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Early Shell-tempered Pots and Corn in the Ozark Highland

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The health benefits of cooking corn (Zea mays) in a shell-tempered pot seem to be at the heart of an important innovation, and is inferred to be strong evidence of corn as an A.D. seventh-century dietary supplement if not a true staple in the Ozark Highland.

An explanation for the widespread co-occurrence of shell-tempered pots and corn (*Zea mays*) in the late prehistoric periods of eastern North America links the evolutionary adaptive fitness of this technology to corn consumption. This makes sense, given corn's prominence in late prehistoric agriculture (Smith 1989, 1992) and that a diet rich in carbohydrates (if not corn) is risky. Thus, Morse and Morse (1983:208-210) note that shell tempering increased vessel strength (see also O'Brien and Wood 1998:250-251) and liberalized shape. This made cooking more efficient due to more even heating and heat transfer, allowed for the softening of dried corn in cooking, and conferred health benefits for corn consumption by being a catalyst for B vitamin niacin that wards off the effects of pellagra. Shell-tempered pots truly were integral to but not synonymous with Mississippian period (ca. A.D. 900-1500) and later corn agriculture adaptations, principally because of the many health benefits associated with alkali processing (Osborn 1988:34-37). These range from the freeing of lysine and tryptophan bound in the gluten fraction of corn protein, improving the uptake of critical minerals such as iron and calcium, and reducing the impact of maize mycotoxins.

Corn consumption and shell-tempered pots must represent the culmination of a historical pattern. Yet, it is puzzling and contrary to expectations. In the American Midwest, corn is identified as a staple only after about A.D. 1000-1200 (Bender et al. 1981; Lynott et al. 1986). As sketched by Smith (1989, 1992, 2011), corn's sudden primacy is at variance to the gradual experimentation for native cultigens over hundreds or thousands of years in prehistoric eastern North America. The history of eastern North America cultigens squares with predictions of agriculture development as a complex agroecology of sequential coevolutionary stages (Rindos 1984); the tropical domesticate, corn, does not. Why did corn replace native cultigens with crop yields of comparable magnitude? Why does the transformation to corn agriculture occur suddenly? Was corn like tobacco or watermelon that, once available in the postcolumbian historic period, had an almost instantaneous global spread? In a similar vein, shell-tempered pots are not on the radar screen of Midwest archaeology until the Mississippian period. And then, they are a fully developed technology. An example is the American Bottom of the Mississippi River valley in western Illinois, where shell-tempered pots first show up after A.D. 1050—that is, at least 200 years after the beginnings of Mississippian developments but when corn was likely a staple (O'Brien and Wood 1998:251).

What brings us to this point, is the question I wish to address here. There are two ways to think about this, "the corn problem." One is to accept the pattern as real; the other as not. Were we to accept the pattern we could chalk it up to the amazing variety of cultural responses of complex society. Or that it is simply human nature to innovate to such a high degree. The alternative is less celebratory but, I believe, closer to the mark.

Quite apart from a viable theory of plant domestication and agriculture (Rindos 1984), we have failed to solve the corn problem. We have looked in the wrong places. We often have misconstrued and forgotten crucial evidence. And we have lacked a sufficiently intelligible climate record to compare with eastern North America prehistoric agriculture.

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We can correct these deficiencies. Not surprisingly, the data can now be shown to fit well with Rindos's evolutionary theory of agriculture and Smith's (2011; see also Weitzel and Codding 2016) chronicle of prehistoric native cultigens for eastern North America.

For reasons that will become clear shortly, I think the logical place to begin our quest is the Ozark Highland adjacent and west of the Mississippi River valley; that is, an oft overlooked area peripheral to the classic Mississippian developments of the Mississippi River valley but by no means divorced from them or their predecessors (Brown 1984). I chart the antiquity of some recent and not so recent discoveries of corn and/or shell-tempered pots in the Ozark Highland and then compare them to both a distribution of dated discoveries of corn east of the Mississippi River (Crawford et al. 1997) and decade scale or longer duration droughts of comparable or greater magnitude to those of the 1930s and 1950s for the past two millennia (Woodhouse and Overpeck 1998). In doing so, I follow the philosophy of many others who in a more detailed fashion address ceramic technological change (Braun 1983, 1987; Briggs 2016; Brown 1989; Dunnell and Feathers 1994; Lynott et al. 2000; O'Brien and Hoard 1996) in the North American Midwest as a prime adaptive response to nutritional stress, food preparation efficiency, or to sources of clay and other raw resources. I am also indebted to George Sabo III, who provided unpublished data used here and whose research at another of the principal sites is fundamental to the thesis I further develop; namely, the linkage of shell-tempered pottery to corn in eastern North America well predated the Mississippian period and first occurred beyond the major river valleys.

