An attempt to dendrochronologically date house features at the King site (9FL5), a 16th century Late Mississippian town in northwestern Georgia, USA

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A B S T R A C T

The King site is a Late Mississippian (ca. 1400–1540 CE) aboriginal town located in northwestern Georgia along the Coosa River associated with the Coosa Chiefdom. The site was settled ca. 1530 but was occupied for perhaps only 50 years or so based on the lack of horizontal stratigraphy. The site was visited by members of either or both the Hernando de Soto expedition in 1540 and/or the Tristan de Luna expedition in 1560. In 1974, archaeologists discovered and removed 36 sections of subterranean charred pine posts from six house features. Our objectives were to determine if the tree rings on these posts could be dendrochronologically dated to verify the dates of site occupation and confirm the construction sequence of several houses determined originally via stratigraphic and archaeological evidence. We were able to graphically and statistically crossmatch 13 measurement series representing 10 posts from 5 of the 6 structures, yielding a 157-year floating chronology (average interseries correlation = 0.60). We were unable to absolutely crossdate this floating chronology with the only regional reference chronology long enough (back to 1378 CE) to reach the 16th century, an eastern red cedar chronology from eastern Tennessee. Archaeological evidence indicated Houses 8 and 23.4 were built later in the King site occupation, confirmed by the tree-ring dates as both houses have the youngest tree rings of the five structures. House 14 had the oldest outermost tree rings but archaeological evidence suggests this house also was likely constructed late in the King site occupancy. We propose some posts were salvaged and reused from abandoned houses as the King site became rapidly depopulated in the last 10–20 years of site occupancy, thus explaining the age of posts used in House 14. We urge archaeologists working in the Southeastern U.S. to consider developing a more formal process for exhuming and preserving charcoalized wood remains from archaeological sites so that these samples can be evaluated using dendrochronological techniques.

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1. Introduction

The King site is a mid-16th century aboriginal town located on the Coosa River in northwestern Georgia. The 2 ha town was laid out as an almost perfect square with a central plaza and surrounding habitation zone, bounded on the north by the Coosa River and by a ditch and palisade defensive perimeter on the remaining three sides (Hally, 1988, 2008) (Fig. 1). Forty or more houses were packed into the habitation zone. Houses generally have a square floor plan and were erected in shallow basins 30–50 cm deep. Exterior walls were of single-set post construction and had earth embanked against their outer surfaces to a height of 40 cm or more. Roofs were supported on exterior wall plates and on four posts set in a square around a central floor space and hearth. Bark and thatch roofs were thickly plastered with clay on their underside to prevent sparks from cooking fires igniting them. Exterior walls and interior partitions were constructed primarily with split posts while interior roof supports were frequently whole posts. Based on post impressions in fired wall and roof clay, all posts were debarked, presumably to reduce the level of insect activity and rate of decay. Houses were often rebuilt in place, some as many as four times (hence, the designation of “House 23.4,” see Fig. 1). Over 250 human burials were interred beneath house floors, in open areas adjacent to houses, and in two plaza locations.

The King site was probably occupied for less than 50 years as suggested by the few cases of spatially overlapping features (such as houses and burials) and the fact that the palisade and public structures have only one construction stage (Hally, 2008). Both show little evidence of repair. Although the site is almost totally devoid of vertical stratification, a number of clues reveal how the town

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changed over time. These include: the close spatial proximity of some houses to one another; evidence that some burials located within the walls of houses either predate or postdate structure occupancy; multiple construction stages for several houses; and shifts in the size, compass orientation, and location of some houses at the time they were rebuilt.

These clues allowed the reconstruction of the life history of the town with a considerable degree of reliability (Hally, 2008:314–329). Site occupation began between 1530 and 1540 CE with the arrival of several households that probably came from established towns located several kilometers up the Coosa River to the east. They built at least four houses: 1, 2, 5, and 15 (Fig. 1). Within the next 10–15 years, a large number of families arrived and the town was formally established. This involved laying out the plaza and surrounding habitation zone, erecting a large pole in the plaza marking the spatial center of the town, construction of the two public buildings, and construction of the town’s defensive perimeter. Over the next decade or so, the population increased slowly largely through the growth of existing households as suggested in part by the construction of smaller sized houses along the margins of the habitation zone. Eventually, the town was abandoned by ca. 1590–1600 when most residents moved elsewhere, presumably down river into present-day Alabama (Smith, 2000:97–117).

