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dissertation entitled

ASSESSING CARBONIZED ARCHAEOLOGICAL COOKING RESIDUES: EVALUATION OF MAIZE PHYTOLITH TAPHONOMY AND DENSITY THROUGH EXPERIMENTAL RESIDUE ANALYSIS

presented by

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has been accepted towards fulfillment
of the requirements for the

Ph.D. degree in Anthropology

Major Professor's Signature

12 August 2010

Date

ASSESSING CARBONIZED ARCHAEOLOGICAL COOKING RESIDUES: EVALUATION OF MAIZE PHYTOLITH TAPHONOMY AND DENSITY THROUGH EXPERIMENTAL RESIDUE ANALYSIS

By

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Anthropology

2010

ABSTRACT

ASSESSING CARBONIZED ARCHAEOLOGICAL COOKING RESIDUES: EVALUATION OF MAIZE PHYTOLITH TAPHONOMY AND DENSITY THROUGH EXPERIMENTAL RESIDUE ANALYSIS

By

Maria E. Raviele

The timing of initial cultigen utilization by hunter-gatherers and early horticultural populations remains a central research issue in understanding the transition to low level food production. Continuing refinement of crop histories leads to a better understanding of the processes, timing, and speed of domestication as well as human use of cultigens and potential cultigens. The adoption of domesticates also speaks to inter- and intra- group social interactions; knowledge of a cultigen does not necessarily arise independently in each hunter-gatherer group which utilizes it. The latter is especially true if the domesticate is non-native, as maize is to eastern North America, and must adapt to an environment if/when it is introduced.

To understand these processes this research focused on two major research goals. First, was to further establish the timing of the adoption of domesticates, specifically maize, in the western Great Lakes region of eastern North America by using a case study from the Saginaw Valley of Michigan. The use of phytolith and starch analysis on ceramic residues offers another line of direct evidence for paleodiet. Through phytolith and starch analysis of ceramic residues from Middle (200 BC-AD 500) and Late Woodland (AD 500-AD 1400) period sites in Michigan, I tested the current hypothesis that maize horticulture is not ubiquitous in the Great Lakes until c. AD 1000.

Secondly, experimental residues were created to test for the presence of phytoliths and starches. The goal of these experiments were threefold: to determine phytolith and starch are presence in residues created for experimental purposes, to determine if quantification of the percentage of maize present is possible through phytolith density, and to determine if one can differentiate between the use of green and mature maize through the presence of phytoliths and starches. Residues were created using increasing 20% increments (0-100%) of maize. Green and mature maize were also used separately in experimental residue creation. Results from the experimental residues were applied to the interpretation of the archaeological residues used in this study.

Analysis and systematic direct dating of the archaeological residues indicates that maize is present during the early Middle Woodland in the Saginaw Valley prior to c. AD 1000. However, application of the experimental results to the interpretation of the archaeological results indicates that it is a dried version, either kernels or flour; there is no evidence for low level maize production. This inference is corroborated by environmental evidence which indicates increased incidence of flooding during the early Middle Woodland which would have made flood plain maize cultivation untenable. It is hypothesized that the presence of maize c. 2000 years ago is due to down-the-line exchange with nearby regional populations. The subsistence shift towards more intensive maize cultivation, occurring during the Late Woodland period c. 1000 AD, appears to be due to environmental change brought on by the Medieval Warm Period. Environmental change caused by the Medieval Warm Period resulted in a shift in the structure of available resources requiring a change in subsistence strategies.

To the memory of my grandfather James W. Bain, one of the wisest men I have known.

"You have to earn it." James W. Bain

ACKNOWLEDGMENTS

There are many people that need to be thanked for their help in the completion of this dissertation. First and foremost is my dissertation committee. My chair and advisor Dr. William Lovis was incredibly supportive throughout the entire process of my dissertation. I also would not have made it to this final step in the graduate program without Bill's guidance and support from the beginning of my graduate career. I have subjected Bill to office drop-ins (with sometimes complicated questions), reading numerous paper drafts and panicked (and not so panicked) emails in regards to classes, funding, and career opportunities. Throughout all this he has provided feedback and guidance with humor and patience. I am happy to consider Bill not only a mentor but also a friend.

The other members of my committee include Dr. Jodie O'Gorman, Dr. Lynne Goldstein, and Dr. Catherine Yansa. Both Jodie and Lynne have challenged me to think more holistically in regards to the interpretation of archaeological data. Their feedback has helped make me a better archaeologist. Catherine has played a huge role in my understanding of environmental reconstruction. I am also exceedingly grateful to Catherine for her generosity in sharing lab space. This enabled me to store materials and most importantly, perform the required processing. Dr. Alison Rautman aided in clarifying my thinking on the transition to horticulture and the processes involved therein. Other department faculty who supported me in various ways includes Drs. Helen Pollard, John Norder, Marietta Baba, and the late Peg Holman and Susan Krouse. External to MSU, Dr. John Hart offered constructive feedback and I need to thank Drs. Deborah

Pearsall and Susan Mulholland for their willingness to train me in phytolith and starch extraction and identification without which this project would never have happened.

I must also acknowledge the institutions and staff which granted me permission to use their collections for my research as well as providing funding. This includes Karen O'Brien at the University of Michigan Museum of Anthropology who was more than accommodating, Barbara Mead at the Office of the State Archaeologist in Lansing who helped identify residues which might be useful in my study, and Jeff Sommer at the Historical Society of Saginaw County who suggested collections which might be useful as well as allowing me to use materials from his ongoing excavations in the Shiawassee National Wildlife Refuge. Major funding for my work was provided through grants from the National Science Foundation and the Wenner-Gren Foundation while the American Indian Studies Program at MSU provided funding for initial research trips.

Of course, none of this would have been possible without the support of my friends and family. My parents have always supported me in my desire to become an archaeologist and in attaining my PhD and for that I am eternally grateful. My friends have helped keep me sane throughout the entire process of graduate school. I especially need to thank Megan (and the pocket advisor) and Charlotte for PFLG/general silliness, Marita for always being there with popcorn and wine, and Marieka for a shared perspective. Finally, many many thanks to Josh for putting up with general grumpiness, late night writing frenzies, and long work weeks. I know I was not always pleasant to live with during my writing year and I am everlastingly grateful for Josh's patience and awareness that this was only a temporary situation. I hope I am as kind in the future.

