REPORTS

REEVALUATING THE EVIDENCE FOR MIDDLE WOODLAND MAIZE FROM THE HOLDING SITE

Mary L. Simon

Maize fragments recovered from the Middle Woodland Holding site (11MS118) in the American Bottom have for several decades been recognized as the oldest directly dated maize east of the Mississippi River. A reevaluation of maize samples from this site indicates that finding was in error. Carbon isotope assessment ($\delta^{13}C$ ratios) run on the original samples dated in 1994 indicated that they were not maize. Six additional samples originally identified as maize were submitted to the Illinois State Geological Survey for carbon ratio assessment and direct accelerated mass spectrometry dating. Three of the fragments, including one from the same feature dated previously, returned non-maize $\delta^{13}C$ ratios. The other three samples were correctly identified as maize, but all returned post–A.D. 900 dates. These results invalidate the original report of Middle Woodland maize at Holding and support our ongoing reevaluations of maize histories in the American Bottom and western Illinois, which show that it was not an important cultivated crop plant in this part of the Midwest until about A.D. 900.

Los fragmentos de maíz recuperados en el sitio Holding (11MS118) del Periodo Middle Woodland en el "American Bottom" han sido reconocidos durante décadas como el maíz directamente datado más antiguo al este del río Mississippi. Una reevaluación de la muestra del maíz de este lugar indica que este hallazgo no fue acertado. Análisis de isótopos de carbono (índice de $\delta^{13}C$) llevados a cabo en las muestras originales fechadas en el año 1994 señalaron que no eran maíz. Seis muestras adicionales de Holding identificadas en principio como maíz fueron enviadas al Instituto Geológico del estado de Illinois para analizar su índice de carbono y ordenar el fechado por masa espectrométrica acelerada. Tres de los fragmentos, incluyendo uno del mismo rasgo fechado anteriormente, devolvió índices de $\delta^{13}C$ distintos a los del maíz. Las otras tres muestras fueron correctamente identificadas como maíz, pero todas arrojaron fechas posteriores al 900 d.C. Estos resultados anulan el informe original del maíz durante el periodo Middle Woodland en Holding y respaldan nuestras reevaluaciones en curso sobre la historia del maíz en el "American Bottom" y al oeste de Illinois, que muestra que no era una planta de cultivo en esta parte del Medio Oeste hasta 900 d.C.

For over two decades, maize recovered from the Holding site (11MS118), located in the American Bottom region of Illinois (Figure 1), has appeared to stand as a testament to the antiquity of maize cultivation in the Eastern Woodlands. This extensive Middle Woodland occupation is the type site for the Hopewell-related Holding phase that Fortier et al. (1989:558–559) place between 50 B.C. and A.D. 150. Designation is based both on standard dates obtained on charcoal, which range in age between about 150 cal B.C. and cal A.D. 300 (Fortier et al. 1989:Table 9) and have a median probability average date of A.D. 141 (dates from Fortier et al. [1989] recalibrated using Calib 7.1 [Stuiver and Reimer 2016]), and on the distinctive material culture (Fortier et al. 1989). The archaeobotanical assemblage included 18 small fragments variously identified as maize kernels, cobs, or cupules from six different features and the midden unit (Parker 1989; Riley et al. 1994:Table 1). Two of the alleged fragments, one identified as a kernel and one identified as a cob, were directly AMS-dated and returned dates of 2107 ± 50 RCYBP (AA-8718) and 2077 ± 70 RCYBP (AA-8717) (Riley et al. 1994:493–494). Using Calib 7.1 (2016), these dates calibrate to 165 cal B.C.–A.D. 75 (2 sigma, $p = 1.0$) and 233 cal B.C.–A.D. 68 (2 sigma, $p = .91$), respectively, placing them

