Number 1 Summer 2014 ISSN 2372-9899

OCCASIONAL PAPERS

Official Publication of the Midwest Archaeological Conference, Inc.

MIDWEST ARCHAEOLOGICAL CONFERENCE, INC.

OCCASIONAL PAPERS

Number 1 Summer 2014

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Reassessing the Timing, Rate, and Adoption Trajectories of Domesticate Use in the Midwest and Great Lakes

Edited by
Maria E. Raviele and William A. Lovis

OCCASIONAL PAPERS

Aims and scope
The Midwest Archaeological Conference Sponsored Symposium held at MAC, Inc. annual meetings is a forum for presentation of problem-oriented current thinking on key midwestern archaeological issues. The publication of such symposium proceedings in the *Occasional Papers* series serves to articulate how innovative breakthroughs and cumulative evidence may question previous interpretations and lead to a new understanding of the midwestern archaeological record.

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Courtesy of the Cahokia Mounds State Historic Site.

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The Occasional Papers Series

Dr. Thomas E. Emerson

MCJA Editor, Illinois State Archaeological Survey, USA

For the first fifteen years (1976–1992) of its existence the MAC, Inc. published a *Special Paper* series. The content of these numbered volumes varied from the treatment of a single site to regional and topical reviews and they appeared at intervals ranging from multiple numbers in a single year to several years intervals between numbers. The series ceased in 1992.

Despite the cessation of the *Special Papers* series, interest by the membership and the MAC Board and editors in promoting the publication of thematic research collections, often as single issues of the Conference's journal, the MCJA, continued. Such single-issue collections were usually generated by scholars from papers presented at the MAC annual meeting or around a timely research event. Recent examples included single volume issues on Angel Mounds, the War of 1812, and Cahokia research.

Recognizing the interest in such publications, the Board decided to create a Sponsored Symposium venue at the annual meetings. Conceptually the Sponsored Symposiums are a forum for presentation of problem-oriented papers on key Midwestern archaeological issues. The publication of such symposium proceedings serves to articulate how innovative breakthroughs and cumulative evidence may question previous interpretations and lead to a new understanding of the Midwestern archaeological record. Symposium proposals are submitted and reviewed by the Board each year and a single proposal is chosen that represents the best of current Midcontinental archaeology. The symposium organizers were encouraged to submit their manuscripts to the MCJA Editor for consideration for publication.

Initially such symposium proceedings were envisioned as special issues within the MCJA. Unfortunately, the result was to quickly create a backlog of regular articles. There was not sufficient journal space available to include the papers from an annual Sponsored Symposium, something that the Board strongly favored. To resolve this issue the Board agreed to accept the Editorial Office's proposal to initiate a MAC *Occasional Papers* series. This series will digitally publish the papers of the Sponsored Symposium. Currently the MCJA Editorial Office staff is handling the copyediting and formatting with funding from the Illinois State Archaeological Survey. The digital volumes will be available through the MAC web site. The first volume in this series *Reassessing the Timing, Rate, and Adoption Trajectories of Domesticate Use in the Midwest*, edited by Maria Raviele and William Lovis, is published here.

MCJA *Occasional Papers* Series

No. 1. *Reassessing the Timing, Rate, and Adoption Trajectories of Domesticate Use in the Midwest and Great Lakes*, edited by Maria E. Raviele and William A. Lovis. 2014 (Summer).

MCJA *Special Paper* Series

No. 1 *The Coffey Site: Environment and Cultural Adaptation at a Prairie Plains Archaic Site*. Larry J. Schmits. 1978. Bound with MCJA 3(1).

No. 2 *Archaeological Survey and Settlement Pattern Models in Central Illinois*. Donna C. Roper. 1979. The Kent State University Press, Kent.

No. 3 *Hopewell Archaeology: The Chillicothe Conference*, edited by David S. Brose and N'omi Greber. 1979. The Kent State University Press, Kent.

No. 4 *The Southeastern Check Stamped Pottery Tradition: A View from Louisiana*. Ian W. Brown. 1982. The Kent State University Press, Kent.

No. 5 *Recent Excavations at the Edwin Harness Mound, Liberty Works, Ross County, Ohio*. N'omi Greber. 1983. The Kent State University Press, Kent.

No. 6 *Rock Island: Historical Indian Archaeology in the Northern Lake Michigan Basin*. Ronald J. Mason. 1986. The Kent State University Press, Kent.

No. 7 *Cultural Variability in Context: Woodland Settlements of the Mid-Ohio Valley*, edited by Mark F. Seeman. 1992. The Kent State University Press, Kent.

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Introduction to the First Midwest Archaeological Conference, Inc., Sponsored Symposium: Reassessing the Timing, Rate, and Adoption Trajectories of Domesticate Use in the Midwest and Great Lakes

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The First Midwest Archaeological Conference Sponsored Symposium,[1] held at the MAC, Inc., 2012 Annual Meeting in East Lansing, Michigan, was, hopefully, the inaugural forum for presentation of problem-oriented current thinking on key midwestern archaeological issues. It is our intent with the publication of these symposium proceedings, as reviewed and revised based on referee, participant, and editor comments, to create a high standard for subsequent efforts. As our prospectus thus framed the session topic, the past two decades of midwestern research have witnessed multiple and complementary advances in the application of analytic methods to long-standing research problems, including the regional and subregional adoption trajectories of domesticates (Hart 2008; Hart and Lovis 2013). These advances have resulted in the production of new and significant data on the origin timing, adoption rates, and contextually variable social and economic uses of both indigenous and tropical domesticates. Much of this enhanced data is based on newer techniques derived from the use of proxies for plant identification, such as stable isotope analysis of bone from consumers (Schoeninger et al. 1983; Schoeninger and Moore 1992), both C- and N-isotope assessments of carbonized food material (Hart et al. 2007; Smith and Epstein 1971), analysis of fatty acids in ceramic fabrics (Eerkens 2005; Malainey et al. 1999), and as is emphasized in this context, on identification and analysis of enhanced assemblages of microbotanical and macrobotanical finds (e.g., Messner 2011; Messner et al. 2008; Mulholland 1993). Such research has been assisted by direct dating of domesticates and carbonized residues employing accelerator mass spectrometry (AMS) (Conard et al. 1984; Lovis 1990; Monaghan, Lovis, and Egan-Bruhy 2006; Myers 2006; Raviele 2010; Riley et al. 1994) coupled with the application of enhanced quantitative approaches, including Bayesian analytic techniques (Hart and Matson 2009; Monaghan, Schilling, and Parker, this volume), and insights gained from molecular analysis (e.g., Sonnante 1994; Vigouroux et al. 2008). Collectively, these various avenues provide corroborative evidence for earlier than expected domesticate use in multiple regions (Boyd and Surette 2010; Boyd et al. 2006, 2008; Hart and Brumbach 2005; Hart and Lovis 2013; Messner 2008; Raviele 2010; Smith and Yarnell 2009; Thompson et al. 2004).

Experimental work performed as a corollary to the use of these techniques has aided in refining and modifying our interpretation of both botanical data and its proxies (e.g., Hart et al. 2007, 2009; Lovis et al. 2011; Raviele 2010, 2011; Wright 2003), including the systematic evaluation of potential age errors associated with the dating of food residues keyed to freshwater reservoir effect (FRE) (Hart and Lovis 2007, 2008; Hart et al. 2013). While the earlier dates on cultigens are significant in their own right, the overlap occurring between the resulting ages and the dates assigned to what have traditionally been thought of as hunter-gatherer societies is also significant (Lovis and Monaghan 2008; Monaghan, Lovis, and Egan-Bruhy 2006; Simon 2011; Smith and Yarnell 2009). Pushing the inception of cultigens into time periods primarily associated with hunter-gatherer subsistence economies raises the need to reassess models that attempt to explain the processes responsible for the overall incorporation of cultigens into settlement-subsistence and social-exchange systems. This includes exploring the intensity and trajectory of cultigen use in different regions within the Midwest since each subregion may have its own use trajectory (Hart and Lovis 2013). However, it is the larger synthesis of these varied trajectories that provides a context for understanding the when (time), where (subregion), and how (mechanism) for the spread of each cultigen. When examined collectively, the cumulative evidence tracing cultigen use has the potential to elucidate cultural interaction, potential food preferences and, therefore, cultural signatures, technological innovation, and environmental and landscape modification.

The focus of the inaugural sponsored symposium session was not simply to discuss the earliest dates for newly identified occurrences of early cultigens but rather to articulate how the cumulative evidence affects previous interpretations of the midwestern archaeological record. Possible questions participants in this session were asked to address included the following:

- Does new data for cultigen use modify, enhance, or appear to have no effect on previous interpretations of settlement-subsistence systems and models for inter- and intracultural interaction?
- What explanatory mechanisms may account for different levels and timing of intensified cultigen use between subregions?
- Is there evidence for fluctuating reliance on cultigens within subregions through time, and if so, what processes may explain these fluctuations?
- How may populations engaged in the adoption of cultigens have modified their surrounding landscape to integrate or accommodate domesticated plant use?

As the contents of this volume reveal, our targeted call for participants resulted in a broad representation of regional foci and of analytic and interpretive approaches. Given this observation, it was to be expected that the outcomes of our limited guidance were not only variable but also uniformly provided new, different, modified, and more or less appealing perspectives on long-standing problems associated with the trajectories of cultigen adoption and use in the Midwest. For one such perspective on the individual and collective result as it relates to future directions in particular, we refer readers to the summary paper by John P. Hart, "A Critical Assessment of Current Approaches to Investigations of the Timing, Rate, and Adoption Trajectories of Domesticates in the Midwest."

That said, the contributors moved well beyond our proposed formulation of approaches, problems, and constraints. Taking a lead from "you are what you eat," for example, Kathryn C. Egan-Bruhy explores the degree to which Oneota, Mississippian, and to a degree Late Woodland populations in the western Great Lakes region possessed what might be characterized as individual and ethnically distinct "foodways"—recognizable through suites of resource choices (particularly cultigens in this case study) and their relative dietary representation. In some ways, a companion piece to her approach is Gary W. Crawford's contribution, which builds on components of ecological theory—including niche construction—to consider the evolution and spatiotemporal distinctions of what have become known as "domesticated landscapes" (cf. Terrell et al. 2003).

The timing of the introduction of dominant cultigens across the Midwest has, of course, been the subject of substantial historical discussion. Current investigations are aided by the ability to directly date, by use of AMS, specific plant parts, and through systematic reevaluation of contexts, both stratigraphic and via quantitative meta-analyses employ contemporary probabilistic partitioning approaches (i.e., Bayesian statistical methods). Both the work of Mary Simon, who focuses on early maize occurrences, and the collective work of G. William Monaghan, Timothy M. Schilling, and Kathryn E. Parker broach this arena from different vantage points. Monaghan, Schilling, and Parker use a suite of direct dates on *P. vulgaris* (common bean) to provide a macroscale perspective on the spatial and temporal spread of common bean in the Midwest and the Northeast, resulting in a hypothesis for initial northern adoptions and subsequent spread and adoption to the south and the west. Likewise, Simon concludes that there is scant evidence for Late Woodland, pre-Mississippian maize in southern Illinois and likewise supports an alternative hypothesis of later adoption as various regional experiments either succeed or fail a la Hart (1999, applying Wright 1932, 1978).

Such regional experiments may well include the differential presence of cultigens demonstrated by Patti J. Wright and Christopher A. Shaffer for parts of the Missouri River valley. Such variation is likewise evident in Ontario, where Matthew Boyd and colleagues document variable use of *Z. aquatica* (wild rice) as early as the Middle Woodland period, but which also occurs in differential frequencies with maize in later contexts. The nutritionally complementary aspects of wild rice appear to have supplanted the adoption of bean where rice is abundant, revealing local-level adaptive choices for resource mixes.

Given the cumulative results of the research collected here, numerous questions arise about the potential uniformity or, more likely, the lack thereof that might be expected in the origin, spread, adoption, and relative representation of cultigens across the region, as well as the degree of accord such variability might have with the overt material remains at a range of regional scales. Continued investigation using multiple lines of evidence, especially the incorporation of botanical proxy data, will be required to further illuminate the intricacies of these questions. The development and use of social and behavioral theory (sensu Skibo and Schiffer 2008) to further explain types of social interaction in the archaeological record different from those previously accounted for may also be required.

Acknowledgments

We thank the Midwest Archaeological Conference, Inc., for this opportunity and for the honor of developing, presenting, and publishing the first *Occasional Papers* from the First Midwest Archaeological Conference Sponsored Symposium and trust that we have attained the high standards intended for this forum. We would like to thank the symposium participants for their thoughtful contributions related to our proposed topic. The contributions benefited greatly from the insightful commentary of several anonymous referees, and we hereby publicly thank them for their contribution to the success of this volume as well.

Notes on Contributors

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William A. Lovis is Professor in the Department of Anthropology and Curator of Anthropology at the MSU Museum, Michigan State University. He is currently researching the transition to horticulture in the Great Lakes, site taphonomic processes, and changing human/environment interactions.

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Note

1 The title of the symposium as originally articulated was *Assessing the Timing, Rate, and Adoption Trajectory of Domesticate Use in the Midwest*. We have chosen an alternative title—*Reassessing the Timing, Rate, and Adoption Trajectories of Domesticate Use in the Midwest and Great Lakes*—for this special issue to better reflect the direction and content of the included papers.

MIDWEST ARCHAEOLOGICAL CONFERENCE INC. OCCASIONAL PAPERS No. 1, 2014, 7–32

Wild Rice (*Zizania* spp.), the Three Sisters, and the Woodland Tradition in Western and Central Canada

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Analysis of carbonized food residue for plant microfossils from 176 archaeological sites distributed across western and central Canada demonstrates that wild rice (*Zizania* spp.) was consumed in combination with maize (*Zea mays* ssp. *mays*) and other cultigens throughout the Middle to Late Woodland periods. Although this pattern is most evident in the boreal forest, *Zizania* was also recovered from some sites on the northern prairies dating to at least A.D. 700. Domesticated bean (*Phaseolus vulgaris*), on the other hand, was less important in places where wild rice was locally available. In general, our data indicate that significant regional variation, and selectivity, existed in the domesticated plant component of diet for northern Woodland populations. We suggest that the traditional emphasis on the wild rice harvest in the southern boreal forest, perhaps in combination with environmental factors, influenced the way in which specific domesticated plants were adopted, or excluded, by local populations.

KEYWORDS wild rice (*Zizania* spp.); maize (*Zea mays* ssp. *mays*); common bean (*Phaseolus vulgaris*); paleodiet reconstruction; Woodland tradition; food residue analysis; plant microfossils

Introduction

The boreal forest of Canada was home to some of the most northerly Woodland populations in North America. Due to extremely poor organic preservation and relatively limited archaeological research in the region, little is known about the subsistence base of subarctic populations prior to European contact. It has generally been assumed, however, that wild rice (*Zizania* spp.) played a strong role in the diet of Woodland populations across the Upper Great Lakes and southern boreal forest. Support for this idea can be found in the apparent overlap in ranges of *Zizania* and Middle and Late Woodland archaeological sites, placement of large habitation sites adjacent to extant stands of wild rice, occasional recoveries of wild rice macrobotanical remains in Woodland and Archaic archaeological sites, as well as the importance of this plant to historic Anishinaabe peoples living in this same region.

Shortly after the initial spread of Woodland cultural influence into the boreal forest, however, domesticated plants—such as maize (*Zea mays* ssp. *mays*), common bean (*Phaseolus vulgaris*), and squash (*Cucurbita* sp.)—became widespread components of diet in the Woodland heartland to the south. These crops, commonly referred to as the "Three Sisters" (Mt. Pleasant 2006), were part of an integrated agricultural system that sustained many late prehistoric complex societies in the New World. Despite their importance, however, considerable uncertainty remains regarding both the timing and nature of cultivated plant dispersal. This is particularly true outside of the known centers of agricultural production, where cultigens may have been acquired through trade or nonintensive horticulture and consumed in small amounts. The recent discovery of maize microbotanical remains at numerous archaeological sites in the Canadian boreal forest and prairies (Boyd and Surette 2010; Boyd et al. 2006, 2008) points to the widespread influence of domesticated foods, well beyond the conventional limit of precontact food production, in areas where northern wild rice was a traditional mainstay of diet. This observation leads to a number of interesting questions about the processes of dispersal and adoption of domesticated plants by hunter-gatherer societies. Why, for example, were domesticated foods adopted by subarctic foragers in the first place? Were these foods acquired primarily through trade or local horticulture? How was the procurement of cultivated foods integrated into the existing seasonal round, and what were the long-term impacts of domesticated plant use on traditional economic activities, such as the wild rice harvest?

This paper focuses on the interaction between wild rice and domesticated food procurements systems and on the degree to which selectivity occurred in the adoption of cultivated plants by northern Woodland peoples. It is generally understood that the Three Sisters agricultural system developed as a result of the nutritional, and ecological, complementarity of maize, common bean, and squash (Mt. Pleasant 2006). However, for societies in which domesticated foods played a minor dietary role or were acquired through trade or who lived where locally abundant wild substitutes were available, adoption of the complete system may not have been necessary or even beneficial. Environmental factors may have also played a role in the preferential cultivation of some plants over others: Common bean, for example, is more vulnerable to spring frost than maize is (Mt. Pleasant 2006), so it may have been less viable as a crop in more northerly settings. In either case, selective use of some domesticated foods, and exclusion of others, may have occurred. Selectivity may have been particularly strong in the boreal forest due to the more marginal growing conditions, the dispersal of domesticated plants via long-distance trade (Boyd and Surette 2010), and the fact that wild rice embodies many of the advantageous characteristics of cultivated plants (it is abundant, predictable, nutritious, and can be stored for winter consumption).

Our ongoing research involves archaeobotanical analysis of food residues from 176 sites scattered across the boreal and prairie zones of western and central Canada, in addition to more comprehensive site-level research employing geophysical survey techniques, excavation, residue analysis, and lake sediment coring in the Whitefish Lake basin of northern Ontario (Figure 1). In recent years, food residues have been increasingly employed in order to address fundamental research questions in archaeology—especially those dealing with food procurement strategies and the forager-farmer transition. Although archaeological residues may be analyzed for a variety of chemical and biological indicators of past diet (e.g., Boyd et al. 2008; Hart et al. 2007; Morton and Schwarcz 2004), the emphasis in this paper is on plant microfossil (phytolith and starch) remains. Previous research has shown that phytoliths and starch granules preserve well in a range of depositional and archaeological contexts and provide subtle knowledge of the plant component of paleodiet (e.g., Boyd and Surette 2010; Hart et al. 2003, 2007; Pearsall et al. 2003, 2004; Piperno and Holst 1998). Recent applications of this technique have led to insight into the development of agriculture in the Americas, long-distance food exchange networks, and the use of wild plants by early and modern humans, among other topics. Furthermore, due to poor preservation of organics in most subarctic archaeological sites, plant microfossils provide one of the few surviving sources of information on past diet, making them essential for understanding past interactions between humans and the environment across the northern reaches of the continent.

Woodland archaeology of the southern boreal forest

Middle (Initial Shield) and Late Woodland periods

Beginning approximately 150 B.C., major changes occurred in the archaeological record of the southern boreal forest due to the spread of Woodland cultural influence into this region—the most obvious of which included the first appearance of pottery technology and, in some cases, burial mounds, larger residence sizes, and a greater emphasis on long-distance trade and regional interaction. Over the next two millennia, a variety of Middle and Late Woodland cultures—distinguished and differentiated almost entirely by pottery style—successively occupied the region. Although a general culture-history framework for the boreal forest has been developed and refined over the last fifty years, major information voids continue to exist because of limited archaeological exploration of the region, a lack of well-dated sites, and generally poor organic preservation and site stratigraphy.

Ceramic production in the Canadian boreal forest began with the Laurel phase (approx. 150 B.C.–A.D. 1100). This widespread Middle Woodland/Initial Shield Woodland culture was distributed from western Quebec to northern Saskatchewan,

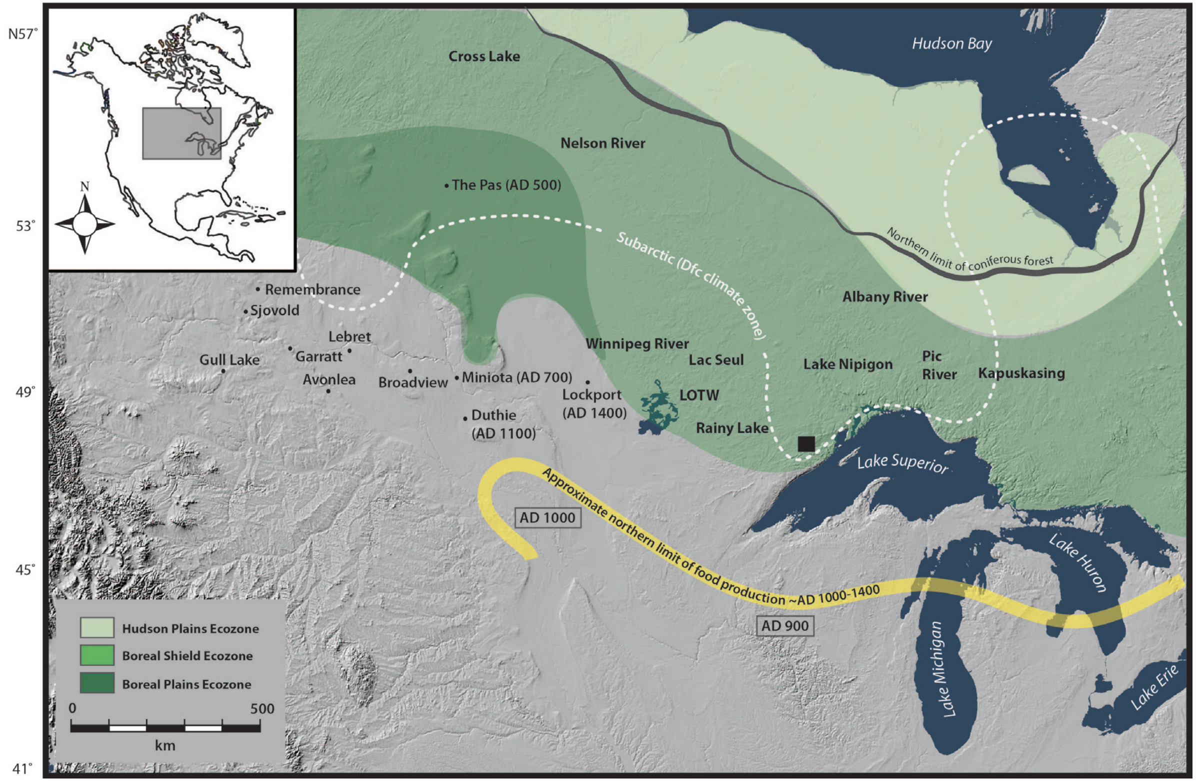

FIGURE 1 Map showing location of study sites and locales in relation to the conventional northern limit of precontact food production, major boreal–subarctic environmental zones, and Whitefish Lake region (solid black box). Dates in boxes are conventional estimates for the first appearance of maize horticulture in the Midwest. Dates in parentheses are estimates for maize consumption based on the recovery of *Zea mays* microfossils or macroremains. *Sources*: Boyd and Surette (2010); Boyd et al. (2006, 2008); Lints (2012).

in addition to northern Minnesota and adjacent regions of the U.S. upper Midwest. As a whole, Laurel components are associated with distinctive conoidal, smoothed, grit-tempered pottery types; perforated antler harpoons; occasional copper tools; burial and effigy mounds; and stemmed/notched projectile points, grinding stones, and a range of other lithic and organic artifacts (Anfinson 1979; Arzigian 2008; Budak and Reid 1995). Burial mound ceremonialism, which is only evident in the southern portion of the Laurel range (especially the boundary waters area between Minnesota and Ontario), may have been derived indirectly from the mortuary complex of the Hopewell culture (Wilford 1955; Wright 1999). However, as Wright (1999:773) observes, there is little evidence that the Laurel participated in the Hopewell Interaction Sphere in any significant way. Broad similarities in pottery form and decoration between Laurel and the Saugeen and Point Peninsula (Middle Woodland) complexes of the Lower Great Lakes also suggest diffusion of some cultural elements across an east–west axis (Wright 1999:727). We also note that Middle Woodland pottery-producing groups are strongly represented in the upper Midwest (specifically the Mississippi River headwaters) and may also be an important source for the northward diffusion of pottery into the boreal forest via the boundary waters region (Anfinson 1979; Lugenbeal 1976; Stoltman 1973). Although its origin is unclear, Laurel is generally regarded as a direct "descendant" of the preceding Archaic tradition (Wright 1999:726), rather than a result of the spread of a new people into the boreal forest.

The Late Woodland period in the boreal forest is associated with a variety of archaeological complexes that are largely defined by differences in pottery style and form. The major complexes—Blackduck-Kathio, Rainy River Late Woodland, Psinomani (Sandy Lake), and Selkirk—generally date to the period after A.D. 1000, although some variants of Blackduck in northern Minnesota and southern Manitoba appear between about A.D. 600 and 800 (Arzigian 2008; Hamilton et al. 2007; Rapp et al. 1995).

The Blackduck-Kathio/Rainy River and Sandy Lake complexes are found mostly in the mixed forest and boreal forest zones of northern Minnesota, Manitoba, and Ontario, although some sites have also been recorded on the northeastern prairies. Blackduck-Kathio and Rainy River ceramics are stylistically complex and typically include cord-wrapped object impressions, deep circular punctates, cord-marked or textile-impressed bodies, and globular vessel forms with constricted necks (Arzigian 2008; Lenius and Olinyk 1990). Sandy Lake pottery, while similar in many ways to Blackduck/Rainy River, is rarely decorated; exterior surfaces are usually either smoothed, cordmarked, or stamped with grooved paddles. Lithic and nonlithic components of Late Woodland artifact assemblages are broadly similar to the Laurel tool kit, with some exceptions (e.g., projectile point form, decreased use of hard-hammer percussion through time, production of unilaterally barbed harpoon heads) (see Arzigian 2008). Construction and reuse of burial mounds continued into the Late Woodland period, particularly in association with Blackduck-Kathio and Rainy River Late Woodland complexes. Burials were usually flexed, and associated mortuary artifacts included pottery, projectile points, red ochre, bone tools, and birch bark (Arzigian 2008).

Selkirk composite (approx. A.D. 1000–protohistoric) ceramics are widely distributed across the boreal forest in northwestern Ontario, northern Manitoba, and

Saskatchewan and have been linked to the Algonquian ancestors of the Cree (Meyer and Russell 1987:25–26). These vessels are generally globular with constricted necks, excurvate rims, and smoothed, fabric-impressed exteriors. The nonceramic portion of Selkirk assemblages, however, is very similar to Blackduck materials (Meyer and Hamilton 1994:119). Between approximately A.D. 1250 and 1500, Selkirk peoples may have expanded out of northern Manitoba and into adjacent regions to the south, east, and west (Meyer and Hamilton 1994:122–123). In Saskatchewan, some sites show influences from cultural groups in the parklands and grasslands—mainly in the form of ceramics with angular rims and shoulders, decorated shoulders, and occasionally S-shaped rims (Meyer 1981). Possible contact between Selkirk peoples and Plains-adapted societies has also been identified in southern Manitoba (Syms 1977:140, 1979).

Diet and subsistence

Many aspects of the northern Woodland subsistence base and seasonal round are unclear due in large part to poor bone preservation on the Canadian Shield (Wright 2004:1409), as well as the lack of attention given to plant remains by archaeologists working in this region. However, it is generally assumed that Laurel and Late Woodland peoples were broad-based, mobile foragers who were primarily adapted to the resources of the boreal and Great Lakes–St. Lawrence forests. Although specific foods varied according to season of site occupation and geographic region, many species of medium- to large-size ungulates (e.g., moose, elk, caribou, deer), other mammals (e.g., beaver, hare, dog, muskrat), birds (e.g., common loon, goose, duck), reptiles (turtles), shellfish, and fish have been recovered from these sites. Site locations and, in some cases, abundant fish remains and bone harpoon heads indicate that fishing was a central subsistence activity from spring to fall (Dawson 1981; Mayer-Oakes 1970; Wright 1999). Fall fishing camps were likely established because of the importance of dried fish during the winter, when large mammals were scarce (James 1830:228–229). In the Laurel component at the Lockport site (Manitoba) (MacNeish 1958), fish and shellfish may have been exploited more intensively through time. In contrast, Middle and Late Woodland sites in the aspen parkland (the transitional zone between grassland and boreal forest) indicate a heavy emphasis on bison exploitation (Buchner 1979:113; Hamilton et al. 1982, 2007; MacNeish 1958). The presence of multifamily dwellings and relatively high artifact densities in some locales may also suggest more sedentary habitation and/or increased populations beginning during the Laurel phase and continuing into the Late Woodland period (Reid and Rajnovich 1985, 1991). This trend has been explained by intensification of wild rice exploitation through time (Dobs and Anfinson 1990), although there is little direct evidence to support this idea.

The recent recovery of maize in multiple Laurel and Late Woodland sites as far north (54° N) as The Pas, Manitoba, indicates that domesticated plants were incorporated into the diet of some subarctic peoples by at least A.D. 500 (Boyd and Surette 2010). As summarized in Boyd and Surette (2010) and Boyd and colleagues (2006, 2008), maize may have been available at these sites through long-distance trade or local horticulture; however, because some of the sites reported in Boyd and Surette (2010) are located at latitudes where native corn was frequently unable to ripen during the fur-trade period, domesticated foods likely flowed through long-distance exchange networks (Boyd and Surette 2010). In other locations in the boreal forest, however, small-scale horticulture may have been practiced. The dietary importance of domesticated plants to subarctic foragers is unknown, but greater evidence of maize in Late Woodland sites in the boreal forest may suggest that cultivated foods became more important and/or widespread through time in this region (Boyd and Surette 2010; Boyd et al. 2008).

Wild rice (*Zizania* spp.) and the archaeological record

Direct evidence of wild rice in subarctic archaeological sites is extremely scarce, despite the prevalence of this plant in boreal aquatic ecosystems, as well as its cultural importance during the historic period. Nevertheless, archaeologists have generally believed that a close connection existed between wild rice and precontact human societies across the southern boreal forest and Upper Great Lakes. For example, the westward and northward spread of the Laurel phase over time has been linked to the dispersal of northern wild rice (*Zizania palustris*) across the Canadian Shield (Buchner 1979:124; Wright 1999). This idea is based largely on the apparent overlap in the distribution of Laurel and Late Woodland sites and of modern wild rice (Rajnovich 1984). However, it is not exactly known when wild rice appeared across this region. Estimates from lakes in northern Minnesota, for example, vary from 12,600 cal B.P. (Birks 1976; Huber 2000) to 1960 cal B.P. (McAndrews 1969). Due to the sensitivity of *Zizania* to water depth and temperature, hydrological fluctuations driven by climate change likely had a major influence on the history of wild rice at the watershed level (Boyd et al. 2013; McAndrews 1969). In any case, the lack of research on the history of northern wild rice makes identifying a dominant cause for its dispersal—whether anthropogenic or environmental—highly speculative.

The occasional recovery of wild rice processing areas and *Zizania* macrofossils in Middle and Late Woodland sites (e.g., Valppu 2000), as well as the proximity of some of these sites to extant wild rice fields (Rajnovich 1984), supports the idea that Aboriginal people exploited this food source in the Great Lakes region during the Holocene. In total, direct or indirect evidence of wild rice has been reported from more than 65 sites in eastern North America (see Surette 2008:Table 1); usually, however, this evidence is limited to the recovery of a few seeds or the presence of features interpreted as "ricing jigs" (Surette 2008). Although the majority of these sites date to the Woodland period, *Zizania* remains have occasionally been associated with Archaic materials (Chapman and Shea 1981; Crawford 1982; Hart et al. 2003, 2007; Johnston 1984), suggesting widespread use of this food resource both before and after the introduction of the Three Sisters agricultural system.

Whitefish Lake

The archaeological record of Whitefish Lake, northern Ontario, Canada, provides an excellent opportunity to study the connection between maize and wild rice in northern Woodland societies. This region, which is located near the northwestern shore of Lake Superior (see Figures 1 and 2), is significant because it marks the northern limit of burial mound ceremonialism in North America, and is associated with a relatively high concentration of Woodland habitation sites. Although Whitefish Lake is located well north of the accepted limit of prehistoric food production (see Figure 1), initial testing of carbonized food residue from several Woodland sites in this region yielded strong evidence of maize, in addition to wild rice (*Zizania palustris*) (Boyd and Surette 2010). Beginning in 2009, a multidisciplinary research program—involving lake sediment coring (Boyd et al. 2013), geophysical survey, archaeological excavation, and residue analysis—was initiated in order to situate the domesticated plant component of diet at these sites against the backdrop of late Holocene environmental change at Whitefish Lake and the emergence of the traditional wild rice economy.

Due to the shallow (approx. 2 m deep) and uniformly flat-bottom shape of its basin, Whitefish Lake supports very large communities of aquatic macrophytes. The largest of these wetlands, located at the western end of the lake (see Figure 2), is 120 ha and dominated by northern wild rice (*Zizania palustris*) (Lee and McNaughton 2004). Other common macrophytes associated with wild rice in the lake include *Nymphaea odorata*, *Nuphar variegatum*, *Sagittaria latifolia*, and *Potamogeton gramineus*. The vegetation surrounding Whitefish Lake is dominated by conifer and deciduous species typical of the boreal and Great Lakes–St. Lawrence forests. Paleoecological (pollen, phytolith) analysis of lake sediment cores indicates that wild rice had colonized the western basin by approximately 6100 cal B.P., in response to a climate-driven rise in lake level (Boyd et al. 2013).

The archaeological record of the Whitefish Lake area is extremely sparse until the Middle Woodland period; the importance of the lake after this time can be seen in the concentration of habitation sites located along the modern shore or on islands within the lake (see Figure 2). Two of these sites (Martin-Bird and MacGillivray) were the focus of archaeological research by Kenneth C. A. Dawson between 1966 and 1970 (Dawson 1980, 1987), as well as by us in 2009 and 2010. Both sites are located on an island at the western end of the lake and contain low burial mounds and extensive habitation zones adjacent to each mound. At the Martin-Bird site, the burial mound is situated on a low, N–S trending, ridge overlooking the western end of the lake. Excavation of the central portion of the mound by Dawson (1987) revealed a 1.4 m-deep pit containing a secondary (bundle) burial enclosed by a birch-bark container, a miniature Blackduck ceramic vessel, a clam shell "spoon," red ochre, a copper pendant, and a variety of precontact lithic and ceramic artifacts. Cultural deposits to the west and the east of the mound are extensive and interpreted as domestic spaces based on the recovery of numerous hearths, pit features, and a wide variety of artifactual debris (Dawson 1987). In 2009 and 2010, survey test pits and excavation units revealed a heavy concentration of fire-cracked rock (FCR) which, based on magnetic and ground penetrating radar (GPR) data, appears to form localized (but quite dense) "pavements" in various places across the southeastern portion of the site (Terry Gibson, personal communication 2010). Ceramics recovered indicate that the Martin-Bird site was repeatedly occupied by a variety of Middle and Late Woodland complexes, including Laurel, Duck Bay, Blackduck, Sandy Lake, and Selkirk. Based on minimum vessel counts, however, Blackduck pottery accounts for roughly 50 percent of the total assemblage, suggesting that the site

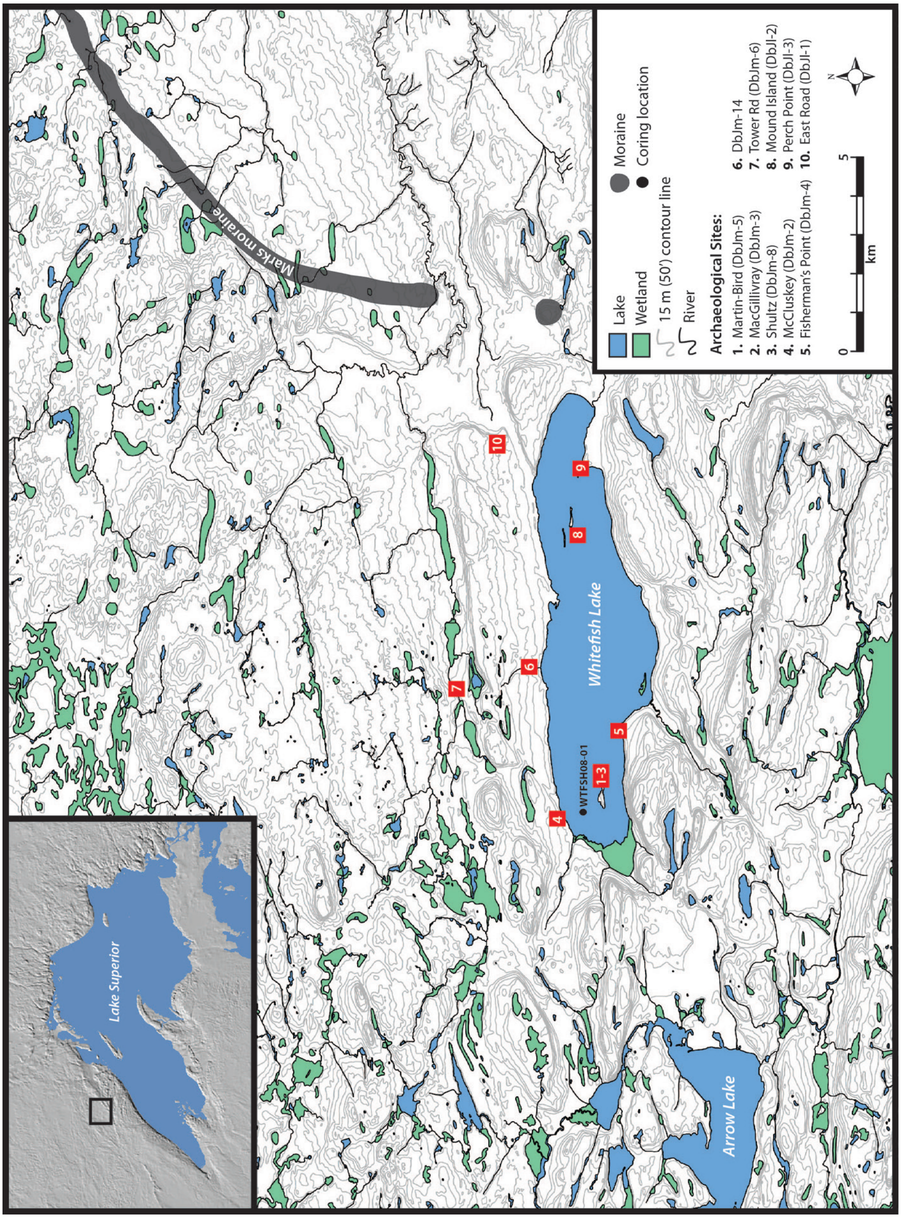

FIGURE 2 Map of the Whitefish Lake, Ontario, region showing locations of major Woodland archaeological sites.

was predominantly occupied by the makers of this and related pottery types (Duck Bay and Kathio). Other ceramic types identified at Martin-Bird and other sites on Whitefish Lake, and analyzed in this study, include Laurel, Brainerd, Sandy Lake, and Selkirk (Table 1).

Methods

The total collection analyzed for this study consists of 379 samples of pottery (and associated food encrustations) from 176 archaeological sites scattered across the southern boreal forest and northern prairies of Canada (see Figure 1), representing nearly all Middle and Late Woodland and Plains Woodland cultures that occupied the region between approximately A.D. 500 and 1500. Most pottery samples were stored in provincial, museum, or university repositories and private collections following excavation at various times after the 1940s. Within the total collection, 63 samples originate from Woodland components on Whitefish Lake and were either found in the field by us or by Kenneth Dawson in the 1960s and 1970s. Presence/absence data from the Whitefish Lake samples are presented in Table 1 (domesticated plants and *Zizania* only), and select results from the larger collection are presented in Figures 3, 4, and 5.

Archaeological sites are categorized in this paper as either being from the "boreal forest" (boreal shield/plains) or the "prairies" based on their location with respect to modern ecozone boundaries. This division, and our macroscale/multisite comparative approach, is justified because (1) the location of vegetation zones has generally remained stable over the last two thousand years in this region (Liu 1990); (2) significant differences in diet, dietary breadth, and other aspects of subsistence are recorded between these two regions (Boyd et al. 2008; Hamilton 1982; Wright 2004); and (3) clear cultural differences often existed between contemporaneous boreal and prairie sites. This is seen, for example, in the restricted distribution of many ceramic wares. Thus, despite their proximity, the boreal forest and the northern prairies engendered distinctive cultural traditions, adaptations, and archaeological records. As discussed below, neighboring boreal- and plains-adapted societies may also have differed in the extent to which domesticated plants were incorporated into diet.

Some limitations exist in the use of plant microfossils (extracted from food residues) for paleodietary reconstructions. In particular, due to the nature of plant microfossil identification, differences in starch/phytolith abundance, and other factors, some domesticated and wild plants will be better represented than others in food residues or other archaeological contexts. For example, maize and, to a lesser extent, common bean are expected to be well represented in our samples because of their high starch content. Squash (*Cucurbita pepo*), on the other hand, does not appear to produce distinctive starch granules (Lints 2012), and phytoliths are only found in the inedible (rind) portion of the fruit. As a result, squash microfossils should be rare in carbonized food residue. Wild rice is also expected to be under-represented in food residues due to its low starch content, lack of identifiable starch morphotypes, and production of diagnostic phytoliths in the "chaff" (glumes) only

TABLE 1

CARBONIZED FOOD RESIDUE SAMPLES FROM ARCHAEOLOGICAL SITES[a] NEAR WHITEFISH LAKE NORTHWESTERN ONTARIO, AND SELECT PLANT MICROFOSSIL RECOVERIES[b]

#	Site Number	Site Name	Cultural Afiliation	*Zea mays* rondel	*Zizania* sp. rondel	cf. *Cucurbita* phytolith	*Zea mays* starch	*Phaseolus vulgaris* type starch
1	DbJl-1	East Road	Selkirk	—	—	—	—	X
2	DbJl-2	Mound Island	Woodland	X	X	—	X	X
3	DbJl-2	Mound Island	Laurel	—	—	—	—	—
4	DbJl-2	Mound Island	Sandy Lake Plain	—	—	—	—	—
5	DbJl-2	Mound Island	Late Woodland	—	—	—	—	X
6	DbJl-2	Mound Island	Blackduck	—	—	—	—	—
7	DbJl-3	Perch Point	Blackduck	—	—	—	—	—
8	DbJm-2	McCluskey	Blackduck	—	X	—	—	—
9	DbJm-2	McCluskey	Blackduck	—	X	—	—	—
10	DbJm-2	McCluskey	Blackduck	X	X	—	X	—
11	DbJm-2	McCluskey	Blackduck	—	—	—	—	—
12	DbJm-2	McCluskey	Late Woodland	—	—	—	—	—
13	DbJm-2	McCluskey	Late Woodland	—	—	—	—	—
14	DbJm-2	McCluskey	Late Woodland	X	—	—	—	—
15	DbJm-2	McCluskey	Late Woodland	—	X	—	—	—
16	DbJm-2	McCluskey	Blackduck	—	X	—	—	—
17	DbJm-2	McCluskey	Late Woodland	—	—	—	—	—
18	DbJm-2	McCluskey	Laurel	—	—	—	—	—
19	DbJm-3	MacGillivray	Laurel	X	X	—	—	—
20	DbJm-3	MacGillivray	Laurel	—	—	—	—	—
21	DbJm-4	Fisherman's Point	Blackduck	X	X	—	—	X
22	DbJm-5	Martin-Bird	Blackduck Mortuary Vessel	X	X	—	X	X
23	DbJm-5	Martin-Bird	Blackduck (rim)	X	X	—	—	X
24	DbJm-5	Martin-Bird	Blackduck (rim)	X	X	—	X	—
25	DbJm-5	Martin-Bird	Blackduck (rim)		X	—	X	—
26	DbJm-5	Martin-Bird	Blackduck complete vessel (FCR feature), rim	X	—	—	X	—
27	DbJm-5	Martin-Bird	Blackduck complete vessel (FCR feature), body	—	—	—	X	—
28	DbJm-5	Martin-Bird	Blackduck (rim)	X	—	—	X	—
29	DbJm-5	Martin-Bird	Blackduck (rim)	X	X	—	—	—
30	DbJm-5	Martin-Bird	Blackduck/Laurel transitional	—	—	—	—	—
31	DbJm-5	Martin-Bird	Brainerd Parallel Grooved	—	—	—	—	—
32	DbJm-5	Martin-Bird	Kathio Series (rim)	X	X	—	—	—
33	DbJm-5	Martin-Bird	Late Woodland	X	—	X	X	X
34	DbJm-5	Martin-Bird	Late Woodland	—	—	—	X	—
35	DbJm-5	Martin-Bird	Late Woodland (body)	X	—	—	—	—
36	DbJm-5	Martin-Bird	Late Woodland (body)	X	X	—	X	—
37	DbJm-5	Martin-Bird	Late Woodland (body)	—	—	—	X	—
38	DbJm-5	Martin-Bird	Late Woodland (body)	X	—	—	X	—
39	DbJm-5	Martin-Bird	Late Woodland (body)	—	—	—	X	—

Continued

TABLE 1

CONTINUED

#	Site Number	Site Name	Cultural Afiiliation	*Zea mays* rondel	*Zizania* sp. rondel	cf. *Cucurbita* phytolith	*Zea mays* starch	*Phaseolus vulgaris* type starch
40	DbJm-5	Martin-Bird	Late Woodland (body)	—	—	—	—	—
41	DbJm-5	Martin-Bird	Late Woodland (body)	X	X	—	—	X
42	DbJm-5	Martin-Bird	Late Woodland (body)	X	X	—	X	—
43	DbJm-5	Martin-Bird	Late Woodland (body)	—	—	—	—	—
44	DbJm-5	Martin-Bird	Late Woodland (body)	X	—	—	—	—
45	DbJm-5	Martin-Bird	Late Woodland fabric impressed (body)	X	X	—	X	—
46	DbJm-5	Martin-Bird	Late Woodland refit (body, n=4)	X	X	—	X	—
47	DbJm-5	Martin-Bird	Laurel (body), wide CWT impressions	X	X	—	X	—
48	DbJm-5	Martin-Bird	Middle Woodland? net-impressed sherd	X	—	—	—	—
49	DbJm-5	Martin-Bird	Selkirk (Clearwater Lake Punctate) rim/neck	X	X	—	X	X
50	DbJm-5	Martin-Bird	Selkirk (neck)	—	—	—	—	—
51	DbJm-5	Martin-Bird	Selkirk (neck)	X	—	—	X	—
52	DbJm-5	Martin-Bird	Selkirk (rim)	X	X	—	X	—
53	DbJm-5	Martin-Bird	Duck Bay (rim)	X	X	—	X	—
54	DbJm-5	Martin-Bird	Selkirk/Rainy River	X	X	—	X	—
55	DbJm-5	Martin-Bird	Indet. fabric impressed (surface find)	—	—	—	—	—
56	DbJm-5	Martin-Bird	Late Woodland (rim/neck), trailed	X	—	—	X	—
57	DbJm-5	Martin-Bird	Blackduck	—	—	—	—	—
58	DbJm-5	Martin-Bird	Blackduck?	X	—	—	—	—
59	DbJm-5	Martin-Bird	Late Woodland	—	—	—	—	—
60	DbJm-5	Martin-Bird	Late Woodland	—	X	—	—	—
61	DbJm-5	Martin-Bird	Laurel	—	—	—	—	—
62	DbJm-5	Martin-Bird	Laurel?	—	X	—	—	—
63	DbJm-5	Martin-Bird	Sandy Lake	—	—	—	—	—

[a]Site locations are shown on Figure 2.
[b]X = presence

(Surette 2008). Secondly, plant remains recovered from carbonized food encrustations represent only one component of the total dietary range of a past population. Obviously, only plant foods that were cooked through extensive boiling in ceramic vessels will be recorded in carbonized residues; plants exclusively eaten raw or cooked in other ways (e.g., roasted) will be invisible. However, in the case of starchy food—such as maize, beans, and squash, as well as wild rice—boiling was commonly required to make it edible or was a preferred cooking method employed by historic Aboriginal societies living in the region (e.g., Wilson 1987).