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CHAPTER 1

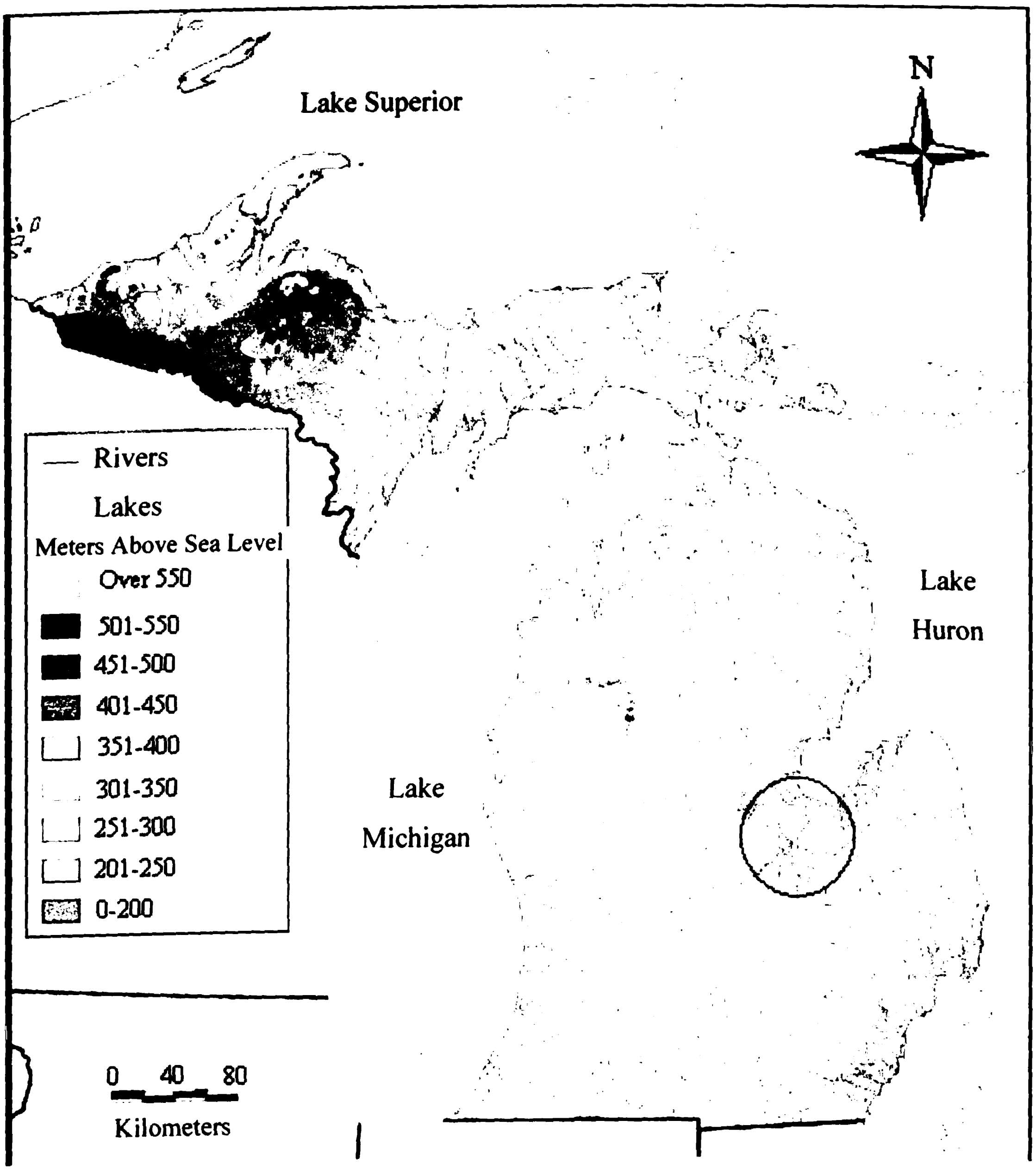
Introduction

Introduction

The research addressed within this dissertation consists of two major components. The first component seeks to explore the transition to horticulture in eastern North America (ENA), specifically with regard to the inception and use of maize, through phytolith and starch analysis of ceramic residues. Phytoliths are microscopic deposits of silica that form in and between the cells of plants and can be found to varying degrees in each plant structure (Mulholland and Prior 1993; Pearsall 2000; Piperno 2006). Starch is produced in all plants and starches derived from long-term storage organs are often diagnostic (Gott et al. 2006; Torrence 2006). I investigate the timing of the adoption of domesticates in mixed subsistence horticultural-hunter/gatherer societies (referred to as low-level food producers) and the concomitant changes, if any, in the resulting seasonal settlement-subsistence round. The adoption of cultigens or domesticated plants by a hunter-gatherer society can have impacts on numerous aspects of hunter-gatherer life including, but not limited to, scheduling of the seasonal round, gender roles and division of labor, and social relations. The Saginaw drainage of Michigan (Figure 1-1) will be used as a case study to explore these changes associated with the transition to maize horticulture. It should be noted that while this research largely focuses on the use of maize, the analysis identifies all diagnostic plant phytoliths and starches.

The second major component of this research is an analysis of experimentally created residues utilizing various forms of maize. The incorporation of experimentally

Figure 1-1: Saginaw drainage study area



produced residues is a direct result of the work done by Drs. William Lovis, John Hart, Gerald Urquhart, and Robert Feranac and their analysis of the masking of C_4 North American resources (i.e. maize) by C_3 North American resources. The experimental residues present the opportunity to determine if the percentage of maize being cooked in a pot, based on phytolith concentration, can be predicted. If quantification is possible, this would provide a baseline to assess the percentage of maize in archaeological residues. In general, however, the experimental residues will allow for the assessment of phytolith and starch taphonomy and its implications for understanding the interpretation of data generated via phytolith and starch residue analysis. It should be noted that at the time of research design, starch identification was not a component of this project. Starch identification was added once it was determined through analysis of the experimental residues that starch remained in the samples.

Since the issue of maize timing is one of the important variables included in this work, there is substantial employment of AMS dating. While the advent of AMS dating of macrobotanicals has substantially refined the chronology, timing and history of maize adoption, the systematic regional utilization of phytolith and starch analysis as independent lines of evidence has not been as widespread. Examination of cooking residues present on ceramics for phytoliths and starches provides the possibility of producing earlier direct evidence of cultigen use not found in the macrobotanical record and is an alternative means to investigating low-level food production (Hart et al. 2007; Mulholland and Prior 1993; Mulholland, Rapp, and Ollendorf 1988; Pearsall 2000; Piperno 2006).

For the purpose of this research, low-level food production is defined as a mixed subsistence economy which utilizes cultigens as a supplement to wild plant and animal resources. The term agriculture is not utilized as this implies the intensive field cultivation of crops. While the adoption of cultigens may result in either situation, the nature of the use of domesticates in the proposed study area of the Saginaw drainage of Michigan is more in line with the definition of low-level food production given above. As this project focuses on the 'middle ground' (Smith 2001) between hunter-gatherers and full scale agriculturalists, the time periods to be studied are the Middle (200BC–AD 500) and Late Woodland (AD 600-AD 1650) periods. It should be noted that the Middle Woodland period coincides with the Hopewell manifestation throughout the Midwest. This manifestation varies but is generally characterized by significant mound construction, exotic raw materials (obsidian, Gulf coast shell, copper, minerals such as galena and mica), and elaborate burial customs (Maxwell 1952; Morgan 1952; Seeman 1992; Wymer 1987).

Background on Terminology

When discussing the transition to horticulture, a distinction between primary and secondary origins of agriculture is required. As defined by Cowan and Watson (1992:207), a primary origin area is one in which plant domestication and horticulture/agriculture occurs without the outside introduction of crop staples. An area of secondary origin has two dominant patterns; one pattern is defined by the introduction of crop staples (either wholesale or one by one) which replace a foraging system while the other pattern is characterized by the introduction of new domesticates into an area that is already dependent on cultivated plants to some extent (Cowan and Watson:207-208). The latter pattern characteristic of a secondary area for the origins of agriculture is directly pertinent to ENA where EAC cultigens are replaced by maize.

In addition to the distinction between primary and secondary origins, there are three separate and often related processes in the transition to horticulture; the process of plant domestication, the transition itself (i.e. adoption), and subsistence intensification. The process of plant domestication, in a primary agricultural origin context, involves the isolation of the planted/raised vegetation from the wild members of their species and the continued annual cycle of harvesting and storing seed (Hayden 1995:274; Smith 1995; Wills 1988). Involved in this process is the selection of desirable characteristics, such as larger seed size and thinner seed coat, by the people raising these plants (Hayden 1995). Most importantly, it is the intentionality of this process that is significant (Hayden 1995; Smith 1995; Wills 1988). Domestication does not, as Smith (2001:17) states, "...define the boundary of either agriculture or hunting and gathering..." but instead acts as a point from which to view either side.