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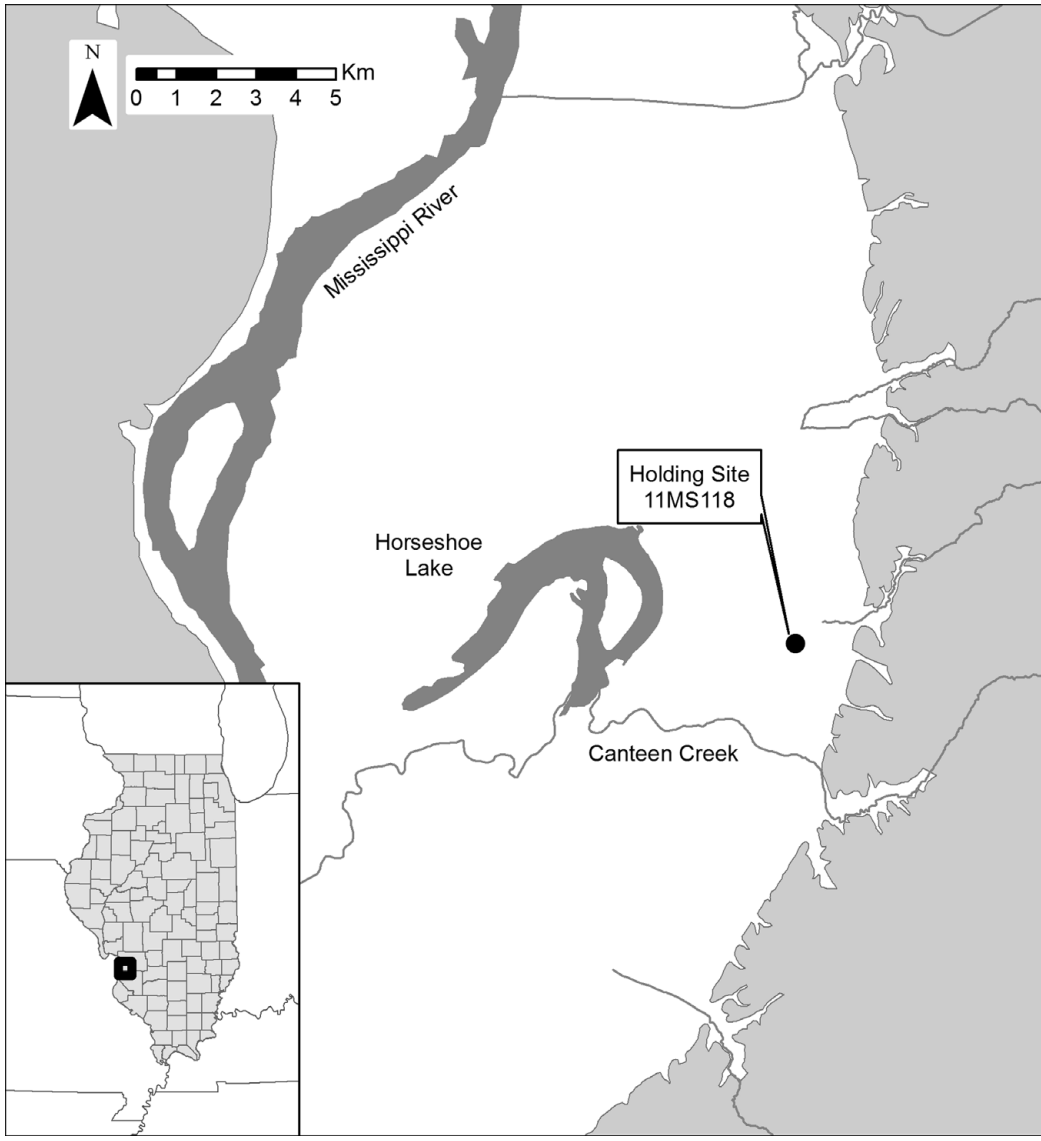

Figure 1. Location of the Holding site in the American Bottom region of Illinois.

well within the date range defined for the Holding phase (Parker 1989; Riley et al. 1994). As such, they have long been considered the oldest directly dated maize in the Eastern Woodlands of North America. Further, given their geographic location, they were ideally situated to provide a temporally credible geographic intermediary between the greater Eastern Woodlands as a whole and the southwestern United States.

