A.D. 1000–1100) Rench site has been tentatively interpreted as a year-round occupation based on the spatial proximity of two structures, one with an internal hearth (cold weather

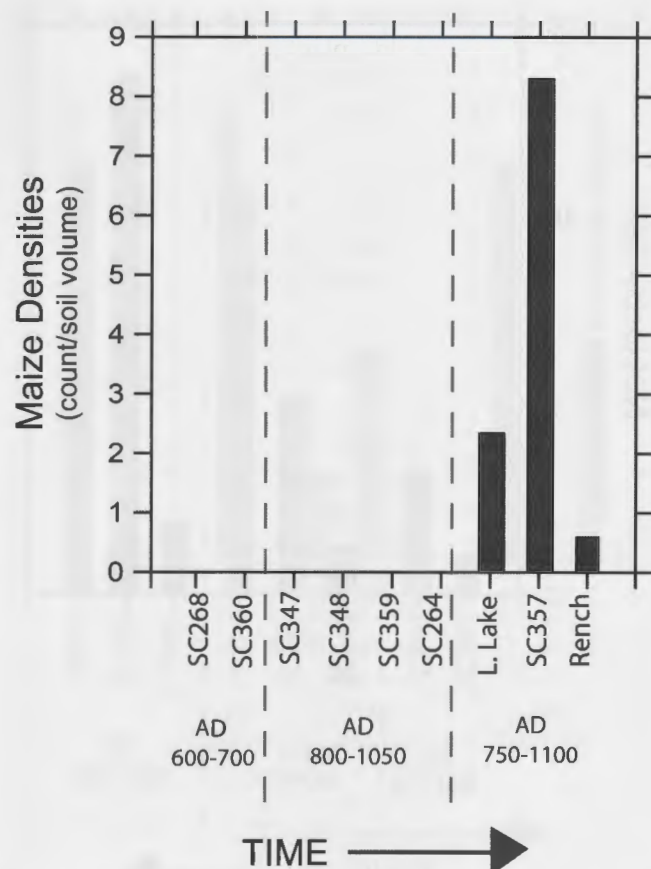


Figure 8. Bar chart showing densities of maize (count/soil volume) for Late Woodland sites (A.D. 600–1100).

domicile) and another lacking a hearth (warm weather domicile), as well as seasonal indicators from faunal and macrobotanical data that support the possibility of year-round occupations (McConaughy 1991; McConaughy et al. 1993:114–115, 123). However, the possibility that the structures at Rench represent temporally separate occupations by different families cannot be ruled out (see McConaughy et al. 1993:128). Many of these inferences about Late Woodland settlement mobility require additional investigation.⁴ Based on the current data, it is difficult to arrive at firm conclusions about the nature of settlement mobility in the region.

Overall, there is clear variability in the plant assemblages from the Late Woodland sample throughout all time periods. There are, however, some clearly definable trends, including the adoption of oily seeds and maize after A.D. 800 and the intensification of starchy seed production and collection after A.D. 900. With the exception of the gradual and variable increase in food production after A.D. 800, there are no clear temporal trends in the exploitation of wild nuts or fruits, suggesting that plant foraging did not change in any major way from A.D. 600 to 1100. Thus the available data from the 500 years preceding the Early

Mississippian occupation at the Lamb site suggest very little change in wild plant subsistence. Starting 300 years before the Lamb site was settled, however, late Late Woodland peoples of the CIRV expanded their reliance on plant cultivation. In the section that follows, we use these Late Woodland data as a point of comparison for the Lamb and C. W. Cooper sites in order to identify shifts in plant subsistence coincident with the Early Mississippian occupation of the region.

Mississippian Plant Subsistence: Results from the Lamb and C. W. Cooper Sites

Prior to comparison with the Late Woodland plant data, we present the basic results from the Lamb and C. W. Cooper sites, summed at the site level (more detailed site reports are forthcoming that present these data aggregated by feature). For the purposes of this paper, we are interested in broader temporal trends in the datasets as a means to establish a baseline of diachronic subsistence patterns for the Late Woodland/Mississippian transition in the CIRV.

Flotation samples from Lamb and C. W. Cooper were collected with variable volumes. The Lamb flotation samples were floated in the 1980s and curated at Western Illinois University until they were transferred to the University of California, Santa Barbara (UCSB) for analysis in 2008. The C. W. Cooper flotation samples were floated using a Model A Flote-Tech flotation machine in 2011. Both light and heavy fractions of all flotation samples were analyzed. Although the materials from the light and heavy fractions were processed and sorted separately, data from the two fractions were combined for analysis. According to standard practice, the light fractions were weighed and then sifted through 2.0-mm, 1.4-mm, and 0.7-mm standard geological sieves. Carbonized plant remains from both fractions were sorted in entirety down to the 2.0-mm sieve size with the aid of a stereoscopic microscope (10–40 ×). Residue less than 2.0 mm in size was scanned for seeds, which were removed and counted; in addition, taxa encountered in the 1.4-mm sieve that were not identified from the 2.0-mm sieve were also removed, counted, and weighed. Maize cupules and acorn nutshell were also collected from the 1.4-mm sieve as these materials tend to fragment into smaller pieces and can be underrepresented in the 2.0-mm sieve.

Botanical materials were identified with reference to the macrobotanical comparative collection at the UCSB Integrative Subsistence Laboratory (ISL), various seed identification manuals (Martin and Barkley 1961; Delorit 1970), and the USDA pictorial website (U.S. Department of Agriculture 2011). All plant specimens were identified to the lowest possible taxonomic level.

Taxonomic identification was not always possible, as some plant specimens lacked diagnostic features altogether or were too highly fragmented. As a result, these specimens were classified as “unidentified” or “unidentified seed.” In other cases, probable identifications were made; for example, if a specimen closely resembled a maize cupule, but a clear taxonomic distinction was not possible (e.g., the specimen was highly fragmented), then the specimen was identified as a probable maize cupule and recorded as “maize cupule cf.” Once the plant specimens were sorted and identified, we recorded counts, weights (in grams), portion of plant (e.g., maize kernels versus cupules), and provenience information. Wood was weighed but not counted; wood identification is currently being conducted by Neal Lopinot and results are forthcoming. Generally, most of the seeds identified in the samples were too small to weigh, and thus only counts were recorded. Hickory nutshell and maize remains were identified only as fragments and were both counted and weighed. Measurements were taken on complete maize kernels and cupules as part of a related project (Gracer et al. 2013) and reveal that maize kernels from both sites are wide and crescent shaped.