A Primer on Ozark Highland Shell-tempered Pots

No one source documents all shell-tempered pottery in the Ozark Highland, nor do I think it likely that any will ever be regarded as complete. The two that, in my opinion, are indispensable are by Carl H. Chapman (1980) and by Susan C. Vehik (1984). Also valuable, and often drawing heavily on one or the other or both of these works, are other compilations (Johnson and Johnson 1998:215-216; O'Brien and Wood 1998:182-270; Sabo and Early 1988:67-73), two unpublished PhD dissertations (Purrington 1970; Reeder 1988), site studies (Dickson 1991; Hilliard and Mainfort 2007; Sabo 1990b; Wood and Brock 1984), and an occasional astute observation (Schambach 1988). Last but not least, James E. Price's (in Price and Price 1984:68-100) formulation of the Varney tradition of the eastern Ozark Highland, and George Sabo III's (1990c) central Ozark Highland study provide essential, and insightful, updates.

Although the Ozark Highland is not notable for pottery, shell-tempered pot sherds are fairly widespread. They present a number of interpretative problems. They often occur in mixed or compressed contexts, rarely are complete enough to be described as vessels, or are in an understood or dated stratigraphy. But regardless of vessel form, surface treatment, or decoration, the biggest problem is the attitude summarized by O'Brien and Wood (1998:246): "When shell-tempered pottery is found, say, in the Ozarks, the usual interpretation *is* that it was traded into the region or, more commonly, that 'Mississippian' peoples brought it with them when they visited or settled in the region" (emphasis in the original). They further observe correctly, however, that "shell tempering was in no way a predictor that a group was on an evolutionary pathway toward becoming 'Mississippian'" (O'Brien and Wood 1998:252), while noting the incorrectness that "if a sherd was shell-tempered, then it had to be Mississippian" (O'Brien and Wood 1998:243).

A strong candidate for "Ground Zero" for shell-tempered pots must be the Middle Woodland period Cooper complex on the Ozark Highland's southwest flank. This shell-tempering technology was described for Delaware County of northeast Oklahoma in the early 1950s by David A. Baerreis (1953), and later for the Delaware A ceramics that preceded it and Delaware B pottery that followed (Purrington 1970:274). According to Purrington (1970:272-283), a major difference between Cooper and Delaware ceramics is the former are decorated and the later are either plain or cord-marked. They often share a similar paste having grit-shell tempering. The Cooper complex has not been directly radiocarbon dated. Its ceramics, however, are dated in north central Oklahoma (Vehik 1984:177-187). An age range of A.D. 100-450 is reasonable for Cooper. Chapman (1980:23) and Vehik (1984:177) depict Cooper geography differently (Figure 1). Shell tempering is discussed only by Vehik who, not surprisingly, better represents its distribution to northeast Oklahoma. To this, one should add Albertson in contiguous northwest Arkansas (Figure 1*a*), where the complex's distinctive shell-tempered ceramics have more recently been discovered in sealed, stratified but undated deposits in this rock shelter in Benton County, Arkansas (Dickson 1991:112-115). Cooper is in the northern tributaries of the Arkansas River. Later, this area was dominated by agrarian, civic-ceremonial centers at Harlan, Norman, and Spiro (Brown et al. 1978; Griffin 1967). It was only then—during the last millennium—that corn became a staple in the Arkansas River basin.

Baerreis's descriptions are notable in several respects. They explicitly document shell-tempered ceramics and define this technology to well-established pottery styles. Cooper ceramics unequivocally show shell tempering is part of the overall Middle Woodland technology and continues into the Late Woodland. Baerreis also identified other carbonate tempers in addition to shell. For Cowskin Dentate Stamped, one of his types, the temper consists of abundant grit with pieces of chert often 5 mm in diameter, plus crushed limestone, bone and shell. That shell is just one of several carbonate tempers mirrors Fourche Maline ceramic experimentation about the same time in the Ouachita Mountains south of the Arkansas River valley (Purrington 1970:275; Schambach 1988:7). Either Fourche Maline and/or Cooper could qualify as the point(s) of origin for the bone-tempered Middle Woodland "Marksville" ceramics of the Alexander site of central Arkansas (Hemmings 1985:36-37). Alexander is downstream in the Arkansas River valley from Cooper (Figure 1*a*), which might have facilitated movement of this technology or the idea, and is closer to Cooper than to the nearest Mississippi River valley Marksville manifestation (Figure 1*b*). Marksville is not known for bone tempering (Sabo and Early 1988:79). The illustrated Alexander sherds are truly generic Middle Woodland rather than clearly identifiable as Marksville (R. Mainfort, personal communication, February, 2001).