Along with a few other alleged early dates on maize (Table 1), these finds have had a subtle but pervasive impact on our interpretations of maize history, both in the interior Midwest—here defined as those regions directly drained by the Mississippi River and its major tributaries, the Ohio River, the Illinois River, and the Missouri River—and farther afield in the greater Eastern Woodlands of North America. It is true that researchers working with collections from the interior Midwest have long suggested that maize did not contribute substantially to the diet of prehistoric peoples of that region until about A.D. 800 to 900 (Asch and Asch 1985; Fritz 1992, 2000; Johannessen 1993; Lopinot 1994,

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1997; Smith and Cowan 2003; VanDerwarker et al. 2013; Wright and Shaffer 2014; Wymer 1993). However, it is also true that, whether overtly noted or more indirectly assumed, the few reported middle and early Late Woodland macrobotanical records have been interpreted not only as evidence for the occasional presence of maize at an early date but also as evidence for its use as a "minor crop" during the centuries prior to its appearance as a major subsistence resource. In Illinois, this subtle conceptualization of maize as an integral, if minor, part of the cropping system during the first centuries A.D. was the basis for the gradualist model of maize use, which posited that low-level maize cultivation was initiated by about cal A.D. 100 and that large-scale cultivation was in place by cal A.D. 900 (e.g., Hastorf and Johannessen 1994; Lopinot 1994, 1997; Simon and Parker 2006; Wagner 1994). Further, this idea that the Holding site maize, along with the few other Middle Woodland macrobotanical records, were "early entries" in a long, gradual process has influenced models for maize use farther afield, including contentions that maize cultivation was widespread in the eastern Great Lakes regions of eastern Michigan, Ontario, and New York State by A.D. 700 (e.g., Boyd and Surette 2010; Boyd et al. 2008:2250; Crawford et al. 2006; Hart and Lovis 2013; Raviele 2010).

Results from recent work with archaeobotanical maize collections in Illinois call into question even the model of "minor maize cropping" among groups living in western Illinois and the American Bottom region prior to circa A.D. 900 (Emerson et al. 2015; Simon 2014). To date, 12 previously published records for pre–A.D. 900 maize in Illinois have been discredited and only one, that from the Edgar Hoener site (1350 ± 20 RCYBP, cal A.D. 647–684, p = 1.0 [ISGS A2242]; $\delta^{13}C = -10.3‰$), has been substantiated (Simon 2014:Table 3). In addition, while isotope values validate most original maize identifications, for two samples those original identifications were incorrect, returning $\delta^{13}C$ values of −25.1‰ and −26.4‰ (Simon 2014:Table 3).

That research prompted the reevaluation of maize from the Holding site. Carbon isotope assessment ($\delta^{13}C$) was conducted on the original 1994 samples and on six additional samples to verify if they were maize. If determined to be maize, they were selected for direct dating using AMS. The results of this work call into question any claims for pre–A.D. 900 maize from western Illinois, including for the Holding site.

Methods and Results

The Holding site macrobotanical samples are curated at the Illinois State Archaeological Survey, Prairie Research Institute, at the University of Illinois Champaign–Urbana. They had been stored, as is standard practice, in plastic vials placed in curation-grade cardboard boxes. Other than small paper tags, there are no associated organic materials, and there is no reason to suspect that contamination is an issue.