The early Eveland phase Lamb site (A.D. 1100–1150) archaeobotanical assemblage consists of 14 samples (all from pit features) representing a total of 85 liters of floated soil. These samples yielded a total carbonized plant weight of 52.6 g, of which 48.4 g are represented by wood charcoal (Table 3). In addition to wood charcoal, 24 taxonomic categories were identified. Maize and possible bottle gourd (*Lagenaria siceraria* cf.) were the only non-native cultigens identified at the site. Native cultigens include squash (*Cucurbita pepo*), oily seeds (sumpweed [*Iva annua*], sunflower [*Helianthus annuum*]), and several starchy seed taxa, including chenopod (*Chenopodium* spp.), knotweed/smartweed (*Polygonum* spp.), little barley (*Hordeum pusillum*), and maygrass (*Phalaris caroliniana*). The knotweed seeds, however, are not consistent with morphological indicators for erect knotweed (*Polygonum erectum*), and the chenopod seeds that still had attached seed coats were more consistent with wild forms based on inspection of cross-sectional margins;⁵ that said, the vast majority of chenopod seeds identified at Lamb (and C. W. Cooper) lacked seed coats entirely. Other wild plant foods include nuts, fleshy fruits, and a variety of wild greens and seeds, most of which are edible and others that are likely weedy incidental inclusions (see Table 3; see also Scarry [2003] for more detailed information on native uses of these taxa).

An evaluation of ubiquity values (or percentage of presence) of the Lamb plants reveals that maize and hickory were identified in all samples (Table 5). The next most ubiquitous plant is purslane, documented in

Table 3. Inventory of plants identified at the Lamb site.

Dates of occupation (A.D.)	1100–1150	
Number of flotation samples	14	
Total soil volume (liters)	85	
Total wood weight (grams)	48.4	
Total Plant weight (grams)	52.6	
Maize/bean/squash triad		Count
Maize cob fragment cf.	<i>Zea mays</i> cf.	10
Maize cupule	<i>Zea mays</i>	631
Maize cupule cf.	<i>Zea mays</i> cf.	28
Maize kernel	<i>Zea mays</i>	171
Maize kernel cf.	<i>Zea mays</i> cf.	25
Squash	<i>Cucurbita pepo</i>	3
Squash/gourd cf. rind	<i>Cucurbita/Lagenaria</i> sp. cf.	1
Nuts		
Acorn cf.	<i>Quercus</i> spp. cf.	1
Acorn shell	<i>Quercus</i> spp.	8
Hazelnut	<i>Corylus americana</i>	5
Hickory	<i>Carya</i> spp.	172
Walnut	<i>Juglans nigra</i>	4
Walnut family	Juglandaceae	10
Fruits		
Nightshade	<i>Solanum</i> spp.	3
Plum/cherry	<i>Prunus</i> spp.	2
Sumac	<i>Rhus</i> spp.	1
Starchy seeds		
Chenopod	<i>Chenopodium</i> spp.	33
Chenopod cf.	<i>Chenopodium</i> spp. cf.	1
Knotweed/smartweed	<i>Polygonum</i> spp.	60
Knotweed/smartweed cf.	<i>Polygonum</i> spp. cf.	1
Little barley	<i>Hordeum pusillum</i>	7
Maygrass	<i>Phalaris caroliniana</i>	5
Oily seeds		
Sumpweed	<i>Iva annua</i>	5
Sumpweed/sunflower	<i>Iva/Helianthus</i>	1
Sunflower	<i>Helianthus annuum</i>	2
Edible wild seeds		
Bedstraw	<i>Galium</i> spp.	1
Purslane	<i>Portulaca</i> spp.	85
Tick clover	<i>Desmodium</i> spp.	2
Tick clover cf.	<i>Desmodium</i> spp. cf.	5
Vetch cf.	<i>Vicia</i> spp. cf.	1
Miscellaneous		
Carpetweed	<i>Mollugo</i> spp.	1
Cheno/am	<i>Chenopodium/Amaranthus</i>	1
Grass family	Poaceae	41
Mallow family	Malvaceae	1
Morning glory cf.	<i>Ipomoea</i> spp. cf.	1
Panic grass	<i>Panicum</i> spp.	3
Panic grass cf.	<i>Panicum</i> spp. cf.	39
Ragweed	<i>Ambrosia</i> spp.	1
Ragweed cf.	<i>Ambrosia</i> spp. cf.	1
Unidentified		23
Unidentified seed/seed fragments		123

50 percent of the samples, likely exploited for its fresh greens, followed by chenopod (35.7 percent) and seeds from the grass family (28.6 percent). All other plant categories were identified in fewer than four samples each, indicating that they were less abundant or more spatially restricted in usage.

The late Eveland phase (A.D. 1150–1200) C. W. Cooper site archaeobotanical assemblage analyzed here derives from the 2011 excavations at the site, which produced 41 flotation samples (most of which come from pit features). Eleven of these samples come from

Feature 13, which was an abandoned earth oven that was filled with in situ cobs of burnt maize. Given the unique contextual nature of Feature 13, we do not include those data here. The remaining 30 samples come from secondary refuse contexts in pit features. These samples encompassed 271 liters of soil, yielding a total carbonized plant weight of 167.3 g, of which 116.4 g are represented by wood charcoal (Table 4). In addition to wood charcoal, 38 taxonomic categories were identified.

Non-native cultigens include maize and common bean (*Phaseolus vulgaris*), the latter which is the earliest common bean identified in the CIRV.⁶ Also identified were three rind fragments of either a squash (*Cucurbita*) or bottle gourd (*Lagenaria*). An array of starchy and oily seeds are present in the C. W. Cooper assemblage, including chenopod, knotweed, little barley, maygrass, sumpweed, and sunflower. As at the Lamb site, however, the knotweed specimens do not appear to be erect knotweed, and the vast majority of the chenopod seeds lack their seed coats, making it difficult to determine whether they represent domesticated varieties; the few chenopod seeds that retained their seed coats displayed cross-sections consistent with wild types (see Smith 1985). In addition to cultigens and possible cultigens, a variety of nuts and fruits were also identified at C. W. Cooper. It is notable that maypop, chokeberry, and hackberry are not native to the CIRV, which is why they are classified as possible specimens (cf.); more likely these seed fragments represent closely related genera or species that are native to the region. The CIRV is also at the northernmost edge of persimmon's natural distribution, which is why the single persimmon fragment is also classified as a possible identification. While it is clear that C. W. Cooper has a broader array of fruit seeds than the Lamb site, this pattern appears to be an effect of sample size, as fruit density values for Lamb (0.058) and C. W. Cooper (0.055) are virtually identical. A variety of wild edible seeds were also present at the site, likely exploited for fresh greens. Finally, several non-food plant species were also identified in the assemblage, some incidental inclusions and other used for medicine and construction (see Table 4; see also Scarry [2003] for more detailed information on native uses of these taxa).