The decision to utilize (i.e. adopt) cultigens, initially as a supplement to a hunter-gatherer subsistence system, can be considered a characteristic of the transition to horticulture for either a primary or secondary agricultural origin area (Smith 2001; Wills 1988). This transition is better described as low-level food production (Smith 2001) instead of horticulture; reasons why are discussed below. Often, but not always, tied to the adoption of cultigens and low-level food production is the process of intensification, either on these cultigens or on an already utilized wild resource. Intensification within a subsistence system may also include using smaller animals, more diverse species, and the storage of resources with abundant production but a limited window of access (Wills 1988:44). In general, intensification occurs on secondary resources, which fit easily into the already existing subsistence system (Lovis et al. 2001; Wills 1988). As Wills (1988:36) states, "...foragers adopt domesticated plants not to become farmers but to remain effective foragers." These resources act to diversify subsistence and buffer against scarcity (Lovis et al. 2001; O'Shea 1989).

An important distinction to make is the difference between cultigen and domesticate. These are both descriptors for the intensity of use of a plant species. These descriptors can have a variety of meanings depending on its context and the theoretical orientation of the researcher. However, the use of the term domesticate implies a plant primarily under human control and reliant upon human intervention for survival and reproduction. The changes present in a domesticate manifest themselves genetically and phenotypically (Ford 1985; Harris 1996; Rindos 1984). Domesticate most often refers to plants that have become morphologically and genetically distinct from their wild ancestors (Vrydaghs and Denham 2007:7). These morphological distinctions are a result of intentional selection by humans for certain desirable traits, which commonly include larger seed size, more compacted seed heads, thinner seed coats, and a brittle rachis to enable easier harvesting (Vrydaghs and Denham 2007:3).

Cultigen, however, is used in reference to a variety of plant foods ranging from domesticates (in the sense described above) to wild plants which may be tended and/or encouraged by people. These wild plants do not rely on human intervention for survival; rather humans will create environmental conditions, sometimes intentionally but sometimes not, which are beneficial to the growth and propagation of these wild plants. Not all human interaction and/or intervention with plants results in domestication and not all human intervention in the life cycle of a plant is the result of agricultural behaviors. Hunter-gatherers are often active managers of resources (Wagner 2003:127).

Ethnographic accounts and archaeological evidence indicate hunter-gatherers and low-level food producers encouraged wild plants via pruning, clearing, and the occasional low-intensity burning to enable better growth, clear trails for hunting and travel, or to increase browse for game animals (Wagner 2003). For these reasons, cultigen is the preferred term used in this dissertation when discussing plant management techniques and strategies.

The issue of intensification brings with it a consideration of how to identify between three macro-level distinctions in regards to reliance on cultivated plants. From most reliant/intensive to least reliant/intensive, these distinctions are agriculture, horticulture, and low-level food production. Each term has distinct implications in regards to how reliant a population is on cultivated plant resources and has been characterized in a number of different ways (c.f. Denham, Iriarte, and Vrydaghs (eds.) 2007; Cowan and Watson (eds.) 1992; Price and Gebauer (eds.) 1995; Smith 1992; Struever (ed.) 1971) in the literature on the origins of agriculture. The presence of domesticates and wild cultigens (hereafter referred to collectively as cultigens) does not always indicate the same level of subsistence reliance and/or intensification on these plants. As demonstrated in the discussion below, the use of cultigens can result in a variety of subsistence adaptations.

Agriculture is most commonly thought of when one thinks of domesticated plant use and does not include wild cultigens. There is an intrinsic implication of intensive field cultivation of crops, which may or may not include the use of draft animals and the plow. Intensive field cultivation, often of monocrops, can result in faster soil depletion than what might naturally occur. The archaeological implication for intensive field cultivation is that agriculturalists may have to clear fields more often or rotate fields in a fallow cycle to allow for soil regeneration. In addition to formal large-scale cleared field cultivation, other cultural characteristics often associated with agriculture include sedentism, permanent storage structures, social complexity, larger population density, and (in some areas) large group aggregation (Bender 1978; Harris 1989, 2007; Keeley 1995). Agricultural communities rely predominantly on crop staples and intensively cultivate the surrounding available arable land. Domesticates are the primary means of subsistence for agricultural communities and dominate food remains identified in the archaeological record.

Next on the scale of reliance/intensity from agriculture is horticulture. Horticulture is the less intensive cultivation of crops, primarily as garden-level food production. Plot size for cultivation is smaller than that found in agriculture. Horticulture also includes greater biodiversity in regards to the types of crops grown. Instead of monocropping, horticulturalists grow a range of plants in their gardens, which better mirrors the biodiversity of the natural environment. Plants grown in these gardens are cultigens, both domesticated and wild/weedy plant species, used for a variety of purposes and not just subsistence needs (Harris 2007; Keeley 1995).

The wild and/or weedy plants grown by horticulturalists are generally characterized as "adventitious and spontaneously occurring" (Harris 2007:24). Wild/weedy plants are valued because they have multiple useful parts including edible fruit, flowers, or leaves, parts used for dyes or fibers, and medicinal applications (Harris 2007:24). As a result of this greater biodiversity, soil depletion progresses at a slower rate than that which occurs with intensive agriculture and the need for clearing new plots or allowing plots to lie fallow is diminished. Cultural characteristics that are often associated with horticultural groups can include incipient social complexity, some form of long-term storage, and some level of sedentism and group aggregation on an annual basis (Bender 1978, 1981; Rosenberg 1990).

The least intensive/reliant-upon-cultigens subsistence adaptation is low-level food production. Smith (2001) coined this term to characterize societies which continue to practice hunting and gathering but which also incorporate some level of plant cultivation into their subsistence regime. In the traditional hunter-gatherer/farmer subsistence dichotomy, these types of societies often proved to be a categorical conundrum. Most often when societies characterized as in-between hunter-gatherers and farmers have been considered archaeologically, this transition has been seen as a rapid and short-lived cultural manifestation with farming as a permanent end product. Once the line from hunting and gathering to farming had been crossed, there was no going back (Smith 2001:2-5). While Smith (2001) is certainly not the first archaeologist to consider, what he terms, this 'middle ground' between hunter-gatherers and farmers (c.f. Ford 1985; Harris 1996, 2007; Rindos 1984; and Zvelebil and Lillie 2000), his conceptualization of this grey area is the most straightforward and uncomplicated.

In general, hypotheses on the transition to horticulture have been framed in terms of either the adoption of cultigens or the conditions necessary for the transition/adoption to occur. These hypotheses include factors such as responses to social relations with other groups, to environmental stress or climatic changes, to rising population density, to resource abundance, to risk buffering strategies, and on the availability of protodomesticates to a group (Bender 1978, 1981; Clark 1989; Hayden

1995; Price and Gebauer 1995; Stone and Downum 1999; Winterhalder and Goland 1997). While all of the factors listed above can play a role of variable importance in the transition to horticulture, in each scenario, people's initial use of cultigens/domesticates is as a supplement to an existing hunter-gatherer diet (Wills 1988).

To deal with this period of mixed subsistence economy, Smith (2001) correctly argues that there needs to be a tripartite (hunter-gatherer/low-level food production/agriculturalist) instead of dichotomous (hunter-gatherer/agriculturalist) framework for thinking about the origins of agriculture. It is important to note that these transitional states, represented by hunter-gatherers as low-level food producers who utilize cultigens as a supplement to their existing diet, or to be put more concisely, mobile low-level food producers, have supporting evidence to indicate they were rather stable and long-term adaptations instead of rapid and unstable, as has been usually assumed in the literature (Smith 2001).