The King site is archaeologically and historically significant because it was visited by either or both the Hernando de Soto expedition in 1540 and/or the Tristan de Luna expedition in 1560. Reconstructed routes of both expeditions pass by the site (Hudson 1988, 1997; Hudson et al., 1985), and iron artifacts such as chisels, knives, and a complete sword, dating to the mid-16th century have been found in six burials (Smith, 1975; Hally, 2008).

During the 1974 field season, three dozen charred posts were recovered from six houses (7, 8.2, 14, 21, 22, and 23.4), four of which (7, 8.2, 14, and 23.4) occupy time-sensitive positions in the town’s reconstructed history. The posts consist mostly of charcoal, indicating the structures had burned at some point. This burning was fortunate because charcoal lasts longer on the landscape (Stokes and Smiley, 1996), even in moist environments, being more impervious to decay than wood in its normal state. Our study had several objectives: (1) determine if tree rings in charcoal samples extracted from archaeological sites in the Southeastern U.S. can be dendrochronologically dated, (2) evaluate the sequence of house construction in the King site by comparing outermost tree-ring dates of several houses, and (3) confirm, refute, or refine the possible years of occupation of the King site. Successfully dating samples from the King site would demonstrate the feasibility of developing a master chronology for sites in the Southeastern United States based on charcoaled wood. Currently, no archaeological site in the Southeastern U.S. has been dated using tree-ring analysis of charcoal.

2. Methods

Each sample consisted of the end section of longer poles emplaced into the soil. On most samples, the portion of the sample

Fig. 1. The King site (9FL5) plan showing numbered primary domestic structures and two public structures (16 and 17). Some houses were multi-staged with two or more plans that changed over time, e.g. structures 1 and 15.
Fig. 2. Post 6A, House 21, showing (A) charcoal on the top portion, (B) charcoal and wood from the side view, and (C) wood on the bottom portion. Note the sand still embedded in the sample. This sample had 66 measurable rings.

deepest in the soil showed evidence of intact wood xylem interfac- ing with the charcoal (Fig. 2). This again was fortunate because this allowed the actual examination of wood xylem to identify the type of wood (softwood versus hardwood) and possibly the genus on several samples. The samples, however, were extremely fragile and had broken apart considerably since initial exhumation. This disintegration was problematic because the samples had to be pieced back together before examination. In addition, a flat surface on which to view and eventually measure the tree rings was difficult to achieve. Finally, another issue we faced was the reflectance off the charcoal surface using standard light sources, but we learned that a fluorescent or LED light source worked best. Because this was the first attempt at tree-ring dating of charcoalized wood from a South- eastern U.S. archaeological site, we provide details on techniques that helped overcome or mitigate many of these issues.

2.1. Stabilization of individual samples

Stabilization was required on most samples to prevent breakage and further disintegration. This was accomplished using ordinary duct tape securely wrapped around and underneath the sample (Fig. 3). String or cord occasionally was used to strengthen the wrapping. The duct tape proved an excellent technique for stabi- lization because, if necessary, the tape could easily be cut back with a razor to reveal the critical outer portions of the charcoal required for additional surfacing and measuring.

2.2. Preparation of the charcoal surfaces

To enhance the definition of the tree-ring boundaries in the charcoal samples, we used one or a combination of the following three surfacing techniques:

(1) **Breakage**: This technique is commonly used for archaeological charcoal samples collected in the American Southwest (Douglass, 1941; Stokes and Smiley, 1996). The charcoal is broken by hand, with a razor blade, or with a small impact instrument. The charcoal will usually break along an even cleavage, revealing a clear set of tree rings. Proper positioning of the light source will maximize the effects of light reflectivity. The latewood bands of the tree rings then appeared as wide, glossy bands.