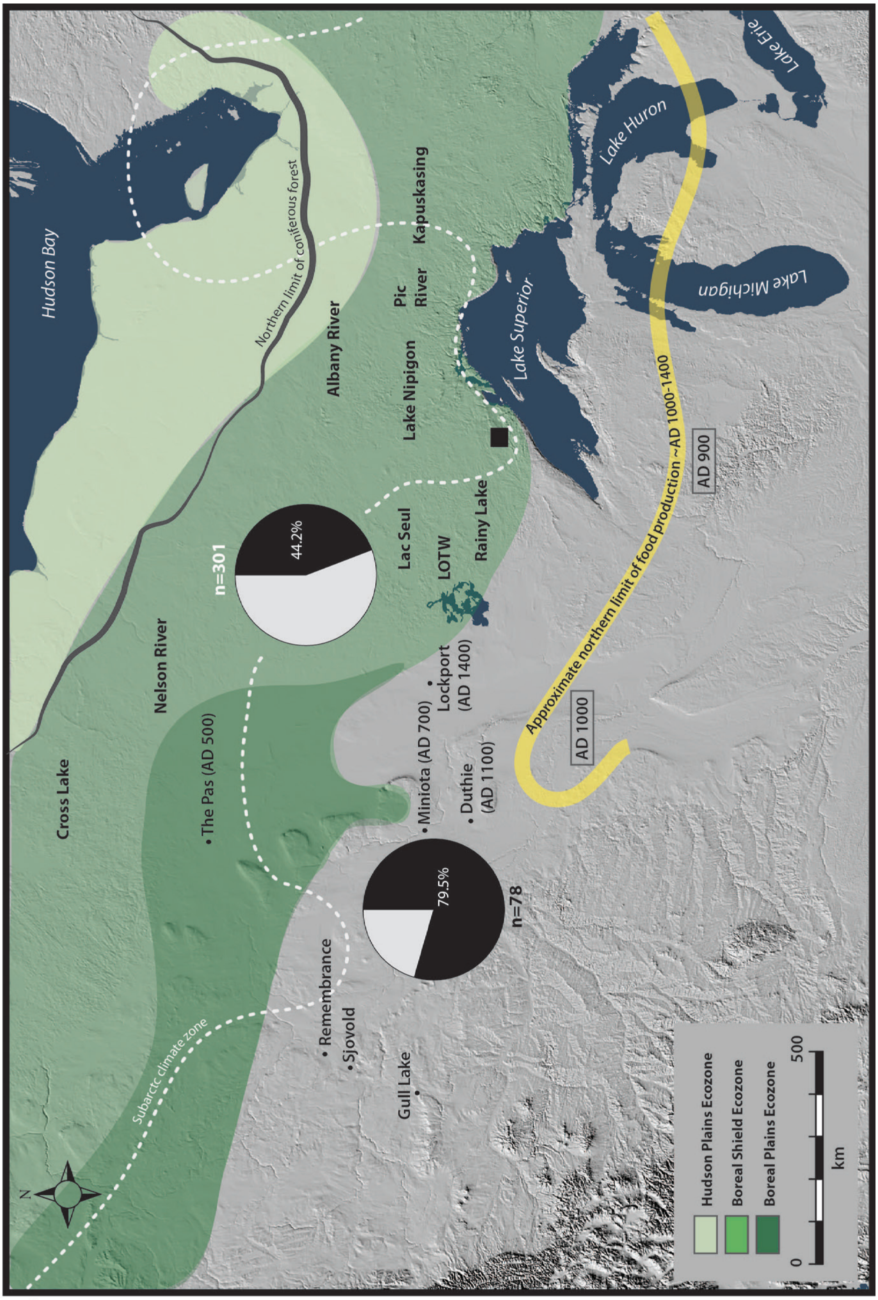

FIGURE 3 Map showing proportion of food residue samples with maize starch and/or phytoliths from the Canadian prairies (lower pie chart, $n = 78$ samples) and boreal forest ($n = 301$).

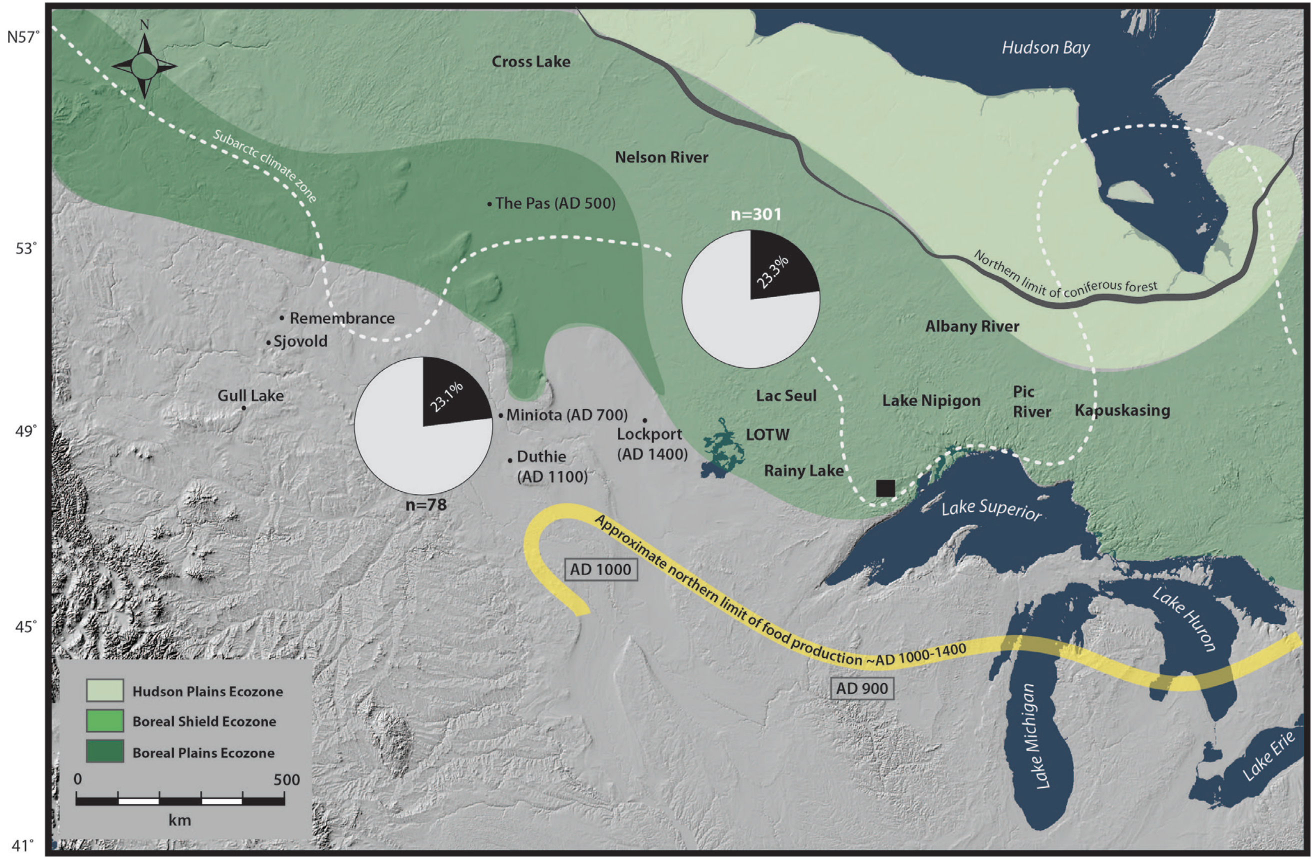

FIGURE 4 Map showing proportion of food residue samples with wild rice (*Zizania* sp.) phytoliths from sites located on the Canadian prairies (*lower* pie chart) and boreal forest (*upper* chart).

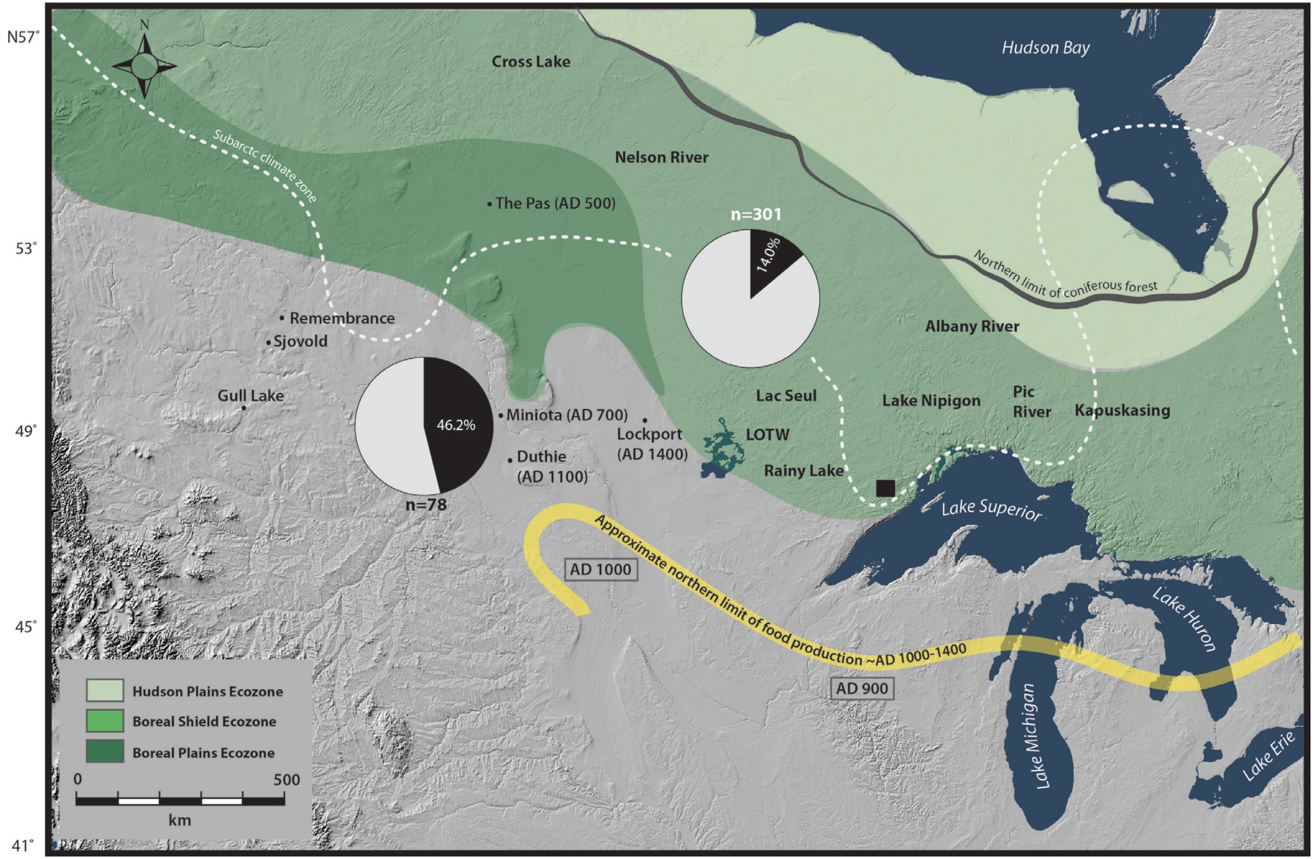

FIGURE 5 Map showing proportion of food residue samples with common bean (*Phaseolus vulgaris*) starch from sites located on the Canadian prairies (*lower* pie chart) and boreal forest (*upper* chart).

Although the contribution of a given plant to the overall diet is difficult to ascertain from food residue alone, it should be possible to say if a particular plant species was more important in one group of sites versus another by comparing the proportion of sites yielding microremains of this plant in each group. For example, if wild rice was consumed more frequently at sites located in the boreal forest (vs. the northern plains), then a higher percentage of carbonized residue samples from this region should contain wild rice plant remains. Conversely, a plant that was cooked (and consumed) less often, or in smaller amounts, in one group of sites should be found in relatively fewer carbonized residue samples regardless of overall starch/phytolith production levels for that plant. Through large multisite comparisons and the use of presence/absence data, the problem of differential plant microfossil visibility is alleviated while, at the same time, providing insight into the relative importance of key economic plants through time and space.

Starch and phytolith extraction

Carbonized food encrustations were removed from the interior surface of each ceramic sherd using a dissecting probe, weighed, and placed in sealed centrifuge tubes. Next, 5 ml of 6 percent hydrogen peroxide was added to the residue and oscillated at 1400 rpm in an orbital shaker for 10 minutes. After washing in pure water, the residue sample was divided into two equal fractions: one for phytoliths and the other for starch. The starch fraction was sieved using 118 µm disposable Nitex nylon cloth in order to remove larger debris; the material that passed through the sieve was then centrifuged, the supernatant was removed, and the remaining residue was placed in a sterile microcentrifuge tube for later mounting and analysis. The phytolith sample was air dried and placed in a warm (55°C) bath with 5 ml of 50 percent nitric acid for 12 to 24 hours. When digestion was complete, the sample was washed several times in order to remove the acid solution, and the remaining material was mounted on slides (in Entellen and thiodiethanol) and analyzed under a compound light microscope equipped with differential interference contrast/cross-polarization.

Contamination controls

By virtue of their small size and abundance, modern microfossils from economic plants such as maize may potentially contaminate archaeological materials at any stage following excavation. We eliminate the risk of modern contamination in the lab by (1) using a clean facility dedicated to plant microfossil extraction; (2) processing comparative plant materials in a separate lab using separate equipment; (3) running sample “blanks” at the start of a new batch and analyzing any resultant residue for microremains; (4) regularly analyzing airborne particle traps (microscope slides with silicone oil and no cover slips) placed throughout the lab; (5) thoroughly cleaning all processing equipment using an ultrasonic bath and frequently using disposable lab equipment, such as pipette tips, sample trays, and filtration cloths; (6) using only pure water in all lab procedures; and (7) eliminating all known modern starch-containing materials from the lab environment at all times (e.g., food, makeup, powdered examination gloves, some powdered detergents). Based on our experience, the risk of introducing modern starch during lab processing is virtually nil with these controls in place. When dealing with archaeological collections from museums, of course, it is impossible to completely assess the risk of modern starch/phytolith contamination during, and following, excavation. However, we note that starch from common Old World economic plants, such as *Triticum* (wheat), are always rare to absent in archaeological residues in our study area, indicating that microfossil contamination is probably not a significant concern when dealing with older collections. Further confidence in results is obtained through the use of multiple lines of evidence for domesticated plants; maize, for example, produces identifiable phytoliths, starch granules, and pollen, all of which may potentially be found in residue (Boyd and Surette 2010; Boyd et al. 2006, 2008). Lastly, many of the artifacts from Whitefish Lake were collected by us in the field during test excavations and were carefully handled to ensure that no contamination occurred.

Identification of plant taxa using starch and phytoliths followed several sources: Bozarth (1993) and Pearsall and colleagues (2003) for *Zea mays*; Boyd and colleagues (2008), Boyd and Surette (2010), and Lints (2012) for *Phaseolus vulgaris*; Bozarth (1987) and Lints (2012) for *Cucurbita* sp.; and Surette (2008) and Yost and Blinnikov (2011) for *Zizania palustris*. Positive identifications were only made for rondel phytoliths if both the base and top were clearly visible; starch identifications were based on observation under both plane- and cross-polarized light. A modern starch and phytolith reference collection, comprising over 154 domesticated and wild species, was used to confirm identifications. An average of roughly 250 phytoliths and 250 starch granules were counted and identified for each archaeological sample. However, only a select portion of the complete data set is presented in this paper. Microfossil data from some of the sites discussed were previously presented in Boyd and Surette (2010), Boyd and colleagues (2006, 2008), and in two master's theses (Lints 2012; Surette 2008). The phytolith/starch results from Whitefish Lake, furthermore, are part of a larger data set from this region that will be reported elsewhere.

Results

Plant microfossils from maize, common bean, squash, and wild rice were recovered from food residue samples obtained from sites in the boreal forest and on the prairies, although in varying proportions depending on the region. These proportions are shown in Figures 3, 4, and 5. In general, maize starch and/or phytoliths were recovered from approximately 44 percent of the food-residue samples from the boreal forest and 80 percent of the samples from the prairie sites (see Figure 3). Starch from domesticated bean, on the other hand, was recorded in only 14 percent of the boreal samples while being found in nearly half (46 percent) of the residue samples from the prairies (see Figure 5). Wild rice phytoliths were less common in food residue from both regions and were recovered in nearly equal proportions (23 percent) (see Figure 4). Squash (*Cucurbita pepo*) phytoliths were generally rare across the study area; in fact, only four samples (1 percent) from the boreal forest and one sample (1 percent) from the prairie (Lints 2012) yielded squash remains.

Microfossils produced by domesticated plants were recovered from 57 percent (n = 36) of the carbonized food residue samples from Whitefish Lake, representing six of the total seven archaeological sites studied (see Table 1). A slightly higher proportion (69 percent, *n* = 29) of the samples from the Martin-Bird site, which dominated our ceramic collection, yielded domesticated food remains. Evidence of maize, furthermore, was frequently found in more than one form: Only nine carbonized food residue samples (14 percent) yielded only *Zea mays* phytoliths, and only four samples (6 percent) yielded only maize-type starch. We also observed that wild rice phytoliths were recovered from most (57 percent) of the food-residue samples which produced maize microfossils. Starch from common bean (*Phaseolus* sp.) was recovered from nine (14 percent) of the samples, and only one squash phytolith was found in the food residue samples from Whitefish Lake. In general, domesticated plant remains were recovered from both Middle (e.g., Laurel) and Late Woodland ceramic vessels.

Interpretations and discussion

Our results show that differences exist in the degree to which cultivated plants are represented in food residues from contemporaneous sites on the northern prairies and in the boreal forest. This, in turn, may imply differences in the relative importance of these plants in the diets of plains- and boreal-adapted Woodland societies. These broad regional trends are also mirrored to some extent at the site level—in our case, by a subset of Middle and Late Woodland samples from Whitefish Lake.

In general, we note that a smaller proportion of samples from sites in the boreal forest (vs. the Canadian prairies) yielded domesticated plant remains. This is particularly true for common bean, which is found in only one of every seven samples examined from this region, in contrast to its being found in nearly half the samples from the northern prairies (see Figure 5). Relatively fewer boreal sites were also associated with maize; although in some locales, such as Whitefish Lake (see below) and Lake of the Woods (Boyd and Surette 2008), the majority of our samples tested positive for *Zea mays* starch and/or phytoliths (see Table 1). With these regional variations aside, it is not surprising that archaeological evidence of domesticated plants generally declines in a northward direction. This would be expected if these plant foods were acquired by trade or local horticulture; in the latter scenario, the short growing season and thin, acidic soil, among other characteristics of the subarctic Canadian Shield, would have imposed constraints on horticulture that increased in severity with latitude. Similarly, a drop-off in the availability of domesticated plants would occur with increased distance from the source of these foods. Significantly, however, we note that maize microfossils have been recovered from ceramic vessels as far north as Cross Lake and the Nelson River in Manitoba, and the Albany River in northern Ontario (see Figure 1). These sites are located near the limit of coniferous forests in North America, indicating that domesticated plant foods were a component of diet at the very northern edge of Woodland cultural influence.

In contrast, and unexpectedly, wild rice phytoliths were found in nearly equal proportions across the boreal forest and the northern prairies (see Figure 4). Once again, however, regional and/or temporal variation is likely masked by this trend. Specifically, nearly all (63 percent) our prairie samples with wild rice were obtained from Avonlea complex (A.D. 300–1100) sites, including Gull Lake, Sjovold, Lebret, Avonlea, Broadview, and Miniota (Lints 2012) (see Figure 1). Based on radiocarbon dates from the Avonlea component at the Miniota site, wild rice was evidently consumed by this plains-adapted culture by at least A.D. 700 (Lints 2012). These results are surprising because wild rice is scarce to absent south of the Canadian Shield/boreal forest (Lahring 2003), implying either that *Zizania* had a larger distribution in the past or that this food was acquired through trade with contemporaneous boreal Woodland cultures such as Laurel (Lints 2012). In any case, despite no previous archaeological evidence of this practice, it seems that wild rice was occasionally consumed by some Plains Woodland societies living outside the modern range of this plant. In many regions of the southern boreal forest, of course, wild rice was deeply embedded in the spiritual and social institutions and subsistence behaviors of historical populations. In our study, less than one-quarter of the residue samples from this region yielded *Zizania* phytoliths; however, due to the underrepresentation of wild rice microfossils in food encrustations and the uneven availability of this food resource across the region, it would be incorrect to assume that this food was generally less important to the Woodland ancestors of postcontact subarctic peoples. Indeed, in some regions, such as Whitefish Lake, where wild rice is locally plentiful, *Zizania* plant remains are found in a majority of food samples (see Table 1).

Close-up: Whitefish Lake

Because Whitefish Lake has probably supported large populations of wild rice since at least 6100 cal B.P. (Boyd et al. 2013), it is not surprising that the remains of this plant are present in most of the food residue samples that we analyzed from this locale. However, our data clearly show that wild rice was only one of several plants consumed by local Woodland peoples. In particular, a close association can be seen between *Zizania* and maize; in most vessels, the remains of both plants were recovered, indicating that these foods were regularly cooked and consumed together. This pattern is not restricted to Whitefish Lake; it is also evident in residue samples from a broad region of the south-central boreal forest (Boyd and Surette 2010:Table 1), in addition to Avonlea complex sites on the prairies of southern Manitoba and Saskatchewan (Lints 2012). Maize, therefore, appears to have been systematically linked to wild rice in the subsistence behaviors of Woodland peoples across a considerable portion of central and western Canada. This pattern may have also extended eastward into the Lower Great Lakes; Hart and colleagues (2003), for example, report recovering maize and wild rice phytoliths (along with *Cucurbita* sp. and sedge remains) from multiple carbonized food residue samples in the Finger Lakes region of New York (see also Raviele 2010).

The low recovery of *Cucurbita* phytoliths and *Phaseolus vulgaris*–type starch granules from sites in the Whitefish Lake region mirrors the overall paucity of these plant remains across the central boreal forest. As discussed above, squash will be strongly underrepresented in microfossil assemblages due to its apparent lack of distinctive starch grains and production of phytoliths in only the inedible (rind) portion of the fruit. Domesticated beans, on the other hand, are starch rich, so the sporadic recovery of these starch granules in our food-residue samples cannot be explained by differential microfossil production alone. In other regions—such as the Canadian prairies, for example—*Phaseolus*-type starch is found in nearly half the samples analyzed (see

Figure 5). We argue, therefore, that common bean was a relatively unimportant dietary component in subarctic locales such as Whitefish Lake, where the remains of wild rice and maize dominate the plant microfossil component of food residue.

One explanation for this trend is that domesticated beans were nutritionally unnecessary in areas where wild rice was locally available (Hart et al. 2003) and where hunting provided the bulk of dietary protein. In the Three Sisters agricultural system, common bean is important as a nutritional complement to maize due to its higher protein content and contribution of the amino acids lysine and tryptophan, which are missing in maize (Hart et al. 2003). Wild rice is nutritionally similar to *Phaseolus*, although its complementarity with maize appears to weaken with cooking because of the reduction of its amino acid and protein content with added heat (Hart and Lovis 2013). A regular supply of animal-derived protein, of course, would also fill the dietary space occupied by common bean in agricultural societies. In the boreal forest, there is no indication that domesticated plants were anything more than a minor addition to a diet largely focused on hunting and gathering (Boyd and Surette 2010). For these reasons, there may have been no advantages to adopting a new source of protein—especially given the long history of use (Chapman and Shea 1981; Crawford 1982; Hart et al. 2003, 2007; Johnston 1984), local abundance, and ceremonial and social significance of wild rice in the region. In contrast, maize may have been more readily adopted by subarctic peoples due to the paucity of starch-rich wild foods in this region. In general, the idea that the availability of wild rice helped discourage the widespread adoption of *Phaseolus* is supported by the higher incidence of this food outside the boreal forest and natural range of wild rice (see Figure 5). However, one important exception to this trend seems to be found in the Avonlea complex (A.D. 300–1100), which, as summarized above, is associated with *both Phaseolus* and *Zizania* remains (along with maize) in cooking residues and accounts for nearly all our evidence of wild rice on the northern prairies. This may suggest that nutritional considerations alone do not fully account for the presence or the absence of specific cultivated plants in the archaeological record (Hart and Lovis 2013).

Environmental constraints may also explain the more selective use of domesticated plants in the boreal forest. Specifically, because common bean is more vulnerable to spring frost than maize (Mt. Pleasant 2006), it may have been more prone to failure in the short growing season of the subarctic. Significantly, in early nineteenth-century descriptions of crops grown by the Ojibway at one of the largest and most productive garden islands in the southern boreal forest (*Menauzhetaunaung*, Lake of the Woods), common bean is not mentioned, although corn, potatoes, and squash routinely are (Canada Provincial Secretary's Office 1858; Harmon 1820; James 1830). This suggests that the near exclusion of *Phaseolus* from boreal gardens—whether due to climate or choice—was a pattern that was established during the Woodland period and continued into historic times.

Conclusions

Domesticated plants and wild rice were widely consumed across the central boreal forest and the northern prairies during the Woodland tradition, although the economic importance of particular taxa appears to have varied geographically at the local and regional levels. In particular, we discern (1) a general northward decline in the evidence of domesticated plants across the prairie/boreal border, suggesting comparatively lower importance of cultigens in the diet of boreal-adapted Woodland populations due to decreased availability of these foods (if acquired through trade) and/or decreased viability of horticulture at higher latitudes; (2) the widespread use of wild rice in combination with maize across the boreal forest and adjacent northern prairies, suggesting that these two foods were closely intertwined components of diet in many northern Woodland societies; and (3) a pronounced drop in the proportion of residue samples with evidence of *Phaseolus* in the boreal forest, which we attribute in part to its nutritional overlap with wild rice and/or its decreased viability in subarctic gardens. In general, these results highlight the spatial variability of domesticated plant use during the Woodland period, as well as the importance of applying new techniques—such as food residue analysis—to the study of old archaeological problems.

Acknowledgments

This project was supported by a SSHRC Standard Research Grant awarded to Matthew Boyd and Scott Hamilton. We are grateful to the MacGillivray and Smiley families for allowing access to the Martin-Bird site over two field seasons. Many of the residue samples analyzed for this paper could not have been obtained without the generous assistance of Andrew Hinshelwood (Ontario Ministry of Tourism, Culture, and Sport), Kevin Brownlee and Leigh Syms (Manitoba Museum), Brian Smith (Historic Resources Branch, Winnipeg), Evelyn Siegfried (Royal Saskatchewan Museum), Dave Norris (Western Heritage), Murial Carlson (Turtleford Museum), Bev Nicholson (Brandon University), Brad Hyslop, and Terry Wilson. Sincere thanks are also owed to Jill Taylor-Hollings for her help with pottery identification; Lakehead University graduate and undergraduate students for their assistance with the archaeological excavations; Terry Gibson (Western Heritage) for geophysical survey of the Martin-Bird site; and Megan Wady, Christine Shultis, Zeb Kawei, and Jen Surette for assisting with phytolith and starch processing. Lastly, we thank Bill Lovis and Maria Raviele for inviting us to present an earlier draft of this paper at the 2012 MAC sponsored symposium.

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MIDWEST ARCHAEOLOGICAL CONFERENCE INC. OCCASIONAL PAPERS No. 1, 2014, 33–52

The Age and Distribution of Domesticated Beans (*Phaseolus vulgaris*) in Eastern North America: Implications for Agricultural Practices and Group Interactions

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Direct dating of domesticated plants is the only way to provide unequivocal, baseline data about when those plants were incorporated into local subsistence strategies. By mapping the age of first appearance of domesticated common beans (*Phaseolus vulgaris*) across eastern North America (ENA), the routes of, rationale for, and mechanisms of their adoption by various groups can be measured. These pathways may also map group interactions and show the presence of important cultural, technological, or economic production barriers. Direct dates on *P. vulgaris* indicate that they entered North America through the Southwest approximately 500 B.C. but did not occur in ENA until 1,500 years later. Between A.D. 1100 and 1200, *P. vulgaris* spread very rapidly from the Great Plains, through the Upper Great Lakes, and into the Northeast. After A.D. 1300–1350, beans spread south and west from the Lower Great Lakes/Northeast into the lower Ohio and Mississippi valleys. This northern pathway suggests that *P. vulgaris* likely first spread through Plains Village/Oneota, northern Late Woodland, Iroquois, and similar horticultural groups and appears to have been adopted by Mississippian agriculturalists much later. The late north–south and east–west spread of beans into the lower Ohio and Mississippi valley sites suggests that either significant "cultural" boundaries or agricultural practice divides existed across upper Mississippi, Great Lakes, or Northeast regions, particularly between Oneota and Mississippian groups in the Mississippi and lower Ohio valleys.

KEYWORDS tropical domesticates; Three Sisters horticulture; plant production systems; Mississippian; North America

Common beans (*Phaseolus vulgaris*) were domesticated and incorporated into the economies of Mesoamerica and South America during the middle and late Holocene but entered eastern North America (ENA) very late compared to the other major tropical cultigens characteristic of the "Three Sisters" agricultural planting system: corn (*Zea mays*) and squash (*Cucurbita* sp.) (Figure 1). Each Three Sisters component has its own diverse, often unrelated, history of domestication and dissemination across North America. Squash was domesticated in Mesoamerica before 9000 B.P. (Smith 1998) and again independently in the lower Mississippi valley after 4500 B.P. (Chomko and Crawford 1978; Cowan 1997; King 1985; Monaghan et al. 2006; Simon 2011; Smith 1989, 1995). Corn and beans were domesticated in Mesoamerica but were not introduced into ENA until after ca. 2300 and 900 B.P., respectively (Adair 2003; Asch and Hart 2004; Hart et al. 2007; Hart et al. 2003; Raviele 2010; Smith 1989, 1992;). Because it was introduced into ENA last and so late, the appearance of *P. vulgaris* is considered the initiation of the Three Sisters planting system in the region (Hart 2008). This system involves intercropping corn, beans, and squash together within constructed beds, hills, or fields and represents a significant Native American innovation in agricultural sustainability and nutrition. Corn provides carbohydrates and protein (incomplete), but its productivity is severely limited by the amount of organic matter, available nitrogen, and moisture in the soil (Mt. Pleasant and Burt 2010:75–77). Beans complete corn protein deficiencies, use the corn stalks for support, and fix some soil nitrogen depleted by the corn, making it available in the next season. Squash supply dietary fat, oil, and some protein. Its trailing habit shades the ground, aiding weed control, and decreases soil erosion.

P. vulgaris is an integral component of the Three Sisters planting system (Hart 2008), but such intercropping is not required and any of the Three Sisters components can be monocropped (i.e., a single crop planted in a garden bed or field). In fact, experimental results indicate monocropped fields of beans have 50 percent higher productivity compared with Three Sisters planting while only a negligible difference exists in corn productivity (Mt. Pleasant and Burt 2010:75; see also Munson-Scullin and Scullin 2005). This suggests that intercropping corn and beans is most productive in places where field space is limited, rather than its being universally so. Thus, the mechanisms and processes through which *P. vulgaris* is incorporated into local food-production systems should be considered in context with the broader plant-production systems in ENA, the history of local plant use, and the enhancements or constraints that such systems imposed through group dynamics, including preexisting local socioeconomic and political organizations and culture history.

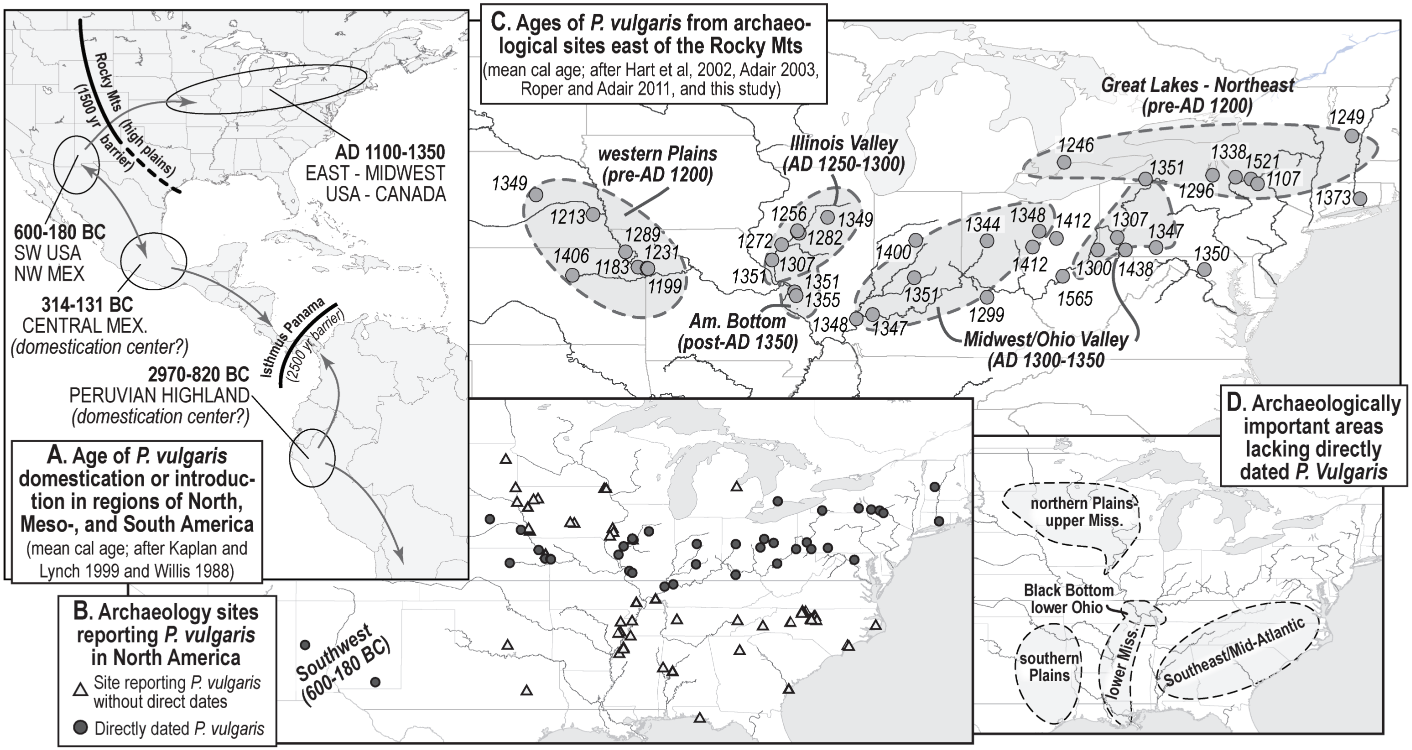

FIGURE 1 Maps showing the ages and distribution of *Phaseolus vulgaris* in North and South America. (A) Calibrated calendar age of *P. vulgaris* domestication or introduction in regions of North and South America (Adair 2003; Hart et al. 2002; Kaplan and Lynch 1999; Roper and Adair 2011; Willis 1988; this study). (B) Locations of archaeological sites reporting *P. vulgaris* in North America. (C) Locations and mean calibrated calendar ages of directly dated *P. vulgaris* in regions of North America east of the Rocky Mountains (after Adair 2003; Hart et al. 2002; Roper and Adair 2011; this study). Ages calibrated in CALIB5.1; calibration after Stuiver and Reimer (1993), Hughen et. al. (2004), and Talma and Vogel (1993). (D) Archaeologically important regions lacking directly dated *P. vulgaris*.

Chronology of *Phaseolus vulgaris* domestication and dissemination in North America

Until the advent of accelerator mass spectrometry (AMS) dating technologies, direct dates on cultigens were relatively rare and age was usually established indirectly through their association with larger fragments of organic material, typically charcoal, that could be conventionally dated. Reliance on longer-lived wood charcoal and composite samples compounded the "old-wood" problem or exacerbated contamination issues (Schiffer 1986). Accordingly, age estimates for the introduction of particular cultigens into a region or for the domestication of cultigens often were too old (Fritz 1994). MacNeish (1967) reported a 5000–3500 B.C. age for a *P. vulgaris* fragment from the Tehuacan valley of Mexico. Such incorrect age estimates led to erroneous assumptions about cultural relationships, plant associations, and production technologies (Kaplan 1967; Kaplan and Lynch 1999) and the fragment was later directly dated by AMS as several thousand years younger (i.e., median age of 300 B.C.) (Kaplan and Lynch 1999). Direct dates of cultigens have also forced a reevaluation of the age of introduction of beans, corn, and squash into ENA (Hart and Scarry 1999; Lovis and Monaghan 2008; Monaghan et al. 2006). In these examples, earlier interpretations that relied on indirect ages of material within the same features or stratigraphic units associated with cultigens were significantly different from actual introduction based on direct dates. The inaccurate ages were easily accepted by researchers because the dates made sense given preconceived ideas about the relative antiquity of plant domestication and production. Direct AMS dates on cultigens ultimately provided correct and equally believable data about the ages, domestication, or introduction of cultigens (e.g., Hart et al. 2002; Hart and Scarry 1999; Kaplan and Lynch 1999; Lovis and Monaghan 2008; Monaghan et al. 2006; Smith 1997, 2001).

Direct AMS ages of *P. vulgaris* from Mesoamerica and South America indicate that it was first domesticated around 2400 B.C. within the Peruvian Highland but did not spread beyond South America. Later, at about 300 B.C., beans were independently domesticated in the Oaxaca and Tehuacan valleys of central Mexico (see Figure 1) (Kaplan and Lynch 1999). Although two independent domestication centers with adoption dates separated by about 2,000 years seems unusual, direct AMS ages on seeds and associated pods, as well as several genetic studies, support the hypothesis of separate centers. To further complicate matters, wild progenitors of *P. vulgaris* found at both centers probably actually originated in central Mexico and spread to South America during the Pleistocene, well before human intervention and thousands of years prior to domestication (Bitocchi et al. 2012).

Once domesticated in central Mexico, *P. vulgaris* spread rapidly across Mexico into the southwestern U.S. region (Adams and Fish 2011; Kaplan and Lynch 1999; Willis 1988), which remained the northernmost extent of *P. vulgaris* in North America until after A.D. 1100, when it first appeared east of the Rockies (see Figure 1). Although direct AMS ages of *P. vulgaris* appear slightly earlier in the Southwest than in central Mexico (i.e., ca. 600 B.C. and 314 B.C., respectively) (Willis 1988), they are actually statistically identical, mainly due to the large standard deviation for the Southwest bean (Tularosa cave, New Mexico, 2470 ±

250 B.P. [Willis 1988]) compared to the bean of central Mexico (Tehuacan valley, Mexico, 2285 ± 60 B.P. [Kaplan and Lynch 1999]) (see Figure 1), and reflect the rapidity with which beans diffused regionally. Once introduced, beans spread nearly instantaneously through the region. Conversely, the 2,000-year lag between the appearances of *P. vulgaris* in the Southwest and the Great Plains regions (see Figure 1) implies that significant barriers prevented interregional diffusion of beans, although the degree to which such barriers were cultural, geographical, historical, developmental, or technological is unknown.

The rapid, nearly instantaneous diffusion across ENA (see Figure 1C) suggests that *P. vulgaris* was highly adaptive and apparently easily adopted into many extant, local food-production systems. The chronology and distribution pattern of its spread, however, was geographically irregular and chronologically patterned, suggesting that *P. vulgaris* was not universally accepted in all regions across North America at the same time, which implies that barriers existed between geographical or cultural areas. Regions where *P. vulgaris* did not spread or appeared much later may indicate that beans were not suited for, or not easily adopted into, existing food-production technologies or that demarcated groups that resisted their use. Ultimately, the rate at which *P. vulgaris* diffused across the continent, the geographical avenues through which it spread, and the time it was first introduced into ENA may provide a map of contemporaneous interregional cultural relationships and regional food-production technologies.

Chronology and geographic eistribution of *Phaseolus vulgaris* in Eastern North America

The value of direct dates on cultigens, particularly beans, noted by Kaplan and Lynch (1999) for Mesoamerica and Hart and Scarry (1999) for ENA, led Hart and colleagues (2002) to undertake a larger study encompassing the Midwest and northeastern regions east of the upper Mississippi valley. Using direct AMS dates from extant collections scattered across the region, they found that *P. vulgaris* remains were generally dated earliest in the Illinois valley and Lower Great Lakes (prior to A.D. 1250) and latest in the upper Ohio valley (after A.D. 1300) (see Figure 1). Similarly, Adair (2003) and Roper and Adair (2011) provided a suite of ages for beans from collections in the Great Plains, particularly from tributaries of the Missouri River in eastern Kansas, Nebraska, and Missouri. These ages revealed that beans were introduced from the Southwest to the Great Plains region just prior to A.D. 1200. Since then, a scattering of other direct dates of *P. vulgaris* beans in the Ohio valley and northeastern regions has been reported, and they generally support the chronological trends noted by Hart and colleagues (2002), except for the earliest *P. vulgaris* dated in ENA, which was recently recorded near Binghamton, New York (Table 1).

Directly dated *P. vulgaris* beans are unevenly distributed across North America (see Figure 1C). Despite the fact that *P. vulgaris* has been reported from archaeological sites scattered across all regions, including the southern and northern plains, lower

TABLE 1

AGE AND CONTEXT OF DIRECTLY DATED *P. VULGARIS* IN EASTERN NORTH AMERICA

Site name	Group[1]	Lab code	^{14}C age (B.P.)[2]	Median[3] age (A.D.)	Age range[4] (A.D.)	Prob.[5] area
Coons	Plains	AA41432	858 ± 78	1165	1028–1274	100%
Hulse	Plains	AA41434	842 ± 76	1179	1034–1278	100%
25SY31	Plains	AA36110	825 ± 90	1188	1022–1299	99%
23CL115	Plains	AA41433	804 ± 84	1208	1030–1302	98%
14DP25	Plains	ISGSA1458	685 ± 30	1296	1268–1314	67%
25BO23	Plains	AA41430	611 ± 84	1350	1260–1445	100%
14GE127	Plains	AA-85329	534 ± 70	1392	1285–1473	100%
Chenango Point	GL-NE	Beta265480	920 ± 80	1115	989–1261	100%
Kelly	GL-NE	T08963	770 ± 50	1232	1036–1328	89%
Skitchewaug	GL-NE	AA-29120	765 ± 50	1237	1039–1330	88%
Thomas/Lucky	GL-NE	AA-29122	695 ± 90	1300	1162–1424	100%
Roundtop	GL-NE	AA-23106	658 ± 48	1327	1205–1441	99%
Onoville Bridge	GL-NE	AA38454	628 ± 33	1344	1267–1419	100%
Burnham-Shepard	GL-NE	AA38463	550 ± 60	1390	1252–1639	100%
Broome Tech	GL-NE	AA-31007	380 ± 40	1541	1391–1681	94%
Larson	IL Vly.	A0176	757 ± 44	1246	1147–1399	91%
Hill Creek	IL Vly.	AA38471	734 ± 33	1270	1163–1327	84%
Orendorf	IL Vly.	AA38967	712 ± 33	1286	1207–1403	99%
Morton	IL Vly.	AA38473	675 ± 33	1319	1237–1408	99%
Noble-Weiting	IL Vly.	AA38964	621 ± 36	1348	1271–1430	100%
Worthy-Merrigan	IL Vly.	AA40138	594 ± 49	1356	1220–1482	100%
Fox Farm	Up Ohio	AA38466	683 ± 33	1312	1224–1405	100%
Portman Trench	Up Ohio	AA38456	682 ± 33	1313	1225–1405	100%
Saddle	Up Ohio	AA38457	675 ± 33	1319	1237–1408	99%
Gnagey	Up Ohio	AA29118	635 ± 45	1341	1224–1438	100%
Gardner	Up Ohio	AA38462	593 ± 33	1353	1284–1431	100%
Baldwin	Up Ohio	AA38459	542 ± 33	1401	1388–1437	65%
Blain Village	Up Ohio	AA16854	510 ± 60	1422	1272–1645	100%
Campbell Farm	Up Ohio	AA40132	462 ± 38	1453	1387–1532	69%
Blennerhassett	Up Ohio	AA38464	301 ± 33	1576	1445–1681	93%
Sun Watch	Low Ohio	A0175	652 ± 42	1334	1223–1428	100%
Clampit	**Low Ohio**	**Beta309454**	**600 ± 30**	**1347**	**1297–1373**	**74%**
Angel Mounds	**Low Ohio**	**Beta303069**	**630 ± 30**	**1351**	**1337–1398**	**59%**
Murphy	Low Ohio	AA38966	603 ± 36	1352	1278–1433	100%
Bakers Trail	Low Ohio	AA40134	539 ± 39	1388	1279–1490	100%
Janey B. Goode	**Am. Bot.**	**ISGSA2412**	**620 ± 20**	**1351**	**1338–1397**	**61%**
GSC#1 (Fea-9)	**Am. Bot.**	**ISGSA2411**	**630 ± 20**	**1355**	**1343–1394**	**60%**
Rosenstock	Piedmont	Beta259069	590 ± 40	1350	1296–1415	100%

[1]General geographical regions and sources. Plains: Great Plains (ages from Adair 2003 and Roper and Adair 2011); GL-NE: Great Lakes-Northeast (ages from Hart et al 2002 and Knapp et al 2011 [Chenango Point site]); IL Vly.: Illinois valley (ages from Hart et al. 2002); Up Ohio: Upper Ohio valley (ages from Hart et al. 2002); Low Ohio: lower Ohio valley (ages from Hart et al. 2002; newly reported dates in bold); Am. Bot: American Bottom (ages from American Bottoms provided courtesy of Illinois State Archaeology Survey). Oldest age selected for region to estimate earliest bean introduction.

[2]Conventionally reported radiocarbon age (uncalibrated).

[3]Calibrated median age of probability distribution (A.D.) ages calibrated in CALIB5.1; calibration after Stuiver and Reimer (1993), Hughen et. al. (2004), and Talma and Vogel (1993).

[4]Most probable calibrated age range of 2σ distribution.

[5]Percent of most probable age range within the 2σ distribution.

Mississippi and Ohio valleys, Southeast and Mid-Atlantic, none has been directly dated from the lower Mississippi valley or the entire southeastern region (see Figure 1B and 1C). We have filled a few gaps by directly dating *P. vulgaris* beans at Mississippian and Fort Ancient/Oliver phase sites (Angel Mounds and Clampit, respectively) in the lower Ohio valley (see Table 1; see Figure 1C). Only a few sites in the American Bottom have reported *P. vulgaris,*[1] including a single undated cotyledon from a Sand Prairie phase pit at Cahokia (Merrell Tract). Elsewhere in the American Bottom, directly dated *P. vulgaris* has been reported at GCS#1 near Horseshoe Lake and the Janey B. Goode (JBG) sites (Thomas Emerson and Mary Simon, personal communication 2013). These yielded similar median calibrated ages of A.D. 1355 and 1351, respectively (see Table 1). The newly reported ages from the American Bottom and lower Ohio valley extend the geography and chronology of *P. vulgaris* significantly southward into Middle Mississippian contexts, more than did those provided by earlier regional studies (e.g., Adair 2003; Roper and Adair 2011; Hart et al. 2002).

Regardless of the newly reported *P. vulgaris*, the remainder of the lower Ohio valley includes few reports from Mississippian (or other) contexts and none have been dated. In the Black Bottom, *P. vulgaris* was reported from the Angelly site but not dated (Blakeman 1974) (see Figure 1B) and none has been reported from Kincaid Mounds. Farther west, beans have also been reported from Plains Village and Caddoan sites in river valleys within the southern plains of Oklahoma (Drass 1993) and east Texas (Bruseth and Perttula 1981) as well as from Oneota, Glenwood, and Mill Creek phase late prehistoric sites in the northern plains of Iowa (Iowa-OSA 2012). No direct dates from any of these contexts have been reported. *P. vulgaris* has also been reported, but not dated, at a scattering of Oneota and Late Woodland sites within the upper Mississippi and Great Lakes regions (see Figure 1). Other important areas that report undated beans include the lower Mississippi valley below the American Bottom and the Southeast, Gulf Coast, and Mid-Atlantic regions (see Figures 1 and 2). Some of these sites have assigned indirect ages for beans based on archaeological contexts. At Moundville, Welch and Scarry (1995) note that beans occur within a Moundville I pit, which implies a very early age for beans, as well as in Moundville NR and Big Sandy contexts. The lack of directly dated beans from southern Mississippian period sites severely constrains our understanding about when and through what avenues *P. vulgaris* spread into the lower Mississippi and southeastern regions.