These are societies which utilize both wild (plant and animal) and domesticated resources. They are not dependent on either resource form exclusively, nor is it possible to determine their trajectory of development (i.e. 'reverting' back to hunting and gathering or becoming farmers). Low-level food production is characterized by the utilization, intensification and management of multiple types of resources in the surrounding environment in an effort to maximize risk buffering strategies (Smith 2001; Wills 1988; O'Shea 1989). Archaeological identification of low-level food producers would demonstrate evidence for the use of multiple resources zones (aquatic/terrestrial, uplands/lowlands), the use of resources both intensively and extensively (demonstrating a broader resource base), and the identification of cultigens (whether domesticated or wild)

(Smith 2001:36). With the variety and abundance of resources present within ENA, Smith's criteria for low-level food producers offers a framework in which to reexamine evidence for the use of domesticates in what have often been considered archaeological backwaters. These regions have been characterized as such due to the perception that nothing interesting (i.e. socially complex and stratified agriculturalists) really happened there prehistorically.

As an example, evidence for low-level food production is demonstrated in Parker's (1996) discussion on the use of cultigens in the southern Great Lakes, which demonstrates maize cultivation as part of a mixed strategy of crop production and wild plant exploitation. Late Woodland inhabitants of the Great Lakes incorporated varying elements of the Eastern Agricultural Complex (EAC) crops into traditional subsistence patterns when it had previously been assumed that little use was made of cultigens (Parker 1996). Low-level food production by hunter-gatherers as a type of subsistence strategy is also corroborated by the chronological refinement on the use of cultigens, especially EAC crops such as squash and chenopod in ENA. The dating of domesticated squash to the Archaic period (8,000-500BC) is especially pertinent to the evidence for mobile low-level food producing populations (Lovis and Monaghan 2008). Chronological refinement on the use of cultigens as part of a nominally hunter-gatherer diet has also consistently demonstrated an earlier use of cultigens.

A demonstration of this earlier use is in the study by Hart, Thompson and Brumbach (2003) where phytolith analysis and AMS dating of cooking residues from ceramics was used to find evidence of maize, squash, wild rice, and sedge being cooked together during the 7th century AD. These data place maize and squash in New York at least 350 years earlier than previously thought. The previously accepted date, of AD 1000, was based on macrobotanical evidence. Further research from Thompson et al. (2004) in New York demonstrates the use of maize as part of a long trajectory of intensification, rather than as a catalyst for intensification.

Maize is a domesticated imported non-native cultigen that requires tending, protection by humans, and adaptation to a more northerly climate. The demonstration of its earlier-than-expected presence in New York extends the time period during which non-native cultivated plants were being used in association with wild subsistence items and native cultigens. Both types of cultivated plants, native and non-native, were acting as a supplement to a traditional subsistence regime. A similar long pattern of co-use is seen with the presence of squash in ENA during the Late Archaic (2000-500 BC). Squash is utilized during the Late Archaic but does not become a significant food source until the Middle Woodland (Lovis et al. 2001; Lovis and Monaghan 2008; Monaghan et al. 2006; Scarry 2003; Wymer 1987). In sum, evidence from ENA seems to support the idea of the gradual incorporation of cultigens and non-native domesticates into a hunter-gatherer diet over a long period of time (thus causing them to be low-level food producers), with subsequent increased intensification of their production (Kidder 1992; Lovis et al. 2001; Monaghan et al. 2006).

Research Problem

A long standing research question on the origins of agriculture/transition to horticulture has been the initial timing of domesticate adoption and utilization by (mobile) low-level food producers. Further refinement of crop histories leads to a better understanding of the processes, timing, and speed of domestication as well as human use of those plants that eventually became cultigens. The adoption of domesticates also speaks to interactions between groups since knowledge of a cultigen does not independently arise in each group which utilizes it. This is especially true if the domesticate is non-native, as maize is to ENA, and must adapt to an environment if/when it is introduced to a new area. The work conducted here clarifies the timing of the adoption of domesticates, specifically maize, in the western Great Lakes region of ENA through the case study of the Saginaw drainage of Michigan. The use of phytolith and starch analysis on ceramic residues offers other lines of direct evidence, besides macrobotanicals, for paleodiet (See Table 1-1 for a summary of cultigens present at sites in research area). As previous studies in New York have demonstrated (see Hart et al. 2003 and Thompson et al. 2004), phytolith analysis has pushed back the date for the earliest use of maize in northern areas of eastern North America. Through phytolith and starch analysis of ceramic residues, I will be testing the current accepted hypothesis that maize horticulture is not ubiquitous in the Great Lakes until c. AD 1000.

The prevailing hypothesis on the use of maize horticulture in the Saginaw drainage of Michigan states that it was not predominant until approximately AD 1000 (Brashler et al. 2000; Lovis et al. 1996, 2001; Parker 1996). This assertion is based primarily on recovered archaeological macrobotanical material (predominantly from flotation) and reconstructed environmental data based on pollen studies, soil types, and modern maize climate requirements (Krakker 1983; Monaghan and Lovis 2005). Until relatively recently, a lack of the systematic use of flotation has hindered the understanding of the use of domesticates simply because seed evidence had been primarily recovered when found in large concentrations, such as in storage pits, during excavations.

The methods used to study the transition to horticulture in the Saginaw drainage (and other areas of the western Great Lakes), have relied predominantly on the presence of macrobotanical remains recovered during excavation or through the use of flotation. Maize macrobotanicals recovered from excavations within the study area have remained at a low level of incidence despite the use of intensive flotation for the past thirty years. Phytolith and starch analysis will offer new, independent lines of direct evidence to document plant exploitation among the prehistoric inhabitants of the Saginaw drainage by testing the current hypothesis that maize horticulture was not ubiquitous until ca. AD 1000 in the Saginaw drainage of Michigan. However, if maize is found to be regularly present prior to AD 1000, several key questions arise:

1) In the terminology of Smith (2001) and Wills (1988), how much earlier is maize being "plugged into" traditional subsistence practices? What implication, if any, does this earlier use of maize have for the seasonal settlement-subsistence round especially in regards to the division of labor, the location of people on the landscape, and scheduling of resource procurement?

2) Is this earlier use continuing the trend of greater reliance on collective resources, such as weedy annuals (a similar argument for collective use is the exploitation of anadromous fish in the Great Lakes by Egan [1993])?

3) To what extent does the use of maize overlap with the utilization of Eastern Agricultural Complex domesticates such as chenopod and squash in the western Great Lakes?

4) Is the low incidence of maize macrobotanicals anomalous or not? If it is not

anomalous, what does this mean for the relationship between mobile low-level food producers and known maize horticulturalists from the surrounding area (Ontario, Ohio, and Illinois)?

Predicted Outcome and Expected Research Gain

A primary purpose of this research is to further refine the understanding of the settlement-subsistence system of Woodland period peoples as well as to refine the chronology on the adoption of maize in eastern North America, specifically within the southern and western Great Lakes region. The study area proposed for this research has a different trajectory of domesticate utilization than that seen in the surrounding areas of New York, Ontario, Ohio, Indiana, Illinois, and Wisconsin (Crawford and Smith 2003; Scarry 2003). These regions all had populations which utilized intensive maize agriculture and examples include Mississippian, Fort Ancient, incipient Iroquoian populations, and Oneota groups. Earlier adoption of the use of maize not only has important implications for the crop history, but also for the interpretation of mobile low-level food producer behavior within the archaeological record. The use of phytolith and starch analysis on ceramic residues offers other independent lines of direct evidence as to the composition of paleodiet that does not have the same limitations as macrobotanicals or the use of stable isotope analysis on residues. Phytoliths and starches also offer the unique perspective of allowing the researcher to identify some of the plant foods being cooked together. This allows for better understanding of nutritional composition and can have implications for the scheduling of resource procurement and, perhaps, seasonality or evidence for storage of specific food resources that may not be preserved as macrobotanicals. When used in conjunction with extant faunal and floral data, a more complete picture of Woodland period diet and the changes that occur throughout the period is possible (e.g. Crawford et al. 2006).