With the exception of two taxa, both Lamb and C. W. Cooper share three of the five most ubiquitous plants in common: maize, hickory, and chenopod. Maize (96.6 percent) and hickory (96.6 percent) are the most ubiquitous taxa at the C. W. Cooper site, with chenopod as a close second (93 percent). Whether these chenopod seeds were being cultivated or gathered from wild stands, it is clear that their dietary importance was considerably greater at C. W. Cooper than at Lamb. Additional taxa that rank high in

Table 4. Inventory of plants identified at the C. W. Cooper site.

Dates of occupation (A.D.)	1150–1200	
Number of flotation samples	30	
Total soil volume (liters)	271	
Total wood weight (grams)	116.4	
Total plant weight (grams)	167.3	
Maize/bean/squash triad		Count
Bean	<i>Phaseolus vulgaris</i>	1
Bean family	Fabaceae	2
Maize cupule	<i>Zea mays</i>	1,125
Maize kernel	<i>Zea mays</i>	1,963
Squash/gourd cf. rind	<i>Cucurbita/Lagenaria</i> sp. cf.	1
Squash/gourd rind	<i>Cucurbita/Lagenaria</i> sp.	3
Nuts		
Acorn meat	<i>Quercus</i> spp.	1
Acorn shell	<i>Quercus</i> spp.	88
Hazelnut cf.	<i>Corylus americana</i> cf.	1
Hickory	<i>Carya</i> spp.	2,483
Hickory cf.	<i>Carya</i> spp. cf.	18
Walnut	<i>Juglans nigra</i>	9
Walnut family	Juglandaceae	3
Fruits		
Blackberry/raspberry	<i>Rubus</i> spp.	2
Chokeberry cf.	<i>Aronia</i> spp. cf.	1
Elderberry	<i>Sambucus canadensis</i>	1
Hackberry cf.	<i>Celtis occidentalis</i> cf.	1
Maypop cf.	<i>Passiflora incarnata</i> cf.	1
Nightshade	<i>Solanum</i> spp.	2
Nightshade cf.	<i>Solanum</i> spp. cf.	1
Persimmon cf.	<i>Diospyros virginiana</i> cf.	1
Plum/cherry cf.	<i>Prunus</i> spp. cf.	1
Serviceberry cf.	<i>Amelanchier arborea</i> cf.	1
Sumac	<i>Rhus</i> spp.	2
Sumac cf.	<i>Rhus</i> spp. cf.	1
Starchy seeds		
Chenopod	<i>Chenopodium</i> spp.	352
Knotweed/smartweed	<i>Polygonum</i> spp.	10
Little barley	<i>Hordeum pusillum</i>	112
Little barley cf.	<i>Hordeum pusillum</i> cf.	13
Maygrass	<i>Phalaris caroliniana</i>	32
Maygrass cf.	<i>Phalaris caroliniana</i> cf.	4
Oily seeds		
Sumpweed	<i>Iva annua</i>	4
Sumpweed/sunflower	<i>Iva/Helianthus</i>	4
Edible wild seeds		
Amaranth	<i>Amaranthus</i> spp.	5
Clover cf.	<i>Trifolium</i> spp. cf.	1
Pokeweed	<i>Phytolacca americana</i>	1
Purslane	<i>Portulaca</i> spp.	11
Tick clover	<i>Desmodium</i> spp.	3
Miscellaneous		
Bulrush	<i>Scirpus</i> spp.	1
Carpeweed	<i>Mollugo</i> spp.	1
Cheno/am	<i>Chenopodium/Amaranthus</i>	7
Goosegrass	<i>Eleusine indica</i>	9
Grass family	Poaceae	28
Spikerush	<i>Eleocharis</i> spp.	1
Spurge family cf.	Euphorbiaceae cf.	1
Violet cf.	<i>Viola</i> spp. cf.	2
Unidentified seed/seed fragments		4

Table 5. Top five ubiquitous plants at the Lamb and C. W. Cooper sites in descending order (wood charcoal excluded).

Lamb	Ubiquity Value (%)
Maize	100
Hickory	100
Purslane	50
Chenopod	35.7
Grass family	28.6
C. W. Cooper	
Maize	96.6
Hickory	96.6
Chenopod	93.3
Acorn	53.3
Little barley	43.3

assemblage, which is more comparable to the Mississippian sites located to the north than the American Bottom assemblages to the south, for which starchy seeds are reported to range from 65–95 percent of plant assemblages (see Emerson et al. 2005:80–81).

A consideration of plant season of bloom at these two sites reveals similar profiles, both to each other and to the majority of the preceding Late Woodland sites, indicating the collection and production of plants from April through November (Tables 6 and 7). The lack of a seasonal signature from December through April is not surprising as wild plants are typically not available during the winter months, nor is it a season for the planting or harvesting of crops. As discussed above, plant data alone are insufficient to make an assessment of seasonal versus year-round occupation. However, given the storability of maize and nuts through the winter, and the presence of large subterranean storage pits at both sites, we suggest that these two twelfth century Mississippian settlements likely represent year-round occupations. We revisit this issue of settlement permanence below with a consideration of pit feature volume from the Late Woodland to Early Mississippian periods.

In summary, basic assessment of the plant assemblages from the sites of Lamb and C. W. Cooper reveal broad similarities in (1) the types of plants collected and produced, (2) the importance of maize, hickory, and chenopod, and (3) the seasonal profiles of the plant inventories. Despite these similarities, however, quantitative analysis reveals significant differences in terms of the density of different plant food categories, differences that allow us to offer insight into the nature of subsistence shifts related to maize intensification.

As the first reconstruction of temporal trends in plant data for the Mississippian period occupation of the CIRV, this study establishes a baseline against which to compare future data sets in order to determine the range of variation within and between temporal phases during the Mississippian period. In order to understand changes that occurred during the Woodland/Mississippian transition, we consider the Mississippian

ubiquity at C. W. Cooper are acorn (53.3 percent) and little barley (43.3 percent). It is worth noting that the next three taxa ranking below little barley are purslane (also important at Lamb), maygrass, and knotweed. These ubiquity values reveal the importance of starchy seeds and nuts as significant supplements to maize. Despite their high ubiquity values, starchy seeds as a whole represent only 8 percent of the C. W. Cooper

Table 6. Seasonality profile for the Lamb site (not including probable identifications [cfs]).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Maygrass				X	X	X						
Little barley					X	X	X					
Squash					X	X	X	X	X			
Bedstraw					X	X	X	X				
Purslane					X	X	X	X	X			
Plum/cherry						X	X	X	X			
Carpetweed						X	X	X				
Sumac						X	X	X	X	X		
Nightshade						X	X	X	X	X	X	
Maize							X	X	X			
Panic grass							X	X	X			
Hazelnut							X	X	X			
Sunflower							X	X	X	X		
Sweet gum							X	X	X	X		
Chenopod							X	X	X	X	X	
Knotweed/smartweed							X	X	X	X	X	
Tick clover								X	X	X		
Pine nut								X	X	X	X	
Ragweed								X	X	X	X	
Sumpweed									X	X	X	
Acorn									X	X	X	
Hickory										X		
Walnut										X		

sites as individual data points against the Late Woodland sites aggregated as a single distribution. We display the Late Woodland distributions as box plots in our analysis. The use of box plots has become more common in archaeological analyses, and thus we limit our description here to the assessment of statistical difference.⁷ If the notched areas (denoted by the hourglass shape and representing the 95 percent confidence intervals) of any two boxes do not overlap, then the two distributions are statistically significantly different at the 0.05 level.