Bean diffusion into Eastern North America

The distribution of directly dated *P. vulgaris* beans indicates that they spread from the Southwest into the Great Plains and the Northeast soon after A.D. 1100, as indicated by their mean calibrated calendar years (see Figure 1C; see Table 1). Interestingly, beans appear similarly early (prior to A.D. 1200) in both the western and the eastern ends of this distribution (e.g., Great Plains and Northeast/Great Lakes, respectively). In fact, dated to A.D. 1107 (Beta-265480, 920 ± 40) the earliest *P. vulgaris* (see Table 1) occurs at the Chenango Point site (BUBi-1274; Knapp et al. 2011) in the Susquehanna valley, New York (see Figure 2A; see Table 1). However,

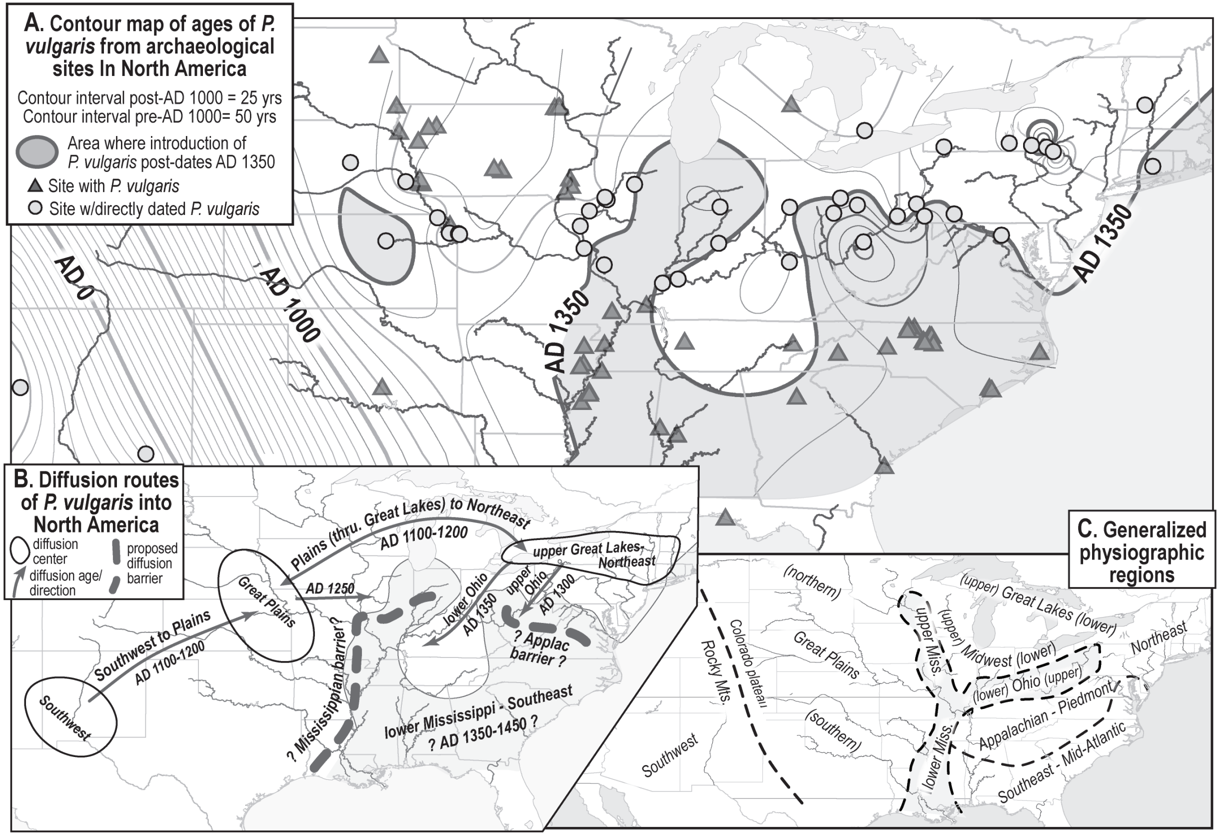

FIGURE 2 Distribution and reconstructed trade routes of *Phaseolus vulgaris* in eastern North America. (A) Contour map of ages of *P. vulgaris* (see Figure 1C) with locations of archaeological sites reporting *P. vulgaris* in North America. (B) Reconstructed routes for diffusion of beans from the Southwest into eastern North America. (C) Generalized physiographic regions of eastern North America of relevance to *P. vulgaris* diffusion.

the earliest *P. vulgaris* ages from the Great Plains and the Northeast are statistically similar to the 95 percent confidence interval (Figure 3; see Table 1). As noted for ages in central Mexico and the Southwest, the similarity of the dates probably reflects how rapidly beans spread across ENA, as well as the paucity of direct dates from relatively few sites. As indicated by the ages of beans at sites in tributary valleys of the Missouri River in Kansas, Nebraska, and Missouri and by the geographical reality of probable eastward routes through which they could have diffused, beans must have first spread through the Great Plains from A.D. 1100 to 1200 (see Figures 1 and 2; see Table 1). By A.D. 1200, beans had spread through the upper Midwest/Great Lakes and into the northeastern/New England regions. They then spread south into the Illinois valley after A.D. 1250 and finally into the upper and lower Ohio valley after A.D. 1300 and A.D. 1350, respectively (see Figures 1C and 2A). Surprisingly, *P. vulgaris* moved from northeast to southwest, from the Great Lakes and Northeast into the Ohio valley, rather than from west to east up the Ohio River from the Mississippi valley. Direct dates on *P. vulgaris* from the American Bottom also postdate A.D. 1350, which supports a north-to-south, downstream diffusion.

Details of the geographical patterning, regional timing, and pathways for the introduction of beans show regional differentiations and similarities in group interactions and modes of plant-production systems across North America (see Figure 2). The statistical similarity of ages from the Plains and Northeast demonstrates how rapidly beans spread across ENA. As noted for Mesoamerica, once introduced, beans rapidly moved across the region. Such rapid spread implies that groups who incorporated beans early likely had significant and productive interactions and also probably shared comparable plant-production systems. Conversely, in areas where beans did not diffuse until later, it suggests the population had fewer interactions with "bean" groups and used plant-production systems into which beans could not be easily or efficiently incorporated.

Despite their presence in the Illinois and upper Mississippi Valley by A.D. 1250, *P. vulgaris* did not appear in the American Bottom or the lower Mississippi River until at least 100 years later (see Figures 1 and 2). This pattern suggests that the Ohio valley (St. Louis to Louisville) marked a significant geographical or cultural barrier to the incorporation of beans and may mark a zone of conflict (or at least a boundary less permeable to positive interactions) between western and northern Oneota/upper Mississippian groups and more southern Middle Mississippians. Hypothetically, such conflict might relate to incompatible plant-production systems and/or the sociopolitical organization required by these production systems. Fritz (2000) notes that before A.D. 1200 the Three Sisters (i.e., corn, beans, and squash) were commonly grown in the upper Mississippi valley but that beans appeared in the central and lower valley (below St. Louis) only after A.D. 1400.

Phaseolus vulgaris as part of plant-production systems in Eastern North America

Plant-production systems represent technologies whose success depends on sociopolitical organization, cultural practices, local suitability of crops, and specific

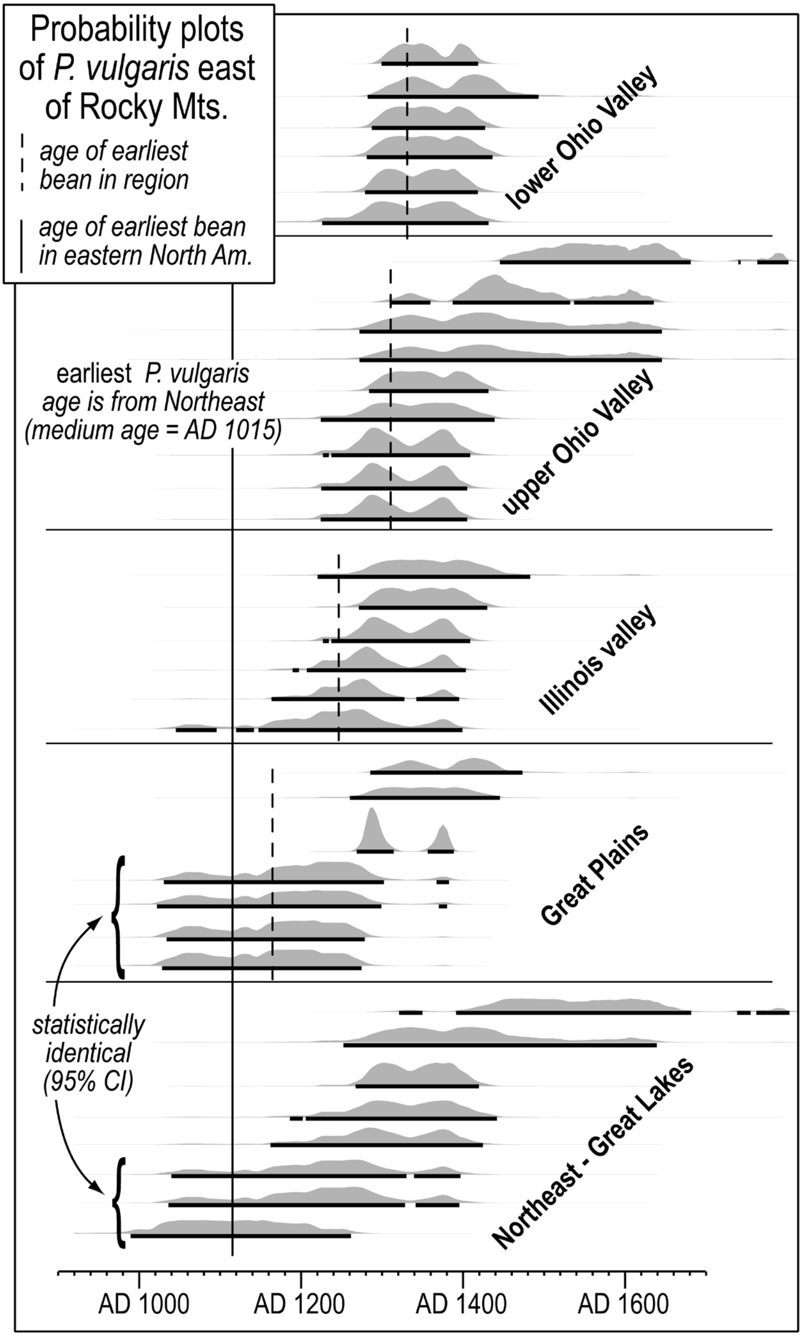

FIGURE 3 Calibrated calendar ages for directly dated *P. vulgaris* samples showing ^{14}C age ranges and 2σ probability distribution (shaded portion) of calibrated calendar years (calibration after Stuiver and Reimer [1993]; Hughen et. al. [2004]; and Talma and Vogel [1993]). Vertical lines show median age of the oldest *P. vulgaris* in each region, which is the earliest probable age for introduction.

local landform conditions. In ENA, two main plant-production systems dominated: field and garden bed. They are not necessarily mutually exclusive but have different strengths and weaknesses and different geographical and ecological distributions. Their effectiveness is constrained by specific social organization (settlement, subsistence, and politics) and environmental factors (climate, soil, nutrients, and vegetation). Although garden beds may be well suited to Three Sisters intercropping, both field and bed systems can accommodate interplanting or monocropping or both.

Garden beds are raised and sometimes referred to as "ridged fields" (Figure 4) (Gallagher et al. 1985; Gartner 1999, 2003); corn hills are constructed features that were used within large fields (Buckmaster 2004; Delabarre and Wilder 1920). Both are constructed landscape features related to plant production. The distinction between the two is not always clear, and both are sometimes used interchangeably (Sasso 2003). Garden beds were often constructed by stripping rich organic surface soil (A- or A_O-horizon) and piling it on top of an existing adjacent surface soil, thus creating linear ridges and furrows (see Figure 4). Corn hills were similarly constructed by pushing surrounding A-horizon material into a hill, and they were often made within fields (see Currie 1994; Mt. Pleasant and Burt 2010:66). Both methods thickened existing A-horizons and effectively increased the organic matter available in soil, which is the greatest limiting factor to maintaining corn yield for subsistence farmers and is even more important than nitrogen levels (Mt. Pleasant and Burt 2010:58). Sustainability was accomplished through crop rotation, bed fallowing, the addition of nutrients on the ridges during reconstruction, and/or companion planting (i.e., Three Sisters). Beds were probably fallowed for a period to allow recovery, and through time, organic matter and nutrients that accumulated in the furrows (see Figure 4) were periodically scraped and placed on the ridges to renew their productivity. Constructed beds represent a significant energy investment and territorial commitment to build and maintain, and groups who used them had significant investment in and ties to place. The relatively small size of garden beds compared to field systems probably implies concentrated, relatively autonomous village organizations focused around landscapes over which the villagers had great incentive to maintain control.

Garden beds occurred across the upper Midwest and Great Lakes regions and were commonly noted by Euroamerican settlers across the area, particularly in Wisconsin and Michigan (Gartner 1999, 2003; Hinsdale 1931; Sasso 2003), while corn hills were more common in the Northeast (Chilton 1999; Currie 1994; Delabarre and Wilder 1920; Hallowell 1921; Mrozowski 1994) but also occurred in the Midwest (Sasso 2003). Antiquarians mapped and documented both garden beds and corn hills during the nineteenth and the early twentieth centuries, so a good historic record of their distribution exists (e.g., Delabarre and Wilder 1920; Hallowell 1921; Hinsdale 1931). Importantly, only a few, probably late, garden beds or corn hills have been noted within the Southeast and lower Mississippi or lower Ohio valley regions (e.g., Fowler 1992). Such a geographical distribution suggests that garden-bed systems may be most effective in areas where a few specific limiting resources (e.g., water, production area, soil nutrients, etc.) required focused settlement at specific locations on the landscape where such resources were most abundant or more predictable. Examples of this include the drier climates of the

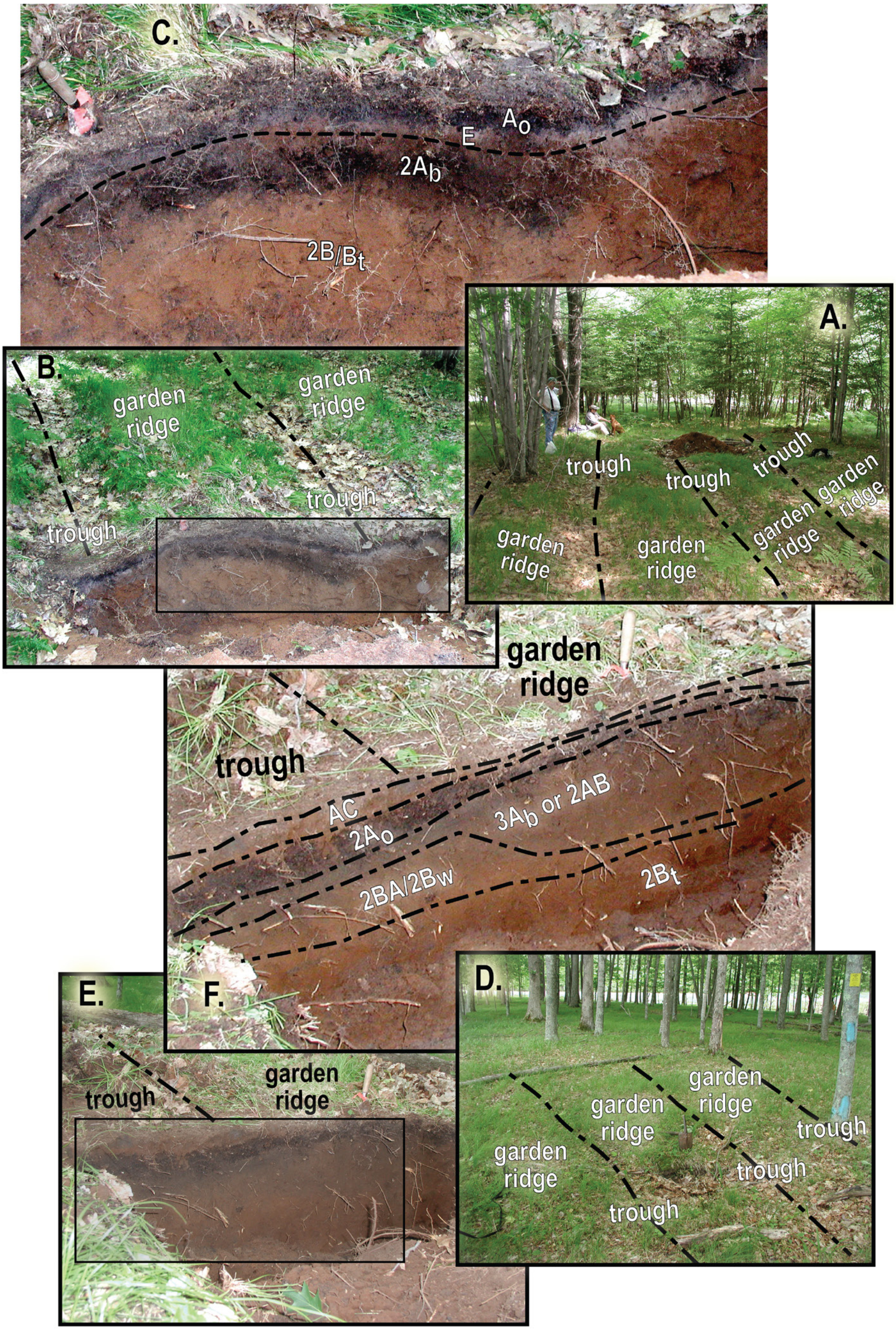

FIGURE 4 Backlund garden beds, Menomonee County, Michigan. Age of beds is estimated to be younger than A.D. 1000 (Buckmaster 2004). (A–C) Photographs of garden beds found in upland position, showing beds' geometry (A) and internal structure (B, C). Note the overthickened A-horizon that is now buried by younger A/E soil sequence developed after 700–1,000 years. (D–F) Photographs of garden beds found on the floodplain of the Menomonee River, showing beds' geometry (D) and internal structure (E, F). Note the extent to which the troughs have filled in with sediment and organic material since abandonment.

Great Plains, where water limits productivity, or the Great Lakes and Northeast, where the growing season is short, forests grow very slowly, and soils (e.g., spodosols) are far less productive. From a comparative standpoint, their concentration in more northern regions may suggest that garden beds and corn hills were better suited, or at least more regularly employed, in areas with shorter growing seasons, and their absence in the Southeast may indicate that garden beds were not significantly better for or more suited to southern areas than field systems (Gartner 2003).

Although few examples of prehistoric field systems within ENA have been reported, the methods employed to clear fields are common across time and occur worldwide (e.g., Scarry and Scarry 2005). Fields were probably cleared using swidden-like techniques that focused on removing natural vegetation from fields (often by burning), although a few large trees may have been left to create a savanna-like ecology. Field systems probably used "hoe" agriculture, similar to methods employed by European colonists in the Mid-Atlantic prior to the eighteenth century, who may have borrowed the fields and planting methods developed by precontact Native Americans (Fowler 1992; Gallagher and Arzigian 1994; Scarry and Scarry 2005). Hoe agriculture can maintain suitable soil organic matter longer than Euro-American plowed–field agriculture can (Mt. Pleasant and Burt 2010:75–76), but unless constructed beds or hills were employed, fields probably required more frequent rotation because A-horizons were not overthickened. Field systems likely worked best in places where rapid forest regrowth replenished organic matter and soil nutrients (e.g., nitrogen [N], phosphorus [P], potassium [K]) in abandoned fields and where relatively large and ecologically diverse tracts were available as fields through which crops could be rotated. Ultimately, field systems may be most effective and productive in the humid, mild climates of the lower Midwest and Southeast regions, where forests regenerate faster, water is less limited, and serial plantings of the same crop in the same field are possible.

Fields were probably not intentionally fertilized. Rather, soil productivity and health, particularly for nutrient-limited, intensive crops like corn, were maintained by field rotation. Periodic rotation allowed fields to fallow for a time, probably years to decades, to allow recovery of organic matter, and nutrients and to refresh soil properties. Once fallowed, new fields within a culturally bounded territory were cleared, prepared, planted, and eventually fallowed. Generally, field systems must incorporate relatively large tracts of land and diverse landscapes of which only small parts are cleared or open for planting at any time. Such a pattern implies expansive territory and a relatively large, dispersed population—settled on farmsteads or in small hamlets—that can easily relocate as fields are rotated and fallowed. A relatively large territory whose boundaries are ill defined is not easily defended by a dispersed population.

One of the advantages of field-systems is that with proper distribution and storage capabilities, and a large and ecologically diverse territory, societies can effectively manage risk (e.g., Peebles and Kus 1978; Scarry 1993a; Zori and Brant 2012). For example, to manage environmental and short-term climatic risks, corn could be simultaneously grown in both floodplain and upland landforms. During dry years, floodplains may produce better crops, and during wet years, uplands may have higher productivity. Such shared risk, however, requires even more territory, as well as a relatively evolved, dependable redistribution organization (Chmurny 1973) to fairly compensate those whose fields were not productive one year but most productive another year.

Whether fields or beds were mono- or intercropped depended on the plants grown, climate (e.g., length of growing season), and soil conditions. Intercropping of fields likely occurred but would be most effective only where the rates of plant maturity and harvest time for all the intercropped plants were similar. Intercropping precludes serially planting the same crop in a field after the first is harvested, which means more than one crop of corn per season cannot be obtained. Unless all plants mature at the same time, harvesting and obtaining maximum yield is problematic. Given their size (see Figure 4) and that walkways probably existed between them, garden beds were probably less constrained by these factors.

Discussion

The north–south dichotomous garden-bed distribution may well reflect the geography of plant-production systems in ENA and, as such, has implications for group interactions in the region. The ages and distribution of *P. vulgaris* across ENA indicate that beans spread north and east through the region of garden beds (particularly the upper Midwest/Great Lakes) and corn-hill fields (mainly the Northeast). Such a geographic distribution suggests that beans may serve as a proxy through which to map climate/growing seasons, plant-production systems, and the kinds of social relationships maintained by populations across ENA.

The rate at which *P. vulgaris* spread across the northern parts of North America is impressive and very rapid (see Table 1 and Figure 2). ^{14}C ages of directly dated beans indicate that they were introduced into ENA from the Southwest around A.D. 1100, spreading from the Great Plains to the Northeast within a generation or two, and suggest that groups along this pathway likely had regular, significant, and beneficial interactions. Such a northern route suggests active socioeconomic relations among western populations, such as Oneota, Plains Village, and related groups, with eastern and northern groups, such as Iroquois, Huron, and other Late Woodland groups, interactions that are not readily visible in the archaeological record. The apparent ease with which beans were incorporated into existing economic systems also implies that groups along that pathway probably had similar plant-production systems and technologies. Conversely, those groups in areas where beans were integrated much later probably interacted infrequently (or unproductively) with groups who adopted beans early. They also may have had different plant-production systems in which beans were either not easily incorporated or had lower productivity or yields than existing crops (i.e., corn).

Initially, *P. vulgaris* spread eastward, routing through northern regions, and only after A.D. 1350, did beans spread into the lower Ohio and Mississippi valleys. Even then, beans moved northeast to southwest from the Great Lakes/Northeast and not through a west-to-east route, which is what would have been expected if beans were incorporated earlier by Mississippian agricultural groups in that region. The northeast–southwest route implies that beans were probably not incorporated into Mississippian economies of the Southeast until at least 200 years after their incorporation by Oneota, Late Woodland, and Iroquois groups. Given how rapidly *P. vulgaris* spread regionally in the absence of significant geographic barriers (i.e., the Rockies), such a lag may imply that a cultural or technological (or both) barrier prevented its spread into the lower Mississippi valley and southeast regions until very late.

We suggest that *P. vulgaris* was initially associated with Plains Village, Oneota, Iroquois, and other northern Late Woodland societies and may have been integrated into garden beds, corn-hill fields, or other intercropped planting systems. Conversely, we propose that beans were not adopted until very late in the lower Mississippi valley and southeast regions because they were not particularly compatible with extant field agricultural systems, particularly if more than one corn crop was expected from the fields. This is in keeping with Scarry's (1993b) suggestion that field systems were associated with Mississippian economies, particularly after A.D. 1200, when corn agriculture intensified in the lower Mississippi valley and Southeast (Fritz 2000). Field systems do not necessarily exclude multicropping but may be most efficient and productive if monocropped, particularly in southern regions.

Climate, available plants, and cultural traditions all affect the choice of plant-production systems. Field production may have dominated across the Eastern Woodlands prior to the introduction of beans, particularly as it related to the intensification of corn agriculture before A.D. 1100 (Fritz 2000; Scarry and Steponaitis 1997). Field systems were probably especially suited for large river valleys and forested uplands in climatically milder areas of the lower Midwest and Southeast. During the Medieval Warm Interval (MWI) approximately A.D. 1000–1300 (e.g., Mann et al. 2009), parts of these areas, particularly the more southern, may have been suitable for multiple harvests of corn from a single field. Regardless of a milder MWI climate, garden beds that included Three Sisters interplanting were probably more effective and sustainable than field systems within more northern climates. As climatic instability increased during the transition from the MWI to the Little Ice Age (LIA), from A.D. 1300 to 1400 (e.g., Mann et al. 2009), garden beds and associated intercropping of the Three Sisters; might have become more sensible, effective, and sustainable for cultivation on land located in a progressively more southward direction. Even as the LIA climate deteriorated, however, field systems likely continued to be productive in the Deep South (e.g., lower Mississippi valley and the Southeast). Transitional areas where planting beds may have been the better choice during the LIA, such as the lower Ohio valley, probably also included different groups who used field or garden-bed production or both. The incompatible social organization and landscape requirements of these production systems may have been an important source for the intra- or intergroup conflict so prevalent across the region after A.D. 1300.

Acknowledgments

The authors thank the Glenn A. Black Laboratory of Archaeology, Indiana University, for providing support for this research. We are also grateful to Tom Emerson and Mary Simon, director and ethnobotanist, respectively, of the Illinois State

Archaeological Survey, Prairie Research Institute, University of Illinois, for providing unpublished direct dates on *P. vulgaris* from the Janey B. Goode and GSC#1 sites in the American Bottom. We also acknowledge the helpful comments and discussions with John Hart, Bill Lovis, Maria Raviele, Tim Baumann, Jeremy Wilson, and Tony Krus on earlier drafts of this paper.

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Note

1 Wild beans from eastern North American (*Strophostyles helvola*), which have been reported from archaeological contexts in the American Bottom as early as the Middle Woodland, are smaller than *P. vulgaris* but have similar nutritional value and can fix nitrogen. However, whether Strophostyles beans are functionally equivalent or had a subsistence role similar to *P. vulgaris* is interesting, but not relevant, to our discussion about the meaning of the age, distribution, and spread of *P. vulgaris* in North America.

MIDWEST ARCHAEOLOGICAL CONFERENCE INC. OCCASIONAL PAPERS No. 1, 2014, 53–72

Ethnicity as Evidenced in Subsistence Patterns of Late Prehistoric Upper Great Lakes Populations

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During the late prehistoric period, circa A.D. 700 to 1300, Late Woodland, Mississippian, and Oneota populations were present in southern Wisconsin and northeastern Illinois. The relationship of these populations to each other is one of the central questions in studies addressing culture change in this region. Paleoethnobotanical analysis indicates that these late prehistoric cultures had distinct subsistence patterns, although there is also evidence of acculturation of Late Woodland populations to their Oneota counterparts.

KEYWORDS subsistence; late prehistory; ethnicity; acculturation

> Food is an integral part not only of a culture's survival strategy but also of its very identity. Farb and Armelagos argue that "what is eaten establishes one's social, religious, and ethnic memberships" (1980:5).

Ethnic distinctions in foodways have been noted in several historic archaeological studies. In the 1980s, a series of articles was published exploring archaeological evidence for ethnicity (Schuyler 1980). Researchers examining Chinese immigrants in California during the late nineteenth and early twentieth centuries (Evans 1980; Greenwood 1980; Langenwalter 1980) observed that acculturation was slow to occur. Particularly noteworthy in all the studies is the observation that the Chinese diet, as well as food preparation and consumption patterns, remained consistent with traditional dietary practices for generations.

Scott's more recent (2000) analysis of race and ethnicity in colonial Fort Michilimackinac notes that within the fort's mixed population of French Canadian, Métis, Jewish, and British residents each group used religion, language, food, and house style to emphasize its cultural traditions. Interestingly, she observes that among these populations, who were forced to coexist within the confines of the frontier fort, these cultural attributes served not only as a means of identification but also, in her interpretation, as a means of distancing themselves from each other and thus maintaining independent identities and subcommunities.

Similarly Franklin (2000), in her study of Afro-Virginian identity, argues that foodways served as a means of defining identity and drawing group boundaries. She argues that, while many of the foods used by the Virginia slave population were similar to those consumed by their owners, they varied in terms of specific assemblage composition and mode of preparation.

Grounded in the paradigm that subsistence patterns are closely linked to ethnic identity and are resistant to acculturative alterations, this study examines the relationships between five cultural groups in southern Wisconsin and northern Illinois in order to identify their cultural origins and affiliations with populations to the south, east, and north.

Cultural context

This investigation focuses on the late prehistoric period, from circa A.D. 700 to 1300, a period characterized by changes in Late Woodland socioeconomic and technological adaptations, incursion of Mississippian populations into the Upper Great Lakes, and development of the Oneota tradition. In fact, during the period from circa A.D. 700 to 1300, there is some overlap in the archaeological delineation of these three cultural traditions and presumably, to some extent, the populations upon which they are defined.

Archaeologists have debated the relationship between these archaeologically defined populations for decades (Emerson 1999; Gibbon 1982; Goldstein 1991a; Green 1997; Griffin 1961; Overstreet 1995, 1997, 2001; Richards 1992; Salkin 1987, 2000; Theler and Boszhardt 2000). Researchers have explored the relationships between these populations by looking at ceramics, territorial ranges as defined by diagnostic artifact categories, technological advances, and chronology, among other attributes. Using ceramics as a basis for delineating analytical units, this study approaches the issue from the perspective of subsistence patterns as they relate to floral exploitation.

In the 1970s, Hurley (1975) proposed a synthesis of the Late Woodland Effigy Mound culture in which he identified three periods, beginning in A.D. 300 and extending until Euro-American contact in the seventeenth century. He argued that key ceramic taxa—including uncollared wares, such as Dane Incised and Madison ware, Collared-wares, and Oneota wares—were contemporary and that all were associated with Effigy Mound culture at sites dating from A.D. 600 to 1000 (Hurley 1975:331–343).

Subsequently, Salkin (1987) proposed two phases for the Late Woodland in southeastern Wisconsin. One is the Horicon phase, dating A.D. 650–1200, which has been characterized as a primarily hunting-gathering society with limited dependence on horticulture. Horicon phase sites include seasonal extractive camps located in a variety of settings along wetlands and waterways, as well as uplands, and also larger seasonally based camps that are found in resource rich zones. Salkin notes that burial mounds and mound groups were built by Horicon phase populations who manufactured uncollared, Madison ware ceramics.

In contrast, according to Salkin (1987, 2000), the Kekoskee phase was a contemporary horticultural society dating between A.D. 800 and 1300. He argues that the Kekoskee phase is characterized by large habitation sites located along wetlands and waterways that were occupied most of the year, as well as small camps and extractive sites. Some Kekoskee phase sites have produced evidence of fences or palisades and many of the large habitation sites contain numerous large storage/refuse pits. In further contrast to the Effigy Mound or Horicon phase, Kekoskee populations did not bury their dead in mounds and in addition to making uncollared, Madison wares, made a variety of Collared-wares, including Hahn Cord Impressed, Aztalan Collared, and Point Sauble Collared.

Use of mounds, ceramic style, and subsistence patterns are three attributes commonly used to distinguish these Late Woodland manifestations. But many contest Salkin's two-phase classification. For example, Rosebrough's (2010) research on effigy mounds makes an argument for the Effigy Mound tradition as a ritual complex, associated with multiple Late Woodland communities. Thus, mound building may not be specifically characteristic of a particular cultural group but rather an overarching ritual tradition. Whether a ritual or a socioeconomic construct, for purposes of this analysis, the Effigy Mound tradition in southeastern Wisconsin is equated with the early Late Woodland–hunter-gatherer populations that manufactured a variety of uncollared, cord and fabric impressed ceramic styles.

Salkin (1987), Kelly (2002), and others have posited that Collared-wares were introduced into southern Wisconsin through the in-migration of foreign residents from the east, including groups from New York, Ontario, Pennsylvania, and Michigan, and the subsequent adoption of this stylistic treatment of ceramics by local residents. Others, such as Mason (1966, 1981) and Stoltman and Christiansen (2000), argue that Collared-wares are closely related to uncollared Madison wares and that the manufacturers of Collared-wares represent a continuation of the Effigy Mound culture. Finally, there are those who look south toward Illinois and see connections between the populations that manufactured Collared-wares at sites such as Aztalan and Fred Edwards and the Middle Mississippian populations who occupied these sites (Goldstein 1991a, 1991b; Hall 1986; Richards 1992).

By circa A.D. 1050, or perhaps slightly earlier, Middle Mississippian influence first appears in the northern frontier, in Wisconsin and Minnesota. It is most commonly identified in terms of the presence of Middle Mississippian–style ceramics (Finney 2000), as well as a subsistence regime heavily dependent on maize agriculture. Aztalan is one of the most important Middle Mississippian sites in Wisconsin. Occupation of the site extends from the Lohmann phase (ca. A.D. 1050–1100) to the Sterling phase (ca. A.D. 1100–1200). Middle Mississippian influence also is represented in western Wisconsin and eastern Minnesota, along the Mississippi River at sites such as Fred Edwards (Finney 1993, 2000), Trempealeau area sites (Boszhardt et al. 2012), and at many later Silvernale phase Mississippian sites in the Red Wing locality (Gibbon and Dobbs 1991; Green 1997). Middle Mississippian influence in this area similarly extends through the Lohmann and Sterling phases, A.D. 1100 and 1300.

Finally, during this same period, circa A.D. 950–1150, Oneota populations were emerging. As is the case with the appearance of Collared-wares, our understanding of the origins of the Oneota is unclear. There are basically three competing models as recently summarized by Bruhy (2007).

Overstreet serves as a primary proponent of the migration model, though he has observed that "a detailed and precise theory of Oneota origin does not exist" (1995:59). He suggests, however, that it is plausible that Oneota and Middle Mississippian cultures had a shared ancestry, and that Oneota populations migrated from the south northward into eastern Wisconsin in the tenth century A.D. Although he acknowledges that data is scant, he points to possible Oneota origins in the broader region that includes southwestern Wisconsin, northwestern Illinois, and eastern Iowa (Overstreet 1995:59–60). Suggesting Oneota populations arrived in eastern Wisconsin around A.D. 950 and were present in the area at that time, he further argues they were recognizably distinct from regional Late Woodland societies (Overstreet 1995:59). In brief, he states that "these early Oneota populations appear to have rapidly replaced local Woodland residents and there is little evidence of interaction with or transition from one to the other" (Overstreet 1995:39). Finally, he posits that Oneota populations were subsequently displaced from the eastern Wisconsin localities during the expansion of Middle Mississippian populations and that the displaced Oneota then moved to the interior forests of northern Wisconsin (Overstreet 2001; see also Bruhy 2002) and the Upper Peninsula of Michigan (Buckmaster 1979); following Aztalan's decline they reoccupied their former territories (Overstreet 1995:59).

The diffusion and degeneration model also involves migration. Unlike migration of fully developed Oneota populations, this model suggests that Middle Mississippians moved northward from the American Bottom, thereby influencing local Woodland populations and, as a result, giving rise to the Oneota. Based on data from southwestern Wisconsin, Theler and Boszhardt (2000), for example, argue that throughout the Late Woodland period Effigy Mound populations became increasingly circumscribed in their settlement/subsistence system. In response to the disruption in or depletion of critical resources they increased their dependence on *Zea mays* (maize), shifting from horticultural to agricultural production and from deer hunting to seasonal bison hunting. Concomitant with these subsistence changes was a shift to agricultural settlements along the Mississippi River that allowed for warm-season exploitation of aquatic resources. They go on to argue that it was the Late Woodland Effigy Mound populations who were the ancestors of the horticultural, bison-hunting Oneota.

Finally, there is the transformation or in situ development model. This model proposes that Oneota culture emerged through the transformation of resident Late Woodland populations who were influenced by Middle Mississippian contact; that is, it was transformation through acculturation. Gibbon has identified two co-occurring sets of processes associated with the emergence of Oneota culture: development of a new settlement-subsistence adaptation; and either creation of or adaptation to a distinctive complex of "diffusing Mississippian traits" (1982:86).

The thesis of this study is that the subsistence patterns relating to floral exploitation at late prehistoric sites will reflect continuity in the identity of related groups, despite dramatic changes in the sociopolitical, ideological, and economic characteristics of these populations.

Analysis

This analysis is based on a relatively small sample of sites for the Late Woodland components (Figure 1). The statistics used are limited by the small sample size and are based on averaged values for each period. Therefore, the herein results presented are to be considered preliminary and should be tested as additional data become available.

Starting with the Late Woodland, several researchers have observed that one of the primary differences between the Late Woodland Effigy Mound populations who manufactured uncollared wares and those who manufactured Collared-wares is in regard to the greater dependence on horticulture by the latter. Averaged values for percentage of maize (Table 1; Figure 2) and densities of maize (Table 2; Figure 3) indicate that there was a significant increase in the use of maize at sites in which Collared-ware Late Woodland ceramics are predominant. While the relative percentage of maize does not increase, densities of maize do increase between the Effigy Mound and the Collared-ware Late Woodland. Also characteristic of the increased exploitation of domesticated resources is the increase in the ubiquity of squash between the Effigy Mound and Collared-ware Late Woodland (Table 3; Figure 4).

Interestingly, the percentage representation of Eastern Agricultural Complex (EAC) taxa (i.e., *Chenopodium* spp. [chenopod], *Phalaris caroliniana* [maygrass], *Polygonum* sp. [knotweed], and *Hordeum pusillum* [little barley]), as well as *Echinochloa muricata* (barnyard grass), a regional favorite, increases within the floral assemblages of the Collared-ware Late Woodland (see Table 1; see Figure 2). However, the overall density of these seeds does not increase but may actually decrease, occurring in densities of less than one seed per 10 L of flotation (see Table 2; see Figure 3). Further, review of the ubiquity of taxa is noteworthy. A relatively narrow range of EAC taxa occur at the Effigy Mound and Collared-ware sites; those being chenopod, maygrass, knotweed, little barley, and barnyard grass; while maygrass and barnyard grass only occur in the Collared-ware assemblages (see Table 3; see Figure 4).

Broadening the comparison to northern Illinois and including Simon's (1998) analysis of Late Woodland sites from the Middle Rock River that produced Collared-wares, a greater diversity of starchy- and oily-seed annuals is noted at these sites (see Table 3; see Figure 4). Identified taxa include *Helianthus annuus* (sunflower), *Iva annua* (sumpweed), and little barley, which do not occur in the Wisconsin Collared-ware Late Woodland sites. However, in both contexts, the density of these seeds is relatively low at less than 10 seeds per 10 L flotation (see Table 2; see Figure 3).

Notably, the density of maize at the Middle Rock River sites is fairly comparable to the Collared-ware sites in Wisconsin, with the former producing an average density of approximately 8.7 fragments per 10 L of flotation and the latter 9.2 fragments per 10 L (see Table 2; see Figure 3). Similarly, maize occurs in a high percentage of Late Woodland Collared-ware sites, 55 percent of the Middle Rock River features, and 84 percent of the Wisconsin Collared-ware sites (see Table 3;

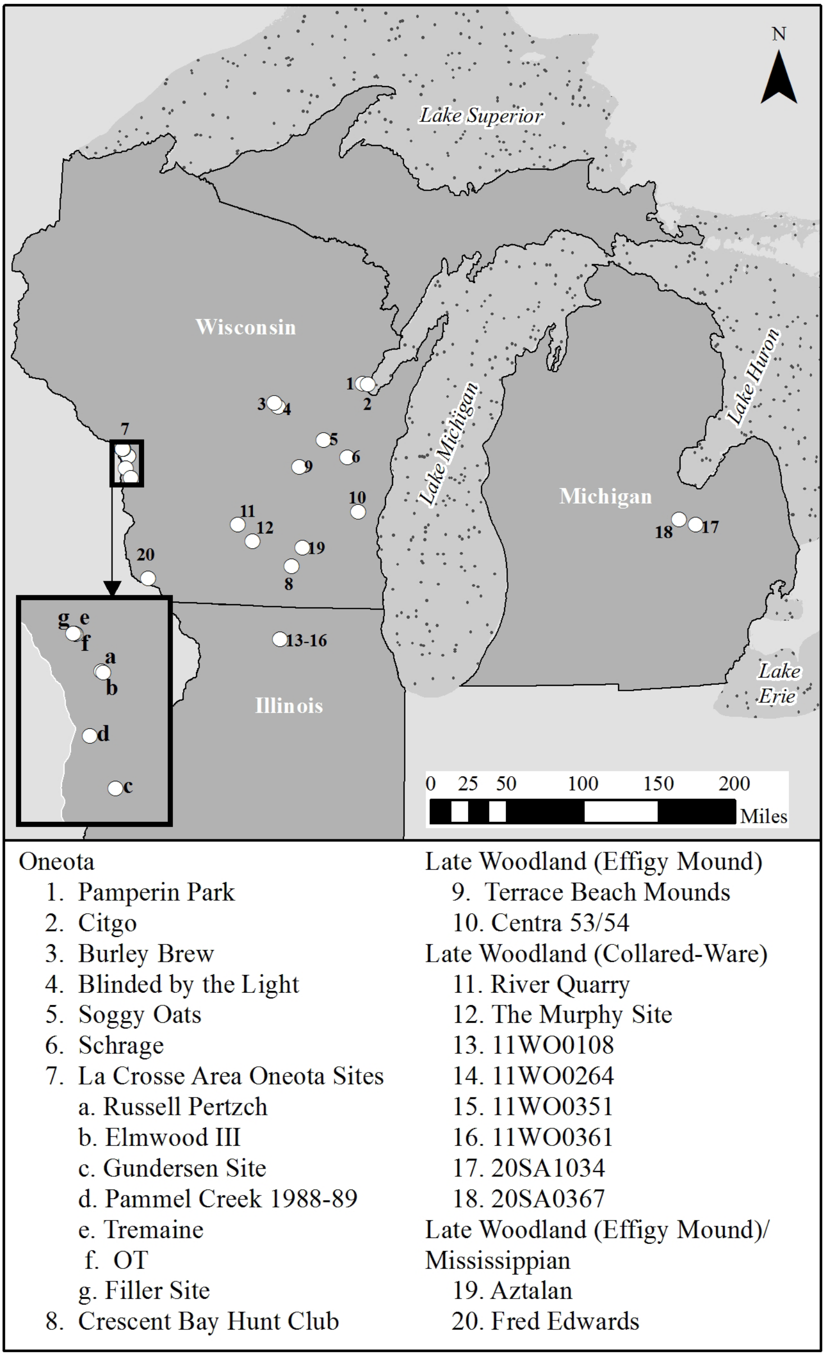

FIGURE 1 Map of study area.

TABLE 1

PERCENTAGES

Component	Site	Number of Features/Sampled Contexts	Number Liters Flot	Nutshell	Maize	Starchy- and Oily-seeded Annuals
Late Woodland–Effigy Mound	Terrace Beach (Egan-Bruhy and Nelson 2008)	8	76	—	—	—
	Aztalan (Egan-Bruhy 2003)	3	26	1.1	.3	—
	Centra 53/54 (Egan 1993)	19	150.5	.13	.3	18
	Average	—	—	.4	.0	6.0
Late Woodland–Collared Ware	Murphy (Egan-Bruhy 2009a)	9	166	24	1.3	17
	River Quarry (Egan 2009a)	2	143	15.5	5.5	—
	Aztalan (Egan-Bruhy 2003)	8	76	3.1	2.4	66
	Average	—	—	14.2	3.1	27.7
Middle Rock River–Collared Ware	11WO108 (Simon 1998)	29	435.5	2.8	10.3	6.2
	11WO264 (Simon 1998)	23	184	2.77	7.5	2.25
	11WO351 (Simon 1998)	3	28	8.77	2.3	1.78
	11WO354 (Simon 1998)	4	40	.52	.39	—
	11WO0361 (Simon 1998)	13	214	4.49	1.63	5.25
	Average	—	—	3.8	4.3	3.1
Mississippian	Aztalan (Egan-Bruhy 2003; Picard 2012)	17	308.9	5.5	3	84.9
Oneota–East of the Wisconsin River	Soggy Oats (Egan-Bruhy 2001)	5	35	—	—	—
	Schrage (Egan-Bruhy 2011)	29	488	50	4.8	.4
	Citgo (Egan-Bruhy 2010a)	3	83	.8	2.6	52
	Burley Brew (Egan-Bruhy 2010b)	10	126	.5	—	—
	Blinded by the Light (Egan-Bruhy 2010b)	39	408	16.2	4.4	25
	Crescent Bay (Egan-Bruhy 2010c)	40	2,860	22.4	4.9	56.7
	Pamperin Park (Egan-Bruhy 2012)	29	269	1	1	77
	Average	—	—	3.4	0.45	2.4

see Figure 4). This is a significantly higher percentage than noted at the Effigy Mound sites. Finally, of note is the fact that the Middle Rock River maize is classified as 10-rowed or less, which is characteristic of the Northern Flint varieties of maize from the Northeast (Simon 1998).

While there are few comparable sites in Michigan, one of interest is 20SA1034, a Late Woodland site in the Saginaw River drainage analyzed by Parker (1996). This site also produced Collared-ware vessels and dates to circa A.D. 1150, comparable to the Wisconsin and Illinois sites. At 20SA1034, Parker found chenopod and sunflower, as well as 8-rowed maize, *Nicotiana* sp. (tobacco), and *Cucurbita pepo*

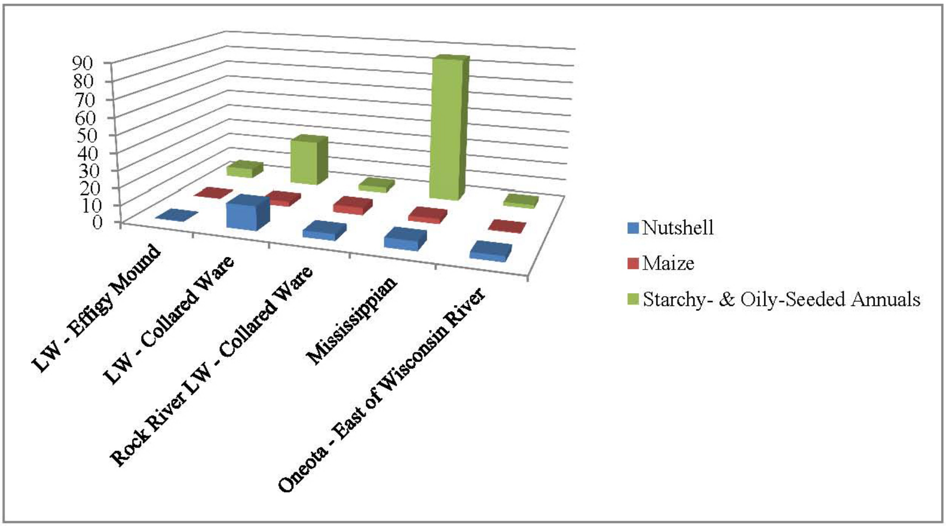

FIGURE 2 Percentage of flora to floral assemblage.

(squash). The low diversity of EAC taxa is similar to that noted in the Collared-ware sites in Wisconsin, and the density of these seeds at .04 per 10 L is lower than in the Wisconsin and Middle Rock River sites. Maize is ubiquitous, occurring in 85.7 percent of the features, in densities of 2.7 fragments to 10 L of flotation.[1] One final characteristic of the 20SA1034 assemblage that Parker notes as somewhat unusual is the predominance of maize (Parker 1996:316–317).

Similarly, analysis of a small number of samples (315 L) from another late Late Woodland site in the Saginaw Valley (20SA367) that contains Ontario-related Collared wares indicates that maize was exploited (3.58 ct/10 L), while EAC taxa are nearly absent, represented only by chenopod (.1 ct/10 L) (Egan-Bruhy 2009b).

Simon and Parker's (2006) comprehensive review of the subsistence data from the American Bottom provides a good comparative data set for populations to the south and for the Late Woodland and Mississippian influenced subsistence at the Middle Mississippian Aztalan site in southeastern Wisconsin. In contrast to the floral assemblages described for the Late Woodland Collared-ware sites in Wisconsin, northern Illinois, and Michigan, the Terminal Late Woodland I (ca. A.D. 900–975) and II (ca. A.D. 975–1050) sites in the American Bottom contain a similar range of EAC taxa as that found at the northern sites; densities of these taxa are significantly higher. Simon and Parker (2006) report average densities of approximately 41.5 seeds per 10 L of flotation. In addition, those taxa commonly comprise approximately 89 percent of the seed assemblages (see Simon and Parker 2006:Table 10). Finally, data from the American Bottom sites indicate that the average density of maize is extremely variable, ranging from an average of 50 to 10 fragments per 10 L flotation.