Cooper and Delaware pots start a ceramic technology centering on shell tempering and that continued in "all but seamless" (Schambach 1993:220) ways later on. This transition to shell tempering was well in place by A.D. 600 in the Arkansas River valley, its tributaries, and farther into the interiors of the Ozark Highland. Delaware plain and cord-marked pottery would be virtually indistinguishable from other Ozark Highland wares typical of the Late Woodland period. There is no consensus on what to call this pottery, which is largely plain or with a cord-marked surface treatment. Nor has it been systematically characterized by petrographic and trace element evaluations. In Missouri, Maramec Plain or Maramec Cord-marked now commonly refer to predominantly limestone-tempered wares in the Ozark Highland; Weaver, to grit-tempered pottery north of the Missouri River or in western or southwestern Missouri (O'Brien and Wood 1998:241). For reasons of geography alone, other designations (Boone, Moreau, etc.) occur too. Shell tempering occurs as well in Maramec (Reeder 1988) and Cooper (Baerreis 1953) ceramics related to Weaver. In the Arkansas River valley and its tributaries in Oklahoma and Arkansas, and in the interior Ozark Highland in central Arkansas, a similar shell-tempered plain ware occasionally represented by flat-bottomed vessels is called Woodward (Freeman and Buck 1959). The southeastern Ozark Highland area of Missouri and Arkansas has a different shell-tempered technology, Varney, that includes red slipped interior surfaces and that seems to be the age-equivalent of Maramec wares (see O'Brien and Wood 1998:256). Shell-tempered Owls Bend pottery also occurs in the Varney area but is distinct from it (Lynott 1989; Price and Price 1984). Owls Bend may have parallels in the Ozark Highland interior too (Sabo 1990c:320-321).

The Early Shell-tempered Pottery and Corn Connection

Shell-tempered pottery in the western and central Ozark Highland is associated with corn, or is present at the same time as corn likely occurs. According to largely consistent radiocarbon dating, the four earliest (and thus, most critical) archaeological sites (Figure 1*a*) go roughly north to south across the Springfield Plateau or its border with the Salem Plateau: Bowling Stone Mound (23CE152) in Cedar County, Missouri; Beech Creek Shelter (3NW637) and Ira Spradley (3NW101) in Newton County, Arkansas; and Dirst (3MR80) in

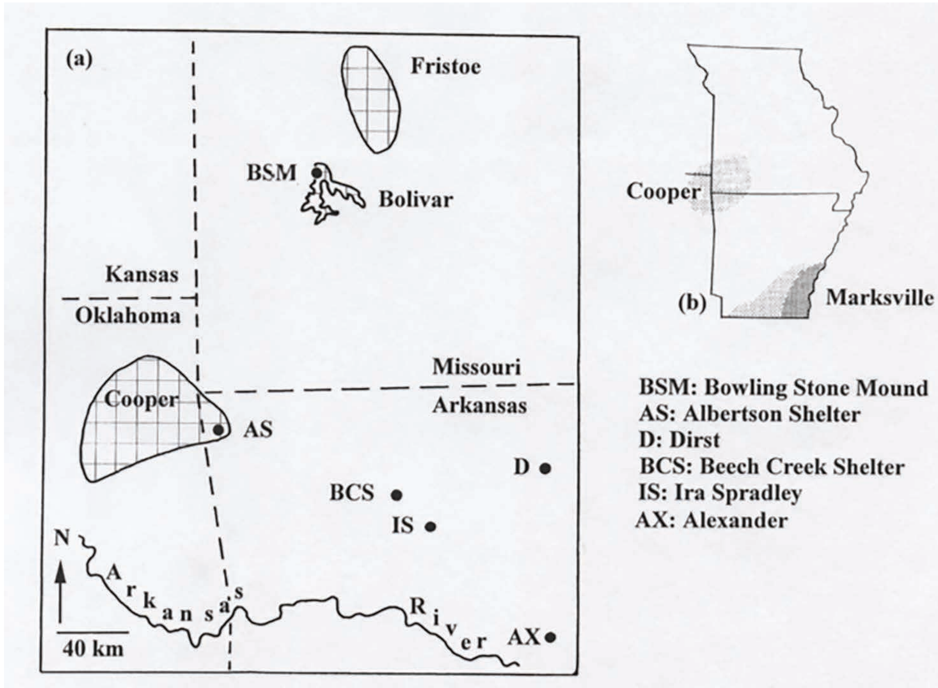

Figure 1. Principal archaeological sites and complexes discussed for the western and central Ozark Highland; *a*, Cooper complex shell tempered pottery distribution is adapted from Vehik (1984) and Dickson (1991), and *b*, Cooper and Marksville complexes are adapted from Chapman (1980).

Marion County, Arkansas. These four sites are on (or well above) widely separated creeks or small rivers that flow in different directions within the Osage, White, and Arkansas drainage basins. Undoubtedly, we are not talking about a single group but rather a general adaptation to highland streams and landscapes.