The 18 items originally identified as maize were collected from five different features and from the extensive Middle Woodland midden present at the site (Riley et al. 1994:Table 1). Sixteen of the fragments remained. All were examined under low magnification (~8x to 60x) using a stereoscopic microscope to evaluate condition and, to the extent possible, verify original identifications. This proved difficult, as most of the fragments lacked clearly distinguishing anatomical features. Consequently, sample selection was based on overall size, context of recovery, characteristic texture, and gross "form." Size was an important criterion as even AMS dating requires a minimum weight of about 20 milligrams and the fragments were quite small. Six fragments—three that were originally identified as kernel fragments, two that were originally identified as cupule fragments, and one that was originally identified as a cob fragment—were selected for $\delta^{13}C$ assessment and direct AMS dating. All the "kernel" fragments tended to exhibit the glossy, porous interior structure characteristic of carbonized, fragmented maize kernels as well as what appeared to be bits of the leathery adherent pericarp. The cupule fragment from Feature 159 retained evidence for the original kernel "boat"; that from Feature 5 was a large piece of porous tissue that was cupule-like only in terms of texture.

The materials identified as "cobs" in the original report were even more problematic.

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Table 1. Early Direct Dates on Maize from the Eastern United States.

Site	Location	Material Dated	Affiliation	Calibrated Date Two Sigma Ranges Median Probability Date*	Analysis Number	Conventonal Date	Reference
Icehouse Bottom	Eastern Tennessee	Kernel	Middle Woodland	Two Sigma Ranges: Relative Area [cal A.D. 25: cal A.D. 441] 0.97313 [cal A.D. 484: cal A.D. 532] 0.02687 Median Probability A.D. 252	Beta-16576	1775 ± 100	Chapman and Crites 1987; Crawford et al. 1997:Table 1
Edwin Harness	South Central Ohio	Kernel	Middle Woodland	Two Sigma Ranges: Relative area [cal A.D. 78: cal A.D. 547] 1. Median Probability A.D. 311	Beta-19291	1720 ± 105	Crawford et al. 1997:Table 1
Edwin Harness	South Central Ohio	Kernel	Middle Woodland	Two Sigma Ranges: Relative Area [cal A.D. 89: cal A.D. 102] 0.0096 [cal A.D. 123: cal A.D. 467] 0.941339 [cal A.D. 480: cal A.D. 534] 0.048981 Median Probability A.D. 301	Beta-18290	1730 ± 85	Crawford et al. 1997:Table 1
Grand Banks	Southern Ontario	Kernel	Early Late Woodland	Two Sigma Ranges: Relative Area [cal A.D. 133:cal A.D. 728) 0.982085 [cal A.D. 736: cal A.D. 771] 0.017915 Median Probability A.D. 530	TO-5308	1500 ± 150	Crawford et al. 1997:Table 1
Grand Banks	Southern Ontario	Kernel	Early Late Woodland	Two Sigma Ranges:Relative Area [cal A.D. 259: cal A.D. 285] 0.02543 [cal A.D. 288: cal A.D. 292] 0.003874 [cal A.D. 322: cal A.D. 648] 0.970696 Median Probability A.D. 481	TO-5307	1570 ± 90	Crawford et al. 1997:Table 1
Grand Banks	Southern Ontario	Cupules	Early Late Woodland	Two Sigma Ranges: Relative Area [cal A.D. 650: cal A.D. 903] 0.930775 [cal A.D. 915: cal A.D. 968] 0.069 Median Probability A.D. 776	TO-4586	1250 ± 80	Crawford et al. 1997:Table 1
Meyer	Southern Ontario	Cupules	Early Late Woodland	Two Sigma Ranges: Relative Area [cal A.D. 607: cal A.D. 979] 1. Median Probability A.D. 765	TO-8150	1270 ± 100	Crawford and Smith 2003:Table 6.2
Forster	Southern Ontario	Cupules	Late Late Woodland	Two Sigma Ranges: Relative Area [cal A.D. 661: cal A.D. 1040] 0.996 [cal A.D. 1109: cal A.D. 1116] 0.004 Median Probability A.D. 871	TO-7039	1150 ± 100	Crawford and Smith 2003:Table 6.2
211-1-1	New York	Cupule	Late Late Woodland	Two Sigma Ranges: Relative Area [cal A.D. 711: cal A.D. 745] 0.036 [cal A.D. 764: cal A.D. 1025] 0.964 Median Probability A.D. 897	B-53452	1130 ± 70	Crawford and Smith 2003:Table 6.2

*Calibrations: Calib 7.1 http://calib.qub.ac.uk/calib/calib.html, accessed May 20, 2016; Stuiver and Reimer 2016.