(2) **Razor blades**: Most surfaces of the charcoal were prepared using a razor blade (Hall, 1939; Stokes and Smiley, 1996). This tech- nique first involved removal of unstable charcoal that crumbled and disintegrated easily when teased with a biological probe or razor blade. Eventually, solid charcoal will be reached. The surface is then shaven with the razor blade along the trans-

Fig. 3. Post 2 from House 8 with 49 measured rings, showing how the surface was prepared with a razor blade and the use of duct tape to securely bind the sample to prevent further breakage and disintegration.
verse (flat) surface. Occasionally, to enhance ring definition, the charcoal was surfaced at an angle to the wood grain.

(3) Sanding: On a few samples, enough wood remained on the underside of the charcoal samples that allowed surfaces to be sanded with an orbital sander or by hand. Once wrapped with duct tape to prevent breakage, the samples were sanded using progressively finer sand paper, beginning with ANSI 180-grit (83–88 μm) and ending with ANSI 400-grit (20.6–23.6 μm) (Orvis and Grissino-Mayer, 2002). This technique produced a wood surface with a high polish on which the cellular structure of the tree rings could be seen under 7–10 × magnification.

2.3. Measurement of ring widths

Tree rings on all samples were carefully marked with standard decadal notation (Stokes and Smiley, 1996; Speer, 2010). Ring widths then were measured to 0.01 mm accuracy beginning with the innermost complete ring that could be identified, which was assigned ring number 1, and ending with the outermost complete ring. Measurements were made using Measure J2X measuring software and a Velmex moving stage micrometer. Each radius measured per sample was given a separate letter, e.g. 21-P6-A and 21-P6-B.

2.4. Crossmatching

Crossmatching is a closely-aligned technique to crossdating, the basic principle used in dendrochronology that ensures that proper calendar years are assigned to individual tree rings (Stokes and Smiley, 1968; Fritts, 1976). While crossdating ensures exact calendar years are assigned to tree rings, crossmatching ensures the tree rings in all samples are dated relative to each other, resulting in a floating chronology. Crossmatching was accomplished using an iterative technique by processing the tree rings from only one sample at a time, beginning with 21-P6 because this post was the largest and best preserved, and had the most pieces from which we could measure five radii and crossmatch them relative to each other. The measurement series being tested was entered into COFECHA as an undated series while all crossmatched series served as the “dated” series (Holmes, 1983; Grissino-Mayer, 2001). If COFECHA suggested a possible match, we evaluated the correlation and its associated t-value. Both had to be statistically significant (usually p < 0.001). We then used the skeleton plot graphing technique to create overlapping sequences that verified the statistical crossmatching. The skeleton plot constructed from the undated series had to be convincing graphically when compared to the evolving master skeleton plot based on the other series crossmatched against each other (Grissino-Mayer, 2001). Finally, we made scatter graphs for each series to complement the crossmatching comparison provided by the skeleton plots. Once crossmatched, the first ring for the measurement series being tested was adjusted using program EDRM (Edit Ring Measurements) (Holmes, 1992) based on the dating position relative to all other crossmatched series.

2.5. Assessing the quality of the final data set

The quality of the final dated series was assessed using two metrics. The interseries correlation is the correlation of each series with a master created from all other series. An average interseries correlation ≥0.40 is desirable (ITRDB, 2016). We also used mean sensitivity, a descriptive statistic used in dendrochronology to identify series and sites that are particularly sensitive to the environment and would therefore have a high degree of environmental information (Fritts, 1976). In the southeastern U.S., values ≥0.25 are desirable as these would indicate series that have a high degree of sensitivity and therefore a high probability of being crossdated.

2.6. Standardizing the measured series for chronology development

Standardization transforms all measurements into dimensionless indices with a mean of 1.0 and provides a means for removing or minimizing effects from growth trends that are not climatically driven (Cook, 1987). The climate signal is desirable because climate impacts considerable influence on tree growth and is largely responsible for the variation in tree growth rates from year to year among all trees. Once each series is transformed to dimensionless indices, the indices for each year from each series are averaged.
together. We used program ARSTAN to fit linear or log-linear models to each series to produce predicted values of tree growth (Cook, 1985). The actual measurements were then divided by these predicted values to produce an index of growth per year per series. The final master chronology was generated by averaging by year across all series to produce the final master tree-ring chronology.