I briefly describe the associations of shell-tempered pots or corn, and their five radiocarbon assays (Table 1). In terms of the history of radiocarbon dating (Taylor 2000) the Bowling Stone Mound assay (Wood and Brock 1984:118) came before the recognition of the C3, C4 photosynthetic pathways and the need for isotopic fractionation. Fortunately, it and the other charcoal samples all follow the C3 pathways. These were directly compared, once calibrated, to determine if they are statistically the same age (Long and Rippeteau 1974). Bowling Stone Mound and Dirst (Sabo 1990a:136-137) assays employed conventional beta counting; the two from Beech Creek Shelter and Ira Spradley, atomic mass spectrometry (AMS). None dates corn directly. The assays range in radiocarbon years from 1560±140 BP (M-1967) to 1250±60 BP (Beta-123306). The calibrated assays were evaluated using Stuiver and Reimer's (1993) calibration program 4.1.2. (This calibration program has been updated almost annually but the updates do not affect the calibrations reported here.) The t-test of sample means showed no statistically significant differences among them at the 95% (0.05) level of confidence interval. This means they are statistically the same age and calculating a weighted average for the five is appropriate. At the two sigma (95.4%) range, the calibrated weighted average of the five samples is cal A.D. 611-716 with 96.9% of the relative area under the probability distribution, cal A.D. 750-763 with 3.1% of the relative area under the probability distribution. For all practical purposes, the most likely age of all four sites falls within cal A.D. 611-716, during the seventh century A.D. Of the Arkansas sites, Ira Spradley and Dirst have shell-tempered pots. Dirst's pottery is directly associated with charred corn. Beech Creek Shelter has unburnt corncobs but no pottery. When applied to the corn, Beech Creek Shelter's date could be questioned but, I think, is still likely.

Bowling Stone Mound had charred maize kernels and a shell-tempered pot. The mound overlooks the Sac River and a tributary, Hawker's Branch. Sac River is a southern arm of the Osage River basin that empties into the Missouri River. The mound is

Table 1. Radiocarbon dates.

Site*	C3 Material	Assay	Radiocarbon Age BP	Calibrated 2δ Age(s)	Relative Area Under Probability Distribution
BSM	nutshell	M-197	1560±140	cal A.D. 139-159	0.009
				cal A.D. 170-197	0.013
				cal A.D. 206-714	0.969
IS	burnt residue	Beta-12330	1250±60	cal A.D. 660-896	0.988
				cal A.D. 927-938	0.012
D	charcoal	Beta-33079	1670±210	142-139 cal B.C.	0.002
				113 cal B.C. - cal A.D. 775	0.998
D	nutshell	Beta-33080	1450±80	cal A.D. 425-713	0.991
				cal A.D. 751-760	0.009
BCS	cordage	AA-9768	1370±50	cal A.D. 597-772	1.000
		Wt. Average	1365±34	cal A.D. 611-716	0.969
				cal A.D. 750-763	0.031

* BSM: Bowling Stone Mound; IS: Ira Spradley; D: Dirst; BCS: Beech Creek Shelter.

part of the Bolivar burial complex (Wood and Brock 1984:35-41, 118). Brock regarded corn consumption as a food supplement for the burial complex as a whole (in Murray and Rose 1995:129), but one which had health consequences for the population. Compared to the largely non-corn-consuming population of the nearby Fristoe burial complex, the rate of carious teeth was 2.6% for Fristoe and 12.5% for Bolivar, dental abscesses 0% for Fristoe and 2.2% for Bolivar, periodontal disease going from 60% for Fristoe to 82% for Bolivar, and a lower survivorship among the maize-eating subadults of the Bolivar complex. The seven individuals from Bowling Stone Mound, however, are not well represented by skeletal elements likely to show pathology (only 8 teeth, of which 7 came from a single adolescent, were recovered). Bolivar burial complex radiocarbon assays date mostly to the A.D. 900 to 1200 range (Wood and Brock 1984:118-119), and include one on maize kernels. (The latter should be reevaluated, in my opinion, because it came before recognition of the C3, C4 photosynthetic pathways.) Wood and Brock (1984:118) regarded the much earlier Bowling Stone Mound assay as problematic: "The [uncalibrated] date of A.D. 250 to 530 from Bowling Stone seems to be too early, especially if the shell-tempered pottery there is not intrusive."

I see no reason to reject the Bowling Spring Mound assay, even though its exact association is unclear. This assay is on charred nut hulls (i.e., a collected annual C3 mast product, and an excellent material for conventional radiocarbon dating). Charred walnut hulls and three corn kernels were "among the bones" of burial 1a/1b in the central burial area (Wood and Brock 1984:37). Other "[s]mall pockets and individual finds of charred maize kernels and hickory shells were common enough that it is probable that the sample recovered (about two ounces) is only a small percentage of the amount originally placed in the structure" (Wood and Brock 1984:41). From this description, it seems the charred nut radiocarbon sample was not associated with any particular interment but did occur with corn deliberately grown for human consumption. All of the Bowling Stone Mound pottery came from a single concentration adjacent to burial 1a/1b in the northwest-central portion of the mound. Undoubtedly, it would not qualify as a concentration were it not for 314 limestone-tempered body sherds from two limestone tempered vessels. This concentration was affected by a "gopher pit" that "probably accomplished little more than to displace some of the sherds in the concentration of pottery in the fill overlying [a bedrock] crevice" (Wood and Brock 1984:35). The shell-tempered cord-marked pottery consists of a single small rim sherd. This "obliquely cord-roughened sherd is 4 mm thick, has a rounded lip, and bears partly smoothed, parallel, vertical Z-twisted cord impressions" (Wood and Brock 1984:38). It is the only clearly cord-marked vessel of the four recovered and has the thinnest rim. Rim thickness varies from 6 to 8 mm for the two limestone-tempered vessels that also have rounded lips. The actual number of rim sherds for each of the vessels is small. The two limestone-tempered vessels had a total of five rim sherds. A grog-tempered vessel had four body sherds but no rim sherds. So, the single shell-tempered rim sherd is not inconsistent with rim sherd representation in the concentration.