Shifting to the Middle Mississippian in southeastern Wisconsin, the density and diversity of EAC taxa are comparable to that reported by Simon and Parker (2006)

TABLE 2

DENSITIES

Component	Site	Number of Features/Sampled Contexts	Number Liters Flot	Nutshell	Maize	Seed
Late Woodland–Effigy Mound	Terrace Beach (Egan-Bruhy and Nelson 2008)	8	76	7.2	—	—
	Aztalan (Egan-Bruhy 2003)	3	26	4.2	1.2	2.3
	Centra 53/54 (Egan 1993)	19	150.5	.3	.07	1.5
	Average	—	—	3.9	.4	1.3
Late Woodland–Collared Ware	Murphy (Egan-Bruhy 2009a)	9	166	107	5.8	.7
	River Quarry (Egan 2009a)	2	143	17.9	6.4	.07
	Aztalan (Egan-Bruhy 2003)	8	76	20.1	15.4	2
	Average	—	—	48.3	9.2	.9
Middle Rock River–Collared Ware	11WO108 (Simon 1998)	29	435.5	.7	24.3	16.0
	11WO264 (Simon 1998)	23	184	3.0	6.9	2.1
	11WO351 (Simon 1998)	3	28	2.0	1.5	.0
	11WO354 (Simon 1998)	4	40	36.8	9.6	7.5
	11WO0361 (Simon 1998)	13	214	3.6	1.3	4.2
	Average	—	—	9.1	8.7	6.0
Mississippian	Aztalan (Egan-Bruhy 2003; Picard 2012)	17	308.9	35.1	23.6	22.9
	Fred Edwards (Arzigian 1987)	15	1,018	UNK	UNK	20.1
	Average	—	—	35.1	23.6	21.5
Oneota–East of the Wisconsin River	Soggy Oats (Egan-Bruhy 2001)	5	35	295	28	2.6
	Schrage (Egan-Bruhy 2011)	29	488	3.2	10.5	1.1
	Citgo (Egan-Bruhy 2010a)	3	83	5.8	0	1.1
	Burley Brew (Egan-Bruhy 2010b)	10	126	67.7	18.2	54.1
	Blinded by the Light (Egan-Bruhy 2010b)	39	408	100.4	22.1	14.2
	Crescent Bay (Egan-Bruhy 2010c)	40	2,860	4.8	9.93	25.2
	Pamperin Park (Egan-Bruhy 2012)	29	269	6.8	1	1.9
	Average	—	—	69.1	12.8	14.3

at Lohmann phase Mississippian sites. The density of these taxa in the Middle Mississippian samples from the Aztalan and Fred Edwards sites is significantly higher than among the Late Woodland Collared-ware samples (see Table 2; see Figure 3). Further, the ubiquity of these species at Aztalan and Fred Edwards is significantly higher than observed at the Collared-ware Late Woodland sites in the region (see Table 3; see Figure 4). Particularly noticeable is the increase in the ubiquity of chenopod, which also occurs in the highest density. Notably, chenopod is one of the most important of the EAC taxa among the Lohmann phase Middle Mississippian populations in the American Bottom (Simon and Parker 2006).

Looking at other Middle Mississippian sites in this northern frontier, including Bryan (Johannessen et al. 2002) and Trempealeau area sites (Kathryn Parker, personal

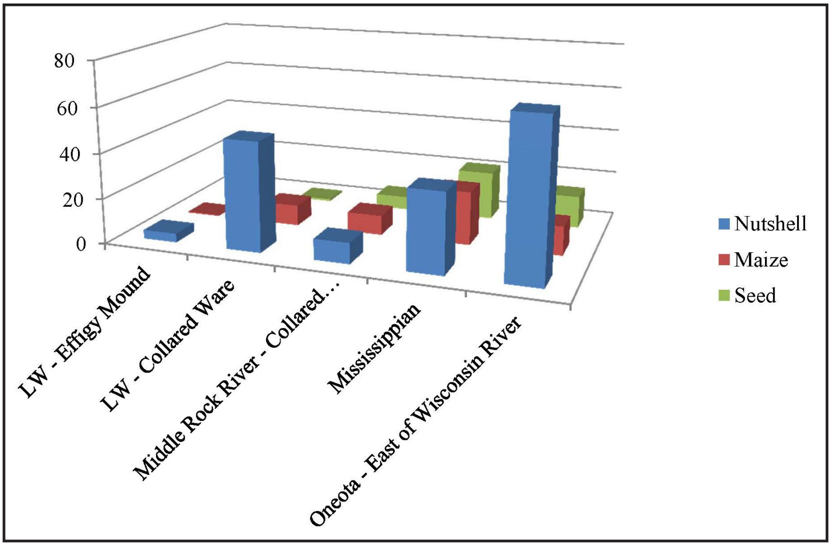

FIGURE 3 Densities of flora per 10 L.

communication 2013), chenopod, maygrass, and knotweed commonly occur, while sunflower, sumpweed, and little barley are less common.

While the percentage representation of maize at Aztalan does not appear to have increased significantly as compared to its occurrence at Late Woodland Collared-ware sites (see Table 1; see Figure 2), this is largely due to occupational intensity and the increase in wood charcoal at the site, which in turn reduces the percentages of identified food plants. Nonetheless, the density of maize increases dramatically as compared to the densities found at Collared-ware Late Woodland sites in Wisconsin and the Middle Rock River valley (see Table 2; see Figure 3). Further, squash continues to be a consistent component of the Mississippian diet, and tobacco appears for the first time in this area (see Table 3; see Figure 4).

The Oneota assemblages from eastern and central Wisconsin (i.e., sites east of the Wisconsin River drainage basin) are significantly different in overall composition, density, and ubiquity to flora from Middle Mississippian assemblages from Aztalan and other sites in the northern frontier and the American Bottom. In terms of percentage of identified flora, density, and ubiquity, maize appears to be less significant at the eastern and central Wisconsin Oneota sites examined (see Tables 1–3; see Figures 2–4). There is also a decrease in the ubiquity of squash (see Table 3; see Figure 4) and, similarly, a decrease in the exploitation of EAC taxa, not only in terms of percentage representation and density, but also in terms of the ubiquity of these taxa (see Tables 1–3; see Figures 2–4). More specifically, there is a considerable difference in the taxa exploited. At the Oneota sites examined, neither sunflower nor sumpweed has been identified in this region, and maygrass is represented by a single specimen at Crescent Bay Hunt Club. Also noteworthy is the appearance of barnyard grass. It does not occur at the Middle Mississippian sites in the northern frontier or in the American Bottom, except during the Archaic and Early Woodland (Simon and Parker 2006); however, it is present at Collared-ware Late Woodland sites in southeastern Wisconsin (see Table 3; see Figure 4).

TABLE 3

UBIQUITY

							Starchy- and Oily-Seed Taxa Represented									
Component	Site	Number of Features/ Sampled Contexts	Number Liters Flot	Nutshell	Maize	Squash	Chenopod	Little Barley	Polygonum	Sunflower	Sumpweed	Barnyard Grass	Maygrass	cf Bottle Gourd	Tobacco	Wild Rice
Late Woodland–Effigy Mound	Terrace Beach (Egan-Bruhy and Nelson 2008)	8	76	—	—	13	13	13	13	—	—	—	—	—	—	—
	Aztalan (Egan-Bruhy 2003)	3	26	66	66	—	—	—	—	—	—	—	—	—	—	—
	Centra 53/54 (Egan 1993)	19	150.5	16	5.2	13	—	13	—	—	—	—	—	—	—	—
	Average	—	—	27	24	9	4	9	4	0	—	0	0	—	—	0
Late Woodland–Collared Ware	Murphy (Egan-Bruhy 2009a)	9	166	66	78	25	—	—	—	—	—	—	—	—	—	—
	River Quarry (Egan 2009a)	2	143	100	100	8	8	—	4	—	—	—	—	—	—	—
	Aztalan (Egan-Bruhy 2003)	8	76	87.5	75	38	28	—	19	—	—	5	5	—	—	—
	Average	—	—	85	84	24	12	0	8	0	—	2	2	—	—	0
Middle Rock River–Collared Ware	11WO108 (Simon 1998)	29	435.5	32	79	3	24	3	7	7	3	—	10	—	—	—
	11WO264 (Simon 1998)	23	184	61	52	—	4	—	—	—	—	—	—	4	—	—
	11WO351 (Simon 1998)	3	28	100	33	—	—	—	33	33	—	—	—	—	—	—
	11WO354 (Simon 1998)	4	40	75	50	—	—	—	—	—	—	—	—	—	—	—
	11WO0361 (Simon 1998)	13	214	85	62	8	8	39	—	—	—	—	8	—	8	—
	Average	—	—	71	55	2	7	8	8	8	1	0	4	1	2	0
Mississippian	Aztalan (Egan-Bruhy 2003; Picard 2012)	17	308.9	87.5	70.1	24	29	12	12	6	6	—	6	6	6	12
	Fred Edwards (Arzigian 1987)	15	1,018	100	100	73	100	40	26	33	0	—	60	—	7	—
	Average	—	—	93.75	85.05	48.5	64.5	26	19	19.5	3	0	33	3	6.5	6

Continued

TABLE 3

CONTINUED

Component	Site	Number of Features/ Sampled Contexts	Number Liters Flot	Nutshell	Maize	Squash	Starchy- and Oily-Seed Taxa Represented: Chenopod	Little Barley	Polygonum	Sunflower	Sumpweed	Barnyard Grass	Maygrass	cf Bottle Gourd	Tobacco	Wild Rice
Oneota–East of the Wisconsin River	Soggy Oats (Egan-Bruhy 2001)	5	35	80	40	—	20	20	—	—	—	—	—	—	—	—
	Schrage (Egan-Bruhy 2011)	29	488	59	90	—	17	—	—	—	—	4	—	—	—	10
	Citgo (Egan-Bruhy 2010a)	3	83	100	0	—	—	—	33	—	—	—	—	—	—	—
	Burley Brew (Egan-Bruhy 2010b)	10	126	70	80	—	30	12.5	—	—	—	10	—	—	—	20
	Blinded by the Light (Egan-Bruhy 2010b)	39	408	82	82	—	36	9	—	—	—	—	—	—	—	9
	Crescent Bay (Egan-Bruhy 2010c)	40	2,860	45	67.5	—	58	4	8	—	—	4	4	—	—	53
	Pamperin Park (Egan-Bruhy 2012)	29	269	58.6	17.2	—	—	—	—	—	—	3.4	—	—	—	—
	Average	—	—	71	54	0	23	7	6	0	0	3	1	0	0	13
Oneota–La Crosse Area	Russell Pertzsch (Egan-Bruhy 1998)	11	247.6	55	91	—	9	9	—	—	—	—	—	—	—	—
	Elmwood III (Arzigian 1998)	17	780.5	82	71	6	35	6	24	—	12	—	—	—	—	—
	Gundersen Site (Arzigian 1994)	13	252	92	92	46	39	39	23	23	—	23	—	—	8	46
	Pammel Creek 1988–89 (Arzigian 1989)	22	152	29	86	14	—	38	33	—	—	19	—	—	—	38
	Tremaine (Egan and Brown 1995)	100	442	5	44	—	—	29	3	—	—	3	—	—	—	10
	OT (Hunter and Berg 1993)	14	110	43	57	7	29	7	—	—	—	7	—	—	—	7
	Filler (Hollinger and Pearsall 1994)	39	250	56	80	23	51	—	5	—	—	10	—	—	—	46
	Average	—	—	52	74	14	23	18	13	3	2	9	0	0	1	21

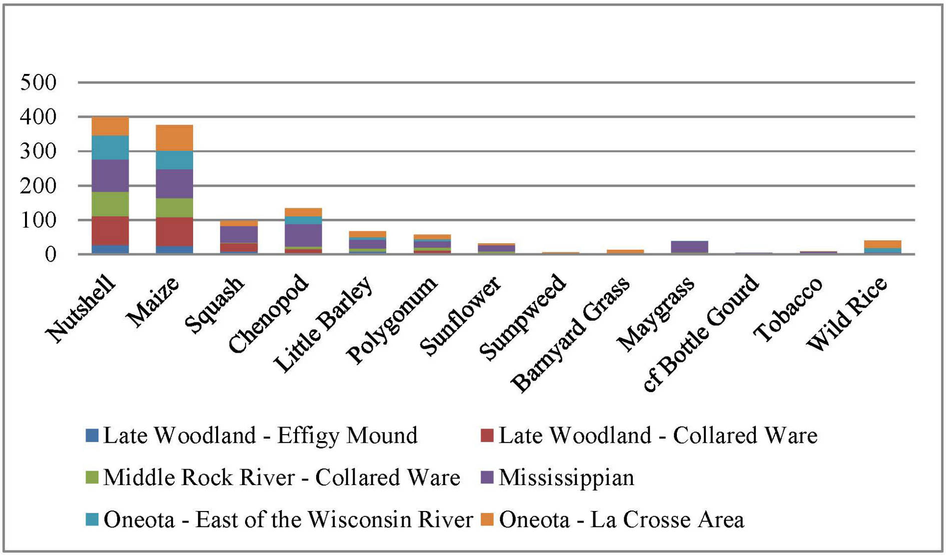

FIGURE 4 Ubiquity of flora.

These decreases in the exploitation of crop plants—including maize and squash—and EAC taxa are offset by increases in the exploitation of other locally abundant wild resources. The percentage representation of (see Table 1; see Figure 2) and density of nuts (see Table 2; see Figure 3) is considerably higher than at Aztalan. Furthermore, there is a dramatic shift from the exploitation of hickory nuts to acorns. In fact, acorn was the predominant nut taxon at every Oneota site in eastern Wisconsin that was included in this analysis.

Another notable change is the dramatic increase in the percentage representation of *Zizania aquatic*a (wild rice); there is considerable variability in the relative importance of wild rice at these sites (see Table 1; see Figure 2). Not surprisingly, aquatic tuber (e.g., *Nelumbo lutea* [American lotus], *Typha* spp. [cattail], and *Sagittaria latifolia* [duck potato]) tends to occur in association with wild rice when it is present (Egan-Bruhy 2010c, 2011).

Finally, the comparison between Oneota sites east of the Wisconsin River (i.e., within the area that drains into the Lake Michigan basin), Oneota sites within the Mississippi River drainage system, and Aztalan and Fred Edwards as examples of a Middle Mississippian site provides further insight into the cultural relationships among these populations. Because of differences in analytical approach, this comparison is based solely on ubiquity. Maize is ubiquitous among all three; although among the Middle Mississippian and Mississippi trench Oneota, maize occurs in more than 20 percent of contexts as compared to sites in eastern Wisconsin (see Table 3). Another difference is that sumpweed and sunflower occur exclusively among the Middle Mississippian and Mississippi trench sites, and knotweed and little barley are also more prevalent at these sites than in the Oneota sites to the east. Finally, chenopod is far less ubiquitous at the Oneota sites, and as noted above, barnyard grass only occurs at the Oneota sites (see Table 3).

Summary and conclusions

The trends observed appear to reflect characteristics of a number of the models summarized at the beginning of this article. First, it appears that the Late Woodland Collared-ware populations in Wisconsin and the Middle Rock River valley, bear a stronger (plant subsistence/foodways) similarity to populations at Late Woodland sites to the east, including 20SA1034 as well as sites farther east in Pennsylvania (e.g., King 1999). Therefore, I agree with Simon (1998), whose conclusion following the analysis of the Middle Rock River collections was that the subsistence regime of the Collared-ware Late Woodland was

> consistent participation in a mixed economy that included limited levels of cultivation combined with wild plant gathering. The relative importance of various crop plants is difficult to assess, but it appears that maize use increases in importance, possibly at the expense of the native cultigens. If so, it would be tempting to tie this increased dependence with the development and introduction of hardier, Northern Flint varieties from the east. Preliminary data from more easterly sites suggest that just such a scenario is plausible, however, in the absence of hard data, this remains speculative [Simon 1998:299].

However, I would suggest that the subsistence pattern is not so much at the expense of native cultigens. Rather, it appears to be a by-product of the subsistence regime from which it comes—that is, an eastern Algonquin subsistence regime with limited dependence on these native cultigens, at least as compared to populations to the south. Importantly, 20SA1034 (Parker 1996) and a number of sites to the east in Pennsylvania (King 1999) include similarly low densities of EAC taxa comparable to that noted in the Collared-ware Late Woodland sites in southeastern Wisconsin and the Middle Rock River valley. Notably, in all of these contexts, some of the taxa represented, such as chenopod and knotweed, are not of the domesticated variety, as is the case with the same taxa from the Collared-ware Late Woodland sites. Further, Simon (1998) identified the maize from the Eastern Middle Rock River sites as 10-rowed or less, which suggests a greater similarity to eastern 8-row maize, which is common farther east at this time than the 10- or more-rowed maize found to the south.

Another distinction between the Collared-ware and southern-based subsistence regime is highlighted in the comparison of the Collared-ware and Terminal Late Woodland I and II sites in the American Bottom, which contain significantly higher densities of EAC taxa, all of which are domesticated varieties (Simon and Parker 2006:Table 10). They occur in significantly higher density and ubiquity than noted among the northern Late Woodland sites. Finally, with regard to maize, while the average density in Terminal Late Woodland I and II sties in the American Bottom is extremely variable (Simon and Parker 2006:Table 10), the presence of high densities among many sites in and of itself suggests a difference from the Collared-ware Late Woodland sites to the north.

Among the Middle Mississippian sites, we also see a greater density of the EAC native cultigens, as well as a higher ubiquity of these taxa. Chenopod occurs in particularly high frequencies, and Simon and Parker (2006) note that it continued to be predominant from the Woodland into the Mississippian phases. Further, in comparison to the Collared-ware Late Woodland sites, the density of maize is significantly higher at Aztalan, as well as at other northern frontier Middle Mississippian sites.

The comparison between Middle Mississippian and Oneota subsistence patterns is particularly enlightening when assessing the potential influence of the Middle Mississippian populations on the evolution of the Oneota. The Oneota assemblages from the area east of the Wisconsin River, within the region that drains into the Lake Michigan basin, are significantly different in overall composition than are the northern frontier Middle Mississippian assemblages, as well as those in the American Bottom. Among the latter, maize is less significant, there is a decrease in the ubiquity of squash, and a decrease in the exploitation of EAC taxa, as well as differences in the taxa exploited. Further, as compared with the Middle Mississippian sites, there is a significant increase in the exploitation of nuts, specifically acorns, and barnyard grass, which first appears with the Collared-ware Late Woodland in this area. Further, there is a dramatic increase in the exploitation of wild rice. Therefore, in a number of respects, the Oneota subsistence strategy in the Wisconsin River drainage differs from the Middle Mississippian. These data argue against the diffusion and degeneration model, which suggests that Middle Mississippians moved northward from the American Bottom influencing local Woodland populations and, as a result, gave rise to the Oneota. It also runs counter to the migration model (Overstreet 1995), which argues that the Oneota and Middle Mississippian cultures had a shared ancestry and that Oneota populations migrated from the south northward into eastern Wisconsin around A.D. 950 (Overstreet 1995:59). There are too many differences in the taxa that were exploited and the relative significance of major categories of resources, including maize, native cultigens, nuts, and wild rice.

Interestingly, however, acorns have been documented throughout northern Wisconsin and the Upper Peninsula of Michigan as a significant resource from as early as the Archaic (Bruhy et al. 1998) and well into the Oneota (Dunham 2009), and Parker (1996) also identified them as a predominant nut resource at 20SA1034. Thus, acorns may have served as important supplements to the Oneota diet, comparable to the EAC starchy- and oily-seed annuals, and have had their roots in the northern reaches of Oneota populations, suggesting potential interactions with populations in this region, as Overstreet (1995) posited.

Overall, the data from sites within the Lake Michigan drainage basin are most parsimonious with the transformation or in situ development model, which posits that Oneota culture emerged through transformation of resident Late Woodland populations that were influenced by Middle Mississippians but not direct descendants of them. The current data do not specifically support a transformation from the Effigy Mound to the Oneota (Gibbon 1982:86), as they disregard the role of the horticultural adaptation of the Late Woodland Collared-ware manufacturers in this region. Importantly, however, in the Mississippi trench, Collared-wares occur in very low frequencies. Therefore, the Late Woodland populations in this region and subsequent Mississippi valley Oneota bear a stronger resemblance to the Middle Mississippian populations, particularly with regard to their use of EAC cultigens. This observation highlights the point made by Gibbon (1982) and others that Oneota manifestations are not being considered in a manner sufficiently diverse;

that is, the ascription of *Oneota* as an ethnically and linguistically cohesive cultural unit may be an obstacle to achieving a cogent theory of Oneota origins.

The variability evidenced between the Oneota in eastern Wisconsin and those within the Mississippi valley drainage clearly highlights this point; the Mississippi drainage Oneota appear to rely more heavily on maize and native cultigens, such as sunflower, sumpweed, knotweed, and little barley, as well as wild rice.

Thus, these data highlight not only ethnic connections between the Collared-ware Late Woodland within the Lake Michigan drainage basin and perhaps populations to the east but also continuity between the Collared-ware Late Woodland populations and eastern Oneota with some potential influences from the north. It further, supports Theler and Boszhardt's (2000) argument for connections between the Oneota in the Mississippi valley region and the Middle Mississippians and, in turn, the differences in the overall subsistence adaptation and presumably cultural ancestry of these late prehistoric populations.

Acknowledgements

I am grateful to Bill Lovis and Maria Raviele for organizing this symposium and inviting me to participate. It has been a pleasure working with the symposium participants and reviewers David Benn and Mary Simon. This study, itself, would not have been possible without the research opportunities, support, and funding from the Wisconsin Department of Transportation via the Museum Archaeology Program, Wisconsin Historical Society; the Historic Research Management Services at the University of Wisconsin-Milwaukee; the National Science Foundation grant (BCS 0004394) secured by Lynne Goldstein of Michigan State University; Bob Jeske and the University of Wisconsin-Milwaukee Crescent Bay Hunt Club support; the laboratory assistance of Jeanne Nelson from Commonwealth Cultural Resources Group, Inc.; and data from colleagues Connie Arzigian, Katie Parker, and Mary Simon. Thank you to Elissa Hulit from Commonwealth Cultural Resources Group, Inc., who provided assistance with graphics. Finally, I am thankful for the love and support of my "outstanding" husband, Mark Bruhy.

Notes on Contributor

Kathryn Egan-Bruhy is an historic preservation specialist working for Commonwealth Cultural Resources Group as Regional Vice-President in their Wisconsin Office.

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Note

1 This value may in part appear deflated relative to the Illinois and Wisconsin sites due to the fact that all 90,000 liters of flot from features was analyzed while at the other sites samples were selected for processing and analysis, perhaps because they were considered to have potential to yield remains.

MIDWEST ARCHAEOLOGICAL CONFERENCE INC. OCCASIONAL PAPERS No. 1, 2014, 73–96

Crop Selection: Perspectives from the Lower Missouri River Basin

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The lower 200 km of the Missouri River basin provides an interesting case for examining crop selection strategies and cropping systems. Between cal A.D. 650 and 1200, so-called Late Woodland and Mississippian populations occupied the Missouri River floodplain and tributary valleys. Multiple lines of evidence, including crop selection, show considerable interaction between central and eastern Missouri populations, and boundaries between these areas are more tenuous and permeable than had once been interpreted. In this study, we assess intersite variability in the presence of starchy seeds and maize for eleven sites. We explore ecological and cultural variables affecting the decision to adopt maize cultivation at some sites and to continue to rely on members of the starchy-seed complex at others.

KEYWORDS paleoethnobotany; maize; Midwest; prehistoric period

Decisions about what crops to plant, how large a field to prepare, how to process the crops, and what to do with surpluses can depend on ecological factors such as climate, landform, soil type, and rainfall, as well as cultural factors like values, traditions, and degree of technological complexity. We use archaeobotanical data from 11 sites excavated within the lower 200 km of the Missouri River basin to assess some of these dynamic, decision-making processes. The archaeobotanical assemblages range between cal A.D. 650 and 1200. Various ecological and cultural aspects of the decision-making processes leading to the continued reliance on members of the starchy-seed complex—chenopod, erect knotweed, little barley, and maygrass—and the addition of maize to an existing repertoire of crops are explored. We consider the frameworks of the niche breadth model (Kennett and

Winterhalder 2006; Piperno 2006; Winterhalder and Goland 1997), the more recent niche construction model (Smith 2007, 2011), and the shifting balance theory (Wright 1932, 1978) as applied to maize evolution in eastern North America (e.g., Hart 1999; Hart and Lovis 2013) in considering the factors that led to the adoption of maize cultivation at some sites but not at others.

Physiographic setting

The data presented herein come from archaeological excavations along the lower 200 km of the Missouri River basin (Figure 1). This stretch of the Missouri River defines the southern limit of continental glaciations and separates the unglaciated Ozark Plateau to the south and the Dissected Till Plains to the north (Galat et al. 2005; U.S. Fish and Wildlife Service 1999). The elevations along this stretch of the river range from about 130 to 530 m asl. The Ozark Plateau is comprised of karst topography with a well-developed drainage system consisting of steep valleys and narrow floodplains. Hill-slope soils are thin and thoroughly leached, while gravelly alluvial soils are found in the secondary stream valleys. The drainage systems on the glaciated side are smaller, having developed since the melting of the Wisconsin ice. This region tends to be characterized by thick loess deposits overlaying limestone bedrock with clay, sand, gravel, and boulders deposited by glacial actions and dissected by glacial runoff.

The Missouri River floodplain varies in width from about 3 to 16 km, with the widest locations nearer its outfall into the Mississippi River (Galat et al. 2005). Historically, the river was braided and shifted frequently, creating sandbars, islands, and unstable banks. The turbidity was high and sediment load and transport was enormous. Over-bank flooding would have been common.

Over 2,500 species of plants and bushes have been documented, making this region one of the richest floral zones in North America (Galat et al. 2005; Ricketts et al. 1999; Wright 1984). Land cover classes include wet and dry prairie/forbs fields, early successional forests, and mature forests. Willow, cottonwood, American elm, sycamore, green ash, and silver maple typify riparian areas. Mixed hardwoods, including a great number of oaks and hickories as well as ash, black walnut, hackberry, redbud, and wild black cherry, characterize talus slopes and secondary stream valleys, with oak and hickories dominating bluff-top forests.

Today, as was most likely the case in the distant past, the climate is mesic. The annual precipitation averages over 100 cm (Galat et al. 2005). Mean monthly temperature ranges from a low of –6°C in January to high of about 32°C in July. The growing season consists of about 180 days.

The Missouri River basin would have supplied late prehistoric Native American communities with an abundant supply of water, game, and wood, as well as other economically useful wild plants. The river additionally provided a means of transportation and an avenue for communication. Its outfall in the Mississippi River (see Figure 1) is only a short distance from the outfall of the Illinois River and from the American Bottom of Illinois; such proximity afforded opportunities for communication with peoples living in these nearby areas.

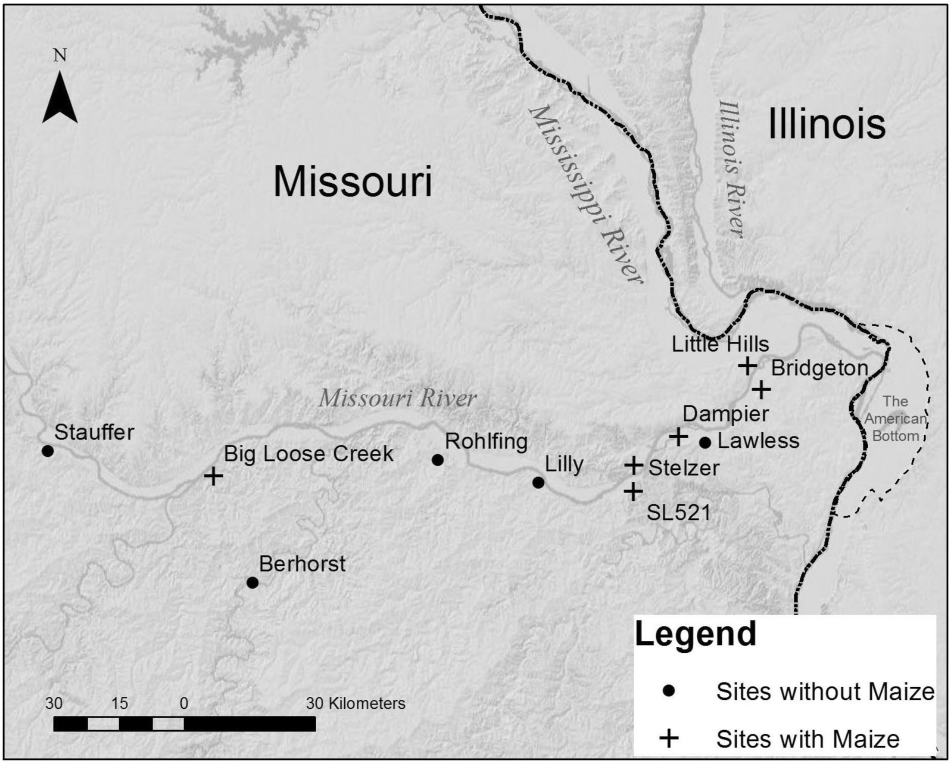

FIGURE 1 Study area.

Crops

While a number of crops have been identified for the region during late prehistoric times, we concentrate on starchy grains including maize and members of the starchy-seed complex. The latter include chenopod (*Chenopodium berlandieri*), maygrass (*Phalaris caroliniana*), erect knotweed (*Polygonum erectum*), and little barley (*Hordeum pussillum*). All are well represented at sites discussed herein and have been recovered in quantities that indicate they were cultivated dietary staples. The relative proportional representation of the individual members tends to vary by site, time, slope, and soil type. Some of the observed variance may be explained by seasonal differences in site occupations. For example, little barley and maygrass are late spring/early summer crops, whereas chenopod and erect knotweed would have been harvested in late summer/early fall. Yet, all could be stored for future use. Factors such as carbonization or recovery are unlikely sources of intersite variation as members of the starchy-seed complex share similar carbonization trajectories (Wright 2003a) and their recovery rates by flotation are relatively similar (Wright 2005). Alternative explanations for the variations may include differences in food preference, in taste, and in tradition (Egan-Bruhy, this volume).

For this research, we are especially interested in the selection and distribution of maize. Its domestication in Mexico, its diffusion across the Americas, and its rise to a major dietary component has been the topic of many discussions that range in depth from published articles (e.g., Barlow 2002; Crawford et al 1997; Diehl 2005; Fritz 2011; Hart and Lovis 2013; Lopinot 1992) to entire volumes (e.g., Smith et al. 2004; Staller et al. 2009). As a case in point, in this volume, Mary Simon reviews the evidence for early maize (i.e., before cal A.D. 900) for nearby west-central Illinois.

Time frame

The sites included in this research span the time frame of cal A.D. 650–1200. Look at any text or site report describing the late prehistoric archaeology of the lower Missouri River basin for this time range and you will see chronological/taxonomic terms like *Late Woodland period*, *Emergent Mississippian period*, *Mississippian period*, *Boone phase*, *Ralls phase*, *Meramec phase*, *Stauffer phase*, *Patrick phase*, *Dohack phase*, and *Lohmann phase,* among others. Periods and phases are cultural-historical units used to organize archaeological assemblages and are based on *fossiles directeur*—such as pottery and/or projectile point types—as the underlying criteria. The terms have a long history of use in the state; some can be traced back to at least W. C. McKern's use of Linnaean taxonomy as the model for development of an archaeological classification system (McKern 1939). The terms are loaded with historical meaning and imply cultural similarity, contemporaneity, and geographic range (see O'Brien and Lyman 2002). While one can argue that they remain beneficial in categorizing data for discussion, late prehistoric periods and phases are frequently based on pottery types, and these types can overlap in space and vary in time. Discussion of the types and relationships are still being argued today, including in the cultural resource management (CRM) reports from which the archaeobotanical data for this study are derived. Ultimately, periods and phases imply temporal and geographic ranges and associated artifacts and certain historical, political, economic, and ecological characteristics particular to them. They do not allow for relations and interactions with members of other communities and the flow of ideas and technological innovations between the areas that are crucial to this study. For that reason, we choose not to use period and phase names, but rather to rely on ^{14}C dates associated with the plant assemblages.

The archaeological sites, plant remains, and other data

Data obtained from the site files housed at the State Historic Preservation Office of the Missouri Department of Natural Resources indicate that 61 late prehistoric sites (ca. A.D. 300–1400) have been recorded as of March 1, 2013, for the western limits of our study area (viz., Cole and Osage counties) while 167 Late Woodland and 72 Mississippian sites have been recorded as of March 1, 2013, for the eastern limits of this study (viz., St. Charles and St. Louis counties). Undoubtedly, these figures are biased toward the greater St. Louis region where a larger number of archaeological projects have been conducted. The higher population densities of these areas also mean a greater number of individuals are likely to find and report sites. Nevertheless, there is a sense among archaeologists working in the region that upstream sites trend toward being smaller and spatially more dispersed.

Unfortunately, formal excavations in which flotation samples were systematically collected and analyzed are few. Starting downstream and moving west or upstream (see Figure 1), we compared data from the Little Hills, Bridgeton, Lawless, Dampier, Stelzer, Lily, Rohlfing, 23FR521, Berhorst, Big Loose Creek, and Stauffer sites. The descriptions provide information about the date of the sites, their physiographic locations, the kinds of features found during excavation, with special notes being made about the presence of large cylindrical or bell-shaped pits that may reflect crop storage and implements that reflect specific types of cropping systems.

Little Hills (23SC572), cal A.D. 650–900

Little Hills is located in eastern St. Charles County, Missouri (Lopinot 1990). It is situated on the bluff edge overlooking the Missouri River floodplain only a few kilometers from where it merges with the Mississippi River. Little Hills is a multicomponent site; the most recent occupation, cal A.D. 650–900, is the subject of this research.

Dating to cal A.D. 650–900, two feature clusters were identified in the excavated area (Lopinot 1990). Cluster 1 reflects the remains of a farmstead. A rectilinear structure basin and nine pit features, three large bell-shaped storage pits were identified. Cluster 2, dominated by large bell-shaped storage pits, possibly represents a year-round occupation with a slight temporal difference from Cluster 1. The ceramic assemblage is very similar in style to that found in coeval sites elsewhere in east-central Missouri and in the American Bottom of Illinois. Eight polished flakes found in seven different pit features and a recovered of a hoe fragment reflect the agricultural technology of the occupants.

Cultivated members of the starchy-seed complex, including chenopod, erect knotweed, little barley, and maygrass, were well represented (Table 1). A single, highly eroded maize cupule was tentatively identified (Lopinot 1990:213). Soils in the area of Little Hills are dominated by Menfro silt loam, which is well drained and easily tilled but of moderate fertility. It is also subject to moderate to severe erosion. By modern standards, Menfro silt loam is considered most suitable for growing wheat, which led Lopinot (1990:213) to suggest that this loam may be more conducive to growing maygrass or the other native crops than the tropical cultigens, maize.

Bridgeton (23SL442), cal A.D. 650–900, 900–1050, and 1050–1200

The Bridgeton site is located in western St. Louis County, Missouri, on a second terrace of the Missouri River. Like Little Hills, local soils are dominated by Menfro silt loam.

During the 1980s, several University of Missouri–St. Louis (UMSL) field schools (Harl 1991; Wright 1984) and a cultural resource management study (Galloy and Vollman 1998) were conducted. The site is multicomponent, with a small probable farmstead for the occupation dating cal A.D. 650–900 and relatively larger villages for the time frames cal A.D. 900–1050 and cal A.D. 1050–1200.

TABLE 1

ARCHAEOBOTANICAL SUMMARY

			Chenopod		Erect Knotweed		Little Barley		Maygrass		Sunflower		Sumpweed		Maize Kernels and Cob Frags		Nutshell	
Site	Date cal A.D.	Float (liters)	Ct.	U.I.	Ct.	U.I.	Ct.	U.I.	Ct.	U.I.	Ct.	U.I.	Ct.	U.I.	Ct.	U.I.	Ct.	U.I.
Stauffer[1]	650–880	317	65	27	124	24	32	27	768	52	4	6	0	0	0	0	371	83
Big Loose Creek[2]	900–1000	515	1,725	79	745	65	94	50	5,279	50	2	4	1	2	5	10	1,786	96
Berhorst[3]	770–980	50	55	83	18	83	3	83	239	100	0	0	3	16	0	0	293	100
23FR521[4]	686–1285	335	1,037	62	306	26	19	7	2,054	29	2	5	5	5	4	3	166	100
Rohlfing[5]	680–960	191	396	35	39/2,672*	20	0	0	156	65	0	0	0	0	0	0	484	70
Lilly[6]	782–987	169	1,984	95	1,558	70	20	50	4,056	50	4	10	9	20	0	0	676	100
Stelzer[7]	1050–1100	239	1	3	2	7	0	0	15	23	8/5,935*	23	0	0	89	77	49	75
Dampier[8]	1100–1200	530	336	41	72	21	7	4	1,936	45	8	11	8	5	7,104	70	2,240	64
Lawless[9]	900–950	454	44	21	241	33	2	5	2,573	26	0	0	1	5	0	0	na	73
Bridgeton[10]	650–900	170	160	67	86	77	74	83	169	92	2	7	0	0	22	43	1,379	100
Bridgeton[10,11]	900–1000	272	150	100	44	82	5	73	205	100	0	0	3	9	212	100	931	100
Bridgeton[10,11]	1050–1100	90	16	56	17	56	2	22	25	89	3	33	1	11	300	100	600	100
Little Hills[12]	650–900	247	164	86	162	62	24	30	374	84	3	5	0	0	1	5	221	97

*Reflects a single mass of seeds.
na = count not available
1. Wright 2003b, 2. Lopinot and Powell 2010, 3. Daniels 2011, 4. Schroeder 2013, 5. Erickson 2006, 6. Parker 2012, 7. Wright 1994, 8. Schroeder 2011, 9. Schroeder 1999, 10. Wright 1984, 11. Parker 1998, and 12. Lopinot 1990.

Features associated with the cal A.D. 650–900 occupation consist of hearths and pits. Galloy and Vollman (1998:3:14), considering pit location and volume from their excavations as well as from the previous UMSL field schools, note the existence of two pit clusters. Differences in the pit sizes and morphologies of the two clusters are interpreted by Galloy and Vollman (1998:3:21) as possibly reflecting specialized activity areas within the settlement or even temporal planning associated with increased needs for bulk storage as horticulture intensified. Ample evidence for the cultivation of the starchy-seed complex is noted (see Table 1). In addition, several fragments ($n = 22$) of maize kernels and cob fragments have been recovered.

For the later (cal A.D. 900–1050) occupation, perhaps as many as eight structures and 43 pits have been identified and excavated (Galloy and Vollman 1998; Harl 1991). Galloy and Vollman note a dramatic 112.2 percent increase in the volume of these pits as compared to those of the earlier occupation. This increase may be associated with a greater need to cache large amounts of foodstuffs that came with more intensive cultivation of maize and members of the starchy-seed complex. Also recovered were a complete hoe, made from Mill Creek chert, and nine polished flakes, three of which are also derived from Mill Creek chert, while the other six are from Burlington derived chert. In the American Bottom, hoes and hoe flakes of Mill Creek chert, a raw material that is imported from southern Illinois, are almost synonymous with maize agriculture. Along with the presence of the hoes is a dramatic increase in the frequency and ubiquity of maize (see Table 1). These data, coupled with the greater numbers for members of the starchy-seed complex, suggest an increase in the intensity of cultivation and a reliance on these crops as dietary staples.

Relatively few features are associated with the cal A.D. 1050–1200 occupation. These include five wall-trench houses and 31 pits. The storage capacity of the pits was roughly 80 percent less than the earlier occupation, leading Galloy and Vollman (1998:3:39) to suggest "a reversal of the trend towards underground storage of large amounts of foodstuffs associated with the adoption of maize agriculture." Interestingly, Parker (1998:8:43) notes a marked decline in the relative density of maize between the earlier and later occupations; through time, maize drops from 329.8 to 33.3 fragments per 10 L. No stone hoes but seven polished flakes, three of Mill Creek and the others of Burlington chert, were recovered. The fewer features, relative decline in maize, and less evidence of Mill Creek hoes may reflect a smaller and, perhaps, shorter occupation, a difference in site use, or a sampling bias for the period cal A.D. 1050–1200.

Lawless (23SL319), cal A.D. 900–950 (A.D. 620–1140)

The Lawless site is located in western St. Louis County (Harl 1999). Situated in a secondary stream valley about a kilometer from the Missouri River bluff edge, it occupies a high terrace above Caulks Creek. The creek is deeply entrenched with a narrow floodplain of only 100–150 m in extent. Here too, Menfro silt loam dominates the local soils.

Six calibrated ^{14}C dates range at 2 from cal A.D. 620 to 1140 (Harl 1999:41). However, Harl (1999:41) notes that the flakes and the point and pottery styles (e.g., jars cordmarked to rounded shoulders and plain rims with angled or extruded lips and an occasional lug, jars with angled lips and loop handles, and the frequency of red slipping) are more consistent with findings in the nearby American Bottom of Illinois that date between cal A.D. 900 and 1050. All things considered, Harl (1999) suggests a transitional occupation, and the date of roughly cal A.D. 900–950 is used herein for purposes of analysis and discussion.

At Lawless, a possible structure, perhaps cremation pits, and 51 pit features were discovered, including three large storage pits with volumes ranging from 136 to 179 m^3 (Harl 1999). A small fragment of a biface exhibiting high polish was classified as a digging tool, but no polished flakes were mentioned in the report. Interestingly, 17 fragments of chert typical of southern Illinois deposits were identified, indicating access to southern Illinois resources, but Mill Creek chert, which is associated with hoe manufacture, was not found. No maize remains were recovered, but a large quantity of maygrass with smaller numbers of chenopod, erect knotweed, and little barley were retrieved (see Table 1).

Dampier (23SL2296), cal A.D. 1100–1200

Dampier is a major market and civic-ceremonial center located in far eastern St. Louis County in the Missouri River bottoms (Harl et al. 2011). It was occupied during cal A.D. 1100–1200 or during the climax of occupation at Cahokia Mounds, and as Harl and colleagues (2011:1) note, "The Dampier Site is unique in that it represents the first major Mississippian center excavated in east-central Missouri in modern times. A number of these centers have been identified, but many were destroyed by development without detailed excavations, and their artifacts have been lost." Two-hundred and twenty-eight features were identified within the right-of-way excavation. These include at least 13 structures with interior and exterior associated pits, an additional 53 wall trenches, earth ovens, post molds, work areas, hearths, aboveground storage structures, earth ovens, and other deep and shallow pit features. Compared to the other sites under study, a wealth of agricultural tools and plant food-processing implements were recovered. These include one complete stone hoe with noticeable polish at its distal end, 2 stone hoe fragments, 157 polished flakes, 15 mussel-shell hoes, 42 metates and manos, and 14 nutting stones. This wealthy assemblage reflects the increase in intensity of growing and processing of plant foods associated with a more densely occupied site.

The relatively broad floodplain surrounding the Dampier site afforded fertile soils belonging to the Black-Eudora-Waldron association (Benham 1982) and ample space for planting maize as well as members of the starchy-seed complex and oily-seed domesticates, like sunflower and marsh elder. Indeed, of all the sites discussed herein, the greatest amount of maize is found at Dampier (see Table 1). Members of the starchy-seed complex and nuts continue to be dietary staples, but they are relatively less well represented compared to maize at Dampier, affording a maize:starchy seed ratio of 3.02:1 and a maize:nutshell ratio of 3.17:1. While the floodplain might support more intensive planting of maize, we know from the historic period that prior to the construction of artificial levees, floodwaters occasionally destroyed crops planted in this area. Additionally, geomorphological research indicates that the site began to be covered with alluvium shortly after its abandonment. Periodic inundation continued over the next 800 years, resulting in burial of the site beneath 1.2 to 1.5 m of alluvium. In addition, the southern end of the terrace and associated portions of the site have been cut away by episode(s) of extreme flooding.

Stelzer (23SC910), cal A.D. 1050–1100

Stelzer is situated within the Missouri River bottoms on a natural levee bordering an old meander scar. During the 1993 flood of the Missouri River, portions of the site—including human remains—were exposed. Excavations at Stelzer salvaged 27 pit features, one house basin, a human burial and a dog burial and have been interpreted as the remnants of a small farmstead comprised of one or two families (Harl and Wright 1994). No ^{14}C dates were obtained, but the similarity in pottery styles to that found in the American Bottom of Illinois and elsewhere in east-central Missouri led Harl and Wright (1994) to suggest a date of cal A.D. 1050–1100 for the occupation at Stelzer. One hoe flake was found but no hoe blades. Chenopod, erect knotweed, and maygrass occur but not in large quantities. Maize kernel and cob fragments were located with a relatively large maize:starchy seed ratio of 4.94:1. Stelzer is surrounded by Haynie soils, which tend to be richer than Menfro and in the present day are associated with good yields of maize (USDA 2013).

Lilly (23FR1553), cal A.D. 900–950

Lilly is situated on a bluff overlooking the confluence of St. Johns Creek with the Missouri River, in northern Franklin County, Missouri, and probably represents a small farmstead of several families (Harl et al. 2012). Excavations revealed 132 features, mostly pits of various sizes, including large storage pits and earth ovens. Harl and colleagues (2012:190–191) speculate that structural remains possibly exist outside the right-of-way.

Four ^{14}C dates were obtained. However, Harl and colleagues (2012:120–121) deemed two of the dates "erroneous." At 2, the dates for the other two samples range between cal A.D. 686 and 1157, but overlap between cal A.D. 782 and 987. Based on the dates and artifacts, Harl and colleagues (2012:121) suggest that Lilly dates around A.D. 900–950, as the styles of the features and their contents are similar to those observed for cal A.D. 900–950 in the American Bottom of Illinois and in St. Louis County, Missouri.

All members of the starchy-seed complex are well represented, especially maygrass and erect knotweed (see Table 1). No maize remains were recovered. Nine polished flakes, comprising only .1 percent of the flaking debris, were identified, but no stone hoes or digging implements were noted (Harl et al. 2012). Six nutting stones, eight metates, and a mano were recovered and attest to the processing of nuts and the grinding of nuts or starchy seeds into meal. Tools are consistent with the plant data and indicate small-scale farming of indigenous cultivars and continued use of wild resources like nuts. Local soils are dominated by the moderately productive Menfro silt loams (USDA 2013).

Rohlfing (23FR525), cal A.D. 680–960

Rohlfing, found in northern Franklin County, is located on a ridge spur above Big Berger Creek and some 2 km upstream from its confluence with the Missouri River

(Herndon 2006). Local soils are dominated by Haymond silt loam, with lower areas subject to frequent flooding (USDA 2013).

Two clusters of pits, possibly representing two farmsteads, were identified. In total, 12 pit features were excavated (Herndon 2006). These include basins, deep basins and bell-shaped pits. At the 2, dates on two features range from cal A.D. 680 to 960. A large mass (n = 2,672) of erect knotweed was discovered (see Table 1). In addition, remains of chenopod and maygrass were identified, but there was no mention of little barley or maize or stone implements associated with cultivation. Two possible metates, most likely associated with the grinding of starch grains or nuts into meal, were found.

23FR521, cal A.D. 686–1265

Site 23FR521, situated in Franklin County, occupies an elevated terrace remnant along Fiddle Creek, just upstream from emergence of the creek into the Missouri River valley (Ahler et al. 2013). Soils within the project area east of Fiddle Creek consist of Menfro silt loam and Menfro silt loam variants (Held 1989:25–26).

Forty-six pits, three house basins, and forty postholes were identified along with bell-shaped and deep cylindrical pits. Neither digging implements nor hoe flakes were discussed. Eleven ^{14}C dates were obtained (Ahler et al. 2013:85–92). Ahler and colleagues (2013:293) suggest that the "locality showed continuous, but episodic, use for a period of five or six centuries (cal A.D. 686–1265), without evidence of complete abandonment. Archaeobotanical remains associated with those two occupations are discussed herein. A few fragments of maize were identified, while members of the starchy-seed complex prevail among carbonized seeds (see Table 1).

Berhorst (23OS174), cal A.D. 770–980

Berhorst is located on a terrace near the Gasconade River approximately 44 km upstream from its confluence with the Missouri River (Daniels 2011). Soils at this location consist of the gravel-laden Reuter silt loam (USDA 2013).

At 2, a single ^{14}C date indicates an occupation between cal A.D. 770 and 980. Excavation at the Berhorst site reflects the salvage of a large storage pit. This pit is similar in morphology to storage pits described by Maxi'diwiac in Wilson's 1917 classic, *Agriculture of the Hidatsa Indians*. It contained a relatively large quantity of grass stem that may reflect the lining of the pit as described by Maxi'diwiac. Members of the starchy-seed complex were also recovered, but no maize was. Tools, possibly associated with digging or agricultural activities, were lacking.

Big Loose Creek (23OS1208), cal A.D. 900–1000

The Big Loose Creek site is located in northern Osage County, Missouri (Grantham 2010). It lies on the floodplain of a creek by the same name, about a mile from the Missouri River floodplain. Soils in the area include Menfro and Gatewood silt loams (USDA 2013).

Considering three calibrated ^{14}C dates (cal A.D. 790–1010, A.D. 870–1030, and A.D. 890–1040) and the ceramic assemblage, Grantham (2010:22) suggests an occupation that ranges from cal A.D. 900 to 1000. Grantham (2010:139) considers this site to be one of the largest within central Missouri to be found and excavated for that time frame. The site covers at least 8.1 ha but may extend to about 24.3 ha; the excavations were limited to the Missouri Department of Transportation (MoDOT) right-of-way.

Within that right-of-way, 99 features—including two house areas, two middens, and a concentration of pits—were excavated. Both earth ovens and deep storage pits were identified. Ten polished flakes were noted, but no hoes were found. One complete metate and six fragments were recovered. Archaeobotanical remains include relatively large numbers of members of the starchy-seed complex, especially maygrass and chenopod (see Table 1). A total of five kernel and cob fragments of maize were recovered. Cupule widths suggest that they derive from one or more high row-numbered cobs (Lopinot and Powell 2010:102).

Stauffer (23CO499), cal A.D. 625–973

Stauffer is located on a slope overlooking the floodplain of Meadows Creek. It is about a kilometer upstream from where Meadows Creek enters the floodplain of the Missouri River. Soils in the area include Wrengart silt loam and members of the Gatewood-Moko Complex, all of which tend to be "very stony" loams (Davis 2003:21; USDA 2013).