The secondary purpose of this research is to determine if it is possible to quantify the percentage of maize used/cooked in a pot as well as differentiate between the use of green and mature maize. The utilization of controlled experimental residues test this possibility. If there is a quantifiable difference in phytolith density and/or size between green and mature maize, it may be possible to identify which is being utilized in archaeological samples. The possibility of identifying which stage of maize is being utilized could explain the low incidence of early macrobotanical remains as well as refining the subsistence regime. The ability to determine the percentage of maize being cooked in a pot has implications for the 'importance' of that cultigen in a prehistoric mixed subsistence economy. The identification of starch in the experimental residues has changed some of the original goals of the experimental residue analysis, but as is further discussed in chapter four, identification of probable maize forms utilized is still achieved.

The working hypothesis of this study is that there will be archaeological identification of maize prior to AD 1000 and this will extend the period of low-level food production. Previous research in the Finger Lakes region of New York by Hart et al. (2003) and Thompson et al. (2004) demonstrate the earlier presence of maize than previously provided by macrobotanical evidence. Both the western Great Lakes and New York were on a trajectory of resource intensification and it is highly likely that maize was utilized earlier in the research area than the dates derived from macrobotanical evidence. However, other outcomes are possible.

One predicted outcome is if early cultigen use is found, but cultigens were not used intensively. Ideally my analysis of experimental residues for quantification of phytolith densities would aid in addressing this issue of intensity as well. If quantification of phytoliths is found to not be a viable means to assess intensity of use, an alternative might be through the presence of cultigen phytoliths identified in ceramic residues but absent as macrobotanicals in the site assemblage. The presence of phytoliths and/or starches with the absence of macrobotanicals could indicate that while these cultigens were utilized they were not intensively cultivated. This outcome could also be used to argue for a scenario of maize exchange (either directly or down-the-line) between foragers and maize horticulturalists.

A final outcome to consider would be if no cultigen plant phytoliths of any kind are found. This would then fail to reject the current hypothesis that maize horticulture was not ubiquitous until AD 1000. Finally, one other outcome that would be possible is the presence of particular cultigens or intensified wetland resources with the absence of phytolith producing cultigens that are expected to be present. This last outcome could have implications for plant storage and seasonality depending on the site context.

While previous research has focused on the transition to horticulture (Egan 1993), and the use of maize in Michigan (Krakker 1983), the utilization of phytolith and starch analysis as independent lines of evidence has not been employed. The presence of macrobotanicals at a site is dependent on both site preservation processes as well as recovery techniques. Analysis of ceramic residues for stable isotopes can provide an overall indication of dietary composition but there is the drastic masking of the presence of C_4 plants by C_3 plants (Hart et al. 2007). By analyzing the phytoliths and starches present in ceramic residues, a direct analysis of what plants were being consumed is possible. This is made even stronger when used in conjunction with the macrobotanicals present at a site since not all food plants are phytolith producers and not all starches are diagnostic (Pearsall 2000; Piperno 2006). Direct AMS dating of the residue also allows for tighter control on the chronology of the use of maize and other cultigens.

Organization of the Dissertation

To address the above questions, the dissertation has been organized along the following lines. Chapter two is an overview chapter on the origins of agriculture within eastern North America. This includes a discussion of both EAC and maize utilization, as well as a Michigan specific overview regarding the explanatory mechanisms for low-level food production and the switch to the reliance on maize production. Chapter three is a discussion of the various lines of evidence, both direct and indirect, archaeologists utilize in the study of paleodiet and subsistence. Chapter four encompasses the experimental work conducted for this study while chapter five provides the background for the archaeological sites used in this work and the results of my archaeological residue analyses. Chapter six provides the larger archaeological context for the results of my archaeological residue analysis. The results of the experimental work discussed in chapter four are also incorporated in chapter six to aid in the interpretation of the archaeological residue results. Finally, chapter seven is the conclusion with my final thoughts and suggestions for future research; for me, this study has raised many more questions than it has answered.

CHAPTER 2

Origins of Agriculture in Eastern North America

Introduction

The geographic definition and boundary of eastern North America (ENA) as it relates to the archaeology of the region roughly follows the extent of deciduous forest starting at the Atlantic coast and moving west to the Ozarks where grassland becomes the predominant landscape. The northern limits of this area are characterized by a mixed deciduous-conifer landscape with shorter growing seasons and colder winters south of the boreal forest and sub-arctic (Gremillion 2003:19). Major plant communities include mast-rich oak-hickory, oak-chestnut, northern hardwoods, southern oak-pine, and numerous wetland and river edge species (Gremillion 2003:20). Animal taxa present reflect the available plant diversity and includes terrestrial game, migratory fowl, and marine, lacustrine, and riverine fish and mollusk species.

Such diversity in both plant and animal resources enabled people to develop a number of subsistence systems including sedentary, socially complex agriculturalists and groups that remained hunter-gatherers until European-American contact. In addition to these two 'extreme' ends of the subsistence spectrum, there is a range of groups which practiced, to certain degrees, hunting and gathering in conjunction with the utilization of domesticated plants. The groups located within this 'middle ground' of subsistence activity are best characterized as low-level food producers (Smith 2001). This variety of cultural adaptations and significant biodiversity makes the origins of agriculture here a complicated and interesting case. This history includes both the independent domestication of indigenous plants as well as introduced domesticates from Mesoamerica. The adoption and utilization of both indigenous and exotic domesticates overlaps throughout ENA and the initial introduction of exotic domesticates from Mesoamerica did not have immediate effects on the extent subsistence systems.

Overview of Eastern North America

Brief History of Research into the Origins of Agriculture in ENA

Evidence for the presence of indigenous domesticates within ENA was first discovered in the 1930s with the identification of cultigens at sites such as Salts Cave and Cloudsplitter and Newt Kash Rockshelters, along with other Ozark and eastern Kentucky sites. It was through the archaeobotanical work of Melvin Gilmore and Volney Jones that caches of seeds found at these sites were posited to have been intentionally grown (Gardner 1987; Gremillion and Sobolik 1996; Smith 1992; Smith and Cowan 1987). That the small, starchy-seeded annuals (such as chenopod and marshelder and dating to around 4500-3400BP) found at these sites were cached, lead Gilmore to suggest that these plants were cultivated and not simply gathered from the wild. For Jones however it was the large seed size of those cached plants, as compared to specimens found in the wild, which suggested that they might be cultigens. The issue of whether these seeds indicated ENA as a primary center of domestication (i.e. an independent in situ development of agriculture through co-evolutionary cultural and agricultural systems processes) was, however, only briefly speculated upon by both researchers (Smith 1992; Cowan and Watson 1992).

It is not until Fowler's (1957) work that the case for ENA as an area of independent development of agriculture 'reopens.' Fowler, using Anderson's (1952)

Dump Heap theory, as well as the work of Gilmore and Jones, proposed that a Late Archaic subsistence pattern, based on a seasonal settlement cycle, set up behaviors for domestication through the gathering of small starchy seeded annuals such as amaranth, marshelder, and sunflower (Fowler 1971). He argued that this pattern of utilizing small-seeded annuals continues virtually unchanged throughout much of ENA. The exception to this pattern is modification to this indigenous system with the introduction of maize.