To sum up, the mound appears to represent a single burial event or related ones over a short time span. The pottery, including the shell-tempered rim sherd, is not randomly distributed but was found near a central burial feature. The assay is on nut hulls directly associated with corn, although the exact location is not specified. The only ostensible strange thing about the Bowling Stone Mound assay, as noted originally by Wood, is its age; not its integrity or association with corn or the shell-tempered sherd. In light of more recent discoveries and this reevaluation, the age of the assay seems consistent with both early corn and shell-tempered pottery in the Ozark Highland.

Ira Spradley is a cemetery on a low alluvial terrace of Big Piney Creek, a tributary of the Arkansas River in south central Newton County, Arkansas, and the farthest south of the sites. The cemetery has no obvious surface expression such as a mound or grave depressions. It was discovered when human bone was plowed up and then salvaged in 1970 and 1971. It is not referenced in a later bioarcheology summary (Rose et al. 1988). The unpublished field notes and report (Gregoire and Gregoire 1971) indicate a minimum of five individuals was interred, although the actual number could be as many or more than 30. Dietary insights from "the limited [dental] caries data from the Ira Spradley Field cemetery…are consistent with a nonmaize diet" (Hilliard and Mainfort 2007:281). A site map of the excavations, labeled 1971, shows the human skeletons include 12 skulls along with a variety of chipped stone tools and 23 shell-tempered pots (two other vessels may have had crushed limestone tempering; see Hilliard and Mainfort 2007). The discrepancy in the number of individuals represented does not materially change the implications for shell-tempered pots. According to the Gregoires' notes and subsequent formal description of Hilliard and Mainfort (2007), the vessels are mostly plain, and lack decoration (one rim has V-shaped notches, another close-spaced punctations, and two vessels have loop handles). They include flat bottoms occasionally with basketry impressions and hemispherical forms with out-flaring rims, and have wall thicknesses of 6 to 7 mm. These vessels are different from the later "standard" Mississippian globular jars that were designed to cook corn hominy and that difference in vessel form has functional implication for cooking vessel technology (see Briggs 2016). A carbonized residue on the interior of one nearly complete pot was submitted in 1998 for AMS radiocarbon dating. The assay (Table 1) provides our most conclusive evidence of the antiquity of shell-tempered pots in the south central Ozark Highland.

Dirst, on an alluvial terrace at the junction of Rush Creek with Buffalo River, is the farthest east of the four sites and is upstream of the junction of the (lower) Buffalo and White River. Dirst is a stratified, multi-component site. It begins with a late glacial Dalton component. It ends with an "apparent lack of evidence for a continuation of occupation into Middle or Late Mississippian times," although other habitations of these sorts are noted in the Rush Creek vicinity (Sabo 1990b:267). So there seems not to be a later source of shell-tempered pottery and corn that somehow might have been mixed into earlier sediments. The Stratum 5 midden contains shell-tempered along with grog, grog and bone, and bone and shell-tempered pottery. Most important is Feature 4, a large pit that originates in Stratum 5. Feature 4 contents included Scallorn arrow points (recovered at Bowling Stone Mound too) and Rice Side Notched dart points, shell-tempered Woodward Plain pottery plus two fired pottery coils, and a "layer of stacked mussel shells accompanied by a couple of handfuls of river snail shells" (Sabo 1990b:264). Although low in seed density, Feature 4 had representatives of the native Eastern North American starchy seed crop complex (Fritz 1990:170-173). Most dominant is little barley; also present is maygrass, knotweed, and sumpweed. The majority (all but two cupule fragments) of corn came from Feature 4 too and includes four whole cupules, 20 cupule fragments, seven glumes, one nearly whole kernel and two possible kernel fragments, and a possible embryo fragment (Fritz 1990:169).