The Stauffer site is a small settlement. At least two structures, deep storage pits, earth ovens, hearths, and shallow basin pits were identified and excavated (Hoard et al. 2003). Seven burial mounds are located within 2 km of the site. At 2, the two radiocarbon dates from the site range from cal A.D. 625 to 973. One fragment of a limestone hoe was recovered, as were several manos, grinding slabs, and celt and pestle fragments. No maize is recorded, but members of the starchy-seed complex are well represented (see Table 1).

The impact of slope and soils

For decades, archaeologists have suggested a high correlation between the distribution of fertile soils and the settlement location of late prehistoric farmers in the region (e.g., Woods 1986). Because slope and soil types are interrelated and because they can influence tillage costs and crop productivity, we set out to model the potential relationship between slope, soil type, and solar radiation potential—as measured by slope and orientation—in the addition of maize to the assembly of starchy-seed annuals.

We used catchment areas one km in diameter to quantify the topography and distribution of soil types for each site. We then calculated the percentage of total land area within each site catchment that fell into six slope categories: 0–2 percent rise, 2–5 percent, 5–9 percent, 9–14 percent, 14–20 percent, and 20 percent and higher. We also calculated the percentage of total land area for each of 115 different soil types from the U.S. Department of Agriculture Soil Survey (2013). We limited our analyses to the 30 most common soil types for all the sites. In addition, we calculated the mean solar radiation for each catchment over the course of a year. We conducted all analyses in ArcMap 10.1 (ESRI).

For 7 of the 11 sites, the most common slope class within the catchment areas was 0–2 percent (Figure 2). This slope class was particularly common at Dampier and Stelzer, making up 58 percent to 90 percent of land area. The distribution of slopes throughout the site catchments was related to geographic location, with more eastern site catchments dominated by 0–2 percent slopes and the more western site catchments having a more varied distribution of slopes. Lilly and sites east of it had very little land with slopes greater than 9 percent, while sites west of Lilly had approximately a third of land with slopes greater than 9 percent.

The soil data revealed a similar geographic pattern. Site catchments east of Lilly had higher percentages of very rich soils characteristic of the Missouri floodplain, including Peers silty loam, low Missouri silt loam, and soils of the Haynie-Treloar-Blake Complex. Site catchments west of Lilly had higher percentages of much less productive soils, including eroded Menfro silt loam on slopes of more than 9 percent, and stony soils like Rueter, Gatewood, and Wrengart (Figure 3).

A comparison of the environmental characteristics of sites where maize was found and those where maize was absent shows a relationship between low slopes, poorly drained silty soils, and maize cultivation. The mean slope for sites with maize was 4.74 and the mean slope for sites without maize was 8.04. Maize sites had, on average, 50 percent of their land area in the 0–2 percent slope class while 20 percent of the land area for nonmaize sites was 0–2 percent slope. While mean slope ($t = -2.14$; $p = .06$) and percentage of land area in the 0–2 percent slope class

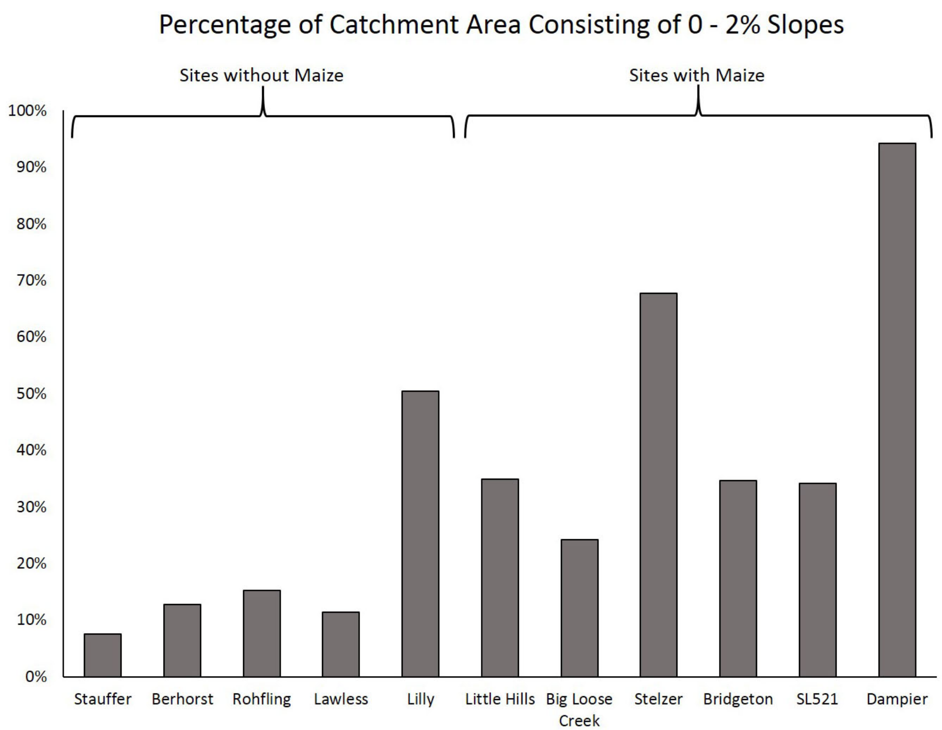

FIGURE 2 Percentage of catchment area consisting of 0–2% slopes.

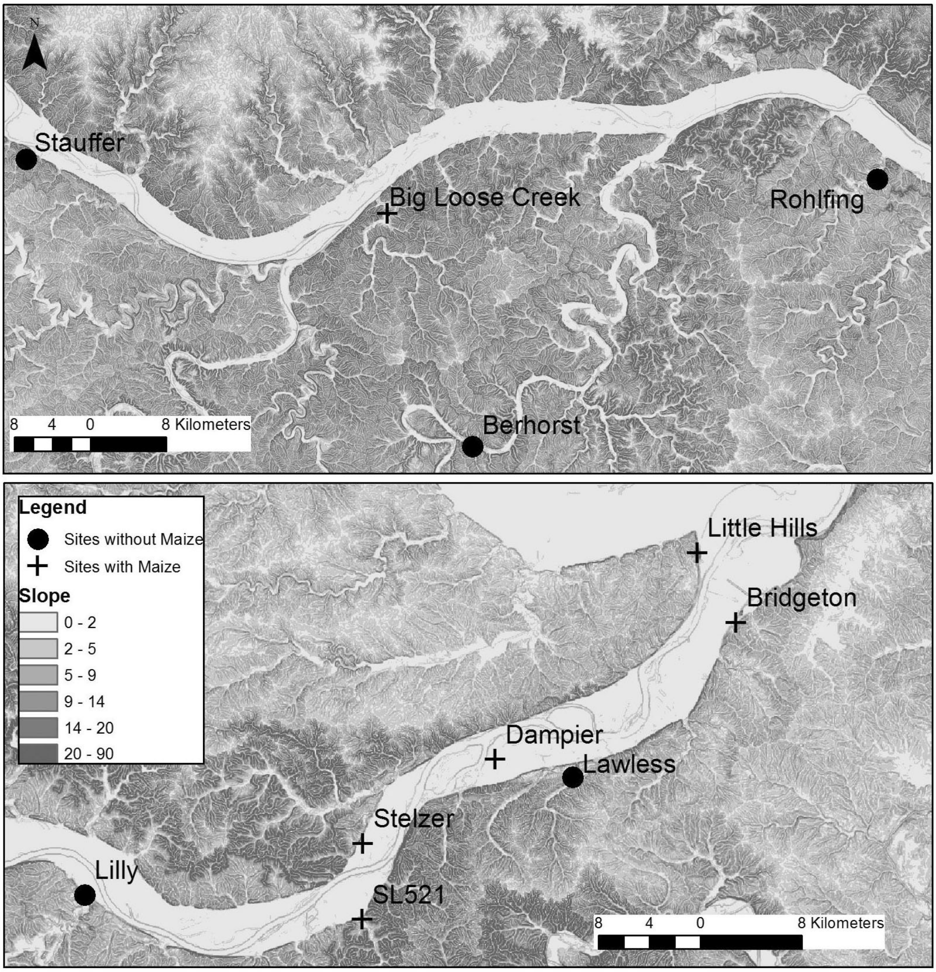

FIGURE 3 Slope map.

(t = 2.12; p = .06) were not significantly different between maize and nonmaize sites, these results approached significance at α = .05. Dampier, Stelzer, and Bridgeton, the sites with the highest frequencies of maize, had 70–96 percent of their land area with slopes of 0–5 percent, and approximately half their area was Peers silty loam and Haynie-Treloar-Blake soils. Despite its eastern location, the Lawless site, where no maize was found, showed relatively high slope values and a correspondingly high percentage of eroded soils. The exceptions to the positive relationship between low slopes and the presence of maize were Big Loose Creek, which had relatively higher slopes and some maize, and Lilly, which had relatively low slopes and no maize. However, the Lilly catchment consisted of a high percentage of eroded Menfro silt loam soils (approximately 35 percent of land area). Although slopes of 0–2 percent were made up only 20 percent of land area, they were the most common slope category in the Big Loose Creek catchment. Big Loose Creek contained the most diverse distribution of slope classes and soil types of all the sites. Solar radiation potential showed little variation across sites and mean solar radiation was not significantly different between maize-producing and nonmaize sites ($t = -1.42$; $p = .20$).

Ecological and cultural explanations for maize adoption

Many explanations exist for why farmers decide to adopt certain crops, ranging from strictly ecological to strictly cultural. The data presented above suggest local ecological conditions played an important role in whether or not maize cultivation was adopted. One commonly invoked model for the adoption of new subsistence strategies is the diet-breadth model, derived from optimal-foraging theory. Optimal-foraging theory predicts that individuals will employ behavioral strategies that maximize the rate of food energy gained per unit of energy spent in its procurement and consumption. Optimality models range from general heuristic frameworks to mathematical modeling of decision making. The diet-breadth model predicts that individuals and groups should expand their dietary breadth (in terms of different resources exploited) when preferred resources become more scarce. According to this model, as humans deplete their environments, the return rates (caloric intake per unit time spent foraging) of traditional resources decrease, and they are forced to expand their diets to include previously low-ranked resources (Kennett and Winterhalder 2006; Piperno 2006). In the context of maize adoption, the diet-breadth model predicts that greater investment in maize cultivation is expected with decreased return rates on other crops and should be associated with a broader, more diverse diet (Barlow 2002).

The diet-breadth model suggests one scenario by which maize would be adopted and become more prominent in the eastern sites. Maize would initially have been included as a relatively minor crop, with minimal field investment, in a mixed system of horticulture and wild resource collection (Barlow 2002). Maize cultivation may have initially been restricted to certain households, with considerable within-site variation in the intensity of cultivation. Within-site variability in maize cultivation has been reported for several Eastern Woodland sites and may have been related to status, household size, and suitability of particular household gardens for growing it (Rose 2008). As settlement sizes increased and return rates for traditional crops dropped, more individuals in the community would have found it advantageous to intensify maize cultivation as part of an expansion of diet breadth. As the community expanded, the gardens of some community members would have become smaller, necessitating more investment in other productive and/or reliable crops. As return rates on other crops or wild resources such as nuts dropped, the cultivation of maize would have become more uniform across the community. Changing circumstances due to habitat depletion would have made it advantageous to exploit the benefits of maize cultivation vis-à-vis traditional crops, like better storage life and higher yields (Rose 2008). In summary, the diet-breadth model predicts that decreased return rates on traditional crops from increased population density would cause people to turn to novel crops, intensifying maize cultivation and increasing their diet breadth. This explanation is consistent with the higher populations found at sites with maize and the fact that maize appears to have been one of a variety of other crops and wild nuts at most of the sites at which it was cultivated. It has long been postulated (e.g., Johanessen 1984; Wright 1984) that some decrease in nut exploitation does occur as maize cultivation intensifies. However, there is little evidence to indicate that traditional crops were being diminished at the sites where maize was found. In fact, at the Bridgeton site, an increase in maize cultivation appears to have been accompanied by a commensurate intensification in the cultivation of starchy seeds as well.

A different explanation for the adoption of alternative subsistence strategies is the niche construction model (Smith 2007). Niche construction describes the process by which an organism modifies its environment and that modified environment acts as a selective pressure for the organism (Laland et al. 1996, 2000). In his adaptation of the niche construction model to explain the advent of food production, Smith (2007, 2011) suggests that the adoption of agriculture was a result of human enhancement of agriculturally productive environments rather than of decreased return rates due to environmental depletion. This model emphasizes traditional ecological knowledge and the engineering of ecosystems through this knowledge. The niche construction model predicts that maize cultivation should be greatest in the most productive environments but need not be associated with decreasing returns for other crops. Using the framework of the niche construction model, the adoption of maize in the eastern sites may have started with low-investment experimentation in areas with highly productive soils. As individuals grew more maize and increased their crop diversity in these productive areas, they would have acquired traditional ecological knowledge about the new crop. This knowledge would in turn allow them to develop more efficient cultivation and processing methods, providing a positive feedback mechanism. Our results fit many of the predictions of the niche construction model. For example, the adoption of maize occurred in resource-rich environments, in settlements that reflect long-term occupation without population packing or overexploitation of resources, and there is evidence of a broad-spectrum resource base at sites where maize was present.

If one broadens the scope of this project to include the American Bottom of Illinois (see Figure 1), Smith's model becomes even more relevant, as evidence points to the flourishing of maize agriculture along with the intensified cropping of the starchy-seed complex in the rich bottomlands of the Mississippi River (Lopinot 1992). Evidence for intensification includes not only archaeobotanical remains but also increases in the manufacture of hoe blades, which includes importation of Mill Creek chert from southern Illinois, and increases in the number and kinds of storage facilities (e.g., Bareis and Porter 1984; Pauketat and Emerson 1997).

Hart (1999) and Hart and Lovis (2013) offer yet another approach to the discussion of maize selection and distribution, this one set in northeastern North America and based on Wright's (1932, 1978) shifting-balance theory. Here the ability of the plant, in this case maize, to adapt to new natural and cultural circumstances and how that adaption might appear in the archaeological record is considered. As Hart and Lovis (2013:183) describe for the Northeast, maize in the Midwest is just another grain added to an existing complex of indigenous cultivated annuals like maygrass (*Phalaris caroliniana*), chenopod (*Chenopodium berlandieri*), little barley (*Hordeum pusillum*), and the like. In "phase I," demes of a maize population would be introduced. In "phase II," one or more demes would ascend to higher fitness peaks as elements of the microdomesticate landscape improved. For example, the demes may respond to improved edaphic conditions or technological changes, and those changes may be seen at the site level as maize frequencies increase. As maize became more productive, its cost relative to other food sources diminished and the human population would have increased the amount of maize sown. During "phase III," the fitness of the entire meta population would have increased, and one might expect to see increases in the recovery of maize remains at the regional level. This process can be slow and from an archaeological perspective may result in what appears to be patchy distributions. This is especially true when predicating discussion of crop adoption on carbonized seed assemblages, which are subject to a host of biases (see Wright 2010). Acknowledgment of these biases has led Hart and Lovis (2013) among others to call for integrating multiple lines of evidence (e.g., macroremains, microremains, residue analysis, stable carbon isotopic analysis of human bone, and so on).

Ultimately, when discussing the adoption of maize or any crop, the issue becomes whether or not the interacting local human population was willing to expend time and energy on its production. Gremillion (1993), Lopinot (1986), Newsom and Trieu Gahr (2011) have tackled this issue by using ethnographic and historical evidence to model some of the biological and cultural aspects of the decision-making process. We use their suggestions about the acceptance or rejection of exotic crops by Native Americans during historic times to discuss further the prehistoric adoption of maize in the lower Missouri River basin:

1. Suitability to local climate and edaphic conditions. We have presented arguments describing potential relationships between maize and edaphic conditions and ground slope. Climate, including length of growing season and available moisture, would also play a factor in the initial introduction of a "tropical" crop like maize.
2. Prolific early successional or pioneer species that readily colonize, grow, and multiply with little or no human intervention. Members of the starchy-seed complex are pioneer species and would thrive in disturbed environments. Maize, however, may have required greater spacing, more weeding, and additional moisture and nutrients (Scarry and Yarnell 2011). Growing maize may have required the acquisition of new knowledge about growth-promoting techniques gained either through experimentation or interaction with other people more familiar with the crop.
3. Potential to blend with the established seasonal cycle of plant production. Like chenopod and erect knotweed, maize would have been planted in the spring and harvested in the fall.

At first glance, these criteria may be thought of as limiting factors. However, they too may be viewed as the most parsimonious paths to positive feedback. For example, if a new crop is chosen based on its ability to blend with an established seasonal cycle of plant production, the likelihood for a successful harvest may be increased.

Cropping systems in the lower Missouri River basin

The Missouri River is well known for its meander within the floodplain resulting in high sediment loads and transport, hence, its nickname "Big Muddy." While floodplain soils would have been frequently replenished by alluvial additions, flooding and the unpredictability of the Missouri River could have posed major problems. For example, ultimately, the large settlement at Dampier was abandoned and eventually covered with deep deposits of alluvium. (Comparatively, the Mississippi River is a much more entrenched, predictable system, and perhaps, its floodplain a much better location for prehistoric agricultural fields [Galat et al. 2005]).

Décrue agriculture, whereby seeds are sown following the recession of floodwaters, is a possibility. Perhaps best described by Harlan (1998), this method has been documented for numerous societies in Africa. Smith (2011) suggests it as a possibility for small-scale, preindustrial societies of the Americas. Although suitable for crops planted in late spring and harvested in late summer or fall, this system would not be practical for planting maygrass or little barley. Both of these crops need to be planted in early spring or late fall and harvested in May or early June; their growth cycles would have been destroyed by seasonal flooding. Rather than planting in the floodplain, Lopinot (1990:27–28) points out that the relatively less productive Menfro soils found along the higher terraces and bluffs of the Missouri River basin may have better supported indigenous crops, especially the annual grasses, like maygrass, as this soil type is noted for production of an analogous plant, wheat (Tummons 1982:Table 5).

Smith (2011), among many others, suggests a slash-and-burn (aka swidden) strategy. Scarry and Yarnell (2011; see also Monaghan et al., this volume) find this strategy probable given ethnohistoric descriptions. They suggest the slashing and burning to clear plots; tolerating useful volunteer plants in active plots; and shifting cultivation with a preference for clearing growth from old fields rather than creating new plots where useful nut and fruit trees and shrubs could be found. They go on to argue that if broadcasting small seeds is the preferred method then crops may have been planted in zones rather than intercropped. Ultimately, Scarry and Yarnell (2011) recount several lines of evidence to suggest that Native Americans may have used different practices for planting indigenous crops versus maize. For example, the small starchy seeds may have been more suited for broadcasting or sowing in rows, while maize could have been planted as individual seeds.

The location of the fields is hard to ascertain archaeologically. An argument could be made that, when found, the presence of harvest by-products such as cobs, cupules, and glumes suggest that maize farming and harvesting took place near the occupation area. Some ethnohistoric accounts confirm this. Adair (Williams 1974:435 [1775]), for example, states, "Every dwelling-house has a small field pretty close to it; and, as soon as the spring of the year permits, there they plant a variety of large and small beans, peas, and the smaller sort of Indian corn, which usually ripens in two months." Others (e.g., Swanton 1922; Varner and Varner 1951) describe small settlements with extensive fields of maize in alluvial settings, which is probably a better fit with the settlement-subsistence strategies of the American Bottom and Mississippi River valley occupants. Maize is a demanding crop and its yields would fluctuate and perhaps decrease over time as its growth depleted soil nutrients. Such circumstances could be ameliorated with perhaps the least amount of labor and the greatest amount of positive feedback by taking advantage of seasonal flooding, as is the case in some floodplain-situated, ridged field systems to the north.

In the Missouri River basin, farming technology based on broad-flat bladed stone hoes, especially those crafted from Mill Creek chert, is lacking. Methods of breaking the ground could have involved wooden digging sticks and hoes that have not survived. Historic records document the use of hafted antler rakes and hoes hafted with blades of bone or mussel shell (Woods 1986). Indeed at Dampier, 15 shell hoe blades were identified (Harl et al. 2011). Ultimately, most of the Missouri River occupants seem to have been using a strategy different from that of the "maize agriculturalists" at Cahokia and other sites in the nearby American Bottom of Illinois.

The above discussion of possible cropping systems is by no means exhaustive as the potential agricultural activities not only include preparing land and sowing crops but also weeding, fertilizing, watering, harvesting, transporting, storing, and processing for consumption. These activities would be determined and scheduled within a much larger complex of behaviors, including hunting, collecting wild plants, and manufacturing tools and vessels, among many other important social, economic, and political pursuits.

Conclusions

While all cultures are dynamic, cultural change can be slow and seemingly haphazard, as people can be very conservative when it comes to adopting new cultural elements, including new or altered technology and subsistence strategies (Cruz-Torres 2004; Lepowsky 1991). From an archaeological viewpoint, the road to the cultivation of the starchy seeds and their eventual inclusion as dietary staples took place over hundreds of years if not more. As Simon (this volume) describes, several researchers have discussed that the initial use of maize may have been limited to ritual use or beer production. If true, one may not expect to find many macrobotanical remains, as the formation of the archaeobotanical record in this region is dependent on the plant resources coming into contact with fire during processing or disposal. The idea is interesting to entertain, given that most maize remains found in the Missouri River basin sites are cupules. Perhaps the number of kernels was few, but they were used and discarded in ways that have obscured their archaeological visibility. Negative evidence is not always indicative of the absence of use. As Hart and Lovis (2013) point out, early macrobotanical evidence for maize use can be uneven across regions as the fitness of the demes was tested.

No doubt complex relationships exist between the crops people grow, their cultural beliefs and practices, and ecological variables such as soil and topography. Adoption of any crop is difficult to understand through solely ecological or cultural explanations. People do not exist in isolation or in a cultural vacuum. Contact with others can play an important role. Several archaeologists (e.g., Ahler et al. 2013; Grantham 2010; Harl 1991; Harl et al. 2011, 2012) who conducted the original cultural resource management investigations from which the archaeobotanical data we use here are drawn remark about similarities in pottery styles that cross previously conceived of phase boundaries. In recent years, the applicability of "frontiers," "boundaries," and "borders" has been reviewed (Trader 2011). Lightfoot and Martinez (1995:475) warn that archaeologically drawn cultural spheres should not be thought of as having inhibited intercultural relationships. These boundaries are, in fact, extremely porous, and interactions among people over large geographic areas were possible. These kinds of interactions likely spawned similarity in pottery styles, as well as fostered the diffusion of maize in the Missouri River basin. In such discussion about interaction, gender may be an important variable. If women were the carriers of knowledge about production and stylization of pottery and production and processing procedures of crops, they may have been the agents of change, and any similarities may be explained as being the by-products of intermarriage and matrilocal residence or the captivity of women (Cameron 2008; Hart 2001; Junker 2008; Wright 1983).

Ecological factors are also extremely important in determining subsistence strategies, as shown by the quantitative and qualitative data presented herein. The adoption of maize would have included an element of uncertainty until well understood and adapted in various ways, allowing it to eventually achieve a measure of importance among a number of groups. Our results indicate that the adoption and intensification of maize in late prehistoric Missouri was part of a broad-spectrum subsistence strategy. Its relative degree of cultivation at individual sites appears to have been highly dependent on local ecological conditions, especially access to areas with low slopes and fertile floodplain soils. In areas with highly productive soils, the cultivation of maize may have started as low-investment experimentation that gradually intensified through time, with increased traditional ecological knowledge and cultural importance providing a positive feedback loop.

Acknowledgments

We would like to thank Maria E. Raviele and William A. Lovis for the opportunity to participate in the MAC 2012 sponsored symposium and for their thoughtful insights on and editing of this article. We would also like to acknowledge the insightful comments offered by Jonathan Hart, Joseph Harl, and any anonymous reviewers. And of course, we take responsibility for any and all mistakes or omissions.

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MIDWEST ARCHAEOLOGICAL CONFERENCE INC. OCCASIONAL PAPERS No. 1, 2014, 97–134

Reevaluating the Introduction of Maize into the American Bottom and Western Illinois

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Archaeobotanical reports of maize from early Late Woodland contexts in western Illinois and the American Bottom have been interpreted to reflect its introduction before A.D. 600, followed by its gradual adoption into an existing horticultural economy. This interpretation is evaluated through accelerator mass spectrometry (AMS) direct dating of maize from Late Woodland contexts. In only two cases were Late Woodland affiliations confirmed. Most directly dated maize samples were determined to be more recent contamination. A review of the archaeobotanical records from both the American Bottom and western Illinois reflect an absence of maize from Late Woodland components unless later maize agriculturalists' occupations were present. Although confirming its rare presence at an early date, these results do not support a model positing the gradual increase in maize use over time. The available data support Hart's model, which proposes multiple introductions and failures of maize in the area until genetically viable, interbreeding population levels were achieved.

KEYWORDS maize, AMS (Accelerated Mass Spectrometry), Late Woodland, western Illinois, American Bottom

Maize (*Zea mays* L.) originated in southern Mexico some 10,000 years ago, with the initial manipulation of the wild grass teosinte (*Z. mays* ssp. *parviglumus*) (Blake 2006; Doebley 1990). Over the ensuing millennia, maize was intentionally carried into both North and South America, undergoing genetic change in response to selective pressures imposed both by changing environmental conditions and by human intervention in its life cycle. This process, still in evidence today, resulted in the development of a highly diverse suite of landraces, adapted to a wide array of growing conditions and expressing varied phenotypes. Nonetheless, all belong to a single domesticated species.

The histories of maize across North and South America vary regionally and temporally. In Mesoamerica, parts of South America, and even the North American Southwest, this important relationship between people and maize developed over thousands of years. In eastern North America, the relationship is of relatively short duration, and histories are defined on a scale of hundreds, rather than thousands, of years (Fritz 1990, 1995, 2011; Hart and Lovis 2013; Johannessen and Hastorf 1994; Staller, Tykott, and Benz 2006). The differences in sequences are important for understanding regional maize histories and the role of maize in social and economic systems across the Americas.

In the following article, I look at maize history for one small part of eastern North America: the section of western Illinois drained by the central Mississippi and lower Illinois Rivers and the American Bottom region immediately south (Figure 1). This extensively studied area has for some time been seen as having a relatively long and gradually increasing record of maize use, beginning about cal 100 B.C. (Table 1) and continuing uninterrupted through European contact. Here I review and reassess that record in light of recent AMS age estimates on maize from Late Woodland (ca. cal A.D. 400–900) contexts and the cumulative, extensive macrobotanical database. As a result of this study, I have found that the Late Woodland record for maize use in the region is more limited than originally thought. Further, although maize was present, the evidence does not support a model for a gradual increase in cultivation through the Late Woodland period.

Early maize in the midcontinent

Based on both AMS-dated maize macroremains and microremains, in the form of phytoliths and starch grains from pottery residue samples, maize is estimated to have been introduced into the Eastern Woodlands during the first several centuries B.C. from the southwestern United States, where it had been under cultivation since about cal 2100 B.C. (Merrill et al. 2009). The oldest directly dated maize macroremains are from the Middle Woodland period Holding site located in the American Bottom of Illinois (Riley et al. 1994) (Table 1). Slightly younger are the directly dated remains from the Icehouse Bottom site in eastern Tennessee and the Edwin Harness site in south-central Ohio (Chapman and Crites 1987; Crawford, Smith, and Bowyer 1997) (see Table 1). The oldest microremains are from sites located in the Northeast and the Great Lakes region. Maize phytoliths have been identified in residues from the Vinette 1 site in eastern New York State dating to about cal 300 B.C. (Hart, Brumbach, and Lusteck 2007:Table 6) and from the Place Royale and Hector-Trudel sites in southern Quebec, dating to between about cal 300 B.C. and A.D. 10 (St. Pierre and Thompson 2013). Raviele (2010) reports maize starch grains from residues on ceramics recovered from three Middle Woodland (cal 200 B.C.–A.D. 500) sites located in eastern Michigan: Liberty Bridge, 20SA1276, and Schulz (Raviele 2010:136, Table 5-20). These data confirm the presence of maize in the Eastern Woodlands by the Middle Woodland period, as early as cal 300 B.C. However, on a regional scale and in absolute numbers, early finds remain relatively few and scattered, reflecting limited use.

Directly dated early Late Woodland maize macro- and microremains are more common but, on the regional scale, still infrequent. In addition to those from Il-

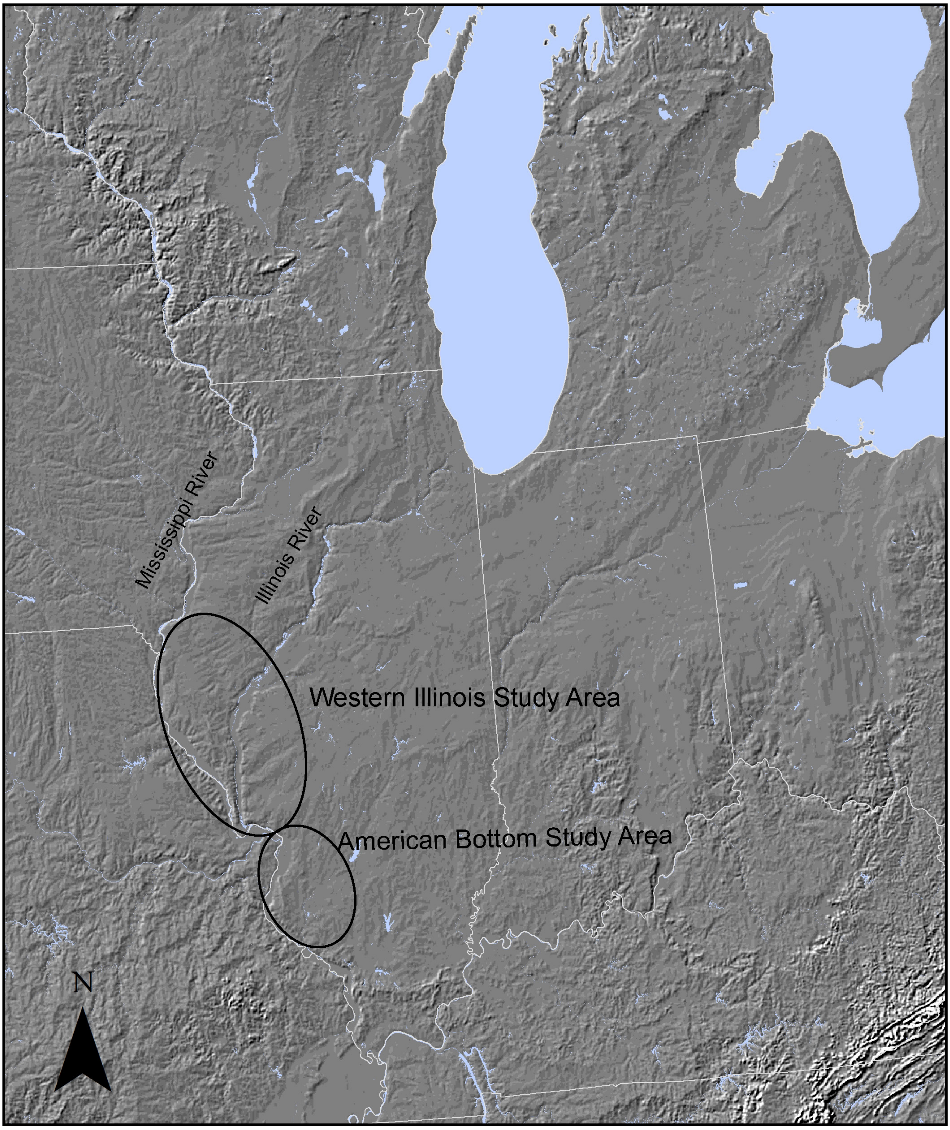

FIGURE 1 Study areas.

linois reported in this article (Table 2), early dates have been obtained on kernel and cupule fragments from the Grand Banks and Meyer sites in southern Ontario (Crawford and Smith 2003; Crawford et al. 1997). Farther east, maize from the Deposit Airport 1 site, on the Delaware River in eastern New York State, returned a 1σ calibrated date of A.D. 770 to A.D. 890 (Knapp 2009:104) (see Table 1).

In regard to early Late Woodland microremains, maize phytoliths were identified in residue samples predating circa A.D. 800 from eight sites located in the Finger Lakes region of New York (Hart, Brumbach, and Lusteck 2007:Table 6; Hart and Lovis 2013:Table 1; Thompson et al. 2004:Table 4). Although not directly dated, maize phytoliths were also identified in Laurel phase ceramic residues from the Pas Reserve

TABLE 1

RECORDS FOR EARLY MAIZE IN THE EASTERN UNITED STATES

Site	Location	Material Dated	Cultural Affiliation	Calibrated Date and Associated Probability (p)*	Radiocarbon Years B.P.	Analysis Number	Reference
AMS Dates on Maize							
Icehouse Bottom	Eastern Tennessee	kernel	Middle Woodland	One Sigma Ranges: [start:end] relative area [cal AD 132: cal AD 352] 0.949144 [cal AD 367: cal AD 380] 0.050856 Two Sigma Ranges: [start:end] relative area [cal AD 25: cal AD 441] 0.97313 [cal AD 484: cal AD 532] 0.02687	1775 ± 100	Beta-16576	Chapman and Crites 1987; Crawford, Smith, and Bowyer 1997:Table 1
Edwin Harness	South Central Ohio	kernel	Middle Woodland	One Sigma Ranges: [start:end] relative area [cal AD 140: cal AD 150] 0.026369 [cal AD 170: cal AD 194] 0.065026 [cal AD 210: cal AD 427] 0.908605 Two Sigma Ranges: [start:end] relative area [cal AD 78: cal AD 547] 1	1720 ± 105	Beta-19291	Crawford, Smith, and Bowyer 1997:Table 1
Edwin Harness	South Central Ohio	kernel	Middle Woodland	One Sigma Ranges: [start:end] relative area [cal AD 216: cal AD 416] 1 Two Sigma Ranges: [start:end] relative area [cal AD 89: cal AD 102] 0.00968 [cal AD 123: cal AD 467] 0.941339 [cal AD 480: cal AD 534] 0.048981	1730 ± 85	Beta-18290	Crawford, Smith, and Bowyer 1997:Table 1
Holding	American Bottom Illinois	kernel	Middle Woodland	One Sigma Ranges: [start:end] relative area [cal BC 89: cal BC 75] 0.077908 [cal BC 57: cal AD 53] 0.922092 Two Sigma Ranges: [start:end] relative area [cal BC 166: cal AD 75] 1.	2017 ± 50	AA-8718	Riley et al. 1994:493–494
Holding	American Bottom Illinois	cob fragment	Middle Woodland	One Sigma Ranges: [start:end] relative area [cal BC 186: cal BC 19] 0.946126 [cal BC 13: cal BC 1] 0.053874 Two Sigma Ranges: [start:end] relative area [cal BC 355: cal BC 288] 0.082975 [cal BC 233: cal AD 69] 0.917025	2077 ± 70	AA-8717	Riley et al. 1994:493–494

Continued

Grand Banks	Southern Ontario	kernel	Early Late Woodland	One Sigma Ranges: [start:end] relative area [cal AD 347: cal AD 370] 0.054529 [cal AD 377: cal AD 648] 0.945471 Two Sigma Ranges: [start:end] relative area [cal AD 133: cal AD 728] 0.982085 [cal AD 736: cal AD 771] 0.017915	1500 ± 150	TO-5308	Crawford, Smith, and Bowyer 1997:Table 1
Grand Banks	Southern Ontario	kernel	Early Late Woodland	One Sigma Ranges: [start:end] relative area [cal AD 406: cal AD 586] 1. Two Sigma Ranges: [start:end] relative area [cal AD 259: cal AD 285] 0.02543 [cal AD 288: cal AD 292] 0.003874 [cal AD 322: cal AD 648] 0.970696	1570 ± 90	TO-5307	Crawford, Smith, and Bowyer 1997:Table 1
Grand Banks	Southern Ontario	cupules	Early Late Woodland	One Sigma Ranges: [start:end] relative area [cal AD 678: cal AD 784] 0.647145 [cal AD 786: cal AD 827] 0.221948 [cal AD 839: cal AD 864] 0.130907 Two Sigma Ranges: [start:end] relative area [cal AD 650: cal AD 903] 0.930775 [cal AD 915: cal AD 968] 0.069	1250 ± 80	TO-4585	Crawford, Smith, and Bowyer 1997:Table 1
Meyer	Southern Ontario	cupules	Early Late Woodland	One Sigma Ranges: [start:end] relative area [cal AD 662: cal AD 829] 0.871975 [cal AD 837: cal AD 867] 0.128025 Two Sigma Ranges: [start:end] relative area [cal AD 607: cal AD 979] 1	1270 ± 100	TO-8150	Crawford and Smith 2003:Table 6.2
Forster	Southern Ontario	kernel	Late Woodland	One Sigma Ranges: [start:end] relative area [cal AD 775: cal AD 987] 1. Two Sigma Ranges: [start:end] relative area [cal AD 661: cal AD 1041] 0.995939 [cal AD 1109: cal AD 1116] 0.004061	1150 ± 100	TO 7039	Crawford and Smith 2003:Table 6.2
Deposit Airport #1	Eastern New York	"maize"	Late Woodland	One Sigma Ranges: [start:end] relative area [cal AD 772: cal AD 883] 1 Two Sigma Ranges: [start:end] relative area [cal AD 687: cal AD 895] 0.984789 [cal AD 925: cal AD 936] 0.015211	1210 ± 40	Unknown	Knapp 2009

*Probability date falls in this interval, *p* = Relative Area × 100.

TABLE 2

ASSESSMENTS OF PRE-A.D. 900 MAIZE REMAINS FROM SITES IN STUDY AREA

Site	Context	Original Evaluation	Source	Final Assessment	Actual Association	Notes
Discredited Sites Reported by David Asch and Nancy Asch Sidell						
Newbridge	White Hall Midden	Contaminant	Asch and Asch 1981 discredited	Contaminant	Mississippian	No maize from feature contexts
Carlin	White Hall Feature	Contaminant	Asch and Asch 1981 discredited	Contaminant	"Later, Late Woodland"	Later Late Woodland occupations postdate A.D. 900–1000
Weitzer	White Hall Feature	Contaminant	Asch and Asch 1981 discredited	Contaminant	Historic	Incompletely carbonized
Koster	Archaic Midden	Contaminant	Asch and Asch 1985a:Table 6.4; Conard et al. 1984	Contaminant	Mississippian	AMS dated
Kuhlman	Archaic Pit (?)	Contaminant	Asch and Asch 1985a:Table 6.4	Contaminant	"Later Late Woodland"	Later Late Woodland occupations postdate A.D. 1000
Cypress Land	Archaic/Early Woodland Midden	Contaminant	Asch and Asch 1985a:Table 6.4	Contaminant	"Later Late Woodland" or historic	Associated with wheat grain
Macoupin	Middle Woodland Midden	Contaminant	Asch and Asch 1985a:Table 6.4	Contaminant	Incompletely carbonized	—
Napoleon Hollow	Middle Woodland Midden	Contaminant	Asch and Asch 1985a:Table 6.4; Conard et al. 1984	Contaminant	Mississippian	AMS dated
Loy	Middle Woodland Pit	Contaminant	Asch and Asch 1985a:Table 6.4	Contaminant	"Later Late Woodland"	Later Late Woodland occupations postdate A.D. 900–1000
Peisker	Middle Woodland Pit and Midden	Contaminant	Asch and Asch 1985a:Table 6.4	Contaminant	"Later Late Woodland" or historic	Historic Indian and Euro-American occupations on site
Crane	Middle Woodland Midden	Contaminant	Asch and Asch 1985a:Table 6.4	Contaminant	Prehistoric, probably Mississippian	AMS date with unacceptable error
Other Records for Pre-A.D. 900 Maize in Western Illinois						
Deer Track	Early Late Woodland Feature with Associated Date	Early Maize	Asch and Asch 1985a:Table 6.3	Contaminant	Modern	AMS dated this study
Buffalo	Early Late Woodland Feature with Associated Date	Early Maize	Asch and Asch 1985a:Table 6.3	Contaminant	Modern	AMS dated this study
Scenic Vista	Early Late Woodland Feature with Associated Date	Early Maize	Asch and Asch 1985a:Table 6.3	Unknown	Unknown	Maize sample was not found in curated material
Kuhlman	Early Late Woodland Feature with Associated Date	Early Maize	Asch and Asch 1985a:Table 6.3	Contaminant	Mississippian	AMS dated this study
Koster East	Late Late Woodland Feature With Associated Date	Early Maize	Asch and Asch 1985a:Table 6.3	Contaminant	Probable Mississippian	Based on presence of later components and fact that maize assemblage was exceptionally large

Continued

TABLE 2

CONTINUED

Site	Context	Original Evaluation	Source	Final Assessment	Actual Association	Notes
Other Records for Pre-A.D. 900 Maize in Western Illinois						
Tickless	Late Woodland Feature With Associated Date	Early Maize	Schroeder 2002	Contaminant	Mississippian	AMS dated this study
Ellege	Late Woodland Feature With Associated Date	Early Maize	Schroeder 1994	Valid	Late Woodland	AMS dated this study
Edgar Hoener	Late Woodland Feature With Associated Date	Early Maize	Schroeder 1996	Valid	Late Woodland	AMS dated this study
Spoontoe	Middle Woodland Pit	Early Maize	Calentine 2006	Contaminant	Mississippian	AMS dated this study
Sartorious/ Sartorial Splendor	Late Woodland Feature	Early Maize	Calentine 2012	Contaminant	19th Century Historic	AMS dated this study
American Bottom, Early Late Woodland Maize Records						
Mund	Early Late Woodland Feature	Early Maize	Johannessen 1983	Not Maize	Mississippian	AMS dated this study
Emge	Late Woodland Feature	Early Maize	Kutruff 1978	Contaminant	Probable Mississippian	Post A.D. 900 Occupation Identified on Site
Cunningham	Late Woodland Feature	Early Maize	Parker 2001a	Contaminant	Terminal Late Woodland or Mississippian	Post A.D. 900 Occupation Identified on Site
American Bottom Patrick and Sponemann Phase Sites with Maize: All Also Have Evidence for Late Occupation (see Table 5)						
Range	Patrick Phase Late Woodland Feature	Early Maize	Johannessen 1987b	Contaminant	Terminal Late Woodland or Mississippian	Post A.D. 900 Occupation Identified on Site
Booker T	Patrick Phase Late Woodland Feature	Early Maize	Parker, data on file with author	Contaminant	Terminal Late Woodland or Mississippian	Post A.D. 900 Occupation Identified on Site
Dugan Airfield	Patrick Phase Late Woodland Feature	Early Maize	Parker 2006b	Contaminant	Terminal Late Woodland or Mississippian	Post A.D. 900 Occupation Identified on Site
Fults	Patrick Phase Late Woodland Feature	Early Maize	Parker, data on file with author	Contaminant	Terminal Late Woodland or Mississippian	Post A.D. 900 Occupation Identified on Site
Billhartz	Sponemann Phase Late Woodland Feature	Early Maize	Parker, data on file with author	Contaminant	Terminal Late Woodland or Mississippian	Post A.D. 900 Occupation Identified on Site
Sponemann	Sponemann Phase Late Woodland Feature	Early Maize	Parker 1991	Contaminant	Terminal Late Woodland or Mississippian	AMS Dated, Fortier, Parker, and Simon 2011
John H. Faust #1	Sponemann Phase Late Woodland Feature	Early Maize	Holley, Parker, Scott, Watters, Harper et al. 2001	Contaminant	Terminal Late Woodland or Mississippian	Post A.D. 900 Occupation Identified on Site
E.J. Pfeifer #1	Sponemann Phase Late Woodland Feature	Early Maize	Holley, Parker, Scott, Watters, Skele, and Williams 2001	Contaminant	Terminal Late Woodland or Mississippian	Post A.D. 900 Occupation Identified on Site
J. Sprague	Sponemann Phase Late Woodland Feature	Early Maize	Holley, Parker, Scott, Watters, Skele, and Williams 2001	Contaminant	Terminal Late Woodland or Mississippian	Post A.D. 900 Occupation Identified on Site

site, in Ontario, Canada. Radiometric dates from this site have calibrated means ranging from A.D. 200 to 500 (Boyd and Surrette 2010:124).

Several reports for early maize are based on standard radiocarbon dating of charcoal from the maize-bearing feature or strata. The oldest is from Meadowcroft Rockshelter in western Pennsylvania, where maize was found in levels containing carbonized wood dating to the second and third centuries B.C. (Adovasio and Johnson 1981). Five other sites in Pennsylvania—Thorp, Backstrum 1, Fisher Farm, Catawissa Stratum III, and St. Anthony—have also yielded maize in association with charcoal remains potentially predating cal A.D. 900 (McConaughy 2008:Table 2-9). However, as McConaughy indicates (2008:19), all these sites have high potential for contamination from later components. Farther west, a single maize cupule was identified from a feature dating to about cal A.D. 350 at the Eidson site in southwestern Michigan (Parker 1996). Maize was also identified in fill from a feature with an associated charcoal date of about cal A.D. 450 at the Childers site in the Ohio River valley (Wymer 1994:421). The Ray site located in northeast Texas yielded cupules and kernels from a feature with a late Late Woodland date of about cal A.D. 850 (Schambach 2002).

More frequently, maize antiquity is based on non-feature-specific radiometric dates or association with diagnostic material. These reports include maize remains from Middle Woodland contexts at the Walling site in northern Alabama (Scarry 1990) and from the Marquette Viaduct locale of the Fletcher site in Michigan (Lovis et al. 1996; Parker 1996). Maize has also been reported from a number of sites located in the Duck River valley of western Tennessee (Cridlebaugh 1985; Crites 1978; Rafferty 2002) and from five Late Woodland sites in east-central Missouri (Hoard 2000; Lopinot 1991; Parker 1997a; Voigt 1989). Fritz identified maize from a Late Woodland feature at the Dirst site in Arkansas (Fritz 1990, 1995), but for the most part, records from the lower Mississippi River valley that predate A.D. 800–900 are few and problematic (Kidder 2002).

Recent residue studies suggest subsistence level maize cultivation developed at an earlier date in the Northeast than it did in the lower Midwest (Hart and Lovis 2013). The time depth for maize in this region is supported by modern genetic studies demonstrating that Northern Flint maize, the characteristic northeastern landrace, has diverged considerably from its southwestern ancestors, suggesting in situ, genetically isolated development of the former over a long period of time (Doebly et al. 1986; Hart and Lovis 2013: Vigouroux et al. 2008). However, these studies do not provide de facto evidence for early maize cultivation everywhere in the northern Eastern Woodlands, and while providing a possible source area for early maize in the lower Midwest, this has yet to be documented.

Maize research in Illinois

Over the past 40 years, Middle and Late Woodland period maize macroremains have been reported from sites located in western Illinois and the American Bottom (see Table 2; see Figure 2 for chronology). Among the earliest were reports for maize from several Middle Woodland contexts at sites located in the lower Illinois River valley and far western Illinois (Asch and Asch 1985a; Conard et al. 1984). These contexts were recognized as problematic, and a number were directly dated in the early 1980s using AMS technology (Conard et al. 1984). Maize from the Middle Woodland Napoleon Hollow, Jasper Newman, and Crane sites produced modern, or at best ambiguous, dates. These results were critical in debunking the idea that complex Hopewell cultures practiced maize cultivation (Conard et al. 1984).

Maize was also reported from early Late Woodland contexts at a number of large complex multicomponent sites located in the lower Illinois River valley. These included incompletely carbonized materials from the Apple Creek and Macoupin sites, as well as maize from questionable contexts at the Peisker, Ansell, Knight, and Loy sites. These finds were reevaluated by Nancy Asch-Sidell and David Asch and were determined to be contamination from later occupations (Asch and Asch 1985a:196–199, Table 6.4). While these records were discounted, there remained a core group of seemingly good Late Woodland maize finds from western Illinois. These were from the Deer Track, Scenic Vista, and Kuhlman sites, located in the Sny Bottom region (Figure 3), and the Koster East site, located in the lower Illinois River valley (Asch and Asch 1985a:Table 6.3). Claims for Late Woodland maize were based on radiometric dates on charcoal from maize-bearing features. Small amounts of Woodland maize recently recovered from one Middle Woodland site

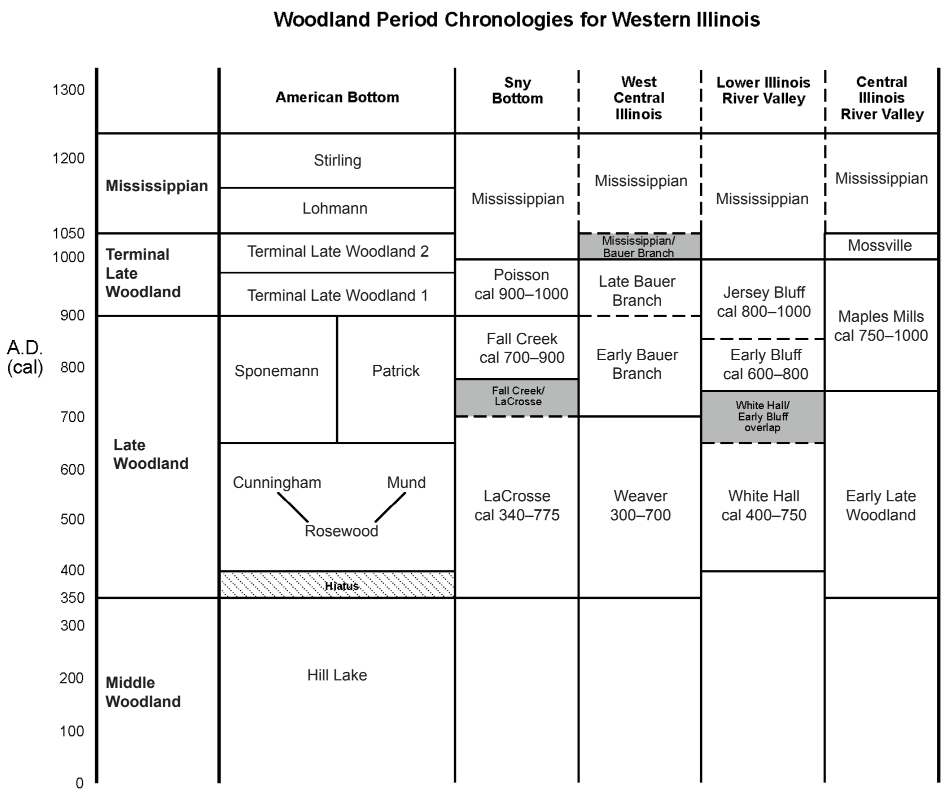

FIGURE 2 Woodland period chronologies for western Illinois.

and four Late Woodland sites in western Illinois (Calentine 2006, 2012; Schroeder 1994, 1996, 2002) (see Table 2) appear to corroborate those early maize records.