The previous work done by Fowler, Gilmore, and Jones is invaluable but it isn't until the 1960s and 70s, that the evidence for ENA as an independent center of domestication is systematically examined. Systematic examination and methodological innovation within the field of paleoethnobotany was undertaken through the work of Struever (1971), Yarnell (1964), and Watson (1976; 1997). Binford's call for more standardized field and laboratory methodology during the 60s and 70s also influenced the methods employed by paleoethnobotanists (as discussed in Chapter 3). During this period, Struever also (1971) argued for the more rigorous use of fine-grained recovery methods, especially flotation, in order to allow for better recovery of charred macrobotanical remains. In conjunction with the use of flotation, Struever (1971) suggested that feature contexts, especially hearths, are the best archaeological source for potential subsistence remains to occur. These types of archaeological features are targeted because it is unlikely for small seeds to have been preserved without charring of some kind.

Another important methodological recommendation by Struever (1971) is the need to compare recovered seeds of the same species from different archaeological sites. This was required in order to (potentially) clarify issues of indicator traits for domesticates. At this point in time, a major methodological question was how to identify if these small starchy seeded annuals were cultigens. For Struever this was particularly important due to the issues surrounding larger seed size as a potential indicator of plant domestication. At the time, there were arguments against using larger seed size as an indicator for domestication.

One line of reasoning against the argument for larger seed size as an indicator for domestication was the potential for unintentional selection during harvesting of larger plants with larger seeds resulting from growing in enriched soil (Yarnell 1971). These views were still prevalent during the 1970s despite Yarnell's (1971) study of seed size in giant ragweed. In this study, randomly sampled seeds from a large plant and from a small plant of giant ragweed were collected and compared for both seed size and seed weight. Plant size was found to have no affect on seed size or weight.

However it wasn't until further work on the markers of domestication by other researchers, such as Asch and Asch (1977, 1978, 1985), that confirmed these plants as domesticates. Along with the identification of larger seed size as a marker of domestication, the identification of thinner seed coat thickness as an indicator of wild or domesticated status was also confirmed. When compared to their wild counterparts, it was clear that the seeds found at those Kentucky cave sites had those clear markers of domestication. This combined body of evidence led to the hypothesis that ENA may have been a center of independent plant domestication and husbandry (Yarnell 1993).

One question raised, however, is the mechanism by which these plants were transformed from wild to domesticated species. The most likely model is that proposed by Edgar Anderson (1952). Anderson (1952) proposes the "dump heap" model as a theory on the process of domestication within ENA. This hypothesis states that dump heaps and disturbed areas caused by human activity are ideal habitats for weedy, invasive plants. These invasive plants are best characterized by many of the oldest cultigens (i.e. the Eastern Agricultural Complex (EAC): squash, marshelder, chenopod, and sunflower) within ENA. This hypothesis has since been expanded upon, primarily by Smith (1995, 2002) who also utilizes the work of Harlan et al. (1973), to develop his theoretical model on the role of domestilocalites in plant domestication.

According to Smith (2002), domestilocalities have four attributes important for a new plant habitat. These include sunlight, soil fertility, soil disturbance, and the continual introduction of seeds. Domestilocalities are open habitats caused through anthropogenic disturbance of the surrounding environment (Smith 2002). These disturbed areas, in conjunction with at first unintentional coevolutionary processes, bring about domestication and eventually active encouragement of plant species (Smith 2002). As weedy invasives, these plants would quickly move into an area disturbed by human activity. Hunter-gatherers moving through their seasonal round and returning back to the same or nearby areas would have noticed these plants and perhaps started to gather their seeds (Smith 2002). The result is that eventually intentional planting or habitat creation would have transformed EAC plants into domesticates.

Crop Histories: Eastern Agricultural Complex

As discussed in Chapter 1, Cowan and Watson (1992) define ENA as both a primary area and secondary area for the origin of agriculture. This is because of the two separate crop systems in ENA, both of which became economically important at different points in time. The first crop system is an indigenous suite of cultigens characterized by small starchy and oily seeded plants that were originally weedy invasive species, as described above. These indigenous EAC cultigens include chenopod (*Chenopodium berlandieri*), marshelder/sumpweed (*Iva annua*), sunflower (*Helianthus annuus*), and squash (*Cucurbita pepo*). Depending on the region of ENA, other wild grasses which in some areas became EAC cultigens include little barley (*Hordeum pusillum*), erect knotweed (*Polygonum erectum*), and maygrass (*Phalaris caroliniana*) (Crawford and Smith 2003 Scarry 2003; Smith and Cowan 2003).

The earliest evidence for the domestication of an EAC species is squash. Evidence for domesticated squash species dating to the Middle and Late Archaic (time periods: 8000-6000BP and 5000-2000BP) is prevalent throughout the Midwest and Northeast. Most Middle Archaic sites come from the Midwest and Southeast and are located around major riverine systems including the Missouri, Illinois, Mississippi and Ohio River valleys. It is not until the Late Archaic that the earliest evidence for squash in the Northeast (New England and the Great Lakes) is found. See Table 2-1 for a list of sites with dates. Throughout all of ENA, however, the early domestication of squash does not have a significant economic impact upon subsistence systems and it is tenuous to argue that food production was occurring in these areas during the Middle and Late Archaic periods due to the utility of squash fruits for non-food purposes such as floats for fishing lines and nets or water containers (Fritz 1999; Gremillion 2003; Hart et al. 2004).

The pattern of site locations (trending south to north) seen in early squash remains is also true for chenopod, sunflower and marshelder. By the Late Archaic (ca. 5000-3000BP) and Early Woodland (ca. 3000-2000BP) in the Midwest and Southeast the earliest domesticated remains of these species are found at several sites including Koster

Table 2-1: Early Cucurbit finds in Eastern North America

Midwest & Southeast Sites	Site Name & State	Radiocarbon Date	Calibrated Radiocarbon Age (2-sigma)	Reference
	Phillips Spring, MO	4440±75 BP	4869-5290 BP	Smith 2000
	Koster, IL	7100±300 BP; 6820±240 BP	7423-8482 BP; 7265-8074 BP	Conard et al. 1984; Asch 1994
	Anderson, TN	6990±120 BP	7606-8017 BP	Crites 1991
	Hayes, TN	5430±120 BP	5936-6438 BP	Watson 1985
	Cloudsplitter, KY	5130±60 BP	5726-5995 BP	Cowan 1997
	Napoleon Hollow, IL	7000±240 BP	7435-8223 BP	Conard et al. 1984
Northeast Sites (Great Lakes & New England)				
	Sharrow, ME	5695±100 BP	6295-6678 BP	Asch Sidell 1999
	Memorial Park, PA	5405±552 BP; 2625±45 BP	4952-7337 BP; 2702-2852 BP	Hart and Asch Sidell 1997
	Meadowcroft, PA	Ca. 3000 BP		Cushman 1982
	Schultz, MI	2820±40 BP	2844-3064 BP	Lovis and Monaghan 2008; Monaghan et al. 2006
	King Coulee, MN	2580±60BP	2461-2795 BP	Perkl 1998
	Scaccia, NY	2905±35BP	2947-3164 BP	Hart et al. 2007

and Napoleon Hollow (IL), Hayes (TN), and Cloudsplitter (KY) (Asch and Asch 1985; Crites 1993; Smith and Cowan 1987). Evidence for these plants in the Northeast does not occur during the Late Archaic. Instead the earliest evidence for chenopod, sunflower, and marshelder in the Northeast is during the Early and Middle Woodland periods (ca. 3000-2000BP and 2000-1650BP). Use of EAC plants continued throughout ENA up to contact with Europeans. However their peak period of use occurred during the Middle

Woodland. Evidence for intensive EAC use during the Middle Woodland is most apparent in Hopewell cultural manifestations in Illinois and Ohio. It is after this period that maize (*Zea mays*) cultivation becomes widespread and use of EAC plants declines, or as is the case in the central Midwest and Southeast, disappears altogether (Crawford and Smith 2003).