This is actually not just impressive for the Dirst site but, according to Fritz (1990:170), is already more than "the total of four cupules from rich middens on Mounds B, D, and E at the Toltec Mounds site." Toltec, the premiere mound center in the Arkansas River valley near Little Rock, was subjected to a flotation recovery system comparable to the one at Dirst. Toltec is identified to Plum Bayou (Coles Creek) culture (Rolingson 1985). It is roughly the same or younger in age than Dirst. About 80 km northwest of Toltec is a second Arkansas River valley Plum Bayou example, the previously mentioned Alexander site. Systematic excavation and flotation recovery at Alexander produced but a single corn cupule from what may be but is not unequivocally a Plum Bayou midden (King 1985). The midden remains also contained hickory nutshell, black walnut, maygrass, goosefoot, knotweed, wood sorrel and purslane, plus a seed of domesticated sumpweed and rind of squash and gourd. Neither differential preservation nor recovery can account for the under-representation of corn at Toltec and Alexander. There does not appear to be nearly the focus on corn in the Arkansas River valley as there is along the Buffalo River at Dirst.

Feature 4 radiocarbon sample selection deliberately dealt in, I think, a highly appropriate strategy to evaluate possible admixtures of botanical materials (Sabo 1990a:136-137). The two samples came from pit fill and allowed for a direct comparison of "two completely different materials—nutshell and wood charcoal." Had the assays been discordant, a likely explanation would have been pit filling from sediments earlier than Stratum 5. The two assays, however, are not different statistically, and seem to date in an appropriate manner the Rice Side Notched points common to both the Stratum 5 midden and Feature 4. The implication is the dates are reasonable for the corn and shell-tempered pottery too.

Beech Creek Shelter had a single desiccated interment, who was carried into the shelter in a large burden basket of woven split cane. Although the subject of a notable textile study (Kuttruff 1988, 1993), the site and circumstances surrounding the discovery have not been written up, even in a cursory fashion, until now. The site was discovered in 1987 by Newton County locals. They first dug up the body along with pieces of the basket, a variety of textiles, corn cobs, and large fragments of gourd rind. Afterwards, they redeposited the body and many of the textiles in the original burial pit and covered it up. They then told others who eventually contacted Michael P. Hoffman of the University of Arkansas Department of Anthropology, Robert Lafferty, another professional archaeologist, and me, and provided most if not all of the materials originally taken. Hoffman's trip to the shelter in late spring recovered artifacts and additional human remains. I went back in the fall with some student volunteers. We mapped the shelter, re-excavated the grave, and retrieved all materials from the back dirt of the original finders. Among the materials left in their back dirt were corn cobs. In our examination of the grave, we found still in place additional human bones and tissue, pieces of the basket, and other textiles. We did not remove any corn cobs other than those in the back dirt. I suspect the cobs were with the burial originally. Later, the shelter was completely gutted. I visited it shortly thereafter and as best as I could tell nothing else was found. So, I think the site was primarily if not exclusively a repository for the dead.

The burial pit was dug into decomposed shale within a natural enclosure of sandstone roof fall slabs. The remarkable state of preservation for the body, basketry, other textiles, and unburnt plant remains is due to the dry conditions of the sandstone shelter. Only along the back wall and well away from the burial pit is there a seep, where gypsum has crystallized. The site overlooks the (upper) Buffalo River and is high on a sidewall of Beech Creek valley. Access to the shelter is difficult under the best of circumstances, as one either goes down a sheer bluff or up a rubble-strewn slope from the valley floor. I think the burial party came from below, because water and sufficient arable land are mainly available there. This difficult route requires a vertical climb of about 250 meters.

The body was partially examined to estimate age, sex, and pathologies (Mulvihill 1988). The interment is that of a young woman about 17 to 19 years old. Her left tibia had a healing osteomyelitis and is 1.5 cm longer than the right tibia. She may have walked with a noticeable limp. Only the teeth of the left maxilla and mandible could be examined. They showed no calculus, caries or abscesses.

Tim Mulvihill and I sampled cordage still adhering to the body for AMS radiocarbon dating in September 1992, over a year and a half after Kuttruff

(1993) had submitted her *American Antiquity* textile article for publication. The cordage provided a conclusive association, as opposed to extraneous materials probably related to the interment but not demonstrably so. This excluded the corncobs, of course.

The assay was received in May 1993, well after Kuttruff's publication and had no bearing on her attributing the textiles as Caddoan. The embedded cordage and cordage impressions are similar to, if not actually identical to, ones detached from the body. Kuttruff (1988:204) identified the latter as naturally colored, finely shredded structural vegetal fibers (stems/leaves) spun into 2-ply yarns and having a balanced twill oblique interlacing structure. Her description of textile vegetal fibers (Kuttruff 1988:128-137) mentions corn shucks from the Ozarks but none identified by her. It seems unlikely that any were in the Beech Creek shelter textiles. (One published example is from Montgomery Shelter in Barry County, Missouri [Scholtz 1975:23].) While it has obvious implications for Kuttruff's (incorrect) Mississippian period age assignment, the assay simply had no bearing on her analysis or revisions to her *American Antiquity* article. Everyone (me included) involved with the Beech Creek Shelter study accepted the conventional wisdom that corn was cultivated during the Mississippian period, because unequivocal evidence existed for the Buffalo River (Lafferty et al. 1988), the larger White River watershed (Sabo and Early 1988:99-101), and the western and central Ozark Highland (Fritz 1986). And the burial probably was Mississippian period too, in keeping with Kuttruff's (1993) published assessment.