As noted above, the AMS dates on maize macroremains from the Middle Woodland Holding site comprise the oldest record for maize in the American

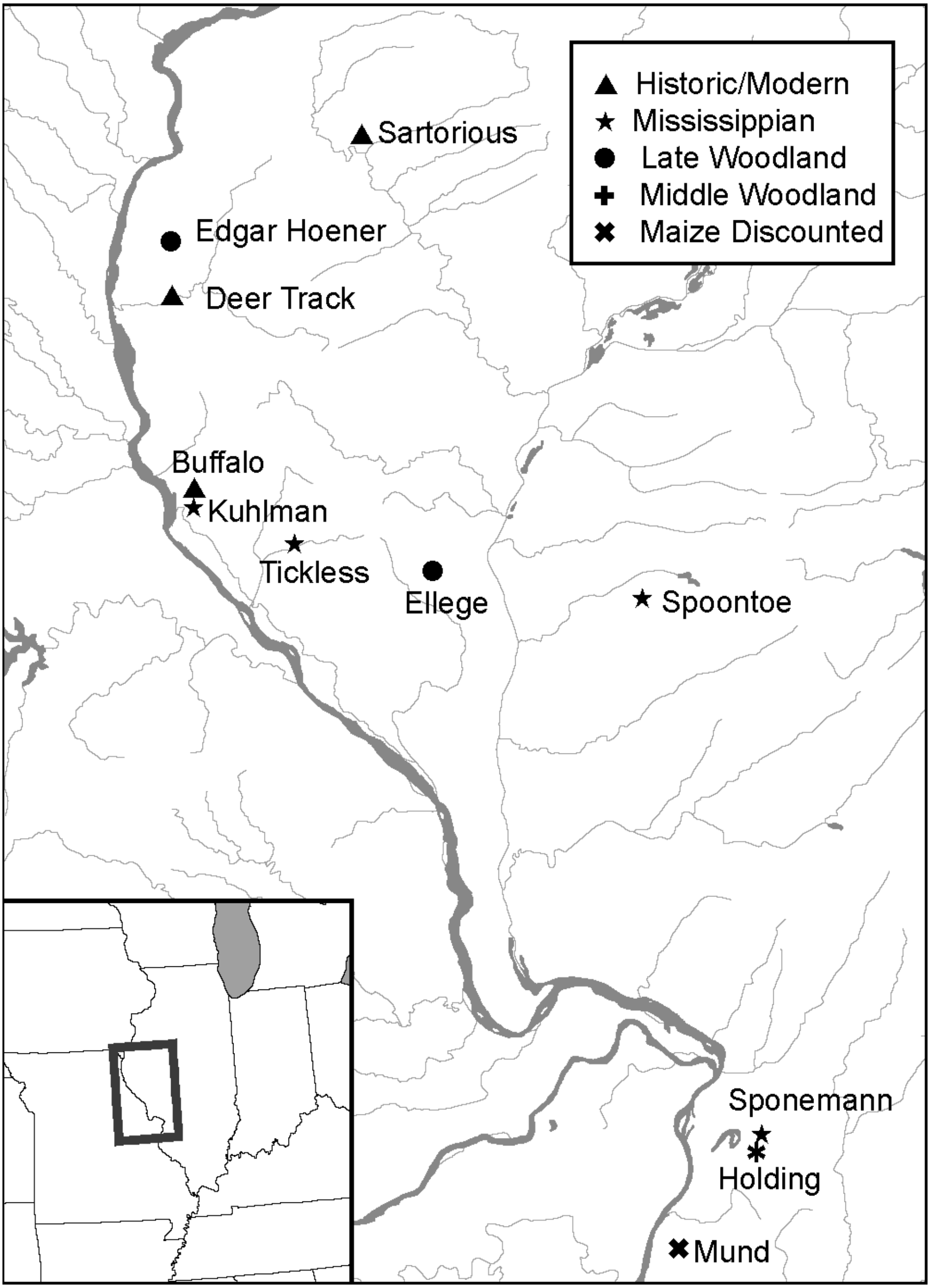

FIGURE 3 Site locations.

Bottom (Riley et al. 1994). Trace amounts of maize were also reported from three early Late Woodland American Bottom sites: Mund, Emge, and Cunningham (Johannessen 1983; Kuttruff 1978; Parker 2001a) (see Table 2). These finds were initially interpreted as showing the gradually increasing importance of maize in the region beginning in the Middle Woodland period. However, we now recognize a post–Middle Woodland abandonment of the American Bottom floodplain, followed by later reoccupation during the early Late Woodland (Fortier and Jackson 2000; McElrath and Fortier 2000:107–115), which complicates interpretations of in situ development.

Nonetheless, the early Late Woodland records from Emge, Cunningham, and Mund seemed valid evidence for the presence of maize in the American Bottom before A.D. 750. A gradual increase in use through time was supported by reports for Late Woodland maize from Patrick and Sponemann phase components (A.D. 750–900) (see Table 2). These reports included the recovery of maize from about one-third of the Sponemann phase features at the Sponemann site (Parker 1991), and in fact, maize cultivation was seen as a diagnostic trait of that phase (Fortier and Jackson 2000; Fortier et al. 1991).

These interpretations were challenged when new evidence showed a clear tie between American Bottom Sponemann phase ceramics and those from contemporary sites in the Sny Bottom of western Illinois. Researchers now believe that the Sponemann culture reflects an influx of people into the American Bottom from the north (Fortier and Jackson 2000). Still, given the maize record from the Sny Bottom, it remained conceivable that these people brought the practice of maize cultivation with them (Fortier and Jackson 2000; Simon and Parker 2006). Consequently, these new findings were not incompatible with interpretations that proposed low-level cultivation of maize, perhaps as a specialty crop, between about cal A.D. 500 and 800 (Hastorf and Johannessen 1994; Simon 2000) and increased use as a subsistence crop beginning about cal A.D. 800 (Johannessen 1993a, 1993b; Parker 1991; Simon 2000; Simon and Parker 2006).

Although our understanding of maize's history has changed over the past 50 years, one constant has been the seemingly continuous record for its use. This was accepted in part because the American Bottom and western Illinois have been subjected to uniquely intensive and extensive archaeobotanical analyses. Recently, given this increasingly large body of data, several American Bottom researchers began to question the gradualist model of maize farming (Koldehoff et al. 2006; Parker 2001b). Although maize was reported from the Sponemann site itself, analysis of flotation samples from 100 percent of all 583 features amounting to 12,369 L at three additional single-component Sponemann phase sites produced no maize (Parker 2012a, 2012b, 2012c). Further, a comprehensive review of Late Woodland maize records showed that all sites with reported maize also have Terminal Late Woodland or Mississippian components (Fortier, Parker, and Simon 2011; Koldehoff et al. 2006; Parker 2001b). This recovery pattern strongly suggested that maize from Late Woodland contexts across the region was contamination from later prehistoric agricultural activities (Koldehoff et al. 2006; Parker 2001b). To test that hypothesis, we initiated a study to directly date maize macroremains using AMS technology, while also reevaluating the archaeobotanical record itself.

Reevaluating the record for maize

Accelerator mass spectrometry

The first step in testing the gradualist model was to run a series of AMS dates on maize remains from apparently secure Middle and Late Woodland contexts. In total, 14 maize samples from ten sites located in the American Bottom and western Illinois were selected for dating (see Figure 3; Table 3). Prior to submission, identifications as maize were confirmed through examination under low magnification (10x to 30x) and in consultation with Marjorie B. Schroeder, at Illinois State Museum, and Kathryn E. Parker, at Great Lakes Ecosystems. With one exception, original identifications were unequivocal. A single problematic sample from Ellege was submitted to the Illinois State Geological Survey (ISGS) for verification using an element analyzer (EA). The EA converts the sample to a gas, measures element constituents, and provides isotopic fractionation values. Thus, it is a quick and inexpensive way to confirm identifications of C_4 plants, like maize, through the ^{13}C ratio obtained. If identification is confirmed, the gas produced can then be used for AMS. As a result of this process, the original Ellege site fragment was discounted as maize and an alternative sample was selected.

Samples for AMS dating were submitted to the ISGS. Conversion to CO^2 gas was undertaken at the ISGS laboratories, under the supervision of Dr. Hong Wang. Gases were then sent to the radiometric laboratory at University of California, Irvine, for counting.

The initial tests focused on four maize samples from seemingly unmixed Late Woodland contexts at the Sponemann site. All samples were from features located at least 10 m, and usually farther, away from features attributed to later Mississippian occupations. Nonetheless, all four returned Mississippian dates (see Table 3, Figure 4) (Fortier, Parker, and Simon 2011). These results led us to revisit one sample from the early Late Woodland Mund site that had been submitted to Oxford University for dating in 1998 (OxA-6291). That sample, which was identified as a cupule fragment, not only returned a Mississippian date but also a ^{13}C value, which indicated that it was not maize. The fragment was very small and distorted, and these results highlight both the difficulty of identifying small fragmentary remains and the need for EA confirmation and direct dating of samples.

The second phase of my investigations was to reevaluate the maize record from western Illinois. A series of maize samples from eight sites was selected for AMS dating (see Figure 3). The Kuhlman, Deer Track, Buffalo, and Tickless sites are located in or near the Sny Bottom of the Mississippi River. The Ellege, Edgar Hoener, Sartorious, and Spoontoe sites are located in the Illinois uplands. Except for the latter two sites, all maize samples selected for dating were from features for which a standard radiocarbon date had already been obtained.

In the following analysis, regional chronologies established for these areas provide the temporal framework as well as the phase designations that simplify both data presentation and discussion (see Figure 2). Dates are presented as calibrated using Calib Rev. 6. 1.0 (Stuiver, Reimer, and Reimer 2011) unless otherwise noted.

TABLE 3

THE RESULTS OF RECENTLY OBTAINED AMS DATES AND ASSOCIATED STANDARD RADIOMETRIC DATES

Site Name	Site Number	Location	Provenience	Material Type	Radiocarbon Years B.P.	Calibrated Date and Associated Probability (*p*), 2 Sigma level	δ13C Value	Cutural Association Based on AMS Date	Provenience	Associated Charcoal Date, Radiocarbon Years B.P.	Calibrated Associated Date [2 Sigma] Probability	Reference
Buffalo	11A1000	Sny Bottom	Feature 5	cupule	−285±20 (ISGS A2238)	1956–1957	−10.5	Modern	Feature 5	1350±70 ISGS 1043	[564 AD:827 AD] 0.978633 [839 AD:864 AD] 0.021367	Asch and Asch 1986
Kuhlman Habitation	11A162	Sny Bottom	Feature 71	cupule	995±20 (ISGS A2237)	[992 AD:1045 AD] 0.849325 [1093 AD:1120 AD] 0.125023 [1140 AD:1148 AD] 0.025652	−9.9	Mississippian	Feature 71	1190±70 (ISGS 864)	[682 AD:982 AD] 1	Asch and Asch 1985
Deer Track	11A835	Sny Bottom	Feature 53	kernel	−4955±120 (ISGS A2239)	1963–1965	−13.9	Modern	Feature 53	1370±75 (ISGS 785)	[539 AD:784 AD] 0.954218 [787 AD:826 AD] 0.030207 [840 AD:863 AD] 0.015575	Asch and Asch 1985
Tickless	11PK1255	Sny Bottom Uplands	Feature 2	kernel	1055±20 (ISGS A2241)	[901 AD:916 AD] 0.067604 [967 AD:1022 AD] 0.932396	−8.9	Mississippian	Feature 2	1270±70 (ISGS 1834)	[645 AD:896 AD] 0.986323 [923 AD:940 AD] 0.013677	Schroeder 2002
Edgar Hoener	11HA756	Western Illinois Uplands	Feature 1	kernel	1315±20 (ISGS A2242)	[657 AD:716 AD] 0.77796 [744 AD:768 AD] 0.22204	−10.1	Late Woodland	Feature 1	1460±70 (ISGS 2324)	[430 AD:670 AD] 1	Schroeder 1996
Ellege	11PK477	Sny Bottom Uplands	Feature 15	kernel	None	N/A	−25.1	(Not dated)	Feature 15	1570±70 (ISGS 1764)	[343 AD:634 AD] 1	Schroeder 1994
		Sny Bottom Uplands	Feature 15	cupule	1490±20 (ISGS A2273)	[542 AD:620 AD] 1	unknown	Late Woodland	Feature 15			
Sartorious	11HA360	Western Illinois Uplands	Feature 54	kernel	130±20 (ISGS A1265)	[1680 AD:1764 AD] 0.346057 [1775 AD:1775 AD] 0.00157 [1800 AD:1891 AD] 0.48944 [1908 AD:1939 AD] 0.159668 [*1951 AD:1953* AD] 0.003265	−10.5	19th C Historic	Feature 30	1370±70 (ISGS 6533)	[541 AD:782 AD] 0.97817 [789 AD:812 AD] 0.015939 [845 AD:856 AD] 0.005891	Fishel 2012
									Feature 64	1530±70 (ISGS 6534)	[400 AD:649 AD] 1	
			Feature 56	kernel	100±20 (ISGS A1264)	[1691 AD:1729 AD] 0.27302 [1810 AD:1923 AD] 0.721377 [*1952 AD:1953* AD] 0.005601	−10.4	19th C Historic				

Continued

TABLE 3

CONTINUED

Site Name	Site Number	Location	Provenience	Material Type	Radiocarbon Years B.P.	Calibrated Date and Associated Probability (*p*), 2 Sigma level	δ13C Value	Cutural Association Based on AMS Date	Provenience	Associated Charcoal Date, Radiocarbon Years B.P.	Calibrated Associated Date [2 Sigma] Probability	Reference
Spoontoe	11MG179	Western Illinois Uplands	Feature 11	kernel	970±15 (ISGS A803)	[1020 AD:1049 AD] 0.51989 [1085 AD:1124 AD] 0.380402 [1137 AD:1151 AD] 0.099708	−9.1	Mississippian	Feature 8	1870±70 (ISGS 5932)	[37 BC:30 BC] 0.004805 [22 BC:11 BC] 0.008083 [2 BC:263 AD] 0.928312 [277 AD:331 AD] 0.0588	Calentine 2006
									Feature 48	1910±70 (ISGS 5938)	[84 BC:80 BC] 0.001442 [54 BC:256 AD] 0.990469 [302 AD:316 AD] 0.008089	
									Feature 12	1750±70 (ISGS 5937)	[87 AD:104 AD] 0.012511 [121 AD:428 AD] 0.987489	
Sponemann	11MS517	American Bottom	Feature 66	kernel	970±20 (ISGS A1768)	[1018 AD:1052 AD] 0.444783 [1080 AD:1129 AD] 0.421901 [1132 AD:1153 AD] 0.133315	−9.2	Mississippian	Feature 49	1240±70 (ISGS 1304)	[657 AD:899 AD] 0.947291 [918 AD:954 AD] 0.047536 [956 AD:961 AD] 0.005173	Fortier et al. 1991 (standard dates) Fortier, Parker, and Simon 2011 (AMS dates)
			Feature 271	cupule	850±20 (ISGS A1796)	[1158 AD:1227 AD] 0.960588 [1232 AD:1243 AD] 0.027673 [1246 AD:1252 AD] 0.011739	−9.9	Mississippian				
			Feature 470	cupule	870±20 (ISGS A1770)	[1052 AD:1080 AD] 0.081731 [1128 AD:1132 AD] 0.006948 [1153 AD:1220 AD] 0.911321	−10	Mississippian	Feature 388	1210±90 (ISGS 1294)	[670 AD:906 AD] 0.878095 [911 AD:971 AD] 0.121905	
			Feature 730	kernel	955±15 (ISGS A1722)	[1024 AD:1053 AD] 0.311405 [1080 AD:1153 AD] 0.688595	−9.2	Mississippian				
									Feature 395	1200±90 (ISGS 1305)	[661 AD:993 AD] 1	
									Feature 665	1340±70 (ISGS 1570)	[577 AD:831 AD] 0.965107 [836 AD:869 AD] 0.034893	
Mund	11S435	American Bottom	Feature 36	cupule	600±60 (OXA 6291)	[1284 AD:1424 AD] 1.	−26.4	Mississippian but NOT CORN	Feature 85	1380±75 (ISGS 643)	[469 AD:478 AD] 0.003618 [534 AD:784 AD] 0.963579 [787 AD:825 AD] 0.022436 [841 AD:862 AD] 0.010367	Fortier, Finney, and Lacampagne 1983
									Feature 123	1470±80 (ISGS 865)	[412 AD:684 AD] 1	

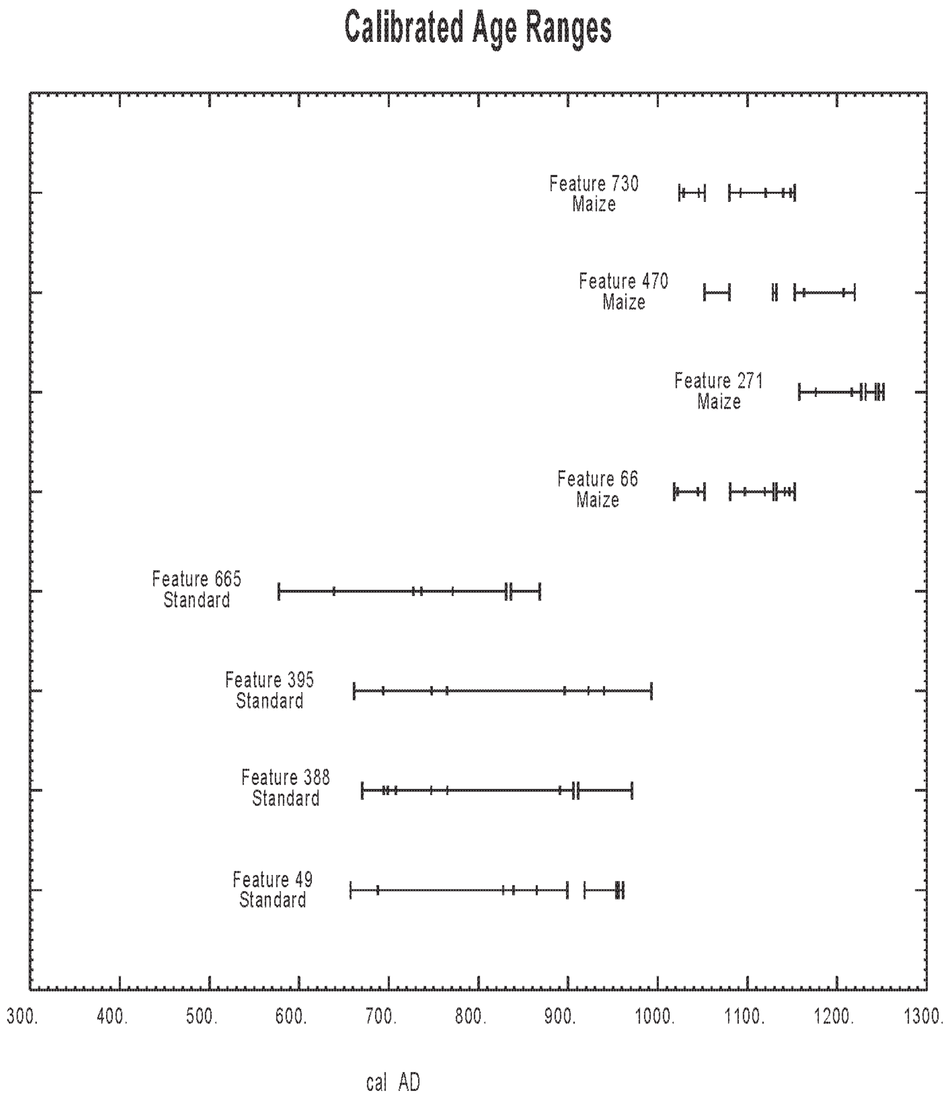

FIGURE 4 Plot of calibrated dates from the Sponemann site 11MS517.

Results of analysis

Only two of the samples submitted returned pre cal A.D. 900 Late Woodland dates (see Table 3, Figure 5). These were from the Edgar Hoener and Ellege sites. Both were unexpected. The Edgar Hoener site is a Weaver phase village, located in the Spoon River drainage uplands of west-central Illinois and so quite distant from a major river valley. The kernel postdates the Weaver phase date range, as defined in the western Illinois chronology (see Figure 2), and only barely overlaps the calibrated date range obtained on charcoal from the same feature (see Table 3). The presence of Weaver phase diagnostics in association with this date indicates the Weaver phase may be of longer duration than the current chronology suggests (Dave Nolan, Illinois State Archaeological Survey, personal communication 2012).

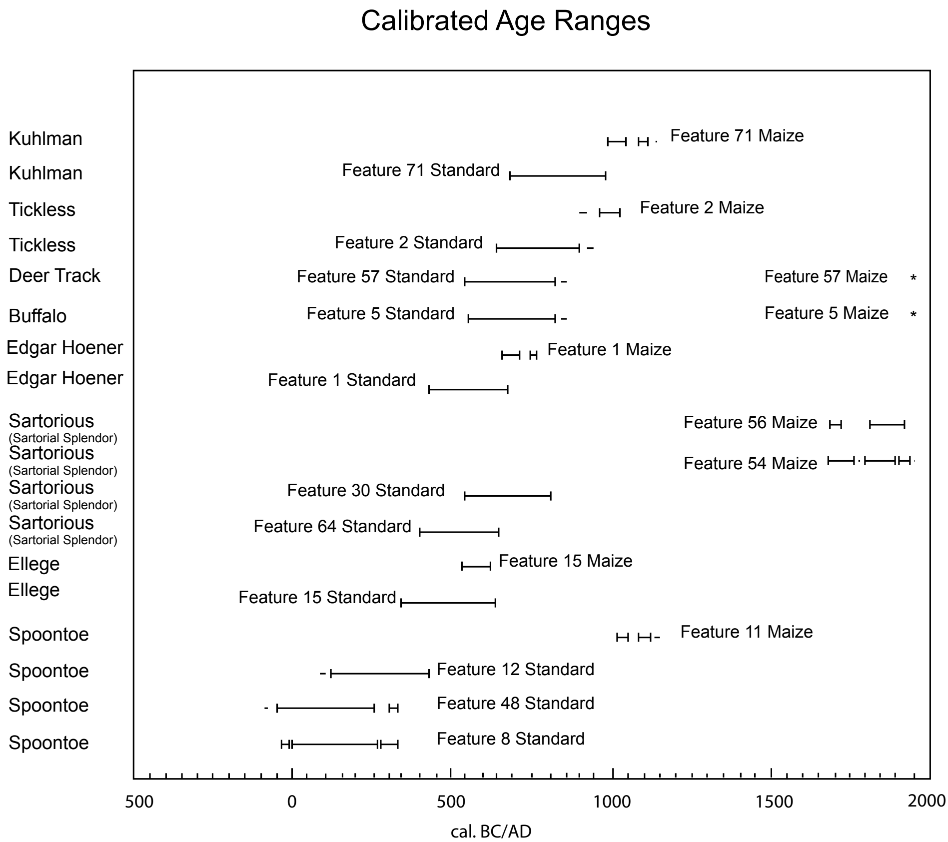

FIGURE 5 Plot of calibrated dates from study area.

The cupule from the Ellege site also returned a Late Woodland date (see Table 3). Ellege is a small, probably single component, homestead located in the uplands of west-central Illinois. The cupule date falls within the range of the charcoal date from this feature and within the broadly defined White Hall phase.

None of the five Sny Bottom maize samples returned dates within the range of the radiometric dates on charcoal from the same features (see Table 3; see Figure 5). The maize samples from Buffalo and Deer Track had negative values, indicating post-1950 associations. Modern dates were not entirely unexpected; maize collections from both sites were unusually large, and materials were exceptionally well preserved.

The Kuhlman site sample returned a Mississippian period date. The radiocarbon date from the associated feature was cal A.D. 682–982. Maize from this site was predicted to be the most recent of the six, with an anticipated date of around A.D. 900. The maize assemblage from Kuhlman is very large and otherwise typical for a Mississippian period habitation site.

The Tickless site sample returned an early Mississippian date roughly contemporaneous with the Kuhlman maize date. The site is located along Hadley Creek, in the uplands just to the west and south of the Sny Bottom. Based on cultural materials and associated radiometric dates, the site dates to the Late Woodland Fall Creek phase (cal A.D. 700–900), with no archaeological evidence for a later occupation (Conner et al. 2002).

Based on material culture and standard radiometric dates, the Spoontoe site dates to the Middle Woodland period (Calentine 2006; Richard Fishel, Illinois State Archaeological Survey, personal communication 2012). However, the cupule from Feature 11 returned an AMS date of 970 ± 15 (ISGS-A0803) (see Figure 5). Like the Tickless site, there was no evidence for a later occupation at this site, but Mississippians may well have used this disturbed locale as a field.

Maize fragments were identified in two features at the early Late Woodland Weaver phase Sartorious site, located in the Spoon River drainage just east of the Mississippi River. The ^{13}C ratios confirmed identification, but both fragments returned nineteenth-century dates (see Figure 5). This site had no evidence for a nineteenth-century occupation. The Tickless, Sartorious, and Spoontoe site analyses highlight the potential for feature contamination, even in the absence of archaeological evidence for later prehistoric or historic activity.

The archaeobotanical record

To further evaluate Late Woodland maize use in western Illinois and the American Bottom, we reviewed the compiled archaeobotanical data from those regions. Given the size of our database—110 sites, 4585 features, and 100,101 L of analyzed flot samples (see Table 4 and 5)—we assumed first that, if maize were being used during this period, it would at least occasionally be identified. Further, if maize use increased gradually through time, this increase should be reflected in the assemblages. We recognize that many factors govern the probability that any given plant part will be recovered archaeologically (Wright 2003; also see Hart 2008), but the large cumulative database should compensate for formation variables. Archaeobotanical analysis has been both comprehensive and extensive. Where feasible, ISAS implements a 100 percent feature sampling strategy as part of its investigative protocol. Consequently, for many sites, the features analyzed number well into the hundreds, with literally thousands of liters of feature fill examined. This greatly reduces the probability of missing even rarely recovered plant remains.

A total of 55 sites with Late Woodland plant assemblages were examined from western Illinois (see Table 4). The early Late Woodland Weaver phase is particularly well represented by 22 sites (producing 16,251 L of analyzed samples), including the Edgar Hoener site, where maize was confirmed. No maize has been reported from any other Weaver phase components, including those located in the same general area as Edgar Hoener (Schroeder 1998). With the exception of Ellege, maize is also absent from all White Hall phase contexts (7 sites, 198 features, 7,910 L of samples) unless that site also has evidence for a post–A.D. 900 occupation.

This pattern is repeated throughout the western Illinois sequence. The "general Late Woodland" occupations at Campbell Hollow, Smiling Dan, Peisker, and Ansell yielded maize, but all sites have evidence for later occupations and strong potential for contamination (Asch and Asch 1985a). Trace amounts of maize were identified from 4 of 31 Schuhardt site features, but all were within 10 m of Mississippian period features in which maize was abundant (Schroeder 2002). Maize

TABLE 4

LATE WOODLAND PERIOD MACROBOTANICAL ASSEMBLAGES FROM WESTERN ILLINOIS

Site Name	Component	Number of Features Analyzed	Volume of Fill Analyzed	Post A.D. 900 Component Present	Maize Identified	Reference
EARLY LATE WOODLAND						
Sartorious/Sartorial Splendor	Weaver	111	1,717	No	No	Calentine 2012
Kost #3	Weaver	10	143	No	No	King 2007
Cooper #1	Weaver	10	100	No	No	Calentine and Simon 2007
Tortured Oak	Weaver	3	30	No	No	Calentine 2005
Marlin Miller	Weaver	177	1,807	No	No	Calentine 2013
White Bend	Weaver	112	1,285	No	No	Simon 2012
Dobey	Weaver	27	537	No	No	King 2012
Carter Creek	Weaver	13	123	No	No	Schroeder 1985
Steuben	Weaver	9	88	No	No	Fishel and Felix 2006
Shaw	Weaver	100	1,000	No	No	Parker 2010
11A1114	Weaver	1	20	No	No	Schroeder 1998
Edgar Hoener	Weaver	7	594	No	Yes	Schroeder 1998
LeLand Wallbrink	Weaver	11	849	No	No	Schroeder 1998
George Brink	Weaver	1	120	No	No	Schroeder 1998
11HA764	Weaver	1	310	No	No	Schroeder 1998
EE Andrews	Weaver	5	133	No	No	Schroeder 1998
Gast Farm	Weaver	46	950	No	No	Dunne 2002
Rench	Weaver	180	3,584	Yes	Yes	King 1993
11SC87	Weaver	1	26.4	No	No	Green 1987
11SC461	Weaver	2	20.8	No	No	Green 1987
Scoville	Weaver	8	113	No	No	Munson, Parmalee, and Yarnell 1971
Guard	Weaver	29	2,701.1	No	No	King 1985
n = 22		864	16,251.3			
Weitzer	White Hall	34	781	Yes	Yes	Asch and Asch 1981
Carlin	White Hall	26	643	No	No	Asch and Asch 1981
Egan	White Hall	41	431	No	No	Simon 2007
Axedental	White Hall	15	793	No	No	Schroeder 1994
Newbridge	White Hall	27	2,331	Yes	No	Asch and Asch 1981
Newbridge (Midden)	White Hall	16	1,357	Yes	Yes	Asch and Asch 1981
Mary Craig	White Hall	33	716	Yes	Yes	King 2013
Ellege	White Hall	6	858.2	No	Yes	Schroeder 1994
n = 8		198	7,910.2			
Fall Creek	LaCrosse	13	286	Yes	Yes	Asch and Asch 1986
Wet Willie	LaCrosse	12	187	No	No	Asch and Asch 1986
Buffalo	LaCrosse	5	180	Yes	Yes	Asch and Asch 1986
n = 3		30	653			
11P783	Meyer-Dickson	15	153	No	No	Simon 2009b
11P784	Meyer-Dickson	8	170	No	No	Simon 2009b
11P786	Meyer-Dickson	5	50	No	No	Simon 2009b
n = 3		28	373			
n = 36 TOTALS		1,120	25,187.5			

Continued

TABLE 4

CONTINUED

Site Name	Component	Number of Features Analyzed	Volume of Fill Analyzed	Post A.D. 900 Component Present	Maize Identified	Reference
MIDDLE TO LATE LATE WOODLAND						
Teddy	Bauer Branch	4	461.0	No	No	Schroeder 1998
Ruth Andrews	Bauer Branch	4	56.3	No	No	Schroeder 1998
11HA762	Bauer Branch	13	379.4	No	No	Schroeder 1998
11HA817	Bauer Branch	4	252.0	No	No	Schroeder 1998
EE Andrew	Bauer Branch	2	39.5	No	No	Schroeder 1998
11A1364	Bauer Branch	8	418.5	No	No	Schroeder 1998
11A1052	Bauer Branch	4	461.0	No	No	Schroeder 1998
11SC87	Bauer Branch	39	300.0	No	No	Green 1987
11SC268	Bauer Branch	8	79.8	No	No	Green 1987
11SC347	Bauer Branch	5	101.4	No	No	Green 1987
11SC348	Bauer Branch	13	86.2	No	No	Green 1987
n = 11		104	2,635			
White Bend	Late Late Woodland, "Adams Variant"	30	201.0	No	No	Simon 2012
Kilver	Late Woodland/ "Bluff"	4	392.5	No	No	Schroeder 1994
Campbell Hollow	Late Woodland/ "Bluff"	4	554.0	Yes	Yes	Schroeder 1994
Smiling Dan	Late Woodland/ "Bluff"	11	1,531.0	Yes	Yes	Schroeder 1994
Peisker	Late Woodland/ "Bluff"	Not reported	Not reported	Yes	Yes	Asch and Asch 1985a
Ansell	Late Woodland/ "Bluff"	Not reported	Not reported	Yes	Yes	Asch and Asch 1985a
n = 6		49	2,679			
TOTALS	Site =17	153	5,314			
LATE LATE WOODLAND						
11A1146	Late Bauer Branch	2	286.5	Yes	Yes	Schroeder 1998
Deer Track	Fall Creek	6	189	Yes	Yes	Asch and Asch 1985b:Table 5.12
Tickless	Fall Creek	7	362	No	Yes*	Schroeder 2002
Schuhardt	Fall Creek	31	617	Yes	Yes	Schroeder 2002
Hadley Creek	Fall Creek	85	2,361	Yes	Yes	Schroeder 2002
n = 4		129	3,529			
Adcock	Late Late Woodland	17	533	No	Yes*	Simon 2006
TOTALS	Sites=6	148	4,349			
GRAND TOTALS	**SITES =55**	**1,421**	**34,850**			

*Very late, associated calibrated date range extends just beyond A.D. 900.

TABLE 5

LATE WOODLAND PERIOD MACROBOTANICAL ASSEMBLAGES FROM THE AMERICAN BOTTOM

Site Name	Component	Number of Features Analyzed	Volume of Fill Analyzed	Post A.D. 900 Component Present	Maize Identified	Reference
Carbon Dioxide	Rosewood	10	435	Yes	No	Johannessen 1985a
Alpha #1	Rosewood	12	430	No	No	Johannessen and Whalley 1988
Steinberg	Rosewood	10	267	No	No	Johannessen and Whalley 1988
Leingang	Rosewood	20	516	No	No	Johannessen and Whalley 1988
Jens	Rosewood	13	155	Yes	Yes*	Parker, data in possession of author
Dohack	Rosewood	7	210	No	No	Holley, Parker, Watters et al. 2001
Rosewood	Rosewood	45	669	No	No	Parker, data in possession of author
Wendy Extension	Rosewood	21	252	No	No	Parker, data in possession of author
Krap	Rosewood	42	445	Yes	Yes	Parker 1998
Rubra	Rosewood	8	80	No	No	Parker, data in possession of author
George Reeves	Rosewood	4	75	Yes	No	Johannessen 1987a
Patty Will	Rosewood	5	60	No	No	Parker 2006a
n = 12		197	3,594			
Cunningham	Mund	110	5,080	Yes	Yes	Parker 2001a
Columbia Quarry	Mund	17	370	No	No	Johannessen and Whalley 1988
Mund	Mund	46	1,496	Yes	Yes	Johannessen 1983
George Reeves	Mund	4	90	Yes	No	Johannessen 1987a
n = 4		177	7,036			
Lembke #2	Patrick	33	456	Yes	Yes	Holley, Parker, Watters et al. 2001
Lembke #3	Patrick	22	280	Yes	No	Holley, Parker, Watters et al. 2001
Adam and Eve Schoebert	Patrick	39	248	No	No	Holley, Parker, Scott, Watters, Skele, and Williams 2001
Technique	Patrick	50	691	No	No	Holley, Parker, Scott, Watters, Skele, and Williams 2001
Bill Schoebert	Patrick	16	242	Yes	Yes	Holley, Parker, Scott, Watters, Skele, and Williams 2001
E.J Pfeifer/Eve Schoebert Complex	Patrick	91	1,240	No	No	Holley, Parker, Scott, Watters, Skele, and Williams 2001
James Faust #1	Patrick	60	565	No	No	Holley, Parker, Scott, Watters, et al. 2001
Samson	Patrick	3	70	Yes	No	Dunavan 1992
Dohack	Patrick	10	280	Yes	No	Johannessen 1985b
Julien	Patrick	13	255	No	No	Johannessen 1984a
Alpha #3	Patrick	12	210	No	No	Johannessen and Whalley 1988
Holdener	Patrick	37	780	Yes	No	Simon 1994
Holdener	Patrick	37	780	Yes	No	Simon 1994
Cramer #2	Patrick	9	200	No	No	Johannessen and Whalley 1988

Continued

TABLE 5

CONTINUED

Site Name	Component	Number of Features Analyzed	Volume of Fill Analyzed	Post A.D. 900 Component Present	Maize Identified	Reference
Fish Lake	Patrick	425	15,155.5	No	No	Johannessen 1984b; Parker 2009
Range	Patrick	44	1,288	Yes	Yes	Johannessen 1987b
Columbia Farms	Patrick	20	251	No	No	Johannessen and Whalley 1988
Booker T	Patrick	32	1,002	Yes	Yes	Parker, data in possession of author
East St. Louis	Patrick	12	102.5	Yes	No	Parker, data in possession of author
Isoceles	Patrick	4	100	No	No	Parker 2005
Westpark	Patrick	2	20	Yes	No	Powell 1993
Stonegate	Patrick	14	140	No	No	Parker 1997b
Woodland Ridge	Patrick	106	2,296.5	Yes	Yes	Parker 2002
Sprague	Patrick	88	2,515	Yes	Yes	Parker 2006c
Rhonda	Patrick	14	1,000	No	No	Parker 2006d
Dugan Airfield	Patrick	75	1,224	Yes	Yes	Parker 2006b
Wilderman	Patrick	35	381	No	No	Wolforth and Simon 1993
Fults	Patrick	10	160	Yes	Yes	Parker, data in possession of author
H. Brush	Patrick	10	180	Yes	No	Parker 2008a
Classen	Patrick	20	292	No	No	Parker 2007
n = 29		1,306	3,1624.5			
Billhartz	Sponemann	14	168	Yes	Yes	Parker, data in possession of author
Sponemann	Sponemann	493	5,800	Yes	Yes	Parker 1991
John H. Faust #1	Sponemann	97	1,009	Yes	Yes	Holley, Parker, Scott, Watters, et al. 2001
John H. Faust #2	Sponemann	236	2,813	Yes	No	Holley, Parker, Scott, Watters, et al. 2001
E.J. Pfeifer #1	Sponemann	16	146	Yes	Yes	Holley, Parker, Scott, Watters, et al. 2001
J. Sprague	Sponemann	6	160	Yes	Yes	Holley, Parker, Scott, Watters, Skele, and Williams 2001
Rays Bluff	Sponemann	39	532	No	No	Parker 2008b
Reilly	Sponemann	491	10,705	No	No	Parker 2012a
Bay Pony	Sponemann	59	1,175	No	Yes	Parker 2012b
Grove	Sponemann	33	489	No	Yes	Parker 2012c
n = 10		1,484	22,997			
Component Site Totals						
Rosewood	12					
Mund	4					
Patrick	29					
Sponemann	10					
GRAND TOTALS	**55**	**3,164**	**65,251.5**			

was also reported from almost one-third of the features at the nearby Hadley Creek site, but radiometric dates show that occupations spanned the period between cal A.D. 600 and A.D. 1040 (Conner et al. 2002:Table 3.7). Kilver, the only site in this group without archaeological evidence for a later component, did not yield maize.

In the central Illinois River valley, the period between cal A.D. 750 and 1000 has been designated the Maples Mills phase. Maples Mills phase sites are numerous, (Esarey 2000:Figure 16.2), but few detailed archaeobotanical assemblages have been reported. Where information is available, maize is associated only with occupations dating toward the end of the phase. This includes maize from the Triple Ho site (Higgins 1989), a small upland camp with a mean calibrated date of about A.D. 1000. Maize was also present in several features at the Liverpool Lake site, where, with one exception, radiometric dates postdate cal A.D. 900 (Esarey 2000:Table 16.1). The exception is Feature 94-10, which calibrates to A.D. 671–939 (Esarey 2000:Table 16.1). Flotation samples from that feature were not analyzed (Schroeder 2000).

Archaeobotanical data from the American Bottom show a similar pattern. Assemblages have been reported from 16 early Late Woodland, Rosewood, and Mund phase sites (see Table 5). Analysis of over 10,000 L of fill from more than 300 early Late Woodland features has provided no conclusive evidence for maize. Maize was present in trace amounts at both the Emge and Cunningham sites, but both have later terminal Late Woodland or Mississippian occupations.

Botanical assemblages have been reported from 29 late Woodland Patrick phase components. Sites are located across the floodplain, bluff top, and interior uplands and vary greatly in size and complexity. The only Patrick phase sites from which maize has been reported are multicomponent sites with evidence for subsequent Terminal Late Woodland and/or Mississippian components. In contrast, maize is entirely absent at Late Woodland sites lacking a later occupation. This includes the extensive assemblage (425 features; 15,155 L of samples) from the Fish Lake site, where seeds alone exceeded 33,000, including four masses of charred native starchy-grain seeds, with each mass numbering seeds in the thousands. If Patrick phase people living at this location were growing maize, we would expect to find some trace of it.

In addition to the Sponemann site, we have archaeobotanical data from nine Sponemann phase occupations (991 features yielding 17,197 L) extending across the northern American Bottom and into the Richland Creek uplands to the east (see Table 5). Among these sites, maize has been identified only where we also have evidence for later Terminal Late Woodland or Mississippian occupations.

Collectively, the macrobotanical data does not support hypotheses for low-level, but sustained, Late Woodland maize cultivation in either western Illinois or the American Bottom. Regardless of the nature of early maize use, whether as a limited "specialty plant" or as "green corn" processed and consumed in an immature state, given the extent of our database I would expect to see some evidence for its presence even if it was being consumed cobs and all. Botanical assemblages show that Late Woodland peoples were cultivating large stands of native seeds and "specialty plants" in gardens or fields, but these efforts did not extend to maize.

Discussion and conclusions

The original model in review

The original model for maize use across western Illinois postulated a gradual but consistent increase in cultivation through the Late Woodland. Maize was seen as an addition to an existing economic system that included cultivation of native domesticated and nondomesticated plants. The fact that maize seemed to have been so readily incorporated into the existing Late Woodland cropping system was seen as evidence that technologies for maize cultivation "fit" into the existing system (Simon 2000). Under this model, once introduced, maize cultivation was both sustained and repeated, increasing and spreading through time. Implicit was the idea that the transition to full-blown maize agriculture was in some sense "inevitable" because people saw maize as a positive, desirable addition to the existing economic and social systems.

Revising the model

The original model has been dramatically altered as a result of this study. Although AMS has confirmed the presence of maize in the American Bottom during the first century B.C. and in western Illinois about 700 years later, the number of records for Late Woodland maize from this entire region are fewer than we once thought. In far western Illinois, only two cases of early maize are confirmed, and in the American Bottom, the Middle Woodland Holding site remains the sole directly dated context for pre–A.D. 900 maize. The three sites are widely scattered in time and space, and maize macroremains consist of one or very few fragments.

Late Woodland associations for maize from the Buffalo, Kuhlman, Deer Track, Tickless, Sartorious, and Spoontoe sites have been invalidated. The first four sites are located in or near the Sny Bottom of the Mississippi River, which was once seen as a possible "heartland" for early subsistence-level maize cultivation. These results are of particular interest to archaeologists studying late Late Woodland societies across the western Illinois and the American Bottom regions. The Sny Bottom was a point of departure for groups who migrated into the northern American Bottom during this time period (Fortier, Parker, and Simon 2011) and who provided the genesis of the "Sponemann culture." However, contrary to the original hypothesis (Fortier, Maher, and Williams 1991), maize cultivation was not part of the Sponemann phase economy. Nor was it part of any Late Woodland subsistence economies in this region.

Understanding the record

Based on isotopic studies of skeletal material, we are increasingly appreciative of the variability in maize consumption levels among post–A.D. 900 populations living across the study area (Bukowski et al. 2011; Hedman 2010; Hedman, Hargrave, and Ambrose 2002). However, although individual consumptive patterns may have varied, both isotopic and macrobotanical records indicate maize cultivation increased rapidly after this date in both western Illinois and the American Bottom. By about A.D. 1000, maize cultivation had been incorporated into existing systems across the study area. This change occurred within a few generations and in the context of a rapidly changing sociocultural milieu. The speed with which maize was incorporated into existing systems is one reason the Late Woodland record is so enigmatic. Our understanding is further complicated by the real, albeit rare, presence of maize before A.D. 900.

Two questions follow from these results: Given its presence, why is maize so scarce in Late Woodland period records from the lower Midwest? And why was it so rapidly and extensively incorporated after A.D. 900? The first question is addressed below; however, the second is a topic for another article.

Explanations for the near-absence of maize in the Late Woodland macrobotanical record are sometimes based on the assumption that early maize was regularly grown for general consumption but at such low levels that it does not attain "archaeological visibility." While we can attest to its lack of archaeological visibility, the corollary, that low-level cultivation was still being practiced, is not supported by our data. Rather, it seems likely that maize is rare in the record because it was seldom grown. Similarly, the idea that early maize was cultivated as a garden crop but consumed only in its "green state," thus leaving no traces in the archaeological record, is not supported. Given the large body of data, if use were at all widespread, we would expect to find more evidence for its presence, if in no other context than from accidental incineration of seed stores. This is not the case, although we do find ample evidence for native grain storage. I conclude that maize was not widely cultivated in small quantities for general consumption. Late Woodland gardens probably did not regularly include maize plants, regardless of its potential as a tasty supplemental food source.

Alternatively, it has been suggested that Late Woodland maize cultivation was limited to select individuals or groups who grew it for use in ritual or ceremonial activities (Hastorf and Johannessen 1994; Johannessen 1993a; Scarry 1993; Wymer 1993, 1994). This model explains limited recovery levels and is based in part on maize's role in the southwestern United States and in Central and South America as well as on postcontact North American ethnography (Bohrer 1994; Hastorf and Johannesen 1994; Ortiz 1994; Stross 2006; Washburn 2012). For the American Bottom, this model was supported by the recovery of maize from apparently ritual contexts at both the Middle Woodland Holding site and the early Late Woodland Mund site (Hastorf and Johannessen 1994). However, the presence of maize at the Mund site has been invalidated. Further, the Holding site maize must be viewed from the perspective of Middle Woodland sociocultural systems that included long-distance trade networks of exotic items. These networks extended to the west, providing a route by which maize may have been introduced. In this context, maize may have been another "exotic," and maize ears may have been obtained, valued, and used in the same manner as other exotics, such as copper and obsidian. However, sustained cultivation, even by an elite few favored with the knowledge of how to grow maize, was probably not feasible (Hart 1999).

Even if maize was part of the Middle Woodland exchange network, which is admittedly speculative, continuity of practice into the lower midwestern Late Woodland cannot be assumed. On a purely biological basis, sustained low-level cultivation cannot be maintained without the continued introduction of new maize germplasm, for which we have no evidence (Hart 1999). Further, Middle Woodland people may have valued maize for its exotic appearance, but appearance alone is insufficient to imbue the plant with the same level of ascribed meaning that it had in Mesoamerica or even in the southwestern United States. This observation applies equally to hypotheses for ritual Late Woodland maize use. In both Mesoamerica and the southwestern United States, there is a long history of maize-human interaction and an increasing reliance on maize as a life-sustaining food. This is simply not the case in the Eastern Woodlands, where maize was not an important food until after A.D. 900–1000. Late Woodland people, without a long tradition of growing and relying on it, would not have viewed maize as the "corn-mother" unless that concept arrived with the plant. Even so, Late Woodland people would have had no reason to adopt a concept that had no relevance to their existing economic, political, or social systems. Consequently, the idea that during the Late Woodland maize was cultivated and consumed green as an integral part of a "green corn ceremony of the harvest" is illogical. Green corn celebrations as ethnographically reported for the Eastern Woodlands are celebrations of the harvest, specifically including successful maize crops (Witthoft 1949). However, these ceremonies and, more importantly, the underlying beliefs behind them did not spring up wholesale. Rather, the interdependency between maize and people took time to develop and was intimately tied to maize's important role in the subsistence economy. Where maize had not achieved status as a sustainer of life, there would have been no reason to organize ceremonies around it. In agreement with Lopinot (1997:56), I would argue that there is no reason to ascribe to maize an almost mythical ceremonial or ritual role in Late Woodland societies.