We initially began our analysis by comparing densities of nutshell, maize, fruits, and the starchy/oily seeds across these different periods—what we found was that every single plant food category was

represented in much greater density during the Mississippian period. Thus we calculated total plant density, finding a significant difference in the overall density of plant remains between the Late Woodland and Mississippian sites (although Rench was a high outlier, with a plant density value on par with the Lamb site) (Figure 9). This pattern may reflect several things: better preservation of more recent plants, a change in the manner of plant deposition through time, and/or a reflection of longer-term settlement and/or higher population during the Mississippian period than during the previous Late Woodland times. What is clear, however, is that density measures cannot speak to differences in plant diet in this particular comparison.

Table 7. Seasonality profile for the C. W. Cooper site (not including probable identifications [cfs]).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Maygrass				X	X	X						
Wax myrtle				X	X	X	X	X	X	X		
Blackberry/raspberry					X	X						
Little barley					X	X	X					
Pokeweed					X	X	X	X				
Magnolia					X	X	X	X	X			
Squash/gourd					X	X	X	X	X			
Purslane					X	X	X	X	X			
Carpetweed						X	X	X				
Spikerush						X	X	X	X			
Elderberry						X	X	X	X	X		
Sumac						X	X	X	X	X		
Nightshade						X	X	X	X	X	X	
Amaranth							X	X	X			
Bulrush							X	X	X			
Maize							X	X	X			
Goosegrass							X	X	X			
Bean							X	X	X	X		
Chenopod							X	X	X	X	X	
Knotweed/smartweed							X	X	X	X	X	
Tick clover								X	X	X		
Sumpweed									X	X	X	
Acorn									X	X	X	
Hickory										X		
Walnut										X		

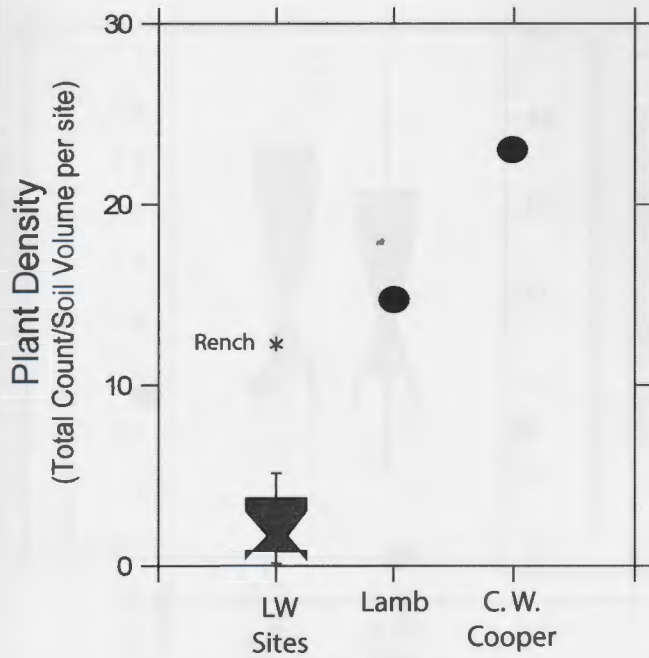


Figure 9. Comparison of total plant density (counts/soil volume) between Late Woodland sites and Early Mississippian sites (Lamb and C. W. Cooper).

Thus we consider other measures of abundance for comparing Late Woodland and Mississippian plant collection and production. To this end, we calculated proportions for key plant groups from the total plant assemblage at each site. For all plant groupings, the Late Woodland sites are displayed as a box plot distribution (for sites dating A.D. 600–1100), with the Mississippian sites plotted individually alongside each distribution (Figures 10–14). When presenting the Late Woodland/Mississippian comparison of maize abundance, we only present those Late Woodland sites at which maize was identified (Liverpool Lake, SC357, and Rench); we also present both densities and proportions for maize. Comparison of proportions of fruits, oily seeds, and starchy seeds reveal that the values for the Lamb and C. W. Cooper sites fall within the range of variation identified at the preceding Late Woodland sites (Figures 10–12). More specifically, Lamb and C. W. Cooper both fall within the 95 percent confidence intervals of the distribution for Late Woodland fruit proportions (see Figure 10). The oily seed plot is a bit more complicated, as oily seeds are rarely found in great abundance ($n = 20$ for all Late Woodland sites in the sample; see Figure 11); thus the Late Woodland box plot is quite small, and two of the five Late Woodland sites with oily seeds appear as high outliers. The Lamb and C. W. Cooper sites, however, fall within the overall range of the Late Woodland data, suggesting little change through time. In terms of starchy seeds, the Mississippian sites of Lamb and C. W. Cooper fall within the notched confidence intervals

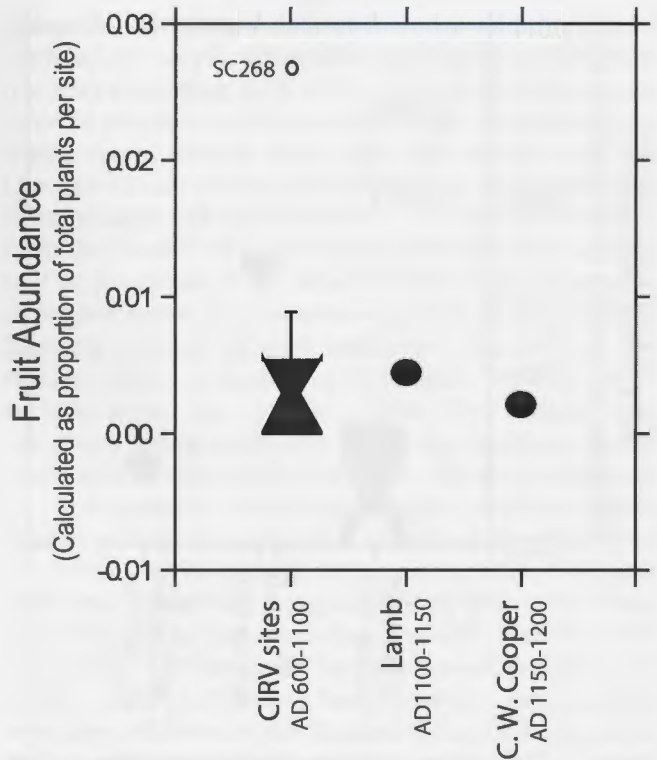


Figure 10. Comparison of fruit proportions between Late Woodland sites and Early Mississippian sites (Lamb and C. W. Cooper).

for the Late Woodland plot, although the values for Lamb and C. W. Cooper both fall just above the lower confidence interval of the Late Woodland box plot. Overall, the proportional representation of fruits, starchy seeds, and oily seeds at the Early Mississippian sites is consistent with the preceding Late Woodland period.