We now know the burial significantly pre-dates the Mississippian period while demonstrating technological continuity with later Caddoan textile production. If nothing else, Beech Creek Shelter affords a second glimpse at Buffalo River adaptations far better illuminated at Dirst. It serves too as a caveat to blindly accepting a preconceived notion. Trust but verify is clearly the operative strategy. Until direct AMS dating is done, we must remain less confident about the antiquity of Beech Creek Shelter corn. In light of the Beech Creek Shelter assay, we must question too the "Mississippian period" designation (Sabo and Early 1988:83, 101) of other nearby sites such as the aptly named Cobb Cave or 3NW539 that have corn and/or shell-tempered pottery.

Corn, a Seventh-Century Staple?

Did growing corn as a staple occur as early as the seventh century? Assuming our chronology is correct, then the answer, I think, is an unequivocal yes. Our direct evidence stems from the nature of our archaeological sites and what they tell us about the Native perception of plant crops.

Our archaeological sites containing corn and shell-tempered pots are of two general types, mortuaries and habitations. Although I suspect the parallels apply to Beech Creek Shelter and Ira Spradley too, we may think of Bowling Stone Mound and Dirst as providing the crucial insights about corn as a dietary supplement if not a true staple. At Dirst, the corn remains are a by-product of intentional disposal, or trash. The evidence we have is that of a (presumably shell-tempered) pot burnt and ruined in the process of cooking corn that was disposed of in a subterranean trash pit. Under such conditions the health benefits derived from cooking corn in a shell-tempered pot seem to be at the heart of an important innovation. What is significant about Dirst is just how commonplace corn and shell-tempered pottery seem to have been. The implication is corn and a shell-tempered ceramic cooking technology was the norm. Neither would have surprised the users as anything beyond the expected, nor should they surprise us. Assuming Dirst corn was the result of everyday cooking, it was both commonplace and profane.

Bowling Stone Mound presents a different but complementary signal of corn as a staple. The corn was deliberately burnt and placed in this mortuary facility as part of a funerary ritual. This act is laden with symbolic meaning about life and death, the sacred and profane. Bowling Stone Mound corn stands in structural opposition to Dirst. Bowling Stone Mound corn was as likely a metaphor for the sacred, a chosen food offering for and—by burning—of the dead. In metaphor, Bowling Stone Mound signals corn to have been the staff of life, a staple.

Connecting the Dots

There are claims (Fearn and Liu 1995, 1997; see also summary in Crawford et al. 1997:112) and counterclaims (Eubanks 1997) for early corn pollen, but the least ambiguous if not best evidence is direct AMS dating of corn macrofossils in eastern North America. The earliest of these is from the Holding site in the American Bottom of the Mississippi River valley in west Illinois, where two AMS assays are reported at the one sigma range (Riley et al. 1994:493-494): 50 cal B.C. - cal A.D. 60 (AA-8718, a corn kernel) and 170 cal B.C. - cal A.D. 10 (AA-8717, a corncob). The two sigma calibrations of these assays is just slightly greater (see Crawford et al. 1997:114-115); and the inescapable conclusion is Holding site corn is about 2000 years old. Slightly younger AMS assays on corn macrofossils come from Tennessee, Ohio, and southwestern Ontario (Crawford et al. 1997). These put corn in eastern North America no later than A.D. 100, and with a widespread distribution east of the Mississippi River by A.D. 500.

Drought exceeding the magnitude of the 1930s was more concentrated from A.D. 250 to 450 and from A.D. 700 to 900 (Woodhouse and Overpeck 1998). So it appears initial corn growing preceded an extended drought period. Its spread in eastern North America came during the A.D. 250 to 450 drought period. Since Griffin's (1967) summary, North American archaeologists regard this time as the late and terminal parts of the Middle Woodland period, and the Hopewell culture climax. The subsequent seventh-century (or Late Woodland period) innovations in shell-tempered pottery cooking technology in the Ozark Highland occurred when pervasive drought was likely to be neither long-term nor as extensive. Or what might have been truly a low-risk period in which to innovate, or experiment, coming just before the A.D. 700 to 900 droughts.