The prehistoric people of eastern North America had a long and complex history of land modification, or "niche construction," aimed at encouraging production or proximity of desirable plants (e.g., for recent concept summaries, see Delcourt and Delcourt 2004; Hart and Lovis 2012; Smith 2009, 2011a, 2011b). Across the midcontinent, prehistoric peoples modified their landscapes by clearing land for cultivation of native plants. In western Illinois and the American Bottom, archaeological records show that native plant cultivation was both extensive and had a great deal of time depth (Asch and Asch 1985a; Johannessen 1984c, 1993b, 2003; Simon 2000, 2009a; Simon and Parker 2006). By Late Woodland times, people in the region were fully engaged in subsistence-farming economies based on the suite of Eastern Complex plants—a group of weedy annuals, chenopod, erect knotweed, little barley, maygrass, sunflower, and sumpweed—that thrive in disturbed soils. Based on morphological changes in the seeds, chenopod, sumpweed, and sunflower were fully domesticated by Middle Woodland times, while squash had also been modified from its wild native form (Cowan 1997).

Because people were already cultivating this suite of plants, and had been for millennia, we at one time suggested that maize would have been an easy addition to existing systems (Simon 2000; Simon and Parker 2006). However, a closer consideration of the technologies involved in cultivating native crops, specifically the four grain crops, and those required for maize cultivation confirms that the two are not necessarily compatible (Scarry and Yarnell 2011; Smith and Cowan 2003:118–123). The seeds of weedy annuals can be broadcast sown in lightly tilled fields (Scarry and Yarnell 2011:493). Plants are closely spaced and ultimately shade out competitors, so stands do not require weeding. In contrast, maize kernels are sown individually or in low numbers in hills, rows, or raised areas. Building hills or raised beds requires labor beyond the initial land clearance. Further, weeds can readily invade open areas between maize plants and outcompete them for valuable resources. Consequently, maize plots require periodic weeding to ensure a good crop. Maize is also very attractive to wild animals, more so than native grains are. Consequently, maize fields require tending throughout the ripening period to protect them from predation. These factors mandate that people be present and attentive to maize crops from the time of sowing through the harvest. This is not equally true for native grains.

Unlike maize, which ripens over a short period of time in the fall, the native grain plants under cultivation in the Late Woodland Midwest became available at different times. Little barley and maygrass ripen early in the summer, while erect knotweed and chenopod ripen in the fall. Further, in the wild, ripening is nonsynchronous. Consequently, scheduling harvests for native cultigens and maize are quite different. Given the predominance of native grains in the archaeological record, it is apparent that Late Woodland people had developed successful systems to accommodate the differences. Adding maize may have complicated existing seasonal rounds, and perhaps there was no compelling reason to alter their routine to incorporate a new unknown commodity.

Prior to human consumption, both native grains and maize kernels require processing. In both cases, technologies involve extracting grain from surrounding tissues, grinding or pounding seeds, and cooking (Gremillion 2004). These basic steps may be the extent to which native grains were processed, and they could also suffice for maize. However, hominy production from maize requires additional labor and is time consuming (e.g., see Katz et al. 1974; Lovis et al. 2011; Myers 2006). In this respect, technologies of preparation also differ (Smith and Cowan 2003).

Finally, unless new seed was obtainable on a yearly basis through exchange, successful propagation of maize crops required a secure method of overwintering seed. The technology for such storage was indeed in place, as we know by the recovery of native grain seed stores and caches. However, the loss of native grain stores through accident or other calamity was probably not catastrophic. Since these plants were native, and were being grown extensively, new seed stock was available. Maize was neither native, precluding collection of wild seed, nor readily available as new stores from other groups who grew it.

The addition of maize, on the scale witnessed later in prehistory, to existing systems of native-crop cultivation was clearly more complex than just simply adding another plant to the mix. Maize cultivation adds considerable labor input at the beginning of the growing season and requires not only a protective presence but also additional labor during the growing season. Maize can be harvested in the fall with chenopod and erect knotweed, but adoption of maize at the expense of the existing native grain complex would require scheduling and labor modifications. Processing for consumption can be complex and a reliable system of seed storage through the winter months is necessary.

The last point is especially important because, regardless of technology, successful and repeated propagation of maize crops is possible only if new seed is periodically available or if populations are large enough to be genetically sustainable. In view of genetic limitations, researchers have proposed a population biology based model to explain the spread of maize in the Eastern Woodlands (Hart 1999; Hart and Lovis 2012; Hart et al. 2012). According to the model, maize was periodically introduced and reintroduced into the area throughout the Middle and Late Woodland period. However, these early maize populations were small and dispersed. In the absence of new germplasm acquired through new seed stock, cultivation over more than a few generations was unsustainable. It was not until genetically viable, interbreeding threshold-population levels were attained that maize crops could be perpetuated.

Biologically and genetically, this model has strong explanatory value, addressing problems inherent in any attempt to perpetuate small, dispersed plant populations. Unsuccessful efforts would be reflected in a sporadic and, apparently, random recovery record, similar to our finding for western Illinois maize. However, the logical implication of this model, that we should see evidence for maize spreading gradually across western Illinois and the American Bottom as populations increased and became proximate, is not evident in the Late Woodland record.

Rather, in the macrobotanical record, maize goes from almost nonexistent to abundant in a single century. The rapid spread may have been facilitated by increasingly large maize-plant populations, but its genesis was not in local Late Woodland maize use. It is instead more likely that there were repeated, post–A.D. 850 to 900 introductions of maize seed into both the American Bottom and western Illinois over a relatively short period of time. Several different source areas are suggested by the highly variable morphologies of Mississippian maize collections from the American Bottom (Blake 1986; Fritz 1992; Lopinot 1994; Parker 1992; Wagner 1994). Collections are dominated by 10- to 12-row types but also include 8-rowed cobs characteristic of the Northern Flint landrace, as well as 16- or 18-row small, popcorn-like materials. The evident diversity supports hypotheses for repeated introductions of materials from the Southwest as well as the Northeast and perhaps for local hybridization among these landraces.

Concluding remarks

In conclusion, our data as reassessed here is best explained through a model that posits the rapid and repeated introduction of maize seeds into the American Bottom and western Illinois over the tenth century and perhaps beyond. We do not see the genesis of this in the Late Woodland subsistence economies or in the ceremonial or ritual contexts in which Late Woodland people lived their lives. We also question the availability of ample maize seed to sustain subsistence-level production prior to about A.D. 900. And even if availability was not an issue, maize, as a subsistence crop, did not necessarily fit in well with existing farming systems. In light of new data and revised occupation sequences, we also question models that see maize as having been introduced as a "sacred" plant with an inherent ascribed meaning.

Gremillion (2002) proposed a similar model to explain the absence of native crop plants in the greater southeastern United States. As she states, "innovation requires risks" (Gremillion 2002:494). If the benefits of growing maize do not overcome the risks, difficulty, and changes in lifestyle that the practice entails, there is no reason for a people to incorporate maize cultivation. Further, we need to be aware of the tendency to look at maize through the glasses of "zeacentricism" (Lopinot 1997). This pertains not only to its presumed role in Mississippian societies but also to the idea that Late Woodland people would have immediately recognized the "rewards" of maize cultivation and strived to obtain them. In fact, perhaps maize cultivation was adopted only under duress, not because it was seen as the ultimate crop plant.

As previously demonstrated in studies of alleged Middle Woodland Hopewell maize (Adair and Drass 2011; Conard et al. 1984), the combination of critical evaluation of macrobotanical assemblages and direct AMS dating of maize remains is a powerful tool for defining regional agricultural histories. This is again demonstrated here. In the central Mississippi River valley region that includes the American Bottom and western Illinois, Late Woodland agricultural systems were balanced and mature, with roots extending back to the Late Archaic. We need to consider the very real possibility that maize did not fit into this highly successful system. This may not hold true across the entire Eastern Woodlands, but that should not be surprising. Histories of maize need not be uniform, and there is no need to extrapolate a single model across a region as large and diverse as the Eastern Woodlands.

In western Illinois and the American Bottom, there are precisely three validated records for pre–A.D. 900 maize. Rather than developing convoluted models and hypotheses to explain this, perhaps the most parsimonious explanation is also worth considering. Late Woodland maize records from western Illinois and the American Bottom are few not because the archaeobotanical record is inadequate; they are few because maize was not part of Late Woodland economic or social systems.

Acknowledgments

The Illinois State Archaeological Survey, a division of the Prairie Research Institute at the University of Illinois, sponsored this research. The support and encouragement provided by ISAS director Dr. Tom Emerson were invaluable and greatly appreciated, as was his editorial assistance. I also want to thank the Illinois State Museum, under the directorship of Dr. Bonnie Styles, for providing access to maize collections curated there and permitting destructive analysis of materials from those collections. Thanks also to Marjorie Schroeder, archaeobotanist at ISM, for her help. David Asch and Nancy Asch-Sidell, then with the Center for American Archeology, originally analyzed many of the samples with maize from western Illinois, and their work, along with Margie's more recent analyses, provided the basis for my western Illinois research.

Special thanks are due to my friend and colleague Katie Parker, Great Lakes Ecosystems, for support, encouragement, and lots of editorial assistance. Her knack for turning a phrase into a concise word contributed immeasurably to the final product. Additionally, it was her work, in collaboration with Dr. Andrew Fortier, ISAS special projects coordinator, that initially caused us all to question the conventional accepted sequence for Late Woodland maize in Illinois.

Aside from Katie, several people took the time to critique drafts of this paper. Thanks to ISAS colleagues Tom Emerson, Andy Fortier, and Dale McElrath for doing so. I also thank my two anonymous reviewers for their thoughtful suggestions. All these individuals' input is appreciated and helped improve the manuscript.

Thanks to Mike Lewis, Mike Farkas, and Corinne Carlson, all of who helped draft the figures. Dr. Hong Wang at the Illinois State Geological Survey processed the samples for AMS dating and his expertise is always appreciated. Thanks to my cohorts—Mary King, Leighann Calentine, and Rosie Blewitt—for keeping the ISAS archaeobotany lab running smoothly during my physical, and mental, absences.

This article is a much-modified print version of a paper I presented at the symposium What, When, and How?: Assessing the Timing, Rate, and Adoption Trajectory of Domesticate Use in the Midwest, at the 2012 Midwest Archaeological Conference in East Lansing, Michigan. Thank you to Dr. Bill Lovis and Dr. Maria Raviele for inviting me to participate. Thanks also to Bill for his encouragement and his valuable editorial assistance.

While the help of many is acknowledged, the article presented is the work of the author, and I accept all responsibility for any errors or omissions therein.

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MIDWEST ARCHAEOLOGICAL CONFERENCE INC. OCCASIONAL PAPERS No. 1, 2014, 135–160

Food Production and Niche Construction in Pre-Contact Southern Ontario

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Niche construction provides a comprehensive perspective for understanding human and environmental interaction both before and after the introduction of food production in southern Ontario. The timing of crop introductions, particularly maize, and the impact of those introductions on culture is only part of the picture. In this paper, a substantial sequence of plant remains from well-defined contexts is assessed in order to begin examining niche construction in south-central Ontario. The development of Northern Flint maize; the appearance of *Cucurbita pepo,* sunflower, and other crops and anthropogenic plants are considered. How settlement patterns changed is another important consideration when assessing food production and human ecology in the region. Grand Banks, Meyer, Forster, and Holmedale are among the Princess Point sites whose data help clarify the issues. The data are compared to immediate post–Princess Point cultures in south-central Ontario, as well as to the Young phase of the Western Basin Tradition. The Late Archaic McIntyre plant remains indicate a distinct form of niche construction, although it has some similarities to that of the Late Woodland. All Late Woodland groups have more similarities than differences largely as a consequence of food production and substantial sedentism but also as a consequence of ecological inheritance that may be rooted in the Archaic.

KEYWORDS Ontario; Archaic; Woodland period; anthropogenesis; niche construction

Classification debates (e.g., hunter-gatherer or farmer? Algonquian or Iroquoian?), culture history, and descriptive questions—such as which crops, and when?—are significant parts of archaeological discourse about Ontario. This is particularly evident when considering maize production. Nuanced, holistic discourse is developing slowly (e.g., Crawford and Smith 2002; Hart 1999; Snow 1995); ecological theory, especially niche construction, offers a context in which to further develop a more nuanced perspective. For example, to what extent are "domesticated landscapes" (Terrell et al. 2003) evident in southern Ontario and the upper St. Lawrence River valley? How can their recognition inform our understanding of human-environment interaction through time in the region? The contact period Iroquoians had a mixed economy of food production, resource management, fishing, hunting, and gathering. Maize, sunflower, common bean, and tobacco (potentially Jerusalem artichoke as well; see Table 1 for plant nomenclature) production was a significant component of this economy. Many ecological communities at the time were associated with resource production ranging from actively cultivated soil to old fields, new clearings, and abandoned hamlets and villages. The development of the Iroquoian niche is crucial to an understanding of the initiation, development, and intensification of food production. In this paper, I ask questions related to the extent to which the Princess Point complex (PP) and the Western Basin Tradition (WBT) niches are similar to the later Iroquoian niche. Crop history and abundance are certainly relevant, but I argue that focusing on only the presence and dating of crops or the ambiguous concept of "agriculture" significantly constrains the discourse (see also Crawford 2008; Terrell et al. 2003). Niche construction or ecological engineering (Collard et al. 2011; Laland et al. 2001; Odling-Smee and Turner 2011) offers the potential to open the discourse to consideration of the broader signals of human-environment interaction within south-central Ontario. I build on previous research that explores anthropogenesis from a paleoethnobotanical perspective (Crawford et al. 2006; Crawford and Smith 2003; Monckton 1992; Ounjian 1998). I also examine whether, in the evolving anthropogenic landscape of south-central Ontario, maize continued to evolve. Niche construction involves complex issues, so this paper initiates the discussion by focusing on the plant component. This case study is based on comprehensive flotation samples from Late Woodland (LW) I and II (Figures 1 and 2) occupations and the potential of the data to help us better understand the niches of these cultures and their predecessors. I draw comparisons among Archaic, LWI, and LWII sites in southern (mainly south-central) Ontario, at least to the extent that data are available.

The paleoethnobotanical record

Plant-remains assemblages from one Archaic and several LWI and LWII sites in southern Ontario are the focus of the comparison presented here. These samples have been collected and analyzed using flotation and similar laboratory methods (e.g., see Crawford 1983; Monckton 1992; Ounjian 1998; Yarnell 1984) (see Figure 1; Tables 2 and 3). The sites are arranged in rough chronological order from oldest to youngest (left to right) in Tables 2 and 3. The data from the McIntyre site (Yarnell 1984) represents the only significant published Archaic plant-remains assemblage from southern Ontario. The McIntyre site was repeatedly occupied, although mainly by Late Archaic people. The earliest radiocarbon dates range from 6000–4800 cal B.P., while five dates cluster around 4700–3800 cal B.P.; minimal

TABLE 1

PLANTS REPRESENTED IN THE ARCHAEOLOGICAL RECORD OF SOUTH-CENTRAL ONTARIO

Type	Scientific Name	Comon Name	Habitat
Crop			
	Zea mays	maize/corn kernels	field
	Zea mays	cupules	field
	Helianthus annuus	sunflower	field
	Cucurbita pepo	squash	field
	Phaseolus vulgaris	common bean	field
	Nicotiana sp.	tobacco	field
Herbaceous			
	Acslepias syriaca	milkweed	open, early successional
	Asteraceae	Aster/Composite	open, early successional
	Helianthus tuberosus	Jerusalem artichoke	perennials of open habitats
	H. divaricatus	Woodland sunflower	dry openings, thin woods
	Fabaceae	legume/bean family	variety
	Amphicarpaea bracteata	hog peanut	vine, woodlands, early successional
	Astragalus canadensis	milk-vetch	perennial, high fire tolerance, sunlit areas
	Chenopodium sp.	goosefoot	early succession/crop
	C. hybridum (C. simplex)	Maple-leafed goosefoot	thickets, sometimes in open habitats
	Cuscuta sp.	dodder (parasitic)	noxious weed
	Galium sp.	Bedstraw/cleavers	annuals and perennials, dry woods to wetlands
	Lepidium sp.	peppergrass	weedy, invasive
	Mentha sp.	mint	weedy, invasive
	Oxalis sp.	wood sorrel	weedy, invasive
	Hypericum perforatum	St. John's wort	weedy, invasive, perennial
	Oenothera biennis	Evening primrose	open, disturbed habitats
	Polygonaceae	knotweed/smartweed	variety, dry to damp habitats
	Polygonum erectum	erect knotweed	early succession/crop
	Portulaca oleracea	purslane	weedy, invasive, field weed
	Uvularia sp.	bellwort	spring flowering, woodlands
	Mollugo verticillata	carpetweed	gardens, waste places
	Viola sp.	violet	variety
	Barbarea sp. (*B. othoceras?*)	American yellowrocket? winter-cress	meadows, riverbanks, grasslands: variety
	Verbena sp.	vervain	weedy, invasive biennial, perennial
Grasses			
	Poaceae	grass family	—
	Agropyron sp.*	wheat grass	weedy, invasive, field weed
	Digitaria sp.	probably fall witchgrass	dry prairies, old fields
	Echinochloa sp. (muricata?)	barnyard grass	heavily disturbed area to wetlands
	Panicum sp. (capillare?)	switch/panic grass	waste places, field weed
	Elymus sp. (?) (canadensis?)	rye grass	perennial, variety of soil,
	Hordeum pusillum/jubatum	little barley	open ground
	Glyceria sp.	manna grass	weedy, invasive, field weed

Continued

TABLE 1

CONTINUED

Type	Scientific Name	Comon Name	Habitat
Herbaceous Fleshy Fruit			
	Empetrum nigrum	black crowberry	perennial shrub, acidic soils, bogs
	Fragaria sp.	strawberry	sunny, open places
	Potentilla sp.	cinquefoil (strawberry-like seeds)	alluvial soils, prairies
	Solanum americanum	American nightshade	openings, commonly spreads to cultivated land
	Physalis sp.	perennial, ground cherry	weedy, invasive
	Vaccinium sp.	blueberry	perennial shrub, dry, open areas, bogs
Aquatic/Mesic			
	Cyperaceae	sedge	mesic, wetlands
	Glyceria sp. (?)	manna-grass	perennial, damp, wet shores
	Sagitaria latifolia	arrowhead	wetlands
	Sagitaria latifolia	arrowhead tuber	wetlands
	Typha latifolia	cattail	wetlands
	Zizania sp.	wild rice	wetlands
Arboreal Fleshy Fruit			
	Aralia sp.	spikenard	river banks, woods, clearings (dep. on species)
	Celtis sp.	hackberry	woodlands, rocky slope, bottomsland
	Cornus sp.	dogwood	middle succession, edges
	Crataegus sp.	hawthorn	early to mid succession, old fields
	Prunus sp.	cherry/plum	woods, openings
	Rubus sp.	bramble	edges, early-mid succession
	Sambucus canadensis	elderberry	damp, rich soils
	Sorbus sp.	mountain ash	open habitats, can tolerate some shade
	Sassafras sp.	sassafras	woods, thickets, can be weedy
Arboreal Dry Fruit			
	Hamamelis virginiana	witch-hazel	woods
	Ostrya and *Carpinus* sp.	ironwood, hornbeam	woods
	Rhus typhina	sumac	weedy, open areas, old fields
Vine			
	Vitis sp.	grape	early to mid succession
Nut			
	Fagus sp.	beech	woods, openings
	Quercus sp.	oak	woods, openings
	Juglans sp.	butternut/walnut	woods, openings; butternut not shade tolerant
	Carya sp.	hickory	woods, openings
	Corylus sp.	hazelnut	thickets

*Introduced.

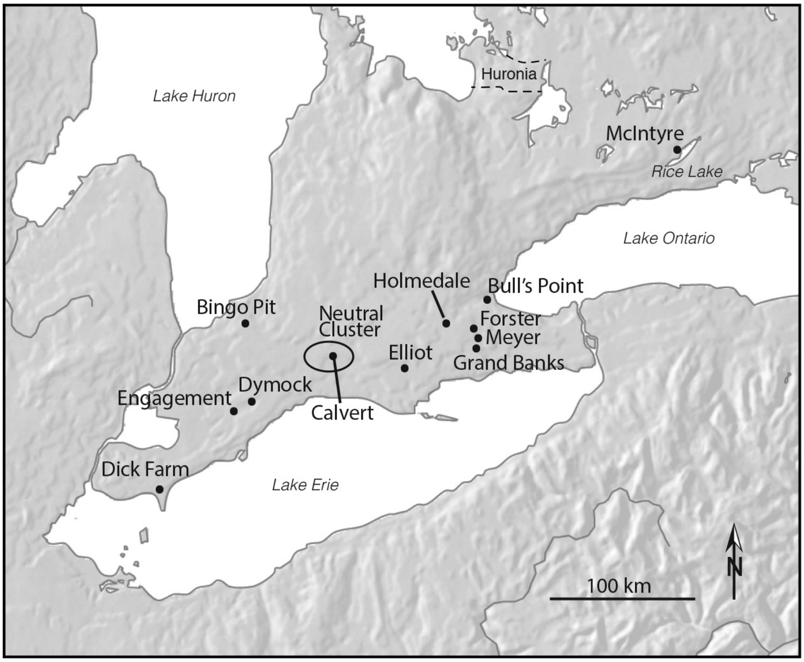

FIGURE 1 Location of sites mentioned in the text.

material evidence of Palaeoindian, Early Archaic, and Early through Late Woodland occupations is also reported (Johnston 1984:74–78). The Late Woodland samples are from two contemporaneous cultural traditions, the Western Basin Tradition (WBT) and the Iroquioan.[1] The two traditions appear to differ particularly in settlement structure and type, post-mortem treatment of human bone, lower dependence on maize in the WBT, and details of material culture (Murphy and Ferris 1990:271–277).

The LWI samples are from five Princess Point (PP) sites (ca. 1500–800 cal B.P.). The PP data are from four sites (Grand Banks, Meyer, Forster, and Bull's Point) tested as part of our Princess Point Project (Bowyer 1995; Crawford and Smith 1996; Crawford et al. 1997; Saunders 2002; Smith and Crawford 1995, 1997) and Holmedale, a CRM project in Brantford, Ontario (Monckton 1999; Pihl 1999). Grand Banks dates from early through late PP, while the other sites are mainly late PP. Two Glen Meyer sites, Calvert and Elliot, provide data from relatively well-established food producers that postdate both PP and the WBT data sets. WBT data are mainly from two Younge phase sites, Dymock I and II (Tables 1, 2, and 3) (Cooper 1982) dating from circa 1100–860 cal B.P. (see Figure 1) (Fox 1982a and b). Other WBT sites at which research is ongoing by cultural resource management (CRM) groups include Bingo Pit, where so far about 3,000 maize fragments have been reported in association with a complex settlement pattern including palisades and longhouse-like structures (Ferris and Wilson 2009). At the moment, no further details on the plant remains are available. Measurements of maize from the WBT Dick Farm site (early Springwells phase) (Murphy and Ferris 1990:249) are included

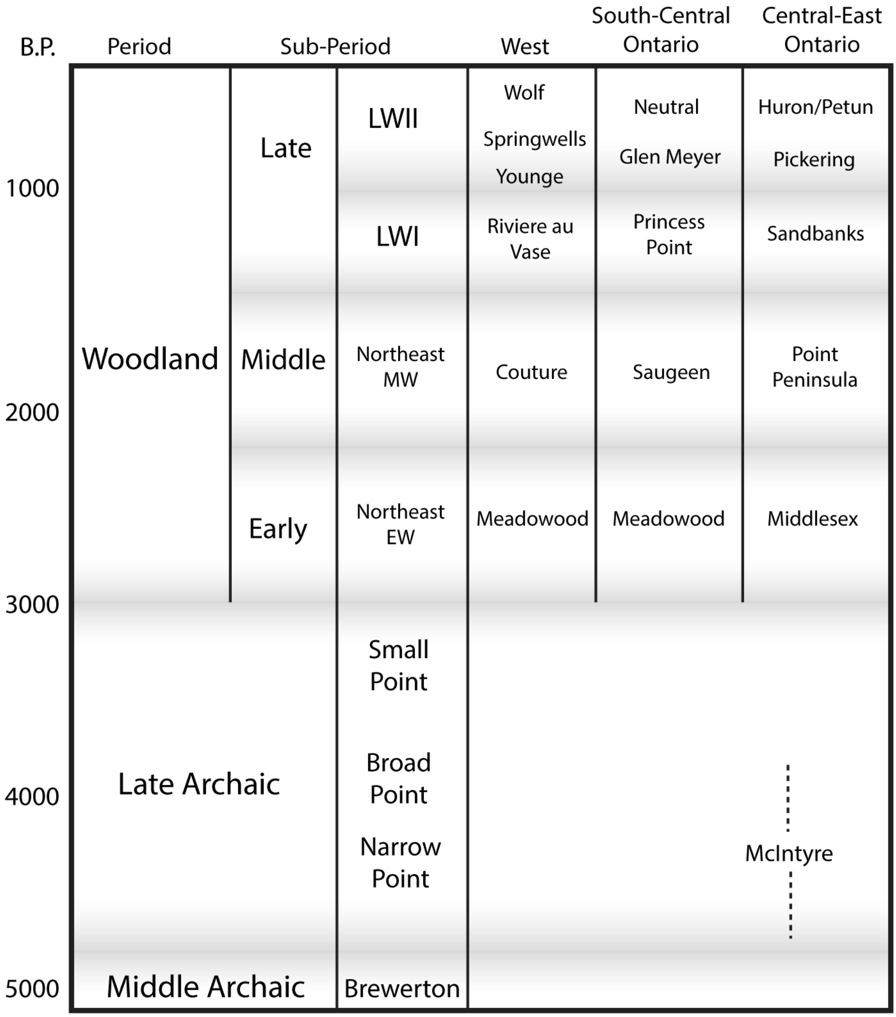

FIGURE 2 Cultural chronology relevant to southern Ontario and eastern Michigan. Riviere au Vase, Young, Springwells, and Wolf comprise the Western Basin Tradition.

here, but no other plant remains are reported from this site (Fecteau 1985). Flotation sampling from the LWI Engagement site, belonging to the Riviere aux Vase phase (ca. 1000–1400 cal B.P.) of the WBT, is ongoing but not yet available for this comparison. The precontact Neutral database is from a cluster of sites: Black Kat; Coleman; Harrietsville; Lawson; Pincombe 2, 5, and 6; Ronto; Smallman; and Windermere (see Figure 2) (Ounjian 1998).

The issues

The understanding of the development of food production in the Northeast is developing rapidly with the contributions of flotation sampling, phytolith and starch

TABLE 2

PLANT REMAINS AS A PERCENTAGE OF THE TOTAL NUMBER OF SEEDS PER SITE

	Archaic	Princess Point								Western Basin		Glen Meyer		Neutral
COMMON NAME	McIntyre	GB (Bowyer)	GB (Saunders)	GB (combined)	GB F. 210	Meyer	Forster	Bull's Point	Holmedale (PP)	Dymock I	Dymock II	Calvert	Elliot	Precontact
CROP														
maize kernels	—	19.0	1.9	5.3	2.3	11.5	1.6	30.9	1.9	11.1	24.0	8.1	4.2	10.6
cupules	—	18.5	2.8	6.0	2.8	23.1	21	26.2	1.9	.1	25.3	8.4	7.6	17.8
sunflower	—	—	—	—	.2	—	—	—	—	—	—	—	—	3.8
squash	—	—	—	—	—	—	—	—	—	.9	—	.4	.2	.2
common bean	—	—	—	—	—	—	—	—	—	—	—	—	—	.4
tobacco	—	—	—	—	—	—	—	2.9	—	—	—	.1	28.8	1.9
TOTAL	—	37.6	4.7	11.2	5.3	34.6	22.6	60.0	3.8	12.1	49.3	17.2	40.8	34.6
HERBACEOUS														
milkweed	—	—	—	—	—	—	—	—	—	—	—	.2	—	—
Aster/Composite	—	—	—	—	—	—	—	—	—	—	—	—	—	P
legume/bean family	—	—	—	—	—	—	—	—	—	—	—	—	P	—
hog peanut	—	—	—	—	—	—	—	—	—	.2	—	—	—	—
milk-vetch	—	—	.3	.3	5.1	—	.5	—	—	—	—	—	—	—
goosefoot	55.0	7.4	4.4	5.3	13.9	3.8	2.7	8.7	3.8	.2	.4	.2	.7	.2
dodder (parsitic)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
bedstraw	35.0	2.1	.3	.7	4.2	—	.5	1.1	7.5	—	—	.4	—	.1
peppergrass	—	—	—	—	—	—	—	.7	—	—	—	—	—	—
mint	—	—	.2	.2	—	—	—	—	—	—	—	—	—	—
wood sorrel	—	—	.2	.2	1.5	—	—	—	3.8	—	—	—	—	P
St. John's wort	—	—	.8	.7	2.6	11.5	—	—	1.9	—	—	—	—	—
white dock	—	—	—	—	—	—	—	—	—	—	—	—	—	.1
knotweed/ smartweed	11.4	—	.3	.3	.5	7.7	.5	—	—	—	—	.3	—	.5
erect knotweed	—	—	—	—	—	—	—	—	—	—	—	—	—	.2
purslane	—	—	79.2	69.0	—	—	—	—	—	.1	.1	.7	3.7	1.1
bellwort	—	—	—	—	—	—	—	—	—	—	—	—	—	P
carpetweed	—	—	—	—	—	—	—	—	—	—	—	—	—	P
violet	—	—	—	—	—	—	—	—	—	—	—	—	—	P
wintercress	—	—	—	—	—	—	—	—	—	—	—	—	P	P
foamflower	—	—	—	—	—	—	—	—	—	—	—	—	—	P
vervain	—	—	—	—	—	—	—	—	1.9	—	—	.2	—	—
TOTAL	82.3	9.5	85.9	76.7	27.8	23.1	4.3	10.5	18.9	.5	.6	2.1	4.5	2.3
GRASSES														
grass family	.2	9.5	3.6	5.0	.8	5.8	.5	.4	28.3	.3	22.3	.3	P	.4
wheat grass*	—	—	—	—	—	—	—	—	—	—	—	.1	—	—
probably fall witchgrass	—	—	—	—	—	—	—	—	—	—	—	.5	—	—
barnyard grass	—	—	—	—	1.4	—	—	—	—	—	—	—	—	.1
switch/panic grass	—	1.6	2.4	2.4	20.9	—	—	—	—	—	—	.3	.1	.1
rye grass	—	5.3	.7	1.6	—	3.8	—	—	—	—	—	—	—	—
little barley	—	—	.1	.1	12.4	—	—	—	—	—	—	—	—	—
TOTAL	.2	16.4	6.9	9.1	35.5	9.6	.5	.4	28.3	.3	22.3	1.2	.1	.6

Continued

TABLE 2

CONTINUED

	Archaic	Princess Point								Western Basin		Glen Meyer		Neutral
COMMON NAME	McIntyre	GB (Bowyer)	GB (Saunders)	GB (combined)	GB F. 210	Meyer	Forster	Bull's Point	Holmedale (PP)	Dymock I	Dymock II	Calvert	Elliot	Precontact
HERBACEOUS FLESHY FRUIT														
black crowberry	—	—	—	—	—	—	—	—	3.8	—	—	—	—	—
strawberry	—	—	.1	.2	—	9.6	—	.4	7.5	.1	—	1.9	10.1	8
cinquefoil (strawberry-like seeds)	—	—	—	—	.8	—	—	—	3.8	—	—	—	—	8.0
American nightshade	—	—	.1	.1	23.2	1.9	—	4.7	—	—	.1	1.4	1.9	33.0
perennial, ground cherry	—	1.1	—	.2	—	—	—	—	—	—	—	—	—	—
blueberry	P	—	.2	.2	.1	—	.5	—	3.8	—	—	—	—	—
TOTAL	P	34.4	.5	.7	24.1	11.5	.5	5.1	18.9	.1	.1	3.3	12.0	11.4
WETLAND														
sedge	—	—	—	—	.1	—	—	.4	—	—	—	.1	—	P
arrowhead	—	—	.1	.1	—	—	.5	—	—	—	—	—	—	—
arrowhead tuber	—	—	—	—	2.65g	—	—	—	—	—	—	—	—	—
cattail	—	—	—	—	3.2	9.6	—	4.4	3.8	—	—	67.1	32.3	5.9
wild rice	—	—	.1	.1	—	—	—	—	—	—	—	—	—	—
TOTAL	—	P	.2	.2	3.4	9.6	.5	4.7	3.8	—	—	67.2	32.3	5.9
TREE & SHRUB FRUIT														
spikenard	—	—	—	—	—	—	—	.4	—	—	—	—	.1	.3
hackberry	—	—	—	—	.1	—	—	—	—	—	—	—	—	—
dogwood	—	—	—	—	.2	—	—	—	3.8	—	—	—	—	—
hawthorn	3.5	—	.2	.2	—	—	—	.4	—	.2	—	.1	—	.1
cherry/plum	.3	—	—	—	—	—	—	1.1	—	—	—	—	—	—
bramble	3.1	1.1	.7	.8	3.7	11.5	71.5	17.1	9.4	2.7	3.5	1.3	8.2	35.6
elderberry	—	—	—	—	—	—	—	—	3.8	.1	—	—	.1	8.3
mountain ash	—	—	—	—	—	—	—	—	—	—	—	P	—	P
sassafras	—	—	—	—	—	—	—	—	1.9	—	—	—	—	—
TOTAL	6.8	1.1	.9	1.0	4.0	11.5	71.5	18.9	18.9	2.9	3.5	1.4	8.4	44.3
TREE: DRY, NON-NUT														
witch-hazel	—	—	—	—	—	—	—	—	3.8	—	—	—	—	—
ironwood, hornbeam	—	—	—	—	—	—	—	—	—	—	—	—	—	P
sumac	.1	1.1	.7	—	—	—	—	P	3.8	84.1	24.2	7.7	1.8	.8
TOTAL	.1	1.1	.7	.8	—	—	—	—	7.5	84.1	24.2	7.7	1.9	.8
VINE														
grape	4.6	—	.2	.2	—	—	—	.4	—	—	—	—	—	—
TOTAL NUMBER	7,472	189	860	987	1,670	52	186	275	53	1,272	691	19,694	7,051	39,108

GB is Grand Banks.
P is present.
Source: Two analyses are included, one by Vandy Bowyer (1995) and the other by Della Saunders (2002). Bowyer primarily analyzed the early, nonpit samples, while Saunders focused on the feature samples that tend to be later.

TABLE 3

PLANT REMAINS DENSITIES (NUMBER PER L) BY SITE

	Archaic	Princess Point								Western Basin		Glen Meyer		Neutral
COMMON NAME	McIntyre	GB (Bowyer)	GB (Saunders)	GB (combined)	GB F. 210	Meyer	Forster	Bull's Point	Holmedale (PP)	Dymock I	Dymock II	Calvert	Elliot	Precontact
CROPS														
maize/corn kernels	—	.03	.02	.02	.21	0.1	.02	.01	.49	.63	.31	1.37	.23	2.54
cupules	—	.03	.02	.02	.25	0.19	.24	.01	.42	—	.33	1.42	.41	4.26
sunflower	—	—	—	—	.02	—	—	—	—	—	—	.01	—	.91
squash	—	—	—	—	—	—	—	—	—	.05	—	.07	.01	.04
common bean	—	—	—	—	—	—	—	—	—	—	—	—	—	.09
tobacco	—	—	—	—	—	—	—	—	.05	—	—	.02	1.56	.45
TOTAL	—	.05	.04	.05	.47	0.29	.26	.01	.96	.68	.65	2.89	2.21	8.29
HERBACEOUS														
milkweed	—	—	—	—	—	—	—	—	—	—	—	.04	—	—
Aster/Composite	—	—	—	—	—	—	—	—	—	—	—	.01	—	.01
legume/bean family	—	—	—	—	—	—	—	—	—	—	—	—	P	P
hog peanut	—	—	—	—	—	—	—	—	—	.01	—	—	—	—
milk-vetch	—	—	—	—	.46	—	.01	—	—	—	—	—	—	—
goosefoot	.62	.01	.04	.02	1.25	0.03	.03	.01	.14	.01	.01	.04	.04	.06
dodder (parsitic)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
bedstraw	.50	—	—	—	.38	—	.01	.03	.02	—	—	.06	—	—
peppergrass	—	—	—	—	—	—	—	—	.01	—	—	—	—	—
mint	—	—	—	.02	—	—	—	—	—	—	—	—	—	—
wood sorrel	—	—	—	—	.13	—	—	.01	—	—	—	—	—	—
St. John's wort	—	—	.01	—	.23	.10	—	.01	—	—	—	—	—	—
dock	—	—	—	—	—	—	—	—	—	—	—	—	—	.03

Continued

TABLE 3

CONTINUED

COMMON NAME	Archaic	Princess Point								Western Basin		Glen Meyer		Neutral
	McIntyre	GB (Bowyer)	GB (Saunders)	GB (combined)	GB F. 210	Meyer	Forster	Bull's Point	Holmedale (PP)	Dymock I	Dymock II	Calvert	Elliot	Precontact
knotweed/smartweed	.02	—	—	—	.04	.06	.01	—	—	—	—	.04	—	.12
erect knotweed	—	—	—	—	—	—	—	—	—	—	—	—	—	.05
purslane	—	—	.66	.28	—	—	—	—	—	—	—	.12	.20	.27
bellwort	—	—	—	—	—	—	—	—	—	—	—	—	—	.01
carpetweed	—	—	—	—	—	—	—	—	—	—	—	—	—	.02
violet	—	—	—	—	—	—	—	—	—	—	—	P	—	—
winte-rcress	—	—	—	—	—	—	—	—	—	—	—	—	—	.11
foamflower	—	—	—	—	—	—	—	—	—	—	—	—	P	P
vervain	—	—	—	—	—	—	—	.01	—	—	—	.04	—	—
TOTAL	1.14	.01	.72	.32	2.49	0.19	.05	.06	.17	.03	.01	.35	.24	.56
GRASSES														
grass family	P	.01	.03	.02	.07	.05	.01	.10	.01	.02	.29	.05	—	.08
wheat grass*	—	—	—	—	—	—	—	—	—	—	—	.01	—	—
probably fall witchgrass	—	—	—	—	—	—	—	—	—	—	—	.09	—	—
barnyard grass	—	—	—	—	.13	—	—	—	—	—	—	—	—	.02
switch/panic grass	—	—	—	.01	1.88	—	—	—	—	—	—	.05	.01	.02
rye grass	—	—	—	.01	—	—	—	—	—	—	—	—	—	—
little barley	—	—	—	—	1.11	—	—	—	—	—	—	—	—	.01
Paniceae	—	—	—	—	—	—	—	—	—	—	—	—	—	.01
TOTAL	P	.02	.06	.04	3.19	.08	.01	.10	.01	.02	.29	.20	.01	.15
HERBACEOUS FLESHY FRUIT														
black crowberry	—	—	—	—	—	—	—	.01	—	—	—	—	—	—
strawberry	—	—	—	—	—	—	—	.03	.01	—	—	.32	.54	1.92
cinquefoil	—	—	—	—	.08	—	—	.01	—	—	—	—	—	—
American nightshade	—	—	—	—	2.08	.02	—	—	.08	—	—	.23	.10	.80
perennial, ground cherry	—	P	—	P	—	—	—	—	—	—	—	—	—	—

blueberry	P	—	—	—	.01	—	.01	.01	—	—	—	—	—	—
TOTAL	P	—	—	—	2.17	.10	.01	.06	.08	—	—	.55	.65	2.72
WETLAND														
sedge	—	—	—	—	.01	—	—	—	.01	—	—	.01	—	—
arrowhead	—	—	—	—	—	—	.01	—	—	—	—	—	—	—
arrowhead tuber	—	—	—	—	.01	—	—	—	—	—	—	—	—	—
cattail	—	—	—	—	.29	.08	—	.01	.07	—	—	11.29	1.75	1.41
wild rice	—	—	P	P	—	—	—	—	—	—	—	—	—	—
TOTAL	—	—	—	—	.32	.08	—	.01	.08	—	—	11.29	1.75	1.41
TREE AND SHRUB FRUIT														
spikenard	—	—	—	—	—	—	—	—	.01	—	—	—	—	—
hackberry	—	—	—	—	.01	—	—	—	—	—	—	—	—	—
dogwood	—	—	—	—	.02	—	—	.01	—	—	—	—	—	.01
hawthorn	.05	—	—	—	—	—	—	—	.01	.01	—	.02	—	.03
cherry/plum	P	—	—	—	—	—	—	—	.02	—	—	—	—	—
bramble	.04	—	.01	—	.33	—	.83	.03	.27	.15	.05	.21	.44	8.52
elderberry	—	—	—	—	—	—	—	.01	—	—	—	—	—	1.98
mountain ash	—	—	—	—	—	—	—	—	—	—	—	P	P	—
sassafras	—	—	—	—	—	—	—	.01	—	—	—	—	—	—
TOTAL	.09	—	.01	—	.35	—	.83	.06	.30	.16	.05	.23	.45	10.61
TREE:DRY, NON-NUT														
witch-hazel	—	—	—	—	—	—	—	.01	—	—	—	—	—	—
ironwood, hornbeam	—	—	—	—	—	—	—	—	—	—	—	—	—	.01
sumac	P	—	.01	—	—	—	—	.01	—	4.76	.32	1.30	.10	—
TOTAL	—	—	.01	—	—	—	—	.03	—	4.76	.32	1.30	.10	.19
VINE														
grape	.06	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTAL NUMBER	7,472	189	860	987	1,670	52	186	275	53	1,272	691	19,694	7,051	39,108
TOTAL VOLUME	5,415	1,358.5	1,032.5	2,391	186	62	161	172	155	225	527	1,171	1,302	1,634
TOTAL DENSITY	1.40	.14	.83	.41	8.98	.84	1.16	1.6	.34	5.65	1.3	16.82	5.42	24.0
MINIMUM TAXA	15	15	25	27	24	12	11	18	20	13	9	32	22	41
TAXA/DENSITY RATIO	10.9	1,07.1	30.0	65.9	2.67	14.3	9.52	11.3	58.8	2.301	6.9	1.9	4.1	1.7

P is present.

grain analysis, and isotopic studies of human bone as well as its proxies (Crawford, Saunders, and Smith 2006; Crawford and Smith 2002; Crawford et al. 1998; Dewar et al. 2010; Ferris and Wilson 1999; Foreman 2011; Hart 1999; Hart et al. 2003, 2007; Katzenberg et al. 1995; Monckton 1999). With some exceptions, these studies emphasize maize: when it arrived, when it became a significant dietary component, and how it adapted to the Northeast. Hart's (1999) expansion of coevolutionary and Darwinian theory to examine the influences on the transmission and development of maize in the Northeast still needs testing in the context of the broader behavioral and ecological setting.

Distinguishing between pristine (or primary) and secondary origins of agriculture is important to understanding ecological developments in the Northeast. Pristine origins are a local process in which domestication and agricultural technology and agricultural ecology develop in relative isolation. Secondary origins involve the introduction of crops and associated food production behaviors into regions neighboring pristine settings (see Cowan and Watson1992 for amplification). In eastern North America, both processes unfolded, but the Northeast and Ontario, in particular, have no evidence of pristine origins. Research on pristine origins usually explores climate change, demography, and ecological issues, whether they are a result of behavioral ecology or anthropogenesis and niche construction (Price and Bar-Yosef 2011; Zeder 2012). In contrast, research on secondary agricultural origins in Ontario tends to focus on the timing of crop introductions and the development of year-round communities sustained by maize production. Increased cultivation as a response to demographic pressure has been viewed as a reasonable hypothesis, particularly in the migration model for northern Iroquoian origins (Snow 1995). Yet the migration hypothesis has significant problems (Crawford and Smith 1996). I won't address these explanations here; rather I add broader ecological issues to the discussion by focusing on the appearance and characteristics of the Iroquoian niche.

We are fortunate to have at least a few descriptions of portions of the Northeast in the early seventeenth century. Champlain, for example, remarked that in the land of Attigouautan (in Huronia) he found "this part being very fine, mostly cleared" (Biggar 1932:44) and that there were good "pastures in abundance" to the extent that he thought raising stock there quite feasible (Biggar 1932:130). He described the Montreal area as "a well cleared country where they plant much Indian corn, which comes up very well, as do also squashes and sunflowers, from the seeds of which they make oil wherewith they anoint their heads" (Biggar 1932:50). He was also impressed with the abundance and variety of fruit such as strawberries, raspberries, and plums (Biggar 1932:51). The number of people in Iroquoian regions was also notable, being "well peopled with a countless number of souls" (Bigger 1932:50). Furthermore, abandoned fields and villages provided correctly aged trees for construction of longhouses and palisades. The dense Iroquoian populations were feasible not only because of food production but also because of the anthropogenic nature of the mosaics of variously aged seres (of terrestrial ecosystems). This in turn impacted the fauna by providing expanded habitat for deer and a range of other animals that proliferate along forest edges and openings. Deer, for example, may benefit from more extensive forest edges, increased understory vegetation in early succession woodlands, and increased winter food availability (imperfect maize harvesting by people, increased forage in an around fields) (e.g., see Côté et al. 2004; Fuller and Gill 2001). The point is that culture, human biology and demography, vegetation, fauna, and abiotic components interact and influence each other.

Intensification of food production (support of higher populations, higher resource availability, increased labor directed to food production, etc.) in Ontario involves (but not exclusively) interaction between maize and people, but the causal arrow usually points in one direction, emphasizing the inevitable impact of maize on settlement and other aspects of culture. One important exception is Hart's (1999) examination of the selection forces on maize in northern latitudes (e.g., the evolution of Northern Flint). The WBT trajectory, thought to involve high mobility, particularly through the Younge phase, is usually considered to differ from the Iroquoian trajectory. The seasonal mobility hypothesis has been modified recently to include new data on animal remains and significant maize consumption in a flexible and somewhat sedentary settlement system (Foreman 2011). PP settlement system evidence is ambiguous but so far includes no indication of winter occupations; instead, occupations appear to be part of a "centered settlement system" (Crawford and Smith 2002; Crawford et al. 1998; Foreman 2011; Haines et al. 2011; Smith and Crawford 1997). Both WBT and PP people were oriented in some significant way to aquatic resources and habitats and both subsistence systems were mixed; that is, they had a combination of hunting, fishing, gathering, and farming. Chronological overlap of Middle Woodland with LWI in Ontario (Smith 1997) suggests that the transition from Middle Woodland to LWI, particularly those aspects involving the adoption of maize production, was not synchronous.

Niche construction

Models of settlement systems and the intensification of food production in Ontario need to be informed by ecological models that go beyond describing generic habitats, seasonality, and specific crops. A human ecological approach offers a more holistic method, with one of its major tenets being interaction among the various components of culture on the one hand and biotic and abiotic components on the other. Niches are species specific and defined with respect to an occupant and are relativistic (Odling-Smee et al. 2003). A niche is not the same as a habitat. The concept is also concerned with what a species is *doing*. It is especially relevant to evolution, a niche being the "sum of all the natural selection pressures to which the population is exposed" (Odling-Smee et al. 2003:40). Barth (1956), in perhaps the first consideration of cultural niches, suggests that cultures are analogous to species and introduces the niche concept to explore the coexistence of distinct adaptations in Swat. Barth's niche definition—"the place of a group in its total environment, its relations to resources and competitors" (Barth 1956:1079)—is consistent with the relativistic niche concept (Odling-Smee et al. 2003:38). Furthermore, habitats are normally influenced by species actions. For people, these actions fall under the umbrella of "anthropogenesis." Anthropogenesis has informed archaeology, particularly paleoethnobotany, for a long time (e.g., Crawford 1984, 1997; Dean 2010; Minnis 1978; Yarnell 1965).

Ecosystems are affected by organisms in predictable ways called "niche construction" or "ecological engineering" (Odling-Smee et al. 2003:38). These effects are implemented through engineering or control webs (Jones et al. 1997) or, simply put in the case of precontact people in Ontario, through the creation and maintenance of living spaces, burning, resource management, field construction, and so on. These are active and proactive processes (Odling-Smee et al. 2003) that can involve agency; people make informed decisions about these actions. These activities or "controls" have a feedback relationship between people and resources (Jones et al. 1997). People have always been niche constructors to varying degrees (Smith and Wishnie 2000). Hunter-gatherer-fishers are not exceptions, although the focus in archaeology tends to be on farmers. Crop adaptations and, ultimately, their success were influenced by settings that were determined by sunlight, temperature, soil chemistry, and so on, as well as by human-mediated changes to ecosystems (anthropogenesis). Ecologists have long recognized the interactive basis of evolution, and since the 1980s, the niche construction rubric has attempted to formally explicate the process (Odling-Smee et al. 2003). Human ecology embraces interaction and reciprocity as fundamental principles, so niche construction holds great promise for better understanding human niches in precontact Ontario. Niche construction is advantageous because it is observable, whereas adaptation is inferred (Smith 2007a, 2007b). In the archaeological record, this is particularly useful in that not only are plant and animal remains relevant but so is technology, as a mediator of human interaction with the environment. The built environment also offers insight into niche construction (Odling-Smee and Turner 2012). Technology is a component of understanding what people were "doing." This is particularly true in the case of small-scale food-producing societies (Collard et al. 2011), such as the precontact Iroquoians (LWII). Niche construction became more extensive and intensive in food-producing societies (Smith 2007a). Much of this ecological engineering among food producers spurred population growth and is associated with tool kits that are less affected by risk than those of hunter-gatherers; in other words, niche construction has an impact on the evolution of technology (Collard et al. 2011).