The only statistical differences that are apparent in the Late Woodland and Mississippian plant assemblages occur with maize and nuts. In terms of nuts, there is a statistical decrease between the Late Woodland period and the Early Mississippian period, with the Lamb and C. W. Cooper values falling below the lower confidence interval of the Late Woodland box plot. It is interesting that this decline in nuts reverses with C. W. Cooper. Although the Cooper value is still lower than the preceding Late Woodland sites, it nevertheless represents a higher value than observed at the Lamb site; if we compare the density values for nuts between Lamb (2.35) and C. W. Cooper (9.53), this pattern remains.

A comparison of maize values from the Late Woodland sites yielding maize remains (Liverpool Lake, 11SC357, and Rench) and the Early Mississippian sites of Lamb and C. W. Cooper reveals a clear statistical increase in the abundance of maize, in terms of both proportion and density (Figure 14). We present

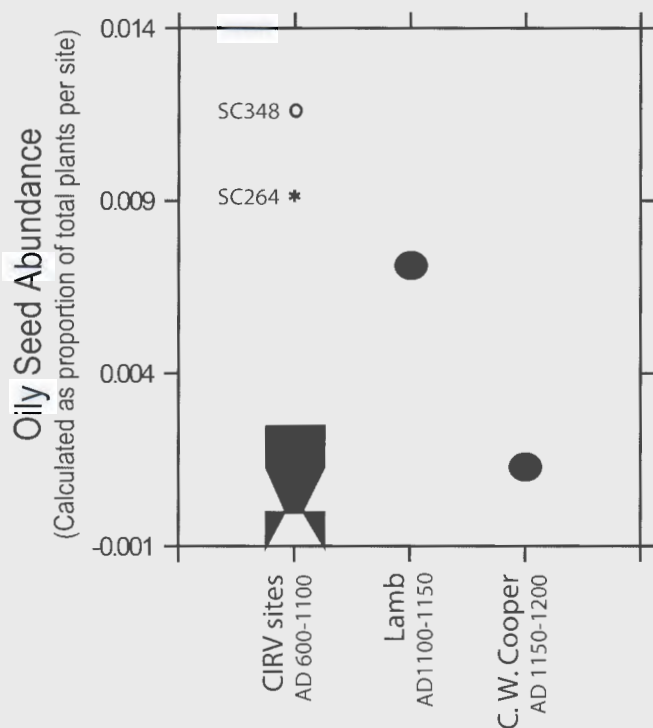


Figure 11. Comparison of oily seed proportions between Late Woodland sites and Early Mississippian sites (Lamb and C. W. Cooper).

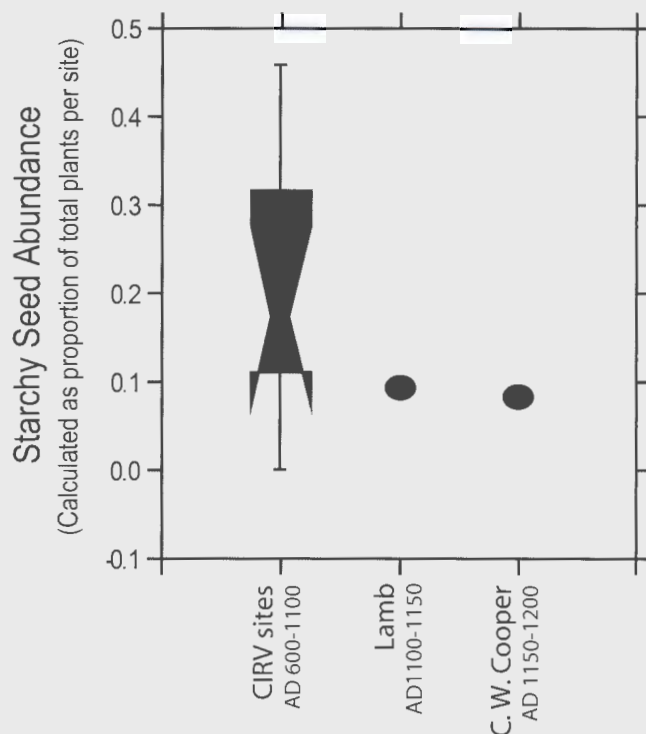


Figure 12. Comparison of starchy seed proportions between Late Woodland sites and Early Mississippian sites (Lamb and C. W. Cooper).

proportions for the reason stated above (the statistical difference in overall plant density between the Late Woodland and Mississippian sites). We present density as well in order to demonstrate the increase in maize abundance from the early Eveland phase (A.D. 1100–1150) occupation at Lamb to the late Eveland phase (A.D. 1150–1200) occupation at C. W. Cooper. Because proportions are dependent measures, the C. W. Cooper maize proportion value was pulled down because of the greater abundance of nuts at that site; we thus present maize densities to provide an independent comparison between the two Early Mississippian sites. Based on these collective data, there appears to be a broad trend toward increasing maize production from the late Late Woodland to Early Mississippian periods.

The statistical increase in maize from the Late Woodland period to the Early Mississippian period occupations of Lamb and C. W. Cooper lends supports to our argument that Lamb and C. W. Cooper were likely occupied year-round. The increase in maize abundance is suggestive of increased production for storage through the winter. Plant seasonality data presented above (see Tables 6 and 7) demonstrates the production and collection of plants through all months except winter (i.e., December, January, February), when plants do not typically bloom. We present a third line of evidence supporting year-round permanent occupations at the Lamb and C. W. Cooper sites in

the form of pit feature volumes and examine changes in intensity of site occupation and use through time with a comparison of data from earlier Late Woodland sites.