From this perspective, our Ozark Highland data fit a much broader pattern of experimentation with corn, if not growing it as a staple. This "experimental stage" spans about a thousand years prior to the Mississippian period. The antiquity of Ozark Highland corn is, thus, not nearly so novel as its connection to shell-tempered pottery. We should further consider the implications for corn becoming economically viable in the Ozark Highland well before the Mississippian period. Arguably what compelled widespread corn agriculture and its elevation as a first-line staple was the independent and longer-term experimentation with carbonate-tempered cooking pots. It became possible to prepare and consume corn in quantity only with the advent of a predictably reliable cooking technology, not the other way around (Braun 1983). Absent innovations in ceramic cooking pots afforded most eloquently by carbonate-tempered pastes (and increasingly, using shell), it would have been impractical to heat corn to the point of gelatinization and, thereby, freeing most of its nutrients. But with the trial-and-error experimentation in ceramic cooking technology over much of the Woodland period, corn became transformed from a mere food supplement to a primary staple in the emergent Mississippian world.

For Ozark Highland people, the most crucial concerns for settlement and agriculture would have been the seasonal availability of water and the likelihood of catastrophic floods. Precipitation is likely throughout the year, although drought is common. Late spring through summer often witnesses the drying up of streams, other than where artesian springs feed them. Flash floods occur often too and rarely have more than short-term effects. Less frequent is a valley-wide flood. In December 1982, the Buffalo River at the Dirst site was over 9 m above its level measured that September, representing the historic high (Guccione 1990:84). Floods of this magnitude are clearly the exception to the rule, whether on the Buffalo River or another stream. Even so, flooding need not have been life threatening, as it is a simple matter to move oneself or an encampment higher up slope to avoid the immediate effects. More lasting is a flood that ruins a crop or destroys a farm field, as opposed to enriching them with additions of organic silt. The greater the flood, the more likely is disaster.

For agriculture to have succeeded, the so typical Ozark Highland pattern of annually recurring floods and drought-related water scarcity late in the growing season must have been offset in some way, or ways. At present, we do not have convincing evidence of water divergence and storage facilities, now recognized in the American Southwest (Bayman et al. 1997; Huckleberry and Billman 1998; Wilshusen et al. 1997), although we certainly cannot rule them out. Applying passive water-management models of prehistoric agriculture from the arid and semi-arid regions of the American Southwest to the Ozark Highland may seem like a stretch, however. But it is justified, I think, because the upland landscape is often an exceedingly dry one and is especially so during the growing season. As Schoolcraft observed on an 1818-1819 trip through the White River country (Park

1955:106), once one leaves the mainstream valleys and goes into the headwaters, the picture of the Ozark Highland rapidly changes to a semi-arid, dendritic mosaic of intermittent, ephemeral tributaries. These carve out narrow valleys in a karst-controlled landscape. Many streams have no surface flow for much of the year but support cave waterways and often spectacular artesian springs. The submerged river Dry Hollow and its alter ego Roaring River in southern Missouri near Cassville starkly show the contrasts afforded by one karst stream system.

The trick of farming corn as a prime crop would have been to balance field management costs against water scarcity or, conversely, catastrophic floods. Drought-related water scarcity would have been predictable seasonally. It could have been offset by smaller costs of water catchment systems such as check dam divergences of an intermittent stream than the larger expenditures of accomplishing the same thing but on a grander scale in the larger stream valleys. Similar weighing the potential loss of a farm field and its settlement to a flood would be less, if only because the scale of an intermittent stream valley is substantially less than the mainstream valley it drains into. Doing so would have made the upland Ozark Highland small tributary valley setting preferable initially to flood risks associated with the major trunk stream valleys. Mastery of the uplands would have been less costly and allowed time to learn how to farm the larger stream valleys. The latter would have been a structural transformation of agrarian society. And contingent on mastery of alluvial valley landscapes by substantially larger populations, which we now can estimate in this region as significantly increasing in size late in the Woodland and subsequent Mississippian periods (Weitzel and Codding 2016).

The Ozark Highland affords other natural opportunities to garden along its many ephemeral streams, to say nothing about the main rivers. In most instances, flood-borne organic silt would renew small valley bottoms. Or, in the event flooding incised a new channel or dumped gravel onto a field, one could relocate nearby to a similar location not so affected. Of interest would be the floodplain below where an artesian spring wells up and creates a pool in a stream bed. Almost every Ozark Highland stream of any consequence is spring-fed to some extent. A spring's presence is easily seen when the rest of the stream dries up. It would not take much to target spring-fed pools, and to use them as a water source during drought for settlement and small-scale agriculture. This knowledge would have made some alluvial lands along most Ozark Highland waterways a potential garden spot that could withstand a growing season drought. These locations dot the highlands and could have supported a widespread corn agriculture prior to the Mississippian period. The pattern that selected small garden areas as often away from a major stream as near one would have required a family-sized group for gardening. Such an approach seems to best suit the Ozark Highland landscape and would have been less labor intensive and risky as farming the flood plain of a major river such as the Arkansas, the Missouri, or the Mississippi. Mississippian period corn agriculture in the major river valleys could not have been more different in its scale, labor needs, and risks. Viewed this way, a fundamental structural transformation of the Mississippian period was transferring highland corn agriculture and shell-tempered pot cooking technology to the riverine setting, thereby creating a new niche.

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