These proved to be small bits of porous tissue lacking anatomical features that would clearly identify them as maize cob fragments. They included one fragment from Feature 1, which also yielded one of the original 1994-dated "cob" fragments. Based on this contextual association, that fragment was also selected for dating. All materials to be tested were photographed and submitted to the Illinois State Geological Survey for conversion to CO_2 and carbon isotope assays. Gases were sent to the University of California, Irvine, for counting using their accelerated mass spectrometer.

The results of these analyses show that (1) some of the original identifications were in error, and (2) items correctly identified as maize were not Middle Woodland in age (Table 2). Of the six new samples, three—an alleged "cob" from Feature 1, a "cupule" from Feature 5, and a "kernel" fragment from Feature 5—returned $\delta^{13}C$ values of −29.5‰, −24.1‰, and −26.25‰, respectively. Identifications of the other three samples, two kernels and one cupule, were verified by carbon ratios as maize, but all three returned post–A.D. 900 dates (see Table 2).

The $\delta^{13}C$ value of −29.5‰ for the alleged "cob" fragment from Feature 1 is of particular interest, as one of the 1994 dates was also derived from a "cob" fragment from that feature. Although no photographs of the item dated in 1994 exist, it is likely to have been similar in appearance to the recently assayed fragment (Figure 2a). That item lacked distinctive morphological characters but did exhibit a porous texture similar to that seen in carbonized prehistoric maize cob and rachis fragments (Figure 2b). Textural similarities no doubt contributed to the original misidentification.

While the dates returned by the University of Arizona AMS laboratory and reported by Riley et al. (1994) were in keeping with a Middle Woodland association, at that time, measuring $\delta^{13}C$ ratios was not standard protocol if the identifications were "confirmed" by the individuals submitting the samples, in this case researchers at the University of Illinois at Urbana–Champaign (Timothy Jull, University of Arizona AMS Laboratory, personal communication 2016). Fortunately, the very small residues from the original samples were still in curation at the University of Arizona, and the Environmental Isotope Laboratory at the university was able to run carbon ratio assays on those residues. The analysis returned $\delta^{13}C$ values of −26.00‰ and −25.3‰, indicating that the original samples were not maize, confirming suspicions raised by the current study.

Considerations for Evaluating Maize Macroremains

Studies of ancient maize from Illinois have highlighted two important issues that must be considered when dealing with these early materials. First and foremost, it is critical that direct dates be obtained on materials to confirm antiquity (Blake 2006; Fritz 1994, 1995; Hart 2008). When assessing maize antiquity, it is no longer sufficient to rely on dates from associated organics or on the age of associated cultural material. This is particularly important for maize, but it should also apply to any unusual or exotic plant materials recovered from unexpectedly early contexts. At least within the Illinois study area, contamination of older features by materials from later occupations is common. Further, contamination occurs even in the absence of evidence for later prehistoric or historic habitation, perhaps as a function of reuse of old site areas for fields. For example, maize from the single-component early Late Woodland (Weaver phase, cal A.D. 350–650) Sartorius site (11HA360) in western Illinois (Fishel 2012:9) was dated to the nineteenth century (Simon 2014). This is interpreted as reflecting use of this space as a maize field during a time substantially postdating the prehistoric occupation (Simon 2014).