Volume data from pit features provide a useful way to examine settlement mobility, particularly in the absence of detailed structure data (as is the case for some of the Bauer Branch sites as well as the Liverpool Lake and Lamb sites). Even if sites contain large pottery assemblages and structures, such sites may represent the remains of one household moving around the landscape, perhaps seasonally (see Hornum and Burks 2011:1). A greater investment in pit construction, particularly large cooking facilities and subterranean storage features, however, can serve as a good proxy to interpret a greater degree of settlement permanence. While shallower pits may be constructed for use in processing and cooking, deep pits suitable for storage are not often found at sites interpreted as special-purpose task camps, such as winter hunting camps (Wagner 1996:267; see Turnbow et al. 1983). And while it is problematic to uncritically correlate storage with sedentism (see DeBoer 1988:8–9), when used alongside other lines of evidence (e.g., plant seasonal indicators and increased maize production), pit volume data can be used to assess changes in occupational permanence as well as organization of subsistence activities. Given the variable nature of the data used to assess seasonality at the Late Woodland sites (discussed above), a comparison of pit volume data through time

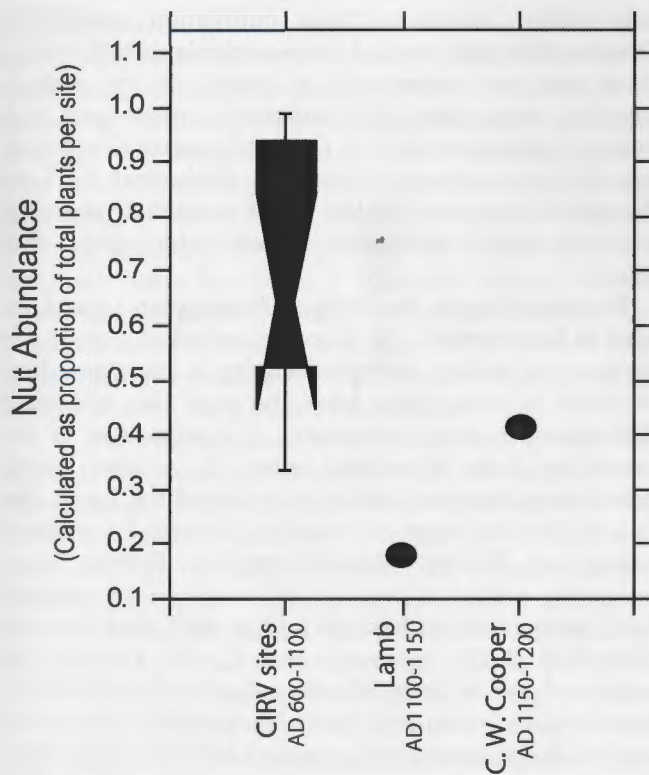


Figure 13. Comparison of nut proportions between Late Woodland sites and Early Mississippian sites (Lamb and C. W. Cooper).

offers a standardized way to examine changes in occupational intensity and site permanence.

Volume data were collected from all the Bauer Branch locality sites reported by Green (1987); the

Bauer Branch feature dataset includes additional sites from which no plant remains were recovered (including sites predating A.D. 600) and were extracted from Green's unpublished excavation forms. Pit volume data were also collected from the site reports for the Liverpool Lake (Esarey 2000:Table 8.2) and Rensch sites (McConaughy et al. 1993:Table 5.1). Volume metrics from the Lamb and C. W. Cooper pit features used here will be presented in detail in forthcoming site reports. Recorded metric and nonmetric attributes were used to calculate volume for each individual feature from the various sites, including pit length, width, depth, surface area, and profile shape. Pit volume was calculated using volumetric formulae based on profile shape (see Fortier et al. 1984:Figure 22) and is reported in cubic meters. Volume estimates generally reflect overall pit volume capacity; however, the calculated volumes must be considered approximations, because some pits presented irregularities in shape not compensated for in the formulae. Volume could not be calculated for features lacking measurements for length, width, or depth; hence, the pit volume data represent a subset of the features excavated at each of the sites discussed in this paper.

Volume data are presented as six box plots, shown in temporal order (Figure 15). There is no statistical difference in pit volumes between the early Late Woodland (A.D. 400-700) and late Late Woodland (A.D. 750-1100) Bauer Branch sites, nor does the Liverpool Lake distribution differ significantly from the Bauer Branch sites. In contrast, the Lamb and C. W. Cooper volume distributions are significantly higher than the Bauer Branch and Liverpool Lake distribu-

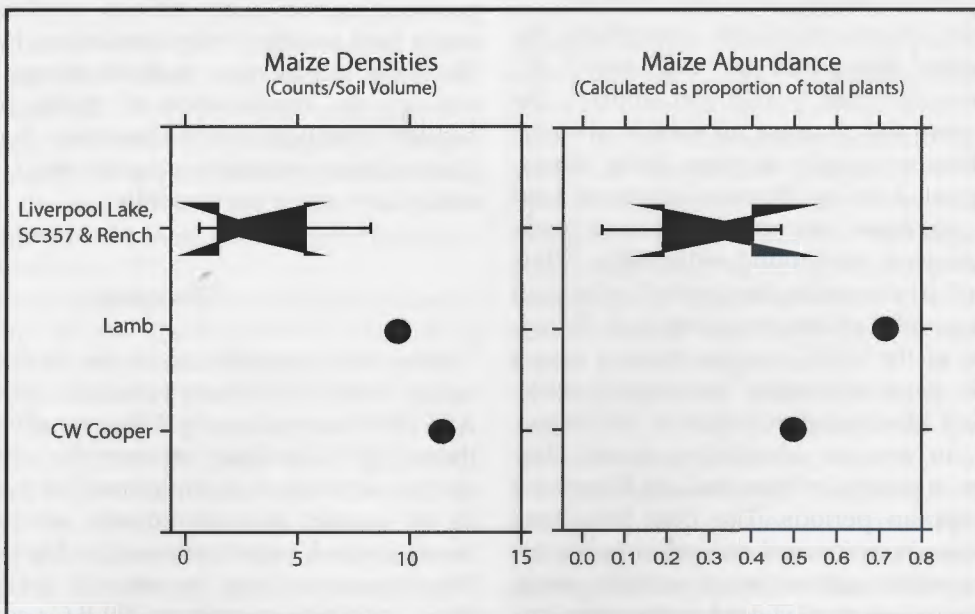


Figure 14. Comparison of maize proportions and densities between Late Woodland sites and Early Mississippian sites (Lamb and C. W. Cooper).