Crop Histories: Maize

It is with the introduction of maize that ENA becomes an area of secondary agricultural origin. The introduction of this crop staple eventually replaces the original mixed foraging-horticultural subsistence system present in many areas of ENA. (Cowan and Watson 1992:207-208). However, the replacement of indigenous domesticates by maize is not represented as an immediate wholesale adoption of maize in favor of EAC cultigens. The adoption of maize as a staple is a gradual occurrence with a number of contributing factors. The primary factor in the lengthy period of time between the first evidence of maize and its use as a staple is due to its initial limitations (environmentally speaking) as an imported tropical non-native domesticate that required adaptation to a more northerly climate. Other secondary reasons include the labor investment to tend and protect maize during the growing season, processing requirements, and a general unfamiliarity with the reliability of this plant to local indigenous populations (Smith and Cowan 2003). For these reasons it took time to move north within ENA and make a significant impact on the traditional subsistence system. However, it is also for these reasons that research concerning the adoption and use of maize within ENA has been so robust.

The timing of maize agriculture in ENA has been an almost continuous area of research. Use of increasingly refined data recovery techniques, especially microbotanical analyses such as phytolith and starch studies on ceramic residues, to approach this problem has meant that the date of initial maize utilization is continually being pushed back. The most recent early date (2270±35BP; Hart and Matson 2009) on maize utilization comes from central New York with the recovery of maize phytoliths from AMS dated ceramic residues. Compared to the earliest AMS dated maize macrobotanical remains which fall into the range of 2050-1800BP from sites located in Ohio and Tennessee (Smith and Cowan 2003) demonstrates some overlap. Earlier initial use for maize is especially pertinent when found in northern areas of ENA, such as the early date from New York, as this indicates that the process of maize adapting to more northerly climes is happening faster than originally expected (See Table 2-2 for summary data).

Initial findings of maize remains in archaeological contexts generally involved large caches of maize. One such cache example comes from the Juntunen (20MK1) site located on Bois Blanc Island, MI. Excavated by the University of Michigan in the 1960s, large caches of charred maize kernels and cobs were discovered. Caches of maize throughout ENA were primarily found prior to the development and use of flotation as a widespread means for recovering archaeobotanical remains. These caches dated to late in the archaeological record of ENA for a number of reasons. First, in order to have caches of plant remains visible to the naked eye, a large quantity of seeds are required. The quantity needed also implied that by the time these caches were made, maize was cultivated to the extent that it was a staple crop and no longer a dietary supplement. Overall for ENA, and especially the Northeast, the dates for maize as a staple are late

Table 2-2: Summary data of early maize

Midwest & Southeast Sites	Site Name & State	Radiocarbon Date	Calibrated Radiocarbon Age (2-sigma)	Reference
	Harness Mound, OH	1730±85 BP; 1720±105 BP	1483-1827 BP; 1403-1872 BP	Smith 1992
	Holding, IL	2017±50 BP; 2077±70 BP	1875-2115 BP; 1881-2182 BP	Riley et al. 1994
	Icehouse Bottom, TN	1775±100 BP	1509-1925 BP	Chapman and Crites 1987
	The Pas Reserve, ON (north western)	1590±50 BP	1366-1579 BP	Boyd and Surette 2010
Northeast Sites (Great Lakes & New England)				
	Vinette, NY	1960±28 BP	1864-1953 BP	Thompson et al. 2005
	Grand Banks, ON	1550±150 BP; 1570±90 BP	1222-1817 BP; 1302-1628 BP	Crawford and Smith 2003
	Fortin 2, NY	1515±27 BP	1337-1422 BP	Thompson et al. 2005
	Wickham, NY	1438±31 BP	1295-1382 BP	Hart et al. 2003
	Eidson, MI	1700±70 BP	1479-1742 BP	Garland 1990
	Marquette Viaduct, MI	1700-1500 BP	1226-2115 BP	Lovis et al. 1996
	20SA1034	1400 BP		Parker 1996

(AD 900-1000 or later). The combination of late dates and large quantities of maize with little intermediary evidence for maize cultivation resulted in the initial hypothesis that the introduction of maize was both late and resulted in rapid change from a hunter-gatherer to an agricultural mode of subsistence.

The rapid adoption of agriculture model was modified, however, with the advent of flotation as a method of data recovery. The use of flotation as a refined recovery technique has produced vast quantities of charred macrobotanical remains that would not have been found otherwise. As a result, a better understanding on the incorporation of domesticates into a hunter-gatherer subsistence system developed. Models on the origins of agriculture within ENA no longer incorporated a rapid transition from a hunter-gather to a maize dominated agricultural subsistence system. Instead, it was recognized that a period of indigenous crop cultivation occurred before the advent of intensive maize agriculture.

History of Origins of Agriculture Research within Michigan

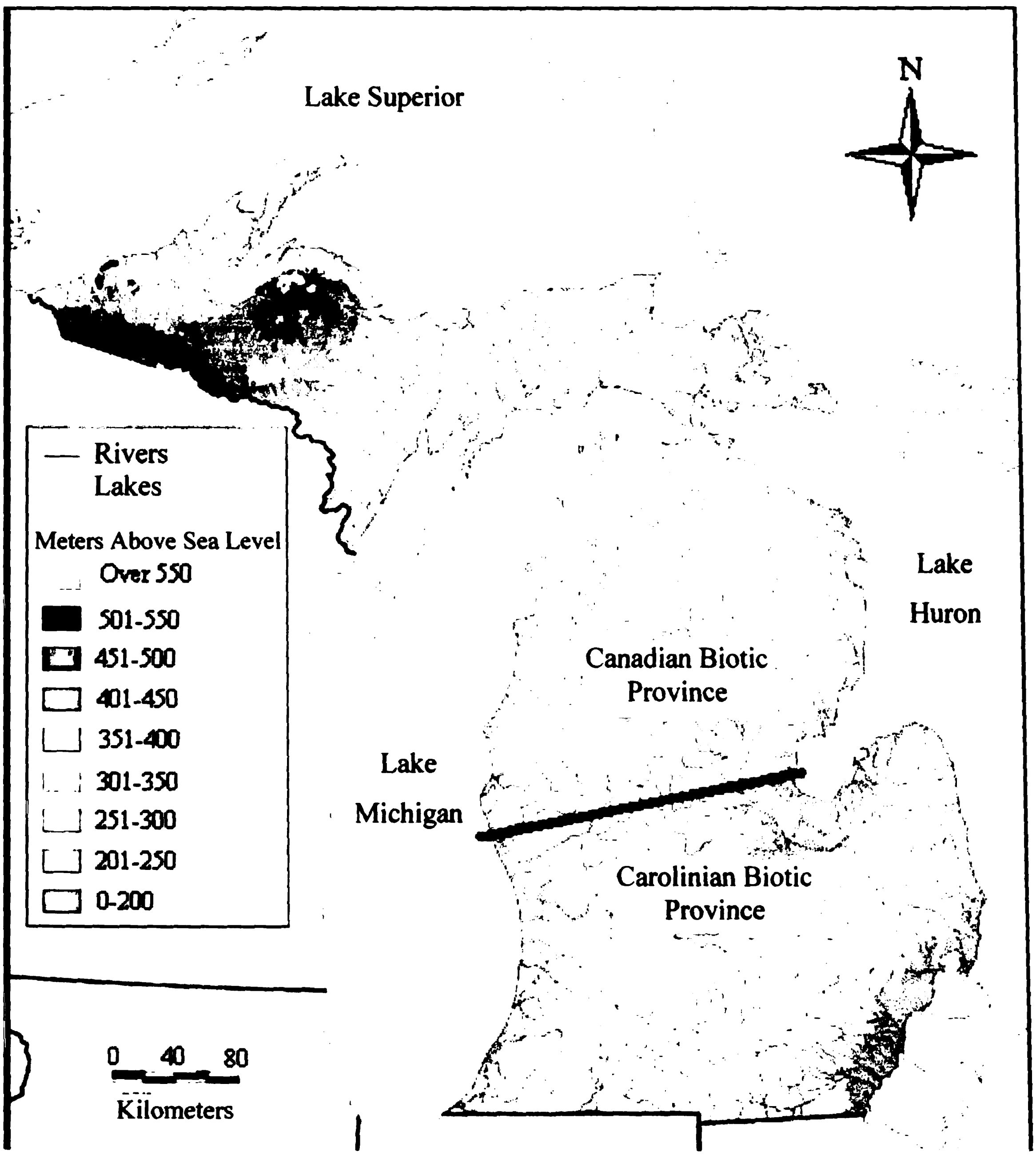
The study of the origins of agriculture within Michigan acts as a good case study and microcosm which mirrors the history of this problem within the larger geographic region of ENA. A short background on the geophysical landscape of Michigan is provided before going into the history of research on the origins of agriculture in Michigan.