The second issue concerns the reliability of identifications of maize macroremains. There are some plants native to the Midwest that follow the C-4 photosynthetic pathway and that likely were consumed by humans, including pigweed (*Amaranthus retroflexus*) and panic grass (*Panicum virgatum*). However, maize, which was introduced to the area from Mesoamerica, was the most important to subsistence in the late prehistoric Midwest. Because the C-4 pathway produces plant tissues enriched with heavy carbon, carbon isotope ratio assays of tissues are a quick and easy way to confirm

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Table 2. Radiocarbon Dates and Carbon Isotope Ratios Returned on Samples from the Holding Site.

Context	Material	RCYPB Date Returned	Analysis Number	Calibrated Date 2 Sigma, Relative Area**		Cultural Period
Feature 1[1]		2077 ± 70	AA 8717	NOT MAIZE*	−26‰	(Date is Middle Woodland)
Feature 5[1]		2017 ± 50	AA 8718	NOT MAIZE*	−25.3‰	(Date is Middle Woodland)
Feature 27[2]	Kernel	940 ±15	ISGS A2715	(1031 A.D.:1059 A.D.) .221771 (1065 A.D.:1073 A.D.) .030115 (1075 A.D.:1155 A.D.) .748114 Median Probability 1100 A.D.	−9.1‰	Mississippian
Feature 9[2]	Kernel	950 ± 15	ISGS A2716	(1025 A.D.:1055 A.D.) .273635 (1077 A.D.:1154 A.D.) .726365 Median Probability 1100 A.D.	−8.9‰	Mississippian
Feature 159[2]	Cupule	1070 ± 20	ISGS A2714	(898 A.D.:920 A.D.) .181234 (945 A.D.:1018 A.D.) .818766 Median Probability 982 A.D.	−9.3‰	Terminal Late Woodland II
Feature 1[2]	Designation per Riley 1994: “cob”	NONE	N/A	NO DATE—NOT MAIZE	−29.54‰	N/A
Feature 5[2]	Designation per Riley 1994: “cupule”	NONE	N/A	NO DATE—NOT MAIZE	−24.13‰	N/A
Feature 5/Midden[2]	Designation per Riley 1994: “kernel”	NONE	N/A	NO DATE—NOT MAIZE	−26.25‰	N/A

1. Original dates returned (Riley et al. 1994).
2. New dates and isotope ratios returned, this paper.
*University of Arizona 2016
**Calibrations: Calib 7.1 http://calib.qub.ac.uk/calib/calib.html, accessed May 20, 2016; Stuiver and Reimer 2016.