2.7. Dating the King site master chronology

When we first analyzed these samples in 1999, we attempted to date the floating chronology using bald cypress (Taxodium distichum (L.) Rich.) chronologies (Stahle et al., 1985; Stahle and Cleaveland, 1992), but we found no conclusive and convincing results using this species. Since then, a new data set was developed from living eastern red cedar (Juniperus virginiana L.) trees collected in the Norris Dam area of eastern Tennessee that overlapped with some longer J. virginiana samples originally collected by Florence Hawley and her colleagues back in the 1930s (Hawley 1937, 1938, 1941). Hawley had collected samples from some of the oldest trees in eastern Tennessee before the valleys became flooded by several dams constructed to generate hydroelectric power as part of a federal land project (the Tennessee Valley Authority) to help stimulate the economy of rural areas in eastern Tennessee (McDonald and Muldowny, 1981). These eastern red cedars once grew along the slopes of now-inundated, steep-sided river valleys, especially in the interface of the sandstone caprock and underlying limestone of the Cumberland Plateau. Even though Hawley was confident of her crossdating of the tree-ring patterns in these samples, her mentor A.E. Douglass was unconvinced and never approved of her crossdating (Nash, 1999). Some of these previously-collected samples were added to the living tree data to help develop a new chronology for eastern Tennessee that dated back to 1378 CE (Cook et al., 2016). We used both skeleton plots and COFECHA in our attempt to date the King site floating chronology against this eastern red cedar reference chronology.

3. Results

All samples examined consisted exclusively of pine (Pinus spp.) but southern yellow pines cannot be keyed out to species (Hoadley, 1990). Based on the native ranges of southern yellow pines, however, the species is most likely shortleaf pine (Pinus echinata Mill.).

3.1. Measurement of samples

A total of 25 radii were measured, representing 15 of the original post samples extracted from five houses: 8, 14, 21, 22, and 23 (Table 1). One post, P6 from House 21, contained five individual samples, and therefore five radii were measured in the hope these would provide a long overlapping series. Two radii were measured from samples 08-P1, 14-P2, 14-P3, 14-P4, 22-P1, and 23-P2, while one radius was measured from samples 08-P2, 14-P2, 21-P1, 21-P2, 21-P3, 21-P5, 23-P1, and 23-P4 (Table 1). Several post samples simply had too few rings (e.g. 08-P1, 14-P1, and 21-P3) and could not be confidently crossdated. These were excluded from further analyses. Some samples that did have enough rings could not be confidently crossdated graphically or statistically (e.g. 14-P2-A, 14-P3-A, and 21-P1) and were excluded from further analyses. Lastly, six samples had disintegrated completely and could not be reassembled for analysis. The final number of samples included 13 measurement series representing 10 posts from five structures (Table 1).

3.2. Chronology building results

The composite skeleton plot for the four 21-P6 series provided a foundation on which the other viable series could be dated. Several years served as pointer years that aided the crossmatching process, especially the narrow rings formed in ring numbers 22 (index = 0.510); 42 (0.604); 57 (0.564) and 58 (0.680); 76 (0.422); 94 (0.607) and 98 (0.619); 113 (0.607); 127 (0.601); and 147 (0.497) (Fig. 4). After all series had been measured, statistically validated via COFECHA, then graphically crossmatched, the final average inter-series correlation was 0.60. All series retained for inclusion in the final chronology had an inter-series correlation of at least 0.40. The average mean sensitivity was 0.30, a value comparable or better than values for other pine chronologies in the southeastern U.S. (ITRDB, 2016). The number of 40-yr segments tested by COFECHA for proper positioning within the chronology was 54, while 10 segments were flagged by COFECHA (Table 2). The percentage of flagged segments (18.5%) is high for the southeastern U.S., but is not unexpected given the difficulty in accurate measurement of the charcoal surfaces. Temporal positioning of all series was verified graphically using skeleton plots, and no series was added to the chronology unless it could be statistically confirmed with COFECHA (Grissino-Mayer, 2001).