My own approach has been informed by anthropogenesis, while other human ecological perspectives involve domesticated landscapes and agricultural ecology, to name two others (Crawford 2008; Terrell et al. 2003). The latter two approaches also eschew classifying cultures as either agricultural or hunter-gatherer. In the case of Japan, I have argued for a more nuanced, less categorical approach to understanding Jomon subsistence, as have Terrell and colleagues (2003) in their proposal for a provisioning spreadsheet approach. My emphasis on niche construction should not be construed as in disagreement with the domesticated-landscape perspective, which appears in many ways to be a form of niche construction. Here I take from these approaches to encourage viewing cultural developments, particularly those related to subsistence in Ontario, in a more nuanced way, be it through conceptualizing anthropogenesis, domesticated landscapes, or culturally constructed niches. Niche construction has not been explored in archaeology to any great extent, but its potential has been outlined in several instances (Bleed 2006; Rowley-Conwy and Layton 2011; Smith 2007a, 2007b, 2012). These approaches are fundamentally multifactorial and evolutionary in scope.

The focus here is on plants in the Ontario archaeological record, but the potential for zooarchaeological research to contribute to an ecologically nuanced approach is largely untapped in the province. I acknowledge that animal ecology is essential to a holistic perspective but do not address that here, except to point out that we are a long way from integrating plant and animal remains analyses to address ecological issues in Ontario archaeology. One recent investigation on the WBT in Ontario is informed by zooarchaeological data and is a constructive attempt to take a fresh view of the WBT settlement system (Foreman 2011). However, I suggest that it, like many other zooarchaeological studies, is premised on a "niche chasing" model (Bettinger 2001) rather than on niche construction or reciprocity. Substitute the word *animal* for *niche* and one way to interpret this is clear: People are chasing animals; animal-population composition and demographics are independent of people and their activities. Neither a feedback nor a predator-prey relationship enter the equation. People, largely as a result of anthropogenic vegetation changes that influenced variables such as cover and food availability, likely influenced the distribution and population of terrestrial animals too.

Paleoethnobotany, whose main purpose is to examine human-plant interaction, can contribute to the study of niche construction in substantive ways. For example, plant taxa have specific requirements—light, water, soil, nutrients, and so on—that determine their place in ecological succession. Crops could be considered early successional species, but they are not the only ones; weedy taxa also share habitats with these crops. Human activities, such as collecting firewood and construction material and clearing around and in fields, are aspects of niche construction.

Coupled with this is the historical ecology of eastern North America (ENA), which has made us increasingly aware of the lack of pristine environments in precontact times (Delcourt and Delcourt 2004; Denevan 1992). Ecologically engineered habitats were probably the norm in most areas of ENA. Champlain likely was not exaggerating when he described the economically rich and open habitats. Human-induced habitat heterogeneity is a crucial aspect of niche construction (e.g., Crawford 1997). Yarnell, too, pointed out that mobile hunters and gatherers who consistently returned to the same locations on a seasonal basis were doing so because these repeatedly used habitats were rich plant-collecting and hunting habitats (Yarnell 1964). Passing on to the next generation the location and the significance of these locales and continuing use of them so as to maintain some level of ecological impact is an aspect of ecological inheritance as conceptualized by Odling-Smee and colleagues (2003:12). The larger populations of food producers along with their more permanent settlements would have left a much greater impact on the landscape. Villages that were abandoned every 15 to 20 years were unlikely to be useless spaces. These spaces probably continued to be used for resource production and extraction, such as for fruit harvesting and hunting. Ecological succession on old village land would have been an important aspect of habitat heterogeneity. The issue is more complex than I can outline here, but my discussion of the paleoethnobotany of and the development of food production in Ontario is generally informed by niche-construction theory. Operationalizing the niche concept involves the analysis of "utilization distributions comprising frequency histograms of the resources used by populations" (Odling-Smee et al.

2003). This is similar to the methodology proposed to elucidate "domesticated landscapes" (Terrell et al. 2003). Tables 2 and 3 are quantitative archaeobotanical data compiled to explore whether meaningful utilization distributions are present and to conceptualize niche construction from before the onset of food production to late precontact/early contact in Ontario.

The plants and their habitats

Well over 60 plant taxa are regularly recovered by flotation from sites in southern Ontario (see Tables 1, 2, and 3). A few taxa are not listed due to their low representation, as well as their singular presence in Neutral contexts. Some listed plants, mainly five herbaceous plants in Table 1, are limited to the Neutral samples. All other plants have at least one record in an earlier context. The plant assemblages, at least their major groupings, are characterized more by their qualitative similarities than by their differences. Significant differences among the assemblages include single taxa presence or absence and differences in taxa diversity (in this case taxa number). Contrasting patterns or trends do not emerge from a qualitative perspective. The main exception is the absence of the LW crops in the Archaic assemblage. Most taxa are early succession plants growing in open, sunlit habitats, many of which are periodically and sometimes severely disrupted. Most of the shrubs and trees in the assemblages are more productive in anthropogenic settings. While qualitative differences among the sites are not present, quantitative differences are evident.

The ecological impact of relatively small populations regularly using the same location is evident at McIntyre. Among the 15 taxa recovered, 7 are in high percentages and densities, meaning diversity is relatively low (see Tables 2 and 3). However, acorn, butternut, goosefoot, and the four fleshy fruits were gathered mainly from clearings, forest edges, thickets, and groves opened by human activities, such as selective cutting and probable burning (Yarnell 1984:109). Butternut is rare and grows only sparingly as a scattered tree in southern Ontario woodlands (Hosie 1969:134; Yarnell 1984:101). Its high density at McIntyre strongly points to anthropogenesis. Butternut, Canada plum and chokecherry, are trees whose distribution may have been influenced by First Nation people in southern Canada and whose management probably began well before food production in the province (Black 1980; Yarnell 1984). Tree management is not a far-fetched concept; evidence shows it as having been important to aboriginal Californians and other small-scale societies around the world. The cultural management of trees is multifaceted and deserves far more attention than it currently receives (e.g., Turner et al. 2009).

The prevalence of cleavers at McIntyre is not explained; six species are native to southern Ontario (Gray and Fernald 1950). None appears to be anthropogenic. Flotation samples from the Scott-O'Brien site in Mississauga contain fleshy fruits common to forest edges and a number of annual herbaceous plants: goosefoot, cat-tail, peppergrass, and cleavers; arboreal plants include acorn, birch, dogwood, and ironwood (Williamson and Pihl 2002). The diversity and quantities of these plants indicate a pre-LW anthropogenic ecology distinct from that of food producers in Ontario.

The first confirmed evidence of a crop and associated food-producer niche in Ontario is maize dating to the fifth century A.D. in the Grand River valley (Crawford et al. 1997). Sunflower, tobacco, and squash occur several centuries after maize (see Tables 2 and 3). I hypothesize that the late Ontario Iroquoian niche was in its nascent stages during the early PP. None of the latter three crops have been directly dated, but they are all from relatively late PP contexts (after cal A.D. 1000). Little barley, a potential crop, has been recovered from one PP feature, so its presence alone is significant. It possibly indicates ties through exchange networks with the south because it is not indigenous to Ontario. Little barley is reported from only one other site in the province (Pincombe 5, in the Neutral Cluster) (see Figure 1). *Chenopodium* and erect knotweed are two other potential crops, but their quantity (in the case of erect knotweed) and morphology (in the case of *Chenopdium*) suggest that they are not domesticated forms. Sunflower has been recovered at only one PP site (late) and does not appear again until the Glen Meyer culture phase. Squash is common at Dymock I and in Glen Meyer and precontact Neutral occupations. Tobacco is reported from one Princess Point site (Holmedale) and subsequently in Glen Meyer and Neutral contexts (Monckton 1999; Ounjian 1998).

Maize kernels and cupules (cob fragments) are represented in all LW sites considered here. The density of maize is lowest during the early PP, while late PP maize densities are significantly higher. The late PP Holmedale site maize densities are the same magnitude as those from Dymock I and II and Elliot. Calvert and the precontact Neutral Harrietsville site have the highest densities reported here. Unsurprisingly, maize densities mirror total crop densities because of the dominance of maize in the assemblages. In general, these densities are relatively low in Princess Point contexts, with the exception of relatively late PP sites. Dymock I and II densities are comparable to those from Holmedale, amounting to close to one specimen per L. Glen Meyer and Neutral densities are considerably higher, ranging from 3 to 6 specimens per L. The density of crop remains generally increases through time.

Grass-family seeds (caryopses) are found in extremely low densities in the Archaic assemblage but are far more common and diverse in LWI and II. Densities (see Table 3) probably better inform the comparison than do percentages (see Table 2). The apparent low diversity of grasses in a few of the assemblages is likely an analytical issue because some analysts do not further identify caryposes. Where taxonomic distinctions are noted, the taxa are in the Triticeae and Paniceae tribes, two groups that are commonly associated with people elsewhere in the world. No chronological pattern is clear other than their comparatively low representation in the Late Archaic. Unless grasses had a significant economic importance that would also result in their having been charred, their representation in any quantity is unusual here. As a comparative example, in Chinese neolithic samples that I have analyzed, small grass seeds are common and associated with an economy that produced small-grained grasses as crops (Crawford et al. 2005; Lee et al. 2007). Weedy grasses in the Chinese example are probably a result of incidental harvesting as well as the use of dung fuel. The situation in precontact Ontario is quite different. Grasses were probably more prevalent in the local ecology than their quantities in the assemblages indicate. They may be evidence of the "pastures" reported by the first European travelers to the region.

A minimum of 21 taxa of nongrasses are among the herbaceous plants. About half are relatively common. The diversity of the plants is similar throughout LWI and LWII. Only two, milk-vetch (a legume with high fire tolerance) and St. John's wort (a weedy perennial), are restricted to PP sites. Peppergrass, common in late precontact Huronia sites (Monckton 1992), is reported from Holmedale but not from other sites in this comparison. *Chenopodium* sp. and purslane are the most common in this group and are found in both LWI and II. They are pioneer weeds and economically useful as herbs. *Chenopodium berlandieri*, of course, is also well-known as an indigenous crop in eastern North America, but Ontario examples do not appear to be this species. However, we should not discount the possibility that the plant was encouraged to grow in fields. *Polygonaceae* achenes are quite common and in high densities in the precontact Neutral. Wetland and damp ground plants are represented by a few species in the LW. The PP and WBT sites under consideration are all situated close to water. The LW II sites are not as close to large bodies of water, but all are near wetlands.

Dry fruits of trees and shrubs include sumac "berries" and nuts. While sumac is present in all periods, it is recovered in substantial quantities at Dymock and Calvert. Sumac is a perennial of anthropogenic habitats, such as old fields and settlements. This may well be a plant that flourished in the heterogeneous mix of abandoned settlements and their fields as well as in sunny disturbed habitats in and around occupied villages. Sumac has utility as a food, for making tea, for smoking (the leaves), and for a wide variety of medicinal purposes (Moerman 1999). Like butternut at McIntyre, one could hypothesize sumac management as a secondary outcome of old field succession. The butternut management hypothesis for McIntyre would represent more primary tree management. Walnut/butternut and acorn are the two commonly represented nuts. Densities have no clear pattern through time. They are poorly represented especially when compared to the Archaic period (McIntyre site). The fleshy fruits, particularly *Rubus* (bramble/raspberry/blackberry), are among the highest density plant remains at Neutral sites, followed by elderberry. It is also in high densities in Huronia samples (Monckton 1992).

The LW plant remains are, on the whole, from fields (crops and field weeds, including old fields), early successional open habitats and woodland edges, and wetlands; there are a few midsuccession plants, including some perennial shrubs. Nut trees (e.g., butternut/walnut, hickory, and acorn) are productive on forest edges and in openings, although butternut in particular is a minor component of forests. Plum and cherry are also sparse in southern Ontario woodlands.

The percentages of the plant groups vary. For example, crop percentages vary from about 4 to 60 percent, with no chronological trend evident after their introductions. This is probably due to sample size, taphonomy, and abundance of other plant remains. After all, percentages simply indicate relative abundance. Crop densities, on the other hand, increase over time. Herbaceous plants and grasses have the highest overall representation, and their overall densities are generally higher than the crop densities. The relative abundance (percentage) of fleshy fruit from trees is the highest of all plant remains in two instances: bramble at Forster and precontact Neutral sites. In terms of density, bramble is unusually dense only in the precontact Neutral assemblage. Nuts are represented throughout the sequence but appear to have been an important resource based on both densities and percentages only during the Late Archaic. Of course, this is a measure of material importance and cannot address cultural importance, which can be attributed even to rare plants.

Northern Flint maize: An update

We have outlined in a previous study that the evidence for maize varietal development in Ontario does not contradict the model that suggests that the ancestor of maize in Ontario is a type of Northern Flint, also known as Eastern Eight-Row maize (Crawford et al. 2006). That is, the earliest maize in Ontario (Grand River valley) appears to have been an eight-row variety (so the evolution of the distinctive Northern Flint maize typical of the Northeast began outside Ontario). Maize kernels dating before A.D. 1100 from both Ontario and eastern Michigan are smaller in size than later archaeological maize from the region. PP kernels are about one-third smaller than LWII kernels. Cupules are smaller too. However, there is no significant difference among the row numbers of the various populations. Northern Flint maize can be hypothesized to have developed by the PP period and continued to have evolved through the LWI and early LWII. Testing a selection model (Hart 1999) based on environmental heterogeneity, multiple founder events, and phenotypic variability should also include the mosaic of habitats that resulted from human niche construction before and after agroecology developed. In Ontario, niche construction is evident during the Late Archaic but it involves a different balance of woody and herbaceous taxa than that found during the LWI and II.

The earliest substantial assemblage of maize in the study region is from the two Dymock localities; Dymock maize is compared here to five other assemblages. This is a larger sample of maize from Dymock I and II than reported previously by Cooper (1982). A total of 67 specimens are from Dymock I and 348 from Dymock II, among which a subset of complete kernels provides excellent measurements (Figure 3). The specimens from Dymock I average 8.8 x 6.7 x 4.7 mm and average 8.5 rows (i.e., the best fit of the population is to 8 rows of kernels per cob). The Dymock II kernels are statistically identical, averaging 8.9 x 6.8 x 5.1 mm and 8.2 rows. Kernel-angle measurements give us an estimate of 70 percent of the kernels being 6 or 8 row, meaning that the kernels are from relatively low row-number, in the range of 8, cobs. The remaining kernels are from 4- and higher-row cobs. This variation may be a result of charring distortion or kernels being from cob ends or from tiller cobs. It may also be an indication of greater variation in maize in the early first millennium A.D. The Dymock and Glen Meyer maize measurements are statistically identical but about 10 percent smaller than precontact Neutral kernels. In other words, Dymock I and II maize is phenotypically well-developed Northern Flint. Maize from another WBT occupation, the Dick Farm site (Fecteau 1985), is statistically identical in size and shape to the Dymock maize.

Kernel size, particularly length and width, increases continuously over a period preceding the Dymock and Glen Meyer occupations through the latest Huronia occupations (see Figure 3). Length and width increase over time while mean thickness

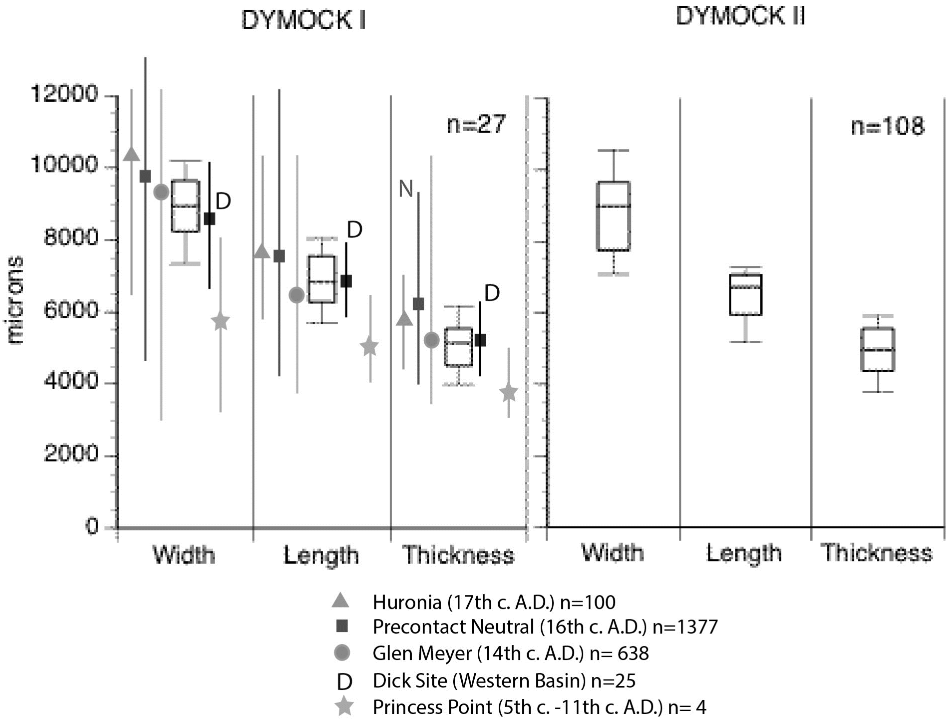

FIGURE 3 Comparison of maize kernel measurements from Dymock I and II with five other populations in the Ontario archaeological record. Only summary statistics are included for the five comparison populations.

shows little variation. Kernel length and width should correlate with the expansion of cob diameter and the typical broad shape of Northern Flint kernels.

Discussion

The comparative approach, at least initially, is useful in building an understanding of niche construction specifically as it concerns food production in precontact Ontario. The database for the LW in south-central Ontario is substantial, but unfortunately, we know considerably less about the paleoethnobotany of earlier periods. Niche construction is evident in both the Late Archaic and LWI and II; however, differences are largely attributable to food production in the LW. The McIntyre site has evidence of nut management as well as a variety of open and semiopen habitats, some of which are anthropogenic. The genera of plants from these habitats are also found in south-central Ontario sites, although the species vary. *Chenopodium gigantospermum* (maple-leaved goosefoot) found at McIntyre grows well in shade as well as in open habitats and seems to have been particularly suited to habitats less disturbed than we might find in the LW. The Middle Woodland is crucial to understanding the foundations of LW niche construction. At the moment, comprehensive flotation sample data are not available for this period. What little we know of the plant remains (e.g., from the Scott-O'Brien site; Monckton 1999) is vague and could fit any precontact culture in Ontario. However, the Middle Woodland settlement pattern is evidence that niche construction was of a different magnitude and quality than that of the Late Woodland of the region.

Middle Woodland sites are dispersed over the landscape in the region while PP sites are, with a few exceptions, situated close to river valleys and other bodies of water. The degree of sedentism at PP sites is ambiguous at best (Crawford et al. 1998; Haines et al. 2011; Smith and Crawford 1997). We have no clear evidence at PP sites for seasonal mobility, nor do we have a particularly clear idea of what the settlement system was. Nearly all the seeds and fruits in Table 1 mature in the fall, particularly by October. Strawberries and some grass species mature in the summer. Most of these can be stored, so the list of plants does not tell us when the sites were *not* occupied although they were clearly occupied in the summer and fall.

The later (LWII) WBT plant remains indicate that niche construction was similar to that of its contemporaries to the east in south-central Ontario. The predominance of maize, herbaceous plants, grasses, and some fleshy fruits, as well as tree fruits and nuts, although not as diverse as in other periods and cultures, fits the food-producing niche and is comparable to the Iroquoian niche. That is, nothing indicates a level of food production lower than that of the Glen Meyer. This means that the later WBT occupations were developing a longevity similar to that of the Glen Meyer. The predominance of a few taxa (maize, squash, sumac, and grasses) may be evidence for niche-construction activities that were subtly different from the Glenn Meyer and precontact Neutral. The prevailing wisdom, with reference to the WBT, is that "A.D. 1000–1300 is characterized as a time when loosely defined communities followed seasonally mobile subsistence rounds that saw groups coalesce and disperse during periods of resource abundance and scarcity" (Ferris and Wilson 1999). A revised perspective may be in order.

Fox (1982a) proposed that we keep an open mind about Dymock. Some of the characteristics of the occupation are consistent with a long-term, nonseasonal occupation, although some degree of mobility cannot be ruled out either. I doubt that it was strictly a warm-weather occupation. Reconsidering the WBT niche is overdue. Bone isotope data are consistent with a significant degree of maize dependence despite efforts to suggest that the data are anomalous (Dewar et al. 2010). They are considered anomalous simply because they are *similar to the LWII* (and presumably should not be). The anomaly can be resolved simply by recognizing that the Younge phase and later WBT occupied a niche similar to that of the Glen Meyer.

The plant remains do not offer straightforward insight on the intensification of food production or the change in dependence on maize. The sequential introduction of additional crops, particularly the common bean, can be viewed as intensification. The common bean provided an additional source of calories and nutrients and also provided amino acids complementary to those in maize (Kaplan 1965:359). Do the higher densities of nearly all groups of plant remains in the precontact Neutral indicate that niche construction was being amplified, po tentially as a result of ecological inheritance? Amplified niche construction would facilitate growing populations; evidence does not indicate negative ecological impact resulting in degradation of local systems and an inability to support growing human populations. Dependence on maize should be considered in the context of population size and density. The best working model/hypothesis assumes that population densities increased significantly with the onset of food production and that maize provided a resource that could accommodate this growth. Clearly, other plant resources, not just maize, were responding to niche-construction activities. Commensal plants, many of which were economically useful and potentially managed, also added to the resource base. Further research on animal resources could add to a more nuanced view of niche-construction.

The LWII (Iroquoian) niche that involved the use of anthropogenic resources and spaces—including old and active fields, occupied villages and abandoned village habitats and their surroundings—and the exploitation of wetlands either from settling next to them (in LWI) or settling some distance from them (as was more common in LWII) was probably established by A.D. 500 in the Grand River valley, Ontario. A survey of the Thames River drainage system found 41 sites from this phase along a less than 40 km stretch of the Thames River (Watts 2006a, 2006b). At the very least, Smith's team has put to rest any notion that the region was unoccupied at the time. Not only was the Grand River valley influenced by LWI peoples, so was the Thames River valley. In this context, maize developed into a local, large-kernel, Northern Flint both through local selection processes and through exchanging maize with groups elsewhere in the local vicinity and the neighboring regions.

Finally, starch-grain and phytolith analyses have not informed this discussion, although the potential for their contribution to the understanding of niche construction is high. Rather than only looking specifically for crop evidence in certain contexts, the complementary data sets derived from these analyses can broaden our understanding of plant use and ecology. For example, the paleosols at PP sites in the Grand River valley (Crawford et al. 1998) may well have an anthropogenic component to their development. Without understanding plant communities on these paleosols when they were formed, we may be missing a crucial aspect of PP success in the valley. Pollen is poorly preserved in the paleosols, but phytoliths are likely well represented.

The environment of the upper St. Lawrence River and Huronia that Champlain found to his liking and that was similar to the French landscape was millennia in the making. He was describing the results of niche construction of LWII peoples that had begun at least during the Late Archaic and probably earlier. The complex engineering web that resulted in the landscape he observed and that is reflected in the plant remains outlined here needs to be considered when investigating culture history in general and the onset and intensification of food production in Ontario specifically and in eastern North America in general. Investigating early agriculture is not only about cultural classification or the first appearance and spread of maize.

Acknowledgments

I would like to thank Maria Raviele and Bill Lovis for the invitation to contribute to the MAC conference in 2012. The symposium papers were all stimulating, and it was a pleasure to see how far we have come in understanding agricultural development in the Midwest, the Northeast, and Canada. Maria and Bill have also been very helpful with feedback on earlier versions of this paper. This paper has also benefited from the insights of Mary Simon, David Smith, and Sheahan Bestel. Rudy Fecteau generously provided the Dick site maize data. Much of the impetus to work on this topic came from stimulating conversations with Peter Bleed, Melinda Zeder, Bruce Smith, and Gyoung-Ah Lee.

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Note

1 The term "Iroquoian" is a general term for First Nations in the region who belong to the Northern division of the Iroquoian language family. Whether Princess Point people spoke ancestral Iroquoian is debated but for the sake of this discussion PP is considered Iroquoian.

MIDWEST ARCHAEOLOGICAL CONFERENCE INC. OCCASIONAL PAPERS No. 1, 2014, 161–174

A Critical Assessment of Current Approaches to Investigations of the Timing, Rate, and Adoption Trajectories of Domesticates in the Midwest and Great Lakes

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The adoptions of maize (*Zea mays* ssp. *mays*) and common bean (*Phaseolus vulgaris*) in the American Midwest remain critical lines of inquiry as the articles in this volume of *Midwest Archaeologial Conference Inc. Occasional Papers* amply demonstrate. Here I provide a critical assessment of current lines of investigation of crop adoptions and agricultural evolution. I argue that three changes are needed in order to build clearer understandings of these important issues: (1) the fuller integration of biological and social theories, (2) the adoption of probabilistic methods, and (3) the use of multiple lines of evidence.

KEYWORDS paleoethnobotany; agricultural evolution; maize; common bean

Crop histories and Native American agricultural evolution remain vital lines of research in midwestern archaeology. The articles collected in this volume provide a snapshot of the current state of affairs in Midwest agricultural research, reflecting a field in a state of transition. The Midwest is recognized as one of the world's "centers of domestication" (Bellwood 2005) based largely on work done in the 1970s and 1980s (e.g., see Ford 1978, 1985; Fritz 1990; Keegan 1987; Smith 1992). The Eastern Agricultural Complex (EAC), consisting of various starchy and oily "seed" annuals, including at least one subspecies of cucurbit (*Cucurbita pepo* ssp. *texana*), was used extensively in the Midwest prior to the widespread adoption of maize (*Zea mays* ssp. *mays*) and common bean (*Phaseolus vulgaris*). However, the adoption of these two crops, which originated in Mexico and in the case of common bean also Andean South America (Bunning et al. 2012; Gepts et al. 1986; Matsuoka et al.

2002), continues to attract the research interest of many archaeologists and paleoethnobotanists as the articles in this volume demonstrate. The reasons for this interest are manifold, but the fact that maize, common bean, and squash (*Cucurbita* spp.) and other bean species (*Phaseolus* spp.) dominated agricultural systems throughout the Western Hemisphere at the time of European incursions and, unlike most EAC crops, subsequently spread around the globe, are primary among them. Another reason is the legacy of the early and mid-twentieth century idea that the major cultural-historic fluorescences in the Midwest—Hopewell and Mississippi—were made possible only by maize-based agriculture and that less complex contemporaneous cultural-historic taxa occurred in areas with climatic conditions that did not allow intensive maize-based agriculture (see Hall 1980; Stoltman 1978). While this equation is rightfully no longer in vogue, understanding the adoption and spread of maize and common bean are important in the quest to understand how and why agricultural systems in the Midwest evolved. While the adoptions of these crops did not result in major cultural transformations, what eventually assembled as maize-bean-squash agriculture was part and parcel of the evolution of societies with varying material-culture expressions that archaeologists interested in the last 2,500 years of Native American history in the Midwest investigate.

The articles collected in this issue reflect current trends in Midwest agricultural research. While still largely anthropocentric, theories used to explore past agricultural behaviors are borrowing more purposefully from biology. Two major innovations during the second half of the twentieth century—flotation recovery of macrobotanical remains and accelerator mass spectrometry dating of important crop remains—continue to dominate the field's methods and techniques, but microbotanical analysis is beginning to make inroads. There generally remains, however, a reliance on single lines of evidence to interpret crop histories. While some consideration is given to processes that form the paleoethnobotanical records, there remains a strong sense in this collection of articles that what one recovers from the record in a given line of evidence is a direct reflection of crop and agricultural histories. Also reflected in this collection is the continued influence of mid-twentieth-century archaeological systematics on problem formulation and data interpretation, as well as a movement away from such reliance.

Three developments are needed as we proceed through the second decade of the twenty-first century. First, we need to build on theoretical advances that combine social and biological theory. After all, crops are biological organisms, not artifacts. It is the interactions of people with crops within particular environmental settings and the crops' responses to both that determine crop histories and affect agricultural evolution. Coupled with this is the need to ensure that our units of analysis are compatible with the theories that we use to explore the past. We should not just assume that twentieth-century cultural historic taxa are the proper units of analysis. Second, we need to adopt probabilistic methodologies to understand the paleoethnobotanical record. What are the probabilities that specific crop remains will enter the archaeological record, preserve in that record, and be recovered and identified? Third, we need to pursue multiple lines of evidence in constructing the histories of crops. Because of underlying probabilities, single lines of evidence are unlikely to provide complete evidence of crop histories. If each of these points is addressed, then we will be in a much better position than currently to build crop histories and explanations of agricultural evolution.

Theory

Plants are sessile organisms; their dispersals are often mediated by animals through movement of propagules. Because plants are sessile, they must be adapted to their specific locations in order to survive and reproduce. Humans are the primary vectors of agricultural crop dispersals. Every time a local human population in the Midwest adopted a new crop, the crop constituted a founder population (King 1987). Many factors contributed to the perpetuation of founder populations, such as their management by humans within a given domesticated landscape (Terrell et al. 2003) or human-constructed niche (Smith 2007, 2012), including any existing agroecology; other environmental factors (e.g., climate, soils); and the founder population's genetics—the subsample of genetic variation from the parent population (Hart 1999a, 2008; Hart and Lovis 2013).

To some extent, all the articles in this volume take climate and/or agroecological variables into account in their assessments of crop adoptions and uses. Boyd and colleagues and Monaghan and colleagues, particularly, build strong cases for regional variations in crop adoption and use based on environmental factors. Intriguing is Monaghan and colleagues' suggestion that varying agroecologies, keyed to different environmental conditions, affected the timing of the adoption of the common bean across temperate northeastern North America and perhaps the Southeast. Boyd and colleagues' comparison of common-bean use in the Canadian prairie and boreal forest includes an assessment of growing-season length. Boyd and colleagues also consider the role of wild rice (*Zizania* spp.) in these regions and the impacts of its use on the commitment of local human populations to maize and common bean. Simon is less concerned with environmental factors in her assessment of maize adoption in the American Bottom and lower Illinois River valley. She argues, instead, that the commitment to EAC crops forestalled a commitment to maize in the American Bottom region for centuries. Egan-Bruhy argues that there were different patterns in plant exploitation between regions characterized by traditional culture-historic taxa. Wright and Shafer consider environmental factors within a small section of the Missouri River valley, emphasizing the location-specific nature of agricultural behaviors irrespective of culture-historic taxa.

Crawford's presentation of niche-construction theory (Odling-Smee et al. 2003) places the other articles in this issue into a theoretical structure that has great potential to enhance our understandings of crop adoptions and agricultural evolution (e.g., O'Brien and Laland 2012; Smith 2007, 2012). As Crawford rightly observes, crops were adopted into human-constructed niches. While it will never be possible to fully reconstruct specific niches, the cumulative paleoethnobotanical and zooarchaeological work over the past several decades has the potential to allow us to gain understandings of variations in the niches into which crops were adopted across the Midwest, as Egan-Bruhy and Wright and Shaffer also suggest. As Crawford clearly demonstrates, listings of macrobotanical remains can lead to new understandings of the varied human-constructed niches into which crops were adopted. This ties in nicely with Monaghan and colleagues' suggestions about the adoption of common bean, Simon's suggestions about agricultural practices in the American Bottom and lower Illinois River valley, and Wright and Shaffer's ideas about what happened in the lower Missouri River valley.

An alternative or complementary theoretical structure, as Crawford mentions, is that of the domesticated landscape (Terrell et al. 2003). An underpinning concept of this theory is the definition of domestication—the local population of a species can be considered domesticated when the local population of another species understands how to exploit it. The domesticated species may or may not exhibit phenotypic changes as a result of changed genotype frequencies from its exploitation by the other species. However, its distribution on the landscape will be affected by that exploitation. By understanding how to exploit a wide range of species, local human populations domesticate entire landscapes. Combining this theoretical structure with biological evolutionary theory can result in important insights into the adoption and evolution of particular crops and agricultural systems. My own preference has been Wright's (e.g., 1932, 1978) shifting-balance theory of evolution (see Hart 1999a, 2001, 2008; Hart and Lovis 2013). This theory seems particularly apt given that it was developed by Wright based on his knowledge of agricultural breeding and it is predicated on what we would now call metapopulations—populations that are divided into many subpopulations, or demes, partially isolated from gene flow from one another. This division is in keeping with human settlement systems when, for example, maize was adopted in northeastern North America. Each local population of maize would have been divided into demes managed by components of subdivided local human populations.

I need not go into details here regarding shifting-balance theory and how it might be combined with domesticated-landscape or niche-construction theory (see Hart and Lovis 2013) and social theory (Hart 2001) to develop new understandings of crop adoptions and agricultural evolution. However, it is worth stressing that whether one makes use of niche construction, domesticated landscape, or other theories to explore crop adoptions and agricultural evolution, it is necessary to take into account the biology of the crops under consideration (Hart 1999a). As an example from the present collection of articles, Monaghan and colleagues postulate that the apparent late spread of the common bean into northeastern North America after A.D. 1000 was the result of "cultural, geographical, historical, developmental, or technological" barriers. What, then, of the much earlier spread of maize east (Vigouroux et al. 2008) and sunflower (*Helianthus annuus*) west (Blackman et al. 2011; Lentz et al. 2008) of the Rockies? An alternative hypothesis is that biological factors contributed to the apparent lag in the spread of common bean.

The common bean is a largely self-fertilizing (>95 percent) species (Ferreira et al. 2000, 2007; Ibarra-Pérez et al. 1996, 1997). Self-fertilization in common bean is accomplished through hermaphroditic flowers—flowers containing both stamens and pistils. Self-fertilizing species can establish a founder population from a single seed (Baker 1955; Barrett 2010), but only if environmental conditions allow the resulting plant to reach sexual maturity and produce viable mature seeds for the subsequent generation(s). Both photoperiod and growing season length affected the ability of common bean founder populations to survive (see Masaya and White 1991). Photoperiod sensitivity to northern latitude long summer-day lengths resulted in delayed flowering from a few weeks to months depending on cultivar. Delayed flowering resulted in delayed fruiting, which depending on growing-season length may have resulted in crop-production failure. Most common bean cultivars currently grown in northern latitudes are photoperiod neutral, defined by White and Laing (1989) as flowering time delayed by no more than 10 days. However, only 32 percent of traditional cultivars in Latin America are photoperiod neutral (White and Laing 1989:123). Common-bean cultivars with indeterminate climbing growth habit (vining), the classic Three Sisters member, have a very low percentage (5.9 percent) of photoperiod neutral cultivars; in White and Laing's (1989:117) study, 67.6 percent of vining cultivars had a delay in flowering of over 100 days.

It is most likely that the apparent late spread of common bean relative to maize was the result of the need for it to be a combination of photoperiod neutral and of short maturation period. In the Southwest, where there are long growing seasons, delays in flowering of several weeks or more would not have been a problem. In eastern North American northern latitudes with short growing seasons, such delays would prevent successful production of common bean, as Boyd and colleagues point out (also see Mt. Pleasant 2006). Cultivars adapted to the long summer days and short growing seasons of northeastern North America had to have evolved to survive in or have been introduced into a northern latitude location by chance. Given that the species is self-fertilizing, photoperiod neutral cultivars with short maturation periods would have been able to spread very quickly once introduced into a region.

Monaghan and colleagues' hypothesis that common bean originally spread through the Upper Great Lakes region and into the Northeast and from there into the Ohio River valley based on agroecological differences is well worth testing with additional data. An added factor may be cultivar growth habit. While indeterminate climbing habit cultivars were well suited to the mound/ridge systems that Monaghan and colleagues suggest were in use to the north, such cultivars would not have been suited to the field systems they suggest were in use in the Ohio River valley and American Bottom. Rather, cultivars with bush growth habit would be better suited to such agroecologies. If Monaghan and colleagues' suggestion of a somewhat later adoption of common bean in the Ohio valley and American Bottom holds, it may reflect the spread of cultivars with different growth habits into various regions that were adopted for their growth habit within the contexts of agroecologies. Waugh (1916) noted that northern Iroquoian farmers grew both bush and vining cultivars at the turn of the twentieth century. Whether this reflected continuing interregional interactions as new cultivars evolved/entered the region after the initial adoption of common bean, large-scale movements of crops and cultivars after European incursions, or part of a deeper pattern suggested by Monaghan and colleagues will require additional research. Problems like this may find resolution as ancient DNA (e.g., Bunning et al. 2012) and molecular phylogenetic (e.g., Bitocchi et al. 2012) methods and techniques continue to evolve.

Along with the integration of plant biology and biological evolutionary theory into our explorations of crop adoptions and agricultural evolution, there is a need to more fully consider our units of analysis. Every scientific discipline has traditions, but unlike other social constructs, the sciences continually revisit their traditions and discard those that are not consistent with current theory, methods, and techniques. It has been my contention that we need to move away from traditional culture historic taxa as units of analysis and historical narrative (Hart 1999b, 2011; Hart and Brumbach 2003, 2005). These taxa were developed under theoretical structures that are no longer current. Their continued use constitutes straightjackets on our understandings of the past (Hart and Brumbach 2003). Even during protohistoric times in northern Iroquoia, culture-historic taxa within historical ethnic territories do not reflect the ways that individuals and communities interacted with one another (Hart 2012; Hart and Engelbrecht 2012).

Wright and Shaffer rightfully discard the culture historic phases used in their study area and instead compare site macrobotanical assemblages to gain insights into regional crop use variation. Egan-Bruhy, on the other hand, frames her exploration of subsistence patterns in the upper Midwest in terms of traditional taxonomic units (also see Crawford). Rather than starting from the premise that these taxa are meaningful units of analysis, a better approach would have been to ask if these taxa have any validity in the exploration of plant exploitation patterns. A K-means cluster analysis using ubiquity indices of subsistence taxa and specifying six clusters suggests not. If the taxa were meaningful in addressing plant exploitation strategies/human constructed niches/domesticated landscapes, then we would expect the members of the taxa to be mostly limited to one of the six clusters. As shown in Table 1, this is not the case. Rather, sites classified in the five taxa with multiple sites are assigned to two to four clusters; the taxa with more sites represented are spread between more clusters. Although the sample is small, if we accept that taphonomic processes and macrobotanical sample sizes are not issues, then this result suggests that there is little if any connection between twentieth-century archaeological taxonomic units and the manners in which ancient people domesticated their landscapes. What we know about humans is that even when norms of behavior and expression are shared, there is always variation in how people interact with their environments and one another. This is the raw material of cultural evolution. Given the large data sets now accessible and the powerful analytical tools now available on personal computers, it seems more useful to explore the past without framing our analyses with mid-twentieth-century culture-historic taxa and all the questionable theoretical baggage they impose on the past. Rather, we need to link our units of analysis to the problems at hand and the theoretical structures we use to explore them (e.g., Dunnell 1971; Lyman and O'Brien 2002).

Probabilistic methods

Sampling theory suggests that rare taxa are more likely to be found with larger rather than with smaller samples; the number of taxa present in a sample is at least in part a function of sample size (Kintigh 1989). This is demonstrated by the recent identification of common bean in a New York macrobotanical assemblage predating the calibrated mid-twelfth century A.D., as reviewed by Monaghan

TABLE 1

K-MEANS CLUSTERING OF SITES USED BY EGAN-BRUHY BASED ON UBIQUITY INDICES FOR FOOD CROPS

Taxon	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Late Woodland—Effigy Mound	—	—	Aztalan	Terrace Beach Centra 53/54	—	—
Late Woodland—Collared Ware	—	—	Murphy	—	River Quarry Aztalan	—
Middle Rock River—Collared Ware	11WO351	—	11WO108 11WO264 11WO354	—	11WO0361	—
Mississippian	—	—	—	—	Aztalan	—
Oneota—East of the Wisconsin River	Soggy Oats Citgo Pamperin Park	Crescent Bay Filler	Schrage	—	Burley Brew Blinded by the Light	—
Oneota—La Crosse Area	—	—	OT	Tremaine	Elmwood III	Gundersen Pammel Creek

and colleagues. Previous work directly AMS dating common-bean samples from across northeastern North America suggested that it was not present until the mid-thirteenth century A.D. (Hart et al. 2002). It is only now, over a decade later and after the processing of undoubtedly many tens of thousands of additional liters of feature fill from sites across the region that there is confirmed evidence for the common bean's earlier presence. Is the pattern Simon identifies by directly AMS dating purportedly early maize macrobotanical remains in the American Bottom and lower Illinois River valley also a reflection of this principle? Does this finding reflect regional patterns in ancient agricultural practices, or is it a sampling issue? The same principle applies to macrobotanical assemblages on a site-by-site basis. That is, the larger the macrobotanical sample from a given site, the more likely it is that rare plant taxa will be recovered. In Simon's case, with 100 percent flotation sampling of features in the excavated portion of each site component and intensive identification efforts, we can be sure that maize was absent in those features. Why would small-seeded indigenous crop macrofossils be found and not maize if maize was in use? Given what we know about maize macrobotanical taphonomy, can we really say for certain that maize was not used? As Lopinot (1992:56) suggested, "to develop more sound interpretations of past human behavior, it is critical to recognize how our data are affected by cultural and natural transformations, and by biases in recovery, sorting, and analytical methods."

As an example, the results of several experiments on the effects of charring on maize kernels have been published (Dezendorf 2013; Goette et al. 1994; King 1987; Wright 2003). What these experiments have shown is that hominy is the most likely form of maize kernel to survive charring in a condition that is likely to lead to preservation in the archaeological record. Myers (2006) suggested that hominy processing occurred only after A.D. 1000 in eastern North America. The probability of maize kernels entering and preserving in the archaeological record prior to the adoption of hominy processing, therefore, is less than after that adoption. Coupled with this were the nature of occupations and the intensity of maize use. The greater the number of times maize, or any other crop, was cooked at a given site the greater was the probability that it would enter and preserve in the archaeological record. There is a higher probability that maize would enter and preserve in the archaeological record when used year-round at a village site occupied by several families then it would at a seasonal camp where maize was used occasionally by one or a small number of families (Hart 2008:90–92). If the primary use of maize at a site had been in its green form, there is less probability that it would have preserved through charring and entered and preserved in the archaeological record than if it had been in dry–kernel form (King 1987; Wright 2003). Similarly, it is more likely that dry, shelled kernels would have been lost than green kernels on a cob would have been. It is, however, even more probable that the small dark "seeds" of indigenous crops, separated from inflorescences during harvesting and processing, would have been lost in and around hearths, where charring is likely to have taken place, than it is that green maize on a cob or shelled, dry, light-colored, much larger maize kernels would have been (see Lopinot 1992:56).

While the value of macrobotanical remains in the investigation of crop histories and agricultural evolution is of undoubted value and can lead to new insights about regional and chronological variations in plant exploitation (e.g., Asch Sidell 2002, 2008; Crawford and Smith 2003), they may not be the best sources of information for early crop histories given all the factors contributing to macrobotanical remains entering and preserving in the archaeological record. And given those factors, the current earliest archaeological macrobotanical evidence of a crop does not reflect its first use in a region (Hart 1999a).

A complementary source of evidence for crop use, the microbotanical record (phytoliths, starch) is slowly making an impact on our knowledge of crop histories in northeastern North America (Boyd et al. 2006, 2008; Boyd and Surrette 2010; Hart et al. 2003, 2007; Messner 2008, 2011; Messner et al. 2008; Raviele 2010; Thompson et al. 2004). These microscopic structures, well preserved in charred cooking residues encrusted on pottery sherd/vessel interiors (e.g., Crowther 2012; Hart et al. 2003; Thompson et al. 1994) and other contexts (e.g., Mulholland 1993), provide important lines of evidence for crop-use histories. Phytoliths are abundant in the inflorescences and leaves of grasses (Piperno 2006) and have, therefore, played a critical role in tracing the histories of maize's spread throughout the Western Hemisphere (e.g., Pearsall et al. 2003). The abundance of phytoliths in a maize cob (e.g., Piperno 2006) and their silicate composition mean that they can provide evidence for maize use when macrobotanical remains do not preserve. Each maize kernel produces more starch grains than a maize cob produces kernels. While easily subject to degradation from abrasion and heat, charred cooking residues can be the ideal context for starch-grain preservation (Crowther 2012; also see Messner 2011; Raviele 2011).

The charred cooking residues from which phytoliths and starch are recovered can be AMS dated providing direct-age estimates of the microbotanical remains (Hart et al. 2003; Raviele 2011). In the three regions of northeastern North America where microbotanical remains from charred cooking residues have been analyzed, the known chronology for maize has been greatly expanded. In New York, the known record of maize has been extended to circa cal 300 B.C. and squash to circa cal 1100 B.C. through the analysis of phytoliths. In Michigan, the analysis of phytoliths and starch has identified maize used as early as circa cal 150 B.C. (Raviele 2010). In western Ontario starch and phytolith analyses have been use to establish the presence of maize by circa cal A.D. 500 (Boyd et al. 2006; Boyd and Surrette 2010).

Experimental work by Raviele (2011) suggests that phytoliths obtain highest abundance in charred cooking residues when green kernels are cooked on cobs that have been cut in pieces. Starch is most abundant when dried kernels are cooked. However, it is not possible to estimate the amount of maize cooked based on phytolith or starch abundance in cooking residues. Boyd and colleagues' approach in the present volume is one possible means of assessing the importance of maize and of other crops in regional cuisines. By comparing the percentages of residues containing maize, common-bean, and wild-rice phytoliths and starch between Canadian prairie and boreal forest from large numbers of analyzed cooking residues from multiple sites, Boyd and colleagues are able to assess the relative importance of these crops. This approach will be even more useful when combined with direct AMS dates on residues rather than relying on culture-historic taxa to provide chronological control.

Multiple lines of evidence

The complexities of archaeological site formation are well established. The complexities of the paleoethnobotanical record formation are becoming increasingly clear (e.g., Crowther 2012; Dezendorf 2013; Raviele 2011). As a result, while individual lines of evidence are important and should be published, drawing firm conclusions from those individual lines of evidence is highly problematic. Rather, it is the combination of multiple lines of evidence that allow us to build reasonable approximations of crop histories. These include macro- and microbotanical, stable isotope, lipid, and DNA analyses that reflect directly on crop use that can be combined with indirect evidence such as tool assemblages and pottery technology.

Simon and Wright and Shaffer have done exemplary work in evaluating the macrobotanical record of maize in the American Bottom and western Illinois and the lower Missouri valley, respectively. However, relying solely on these records to suggest histories for maize use is questionable. Rather than accept the macrobotanical records as a reflection of crop histories, it would be better to treat these records as hypotheses to test with additional independent lines of evidence. As already noted, microbotanical analyses elsewhere in northeastern North America have produced evidence for more extended histories of crops than that allowed by the macrobotanical record alone. Does the microbotanical record fill in the gap between the Holding site and Ellege and Edgar Hoener sites in west-central Illinois? Do the microbotanical records extend the evidence for maize use prior to the earliest macrobotanical remains in the American Bottom and lower Missouri River valley? How does the stable carbon isotope record on human bone from west-central Illinois, with elevated values on some samples occurring as early as circa A.D. 400 (Rose 2008), contribute to our knowledge of maize use in the region? Is there a reason to dismiss this evidence? Do changes in stable carbon isotope values on charred cooking residues correlate with changes in pottery technology suggesting increased processing of maize (Hart 2012; Hart et al. 2012)? My efforts with colleagues to better understand the history of maize in central New York has benefited from the consideration of multiple lines of evidence (see Hart 2012 for a summary). Following a similar strategy throughout northeastern North America, including the Midwest, will undoubtedly result in more complete histories of crops on various temporal and spatial scales.

Conclusions

The adoption of flotation recovery, the emergence of paleoethnobotany, stable carbon isotope analysis of human bone, and AMS radiocarbon dating during the second half of the twentieth century resulted in a revolution in our understanding of crop and agricultural histories in the Midwest. These techniques and methods remain important tools today, as demonstrated by several of the articles in this collection. However, there are new methods and techniques, such as microbotanical analyses, that can add to our evidence for the histories of specific crops and agricultural systems, as shown by Boyd and colleagues in this collection. Combining multiple lines of evidence can lead to more complete crop histories. The adoption and development of new theoretical structures can provide new insights into existing lines of evidence as suggested by Crawford in his discussion of human niche-construction theory. The biology of crops needs to be taken more specifically into account when investigating their adoption and spread. Integrating this with biological evolutionary theory and social theory can lead to important new insights. Shedding the straightjacket of mid-twentieth-century culture-historic taxonomies can result in a more dynamic picture of the manners in which humans interacted with each other and lead to understandings of how agricultural behaviors varied within and between regions. Researchers in the Midwest led the development of paleoethnobotany in North America. There is great potential to continue to lead by extending that discipline through the adoption of new methods, techniques, and theoretical structures.

Notes on Contributor

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Number 1   Summer 2014 ISSN 2372-9899

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