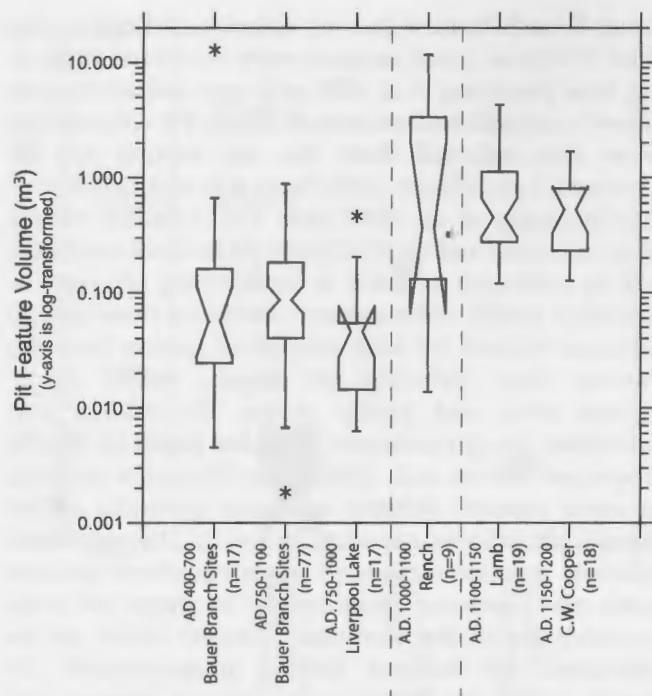


Figure 15. Comparison of pit feature volumes between Late Woodland sites and Early Mississippian sites (Lamb and C. W. Cooper).

tions, as seen in the lack of overlapping confidence intervals signaled by the notches in the box plots. The confidence intervals for the Rench site box plot overlap with all of the distributions, suggesting that the Rench site is transitional between the late Late Woodland and Early Mississippian sites. Rench's small sample size of pit features ($n = 9$) is also noteworthy, leading to a longer box with a much wider confidence interval.

This increase in pit feature volume strengthens the arguments presented above that the Lamb and C. W. Cooper sites were occupied year-round. Indeed, the correlation between the increase in maize and the increase in pit feature capacity at these Early Mississippian sites suggests a linkage between increased food production and increased storage that is commonly attributed to permanent, year-round settlements. While it remains difficult to determine the level of settlement permanence/seasonality of the preceding Late Woodland occupations of the CIRV, we can make a strong case that people were inhabiting year-round settlements by the Early Mississippian period in this region.

In summary, our analysis establishes several clear temporal changes in plant diet from the Late Woodland to Early Mississippian periods. The Late Woodland diet appears to have been focused around nuts and the collection and possible cultivation of starchy seeds, supplemented by minimal oily seed cultivation and fruit collection. Near the end of the Late Woodland period, people living in the central Illinois River valley

also added maize to their cultivation repertoire. Despite this shift toward increased plant cultivation, there was no corresponding change in pit feature capacity, suggesting that settlement investment and intensity of site use did not change dramatically during this 500-year period. Indeed, it is likely that the Late Woodland residents of the CIRV combined seasonal and year-round settlement patterns throughout this time.

The transition to the Early Mississippian period, as seen at Lamb and C. W. Cooper, included a dramatic increase in maize accompanied by a corresponding decrease in nuts; these were the only two statistical differences in plant abundance in comparison to the preceding Late Woodland sites. It is also worth mentioning that the density of maize at the Lamb site falls within the range of variation (close to the median value) for Stirling phase American Bottom sites, indicating a level of production comparable to permanent, year-round settlements within the Cahokia polity (Bardolph 2012). If Lamb and C. W. Cooper are representative of Early Mississippian sites in the CIRV, then the Late Woodland/Early Mississippian transition can be characterized by a tradeoff between two staple food groups: maize and nuts (primarily thick-shelled hickory nuts). Both maize and hickory nuts represent significant staple plant foods that are highly storable; although residents of Lamb and C. W. Cooper may have increased maize production while decreasing hickory collection, they nevertheless relied heavily on both maize and hickory nuts as their two primary staple plant foods. Indeed, hickory is as ubiquitous as maize at both Lamb and C. W. Cooper. Thus the increase in pit feature capacity at Lamb and C. W. Cooper over the previous period likely reflects a relative increase in staple food storage for both maize and hickory nuts. It is likely that this increase in staple storage (made possible through the combination of maize production and hickory collection) was the insurance that allowed Early Mississippian residents of Lamb and C. W. Cooper to settle down more permanently.

Discussion

Why did groups living in the central Illinois River valley intensify maize production beginning around A.D. 1100, approximately 300 years after its adoption in the region? This delay between the adoption of maize and its elevation to a staple resource is not uncommon in the greater midwestern and southeastern United States. Indeed, recent research by Hart et al. (2012:317) has documented the presence of maize phytoliths in New York state as early as 300 B.C.; comparative data from Michigan yielded maize phytoliths dating to 400–350 B.C. (see also Raviele 2010). These data make it clear

that people were growing maize in the broader Eastern Woodlands more than a millennium before it became a dominant component of the diet. While the varieties of maize that were originally imported from Mesoamerica (through the Southwest and Plains) certainly would have needed time to adapt to a different set of growing conditions, it should not have taken 1,400 years to engineer a variety (or varieties) that could produce sufficient yields to elevate it to staple status. Indeed, Mesoamerican maize varieties had already passed this threshold around 1000 B.C. (Kirkby 1973; Smalley and Blake 2003), two millennia before maize was adopted as a staple food in the Eastern Woodlands.

It is likewise unlikely that a burgeoning regional population played a prominent causal role in the Early Mississippian intensification of maize cultivation in the CIRV. Population pressure models of agricultural intensification typically propose that imbalances between food resource abundance/availability and population levels led to an intensification of existing cultivation systems (Boserup 1965; Cohen 1977). In order to produce enough food for a growing population, farmers would have had to increase their yields, thus requiring more time and labor investment into agricultural tasks. Sometimes implicit in these models is a relationship between increasing population size and political development, wherein political complexity is seen as emergent based on population increase, often conceived in terms of managerial necessity. Given this scenario, intensification would occur after significant population increase and would be coincident with or a consequence of political development. There is, however, no clear evidence of an Early Mississippian population increase in the CIRV. Likewise, there is no indication of an early twelfth-century organizational shift toward nucleated settlements in the region. Early Eveland phase sites were small and widely scattered, and most settlements were probably single-family homesteads (Harn 1991:138–141). Nucleated, “village-sized” settlements do not appear in the region until the second half of the twelfth century, after the Early Mississippian shift toward increased maize production that we document here.

The role of climate change in the intensification of maize production in the CIRV is more difficult to evaluate than that of population pressure. Recent tree-ring data have demonstrated that a series of droughts began plaguing the greater Southeast and Midwest beginning around A.D. 1100 (Benson et al. 2009), around the same time that maize was elevated to staple status in the CIRV. Indeed, Benson et al. (2009:474) report that west-central Illinois experienced severe drought 140 out of 145 years following A.D. 1100. It is difficult to reconcile drought conditions with an increase in maize production; indeed, contemporary drought conditions in Illinois have led to radically

decreased maize yields in 2012 (Spak 2012). Moreover, a drought in the 1950s also negatively impacted maize yields in Illinois (Benson et al. 2009:478).