3.3. Dating the King site master chronology

Despite the 157-yr floating pine chronology having many narrow “pointer” years to aid the crossdating process (Fig. 4), we could find no convincing crossdating against the skeleton plot of the long chronology developed from eastern red cedar for the Norris Basin in eastern Tennessee. Further, COFECHA could not find any systematic dating adjustment for all or most of the tested segments in the pine chronology, nor were any correlations for any tested segments particularly outstanding. In summary, we failed to crossdate

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Table 1

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the floating pine chronology from the King site with the anchored eastern red cedar chronology.

4. Discussion

We developed a floating tree-ring chronology from charcoal specimens for an archaeological site in northwestern Georgia, the first time a charcoal tree-ring chronology has been developed for an archaeological site in the southeastern U.S. This suggests that charcoal from other archaeological sites in the Southeast potentially can be dated using established graphical and statistical tree-ring dating techniques. The biggest hurdle, however, will be the eventual development of longer reference tree-ring chronologies to date the charcoal samples from these sites. Currently, the reference pine chronology from several sites in the interior portion of the Southeast (west of the Appalachian Mountains) dates back to 1652 CE and is composed of pine samples from 12 sites collected in northern Georgia, western South Carolina, eastern Tennessee, western North Carolina, and central and southern Virginia. Still, this pine chronology does not extend enough back in time to date Late Mississippian sites. Nor are the longer balsam cypress chronologies from coastal plain locations in the Southeast close enough to have tree-ring patterns in common with the north Georgia pines.

Although individual houses could not be dated in absolute calendar years due to the absence of a suitable master chronology for the region, we turned our focus instead to (1) dating different posts within one structure, and (2) dating the four houses relative to one another based on outermost ring dates. Presumably, most trees were harvested within a few kilometers of the site, and most posts should temporally overlap given the relatively short occupation span of the site (<50 years), especially within an individual structure. The caveat is that we could not determine how close we were to the true cutting dates given that the posts were both burned and had decayed, causing loss of most or perhaps all sapwood.

For example, House 14 had two posts with measurement series that supported what could be the earliest cutting date of the 5 structures analyzed, with terminal rings in relative years 62 and 67 (Fig. 5). The near-common innermost rings (15 and 18) and outermost rings suggested that these two posts actually could be from the same tree. The correlation of these two measurement series is statistically significant 0.65 (t = 5.68, n = 45, p < 0.0001). If not from the same tree, then the two posts were likely fashioned from two trees that grew close together when originally harvested. Curiously, archaeological evidence indicated that House 14 was constructed late in the occupation history of the King site and was contemporary with House 23.4. House 23.4 is one of the latest houses built on the King site based on horizontal stratigraphic and archaeo logical evidence. Two posts from House 23 did indeed yield the second and third youngest tree rings (rings 142 and 154) of all 13 samples. Archaeological evidence indicates that House 8.2 also dates late in the town’s history, but not as late as House 23.4. House 8 has the youngest tree-ring date in the master chronology (ring 157).

The number of years that separates House 14 from Houses 8.2 and 23.4 are at odds because archaeological evidence indicates construction of House 14 near the latter part of the King site occupancy. To explain this, we propose that posts were scavenged from houses built earlier and reused to build later houses. After most of the town’s inhabitants had moved away, a large supply of posts would have been available for scavenging from abandoned houses. The inground portion of these used posts, probably measuring no more than 60 cm in length, would have suffered some amount of decay and possible insect infestation and this 60 cm portion would have been removed to produce a serviceable post for later construction. The sizes of houses at the King site, measured by floor area, range between 28.5 m² and 100 m² (average = 57 m²). At 62 m², House 14 was of average and below average size. The larger the horizontal dimensions of a house, the taller its central roof support posts have to be to provide a roof pitch steep enough to effectively shed rainwater. Using a roof pitch of 53° from the horizontal, a comparison of house size and central roof support post spacing indicates that central support posts increased in length an average of 60 cm for every 90 cm increase in structure size. This being the case, several abandoned houses located in the excavated portion of the site would have had central roof support posts long enough for reuse in House 14.