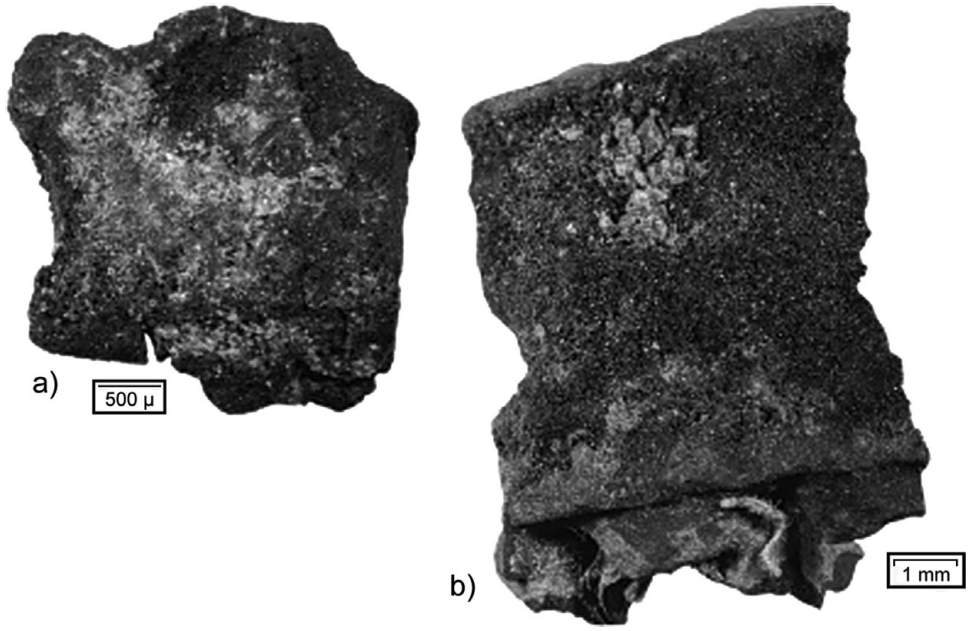

Figure 2. (a) Fragment of item originally identified as a "maize cob," and which returned a non-maize carbon isotope value, showing characteristic texture; (b) interior of a rachis fragment from the late prehistoric Palos site, 11CK26, in Illinois. Note similarities in texture despite large differences in scale.

that archaeological materials being evaluated are truly maize. Studies to date have shown that identifications by experienced researchers are usually accurate (Simon 2014), but, as exemplified by the Holding site samples, there are occasions when this does not hold true. Even for small fragments, technologies are now such that carbon isotope ratios can be readily assayed as standard protocol. These assays can be inexpensively obtained using stable isotope ratio mass spectrometry (SIRMS), confirming identifications before radiometric dates are even run. In the absence of carbon isotope confirmation, particularly for problematic materials or in situations where the material is from an unusually early context, it is reasonable to question dates on materials reported as "maize."

Revising and Reconsidering the Model for Maize Use in Illinois

The results of the Holding site maize studies effectively rewrite the history for maize use in the American Bottom and have implications for understanding its history over the broader Midwest and even the greater Eastern Woodlands. Simply put, the Holding site maize no longer stands as the oldest directly dated maize in the midwestern United States. The most recent set of dates and carbon isotope assessments, and carbon isotope values obtained on residues submitted for dating over two decades ago, show that some of the material was originally misidentified and that those materials that are maize date to almost one millennium later than the Middle Woodland period.

In Illinois, the oldest directly dated maize reported thus far is from the Edgar Hoener site. This fragment dated to between about cal A.D. 700 and 750 and provided a $\delta^{13}C$ of −10.1‰ (Simon 2014:Table 3). It is not unreasonable to assume that maize was occasionally present by ca. A.D. 750 in the Midwest. The question becomes how to interpret this presence. For example, it may reflect early efforts at maize cultivation or the acquisition of an unusual item through trade. Regardless, its near absence from the massive archaeobotanical database that has accumulated in Illinois over the past several

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decades (e.g., Asch and Asch 1985; Johannessen 1984, 2000, 2014; Simon and Parker 2006) indicates that if maize was occasionally obtained it was inconsequential, even as an occasional garden plant, until about A.D. 900, when its use literally exploded. This is a subtle, but important, shift in our model. Although technically qualifying as "maize cultivation," meaning that it reflects the planting and care of a plant, this recovery should not be interpreted as indicating a widespread practice at this early date, nor are there any implications of continuity within the Illinois study region. "Cultivation" may well have been a one-and-done activity. It is also important to consider how the technology of maize cultivation fits our understanding of existing prehistoric subsistence technologies (Hart and Lovis 2013; Reber 2006; Scarry 2006; Smith and Cowan 2003). Technologies for native-plant cultivation and maize cultivation differ and may not have been compatible under some settlement systems (Smith and Cowan 2003).

The Maize Paradox

The history of maize in the Eastern Woodlands remains a subject of paramount interest and paradox. Among the most interesting is the contrast between dated macroremains and dates obtained on residues containing maize microremains. AMS dates on maize from sites in western Illinois and eastern Kansas indicate that, with the exception of the Edgar Hoener maize discussed above, those materials, once thought to date to the Middle and Late Woodland periods, are actually much younger than the contexts of recovery would suggest (Adair 2012; Adair and Drass 2011; Conard et al. 1984; Simon 2014). In Illinois, these results are strongly supported by recent skeletal isotope analyses (Emerson et al. 2015).