The intensification of maize cultivation during an era of severe drought and in the absence of a notable population increase or settlement nucleation indicates that the Early Mississippian inhabitants of the CIRV did not alter their subsistence strategies for purely economic or ecological reasons, which leads us to consider additional social explanations. Other possible reasons for these subsistence changes relate to the northward expansion of the Mississippian frontier and the adoption of Cahokian-style religious practices and institutions by local Woodland groups. Many of the other early twelfth-century changes in the CIRV, such as the establishment of small temple and mortuary complexes and the adoption of Ramey Incised pottery (Conrad 1989, 1991; Harn 1991), relate directly to the northward spread of a Cahokian-inspired religious tradition. Thus the intensification of maize cultivation may have been a component of this expanding religious movement (see also Bardolph 2012, 2014; Wilson 2012).

Previous research has revealed that maize was a plant imbued with deep ritual meaning in the American Bottom and elsewhere in the Eastern Woodlands. Johannessen (1993a) notes that, in contexts dating prior to the widespread cultivation of maize in the American Bottom, most macro-maize remains are recovered from communal public features, suggesting a ceremonial role for the plant. Scarry (1993b) argues that early maize was rare because it held cosmological significance, and so its use was restricted to certain social and ceremonial events. Given the presumed ritual importance of maize, Scarry focuses on social causes to explain changes in crop production occurring with the Mississippian transition, linking the increase in maize to its inherent cultural and ceremonial value. Based on her Moundville research, Scarry proposes a model of competitive generosity to explain maize’s transition from rare delicacy to everyday staple (*sensu* Hayden 1992, 1995, 2009). She argues that certain individuals (e.g., aspiring elites) co-opted the ritual symbolism of maize by using it in prestige-building activities, such as competitive feasting. This process would have brought various social groups together, creating a cycle of debt between hosts and guests that could only be repaid through the escalation of such events, thus requiring increases in production levels.

Recent isotope research in the Spiro region of eastern Oklahoma has revealed a correlation between higher-status individuals and higher maize consumption during the Terminal Late Woodland period, suggesting a link between social status and consumption of a ritually significant food (Rogers 2011). This linkage suggests that high-status people were the “early

adopters" of maize (Rogers 2011:102). This pattern fits well with Scarry's ideas of competitive generosity, as it would be the higher-status community members that would be hosting prestige-building events at which maize would be displayed and served. Ideas of the ritual significance of maize and its early linkage with elite activities are widespread throughout the New World. For example, similar arguments have been proposed by Mesoamerican archaeologists to explain the relatively low abundance of maize in Early Formative Olmec contexts, suggesting the use of maize as a ritual beverage in public ceremonial contexts (e.g., Clark and Blake 1994; Smalley and Blake 2003; VanDerwarker and Kruger 2012). Finally, it is noteworthy that the intensification of maize cultivation had already begun in the American Bottom by the Lohmann phase consolidation of Cahokia around A.D. 1050, and there is evidence that large-scale feasting events took place at this time in the vicinity of Cahokia's grand plaza (Pauketat et al. 2002). Thus the emphasis placed on maize cultivation in the early-twelfth-century CIRV may have been fueled by an emulation of Cahokia's intensified ritual economy in which feasting events played a prominent role.

Conclusion

The archaeobotanical assemblages from the Lamb and C. W. Cooper sites are the first Mississippian plant data to be published from the CIRV. Considering the limited nature of the current information, we can only hypothesize about the motivations behind the Early Mississippian maize intensification in the region. While our findings cast doubt on some causal scenarios, our views regarding the relationship between maize intensification and the northward spread of a Cahokian-inspired politico-religious movement are preliminary and tentative. Further details concerning if and how maize was used and displayed in events related to competitive generosity require investigation and evaluation. Regardless of the impetus of maize intensification in the CIRV, there would have been consequences for CIRV residents related to site permanence, gendered and seasonal work patterns, and land-use tenure. Thus the "meaning" of maize production would have not been simply symbolic but may have also derived from the way it shaped the rhythms of everyday life.

Ongoing analysis of additional floral and faunal data from multiple sites spanning the regional Mississippian chronology will allow us to determine the variability of plant and animal subsistence through time and across space in the CIRV. The patterns presented here nevertheless allow us to contribute to the debate regarding the variation in the timing of maize intensification throughout the midwestern and southeastern United States. In

order to understand how and why ancient people intensified maize production, we need to consider more than simple changes in maize abundance and/or ubiquity. Rather, we argue that interpretations regarding the intensification of maize need to be understood within the context of changes occurring in the overall subsistence system. Using such an approach takes us beyond description and allows us insight into the reasons why people chose to increase maize production during the Mississippian period.

Notes

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¹ The Roskamp site dates to the Orendorf phase, representing a Middle Mississippian site in the CIRV. The plant assemblage has been fully analyzed and a report is currently in process.

² Fleshy fruits include sumac, nightshade, blueberry, blackberry/raspberry, hawthorn, strawberry, elderberry, grape, and persimmon. Nutshell includes hickory, walnut, acorn, and hazel. Oily seeds include sumpweed and sunflower, as well as any specimens grouped into a sumpweed/sunflower category. Starchy seeds include chenopod, knotweed/smartweed, maygrass, and little barley. Although the chenopod and knotweed specimens are not clear domesticates, we nevertheless include them in the starchy seed category as they were likely processed similarly to their domesticated counterparts.

³ Due to the lack of meaningful results from the PCA, we do not present the analysis in this paper.

⁴ Indeed, researchers in the CIRV have continued to raise the question of seasonal versus year-round occupation well into the Mississippian period. For example, Harn (1978:248) has characterized the Late Mississippian Larson phase (A.D. 1250–1300) settlement pattern as one in which populations aggregated in large towns (e.g., Larson) during cold seasons and then dispersed into smaller groups during the warmer seasons. Conrad (1991:155) disagrees with Harn's assessment, arguing that Orendorf and Larson phase settlement patterns are comparable to those in other portions of the Middle Mississippian cultural area that have been widely interpreted as permanent, year-round occupations. Given this debate in the regional literature, we revisit the issue of seasonal

occupation throughout the paper as it relates to Late Woodland through Early Mississippian period occupations.

⁵The Polygonum specimens were directly compared with confirmed samples of erect knotweed from the West Park site, Illinois, provided courtesy of Dr. Gayle Fritz. The chenopod specimens were compared with images provided in Smith (1985); none of the seeds demonstrated the truncate margin that is consistent with domesticated specimens.

⁶Once the flotation samples from the 2012 and 2013 excavations of C. W. Cooper are fully analyzed, all bean specimens will be sent for AMS dating.

⁷Box plots display distributions of data, in which the actual box (or hinges) represents the middle 50 percent of the data (see Cleveland 1994; McGill et al. 1978; Wilkinson et al. 1992). Lines, or whiskers, extend from the box on either end, representing the remaining top and bottom 25 percent of the distribution. Outliers are depicted as asterisks, and far outliers as open circles. The notched area denoted by the hourglass shape represents the 95 percent confidence interval, and the area of maximum constriction at the center of this hourglass represents the median value of the distribution.

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