A key question concerns the number of years that separate the earliest and latest outermost ring dates for the five structures. Ninety years separate Houses 14 and 22 from House 8, but the short span of occupancy inferred from the archaeological evidence suggests only a 30–40 year difference should exist. We propose several possible scenarios that might explain this. First, the sapwood could have been intentionally or unintentionally removed when the logs were debarked prior to house construction. In the more resinous southern pine species, sapwood is less resistant to decay than heartwood because the heartwood contains natural chemicals that retard the growth of decay fungi (Highley, 1995; Forest Products Laboratory, 1999; Shupe et al., 2008). The indigenous builders of the King site likely knew that posts would last longer if the sapwood was removed. Second, standing dead trees could have been used for construction because pines can remain standing for a number of years after tree death (Dahms, 1949; Conner and Saenz, 2005). Third, the posts used at the King site could have been

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The text is a part of a scientific article discussing tree-ring dating and its application to archaeological sites, particularly focusing on the King site in northwestern Georgia. The discussion includes the development of a tree-ring chronology for archaeological sites in the Southeast and its implications for understanding the history of the site. The text also explores potential scenarios for the preservation of tree-ring data in archaeological contexts.
salvaged from structures built earlier at a nearby site and reused. Finally, large segments of outer rings may have been lost in the ground during field recovery despite our best efforts to keep the wood intact. This is supported by the outermost dates for the five series from Post 6 in House 21, which differ by 23 years, a situation that can only be explained by loss of outer rings at some point after House 21 was built.

5. Conclusion

We developed the first tree-ring chronology in the Southeastern U.S. based on charcoalized wood remains from an archaeological site in northwestern Georgia. Thirteen measured series from five houses at the King site crossmatched with each other to create a 157-year floating chronology. Several other samples yielded measurable tree rings but these were either too short to be crossmatched or the ring patterns were too erratic to match the other series. The interseries correlation values and the average mean sensitivity indicated tree-ring patterns that responded significantly to an over-arching climate signal that could have allowed absolute crossdating with an anchored reference chronology. Unfortunately, the regional reference pine chronology was likely too short to crossdate with the floating chronology, and the houses at the King site must remain undated for now. We learned, however, that we can more accurately depict the temporal sequence of house construction but also learned that the lack of outermost tree rings due to intentional removal, fire, or decay creates a level of uncertainty that must be considered. Overall, though, our interpretations of the sequence of house construction based on tree-ring dates followed the archaeological and stratigraphic evidence for two of the three houses that had time-sensitive context.

Our study demonstrated that floating-tree-ring chronologies based on charred construction posts from archaeological sites in the Southeastern U.S. can be developed if well-preserved charred posts are available in large numbers. These conditions are potentially achievable across the Southeast with Mississippian period materials. The research potential of site specific or region-wide floating chronologies is considerable and suggests that archaeologists can make accurate estimates of how long domestic structures and sites were occupied, how long temple mounds and their individual construction stages were used, and how long individual chiefdoms lasted. Of equal research value, floating chronologies would allow archaeologists to establish contemporaneity between archaeological contexts, i.e., individual houses at a site or separate sites in a region. For example, Hally (1986) proposed that clusters of late Mississippian towns in eastern Tennessee, northwestern Georgia, and northeastern Alabama represent the component settlements of individual chiefdoms. Relative dating with tree rings could establish beyond doubt the contemporaneity of the settlements within individual clusters and the contemporaneity of the clusters themselves.

For this to happen, however, we reiterate suggestions first proposed by Grissino-Mayer (2009) concerning extraction of wood and charcoal from Southeastern U.S. archaeological sites. Much of the literature has focused on conservation of waterlogged wood (Oddy, 1975; Brunning, 1995; Bjurhager et al., 2010) but relatively little can be found for preservation of charcoal or non-waterlogged wood from archaeological sites. In the Southeastern U.S., extraction and preservation of wood remains has been a low priority because, currently, tree-ring dating from prehistoric sites in this region is difficult to achieve. Further, a standard sampling protocol must be established and tested to ensure that wood and charcoal samples are preserved and remain intact so that tree-ring dating can be attempted. Once the wood or charcoal is removed from the ground, the decreased pressure will cause the fragile samples to expand and disintegrate, even when encased in gauze or paraffin (not suggested) and wrapped tightly with string. We urge archaeologists working in the Southeastern U.S. to work with dendrochronologists to establish such a protocol before more potentially datable tree-ring samples disintegrate.

References


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