The only remaining macroremains directly dated to the Middle Woodland period are from the Icehouse Bottom site in Tennessee and the Edwin Harness site in Ohio (see Table 1; Chapman and Crites 1987). Somewhat younger are maize macroremains from the Grand Banks and Meyer sites, in southern Ontario, which have been dated to the Late Woodland period using AMS (see Table 1 for calibrated dates on these sites; Crawford and Smith 2003; Crawford et al. 1997). However, as was true for the original Holding site materials, AMS dates for these samples were run at a time when obtaining $\delta^{13}C$ assays was not standard protocol, so all are unfortunately lacking confirmation of identification.

On the other hand, maize microremains, whether phytoliths or starch grains, have been identified in pot residues dating to as early as 200–300 B.C. in New York State and to the first centuries A.D. from sites in Michigan, New York, and Ontario (Hart 2008; Hart et al. 2007:Table 6; Hart and Lovis 2013; Hart et al. 2003; Raviele 2010; St-Pierre and Thompson 2015; Thompson et al. 2004). Consequently, as dates on maize macroremains in the interior Midwest push our temporal scale for use forward in time, residue analyses of phytoliths and starches from ceramics recovered from the Great Lakes region extend its use back in time.

Among the many questions raised by these seemingly conflicting data sets are those concerning routes of transmission; that is, how did corn get from Mesoamerica or the southwestern United States to the northeastern United States by 200–300 B.C.? Assuming a transmission route through the central Midwest, whether overland or via the Mississippi River and its tributaries, why and how did it leave almost no evidence for its passage? This is particularly puzzling if, as suggested for what is now New York State, the evolutionary process that ultimately resulted in the genetically distinct Northern Flint maize variety (Doebley et al. 1986) was initiated by 300 B.C. and proceeded over the centuries immediately following (Hart and Lovis 2013:200). Seed stock would have had to have been repeatedly introduced over those ensuing centuries to provide a viable maize crop that would enable the whole evolutionary process. The transmission route or routes for maize into the eastern United States remain unclear, although the Illinois and Kansas data cited here suggest that it was not through the central Mississippi River valley via either the Missouri River or an overland route. Nor do we have evidence for its early passage via the lower Mississippi River (cf. Fritz and Kidder 1993; Kidder 1992; Wilson and Perttula 2013). Recent research has suggested a more northerly transmission route for domesticated

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bean into the Northeast, albeit at a much later date than maize (Monaghan et al. 2014). Again, early records for maize across the northern Great Plains, Minnesota, and Wisconsin are absent, although maize starch was identified in vessel residues from Michigan (Raviele 2010).

As Hart (2014:170) has noted, models and hypotheses are strengthened when supported by multiple lines of data. We plan to initiate parallel analyses of residues from Late Woodland ceramics to determine whether maize phytoliths are present and to help clarify our understanding of maize history in our study region. At the same time, it is also imperative that those working in other areas increase their attempts to identify macroremains that corroborate the microremains record. Thus far, the flotation database from the northeastern United States and extending into eastern Pennsylvania has yet to include any direct dates on maize from that region predating ca. A.D. 850 (Asch-Sidell 2002; Cassedy and Webb 1999; Chilton 2006; Hart 2008; Hart and Lovis 2013; McConaughy 2008). While it is not unreasonable to assume that histories of maize will vary among geographic regions (e.g., Staller et al. 2006), this paradox indicates there is still much to learn about those histories.

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Data Availability Statement. The remaining Holding site maize samples are curated at the Illinois State Archaeological Survey, Champaign. The data records collected from the analyses presented here are also available from the Illinois State Archaeological Survey. These data records are available upon request from the author.

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