<u>Geologic and Geographic Setting of Michigan</u>

Michigan's lower peninsula represents the transition between two ecotones, Northern Hardwood-Conifer forest in the northern part of the lower peninsula, and Beech-Sugar Maple forest to the south. The floristic tension zone present within the lower peninsula of Michigan (Figure 2-1) is primarily a product of weather and climate but soil characteristics also play a role in the distribution of plant communities within the state. These soil characteristics are directly related to the glacial history of Michigan in regards to the deposition of gravel, glacial till, alluvium, and beach sand (Dorr and Eschman 1970; Monaghan and Lovis 2005).

Lake level extent and fluctuation during the pre-Holocene (end of the Wisconsin glaciation, c. 14,500 BP) and Holocene (12,000 BP to present) were directly influenced by glacial advance and retreat as well as by-products of glaciation such as

Figure 2-1: Approximate division of ecotones in Michigan



isostatic rebound (Dorr and Eschman 1970; Monaghan and Lovis 2005). During the early Holocene isostatic rebound played the biggest role in regards to lake level fluctuation in the Michigan and Huron basins primarily due to the opening and closing of drainage outlets (Monaghan and Lovis 2005). Before retreat of the Laurentide Ice sheet opened the outlet at North Bay, Ontario, drainage for the Michigan and Huron basins was to the south at the Chicago and Port Huron outlets (Monaghan and Lovis 2005). Pre-Holocene lakes went through a number of high and low water stages during glacial retreat.

In the Lake Michigan Basin, pro-glacial Lake Chicago went through a number of high-low-high lake level phases. The low phase was directly due to the retreat of the Lake Michigan Ice Lobe which opened the outlet at the Straits of Mackinac, c. 13,500 BP (Dorr and Eschman 1970; Monaghan and Lovis 2005). This changed drainage of Lake Chicago towards the north and east through the Port Huron outlet and the now connected Michigan and Huron basins formed Lake Arkona (Monaghan and Lovis 2005).

Reflective of the fluctuations in Lake Chicago, pro-glacial lake levels in the Huron and Eerie basins mimicked glacial advance and retreat but were more prone to significant changes in water levels (Dorr and Eschman 1970). Lake Maumee (c.14,000 BP), the oldest and highest of the major lake phases in the Lake Eerie basin had 3 stable high-low-high water phases. Initial drainage of Lake Maumee was through the Fort Wayne outlet, however glacial retreat opened an outlet across southeast Michigan. The result was Lake Maumee draining to the west via the Glacial Grand River channel to Lake Chicago (Monaghan and Lovis 2005). Lake Maumee became a part of Lake Arkona, mentioned above, once glacial ice retreat opened up the Straits of Mackinac. As glaciers advanced during the Greatlakean stade, the Straits of Mackinac outlet was cut off and glacial lakes Chicago (Michigan basin), Whittlesey (Eerie basin), and Saginaw (Huron basin) were formed c. 13,000 BP (Dorr and Eschman 1970; Monaghan and Lovis 2005).

During the early Holocene the low water phases and drainage outlets for Lakes Chippewa and Stanley (c. 10,300 BP) were primarily controlled by isostatic rebound at North Bay, ON. This outlet was reopened and allowed water in the lakes to drain north and east (Monaghan and Lovis 2005). Once the North Bay outlet was raised higher, due to isostatic rebound, than the Straits of Mackinac, water level in Michigan and Huron basins increased. With the continued uplift of the North Bay outlet, it was eventually raised above the altitude of the southern outlets and drainage back to the southern outlets, initiated Lake Nipissing at c. 5,000 BP (Monaghan and Lovis 2005).

Subsequent changes in Holocene lake levels during the mid-Holocene and later were in part due to isostatic rebound but not to the extent it played during the early Holocene (Larsen 1985; Monaghan and Lovis 2005). Starting with Lake Nipissing, and continuing through to modern lake levels, lake level fluctuation was less due to isostatic rebound but more to shifts in climate, primarily between cooler and wetter and warmer and drier shifts in climate (Monaghan and Lovis 2005). Cooler climates resulted in less water evaporation while wetter conditions contributed greater precipitation to the lakes; the opposite mechanisms operated during periods of warmer and drier climate. Warmer temperatures raised water evaporation rates while drier climatic conditions meant less precipitation was available to replace water lost through evaporation (Monaghan and Lovis 2005).

Such shifts in lake levels during the Holocene resulted in flooding of low lying areas such as floodplains and the Shiawassee Flats during high water stages. Incising and erosion of river beds occurred during the low water stages. These processes resulted in the formation of wetlands and swamps during high water stages, the deposition and subsequent erosion of gravels and alluvium, along with burial of archaeological sites, during various points in time (Monaghan and Lovis 2005). The result of this complex geologic history has played a direct role in the location of plant communities throughout lower Michigan and in the Saginaw drainage due to the variable soil types and their characteristics which resulted from glaciation and repeated episodes of flooding and erosion. However soil characteristics are not the only factor which affects the location of plant communities; weather and climate also play a role.

The most important aspects of weather and climate which influence the distribution of plant communities within Michigan are a result of rain fall, solarization, wind, and its proximity to the Great Lakes (Andresen and Winkler 2009). The Great Lakes have an ameliorating effect on Michigan climate in the state's higher latitudes, especially along the Lake Michigan shoreline, which allows for a longer growing season due to variations in microclimate which can warm soils faster and mitigate frost formation (Andresen and Winkler 2009). It is due to these factors that species with southern affinities, such as *Quercus velutina* (Black Oak) and *Carya ovata* (Shagbark Hickory), extend as far north as Missaukee and Manistee counties in Michigan (Harmon 2006). The same is true of species with more northern affinities, such as *Tsuga canadensis* (Eastern Hemlock) and *Pinus strobus* (Eastern White Pine), which occur as far south as Berrien county (Eastern Hemlock) and Bay county (Eastern White Pine) in

Michigan. In the instance of northern affinity species, it is the presence of patches of sandy, acidic soils in conjunction with the ameliorating effects of the Great Lakes on summer heat which allow for the southern extent of these species.

The location of the Saginaw drainage on the border of these two macro-patterns of plant communities allowed for a varied subsistence base. Exploitation of plant resources in both deciduous and coniferous forested zones allowed for a more diverse woodland resource base. Recognizing that the floristic tension zone between deciduous and coniferous forest in the Lower Peninsula varies across the state, it also makes ease of discussion in regards to plant geography cumbersome. In order to ease discussion, the area north of the tension zone will be referred to as the Canadian Biotic Province (i.e. predominantly coniferous forest) while the area south of the tension zone will be referred to as the Carolinian Biotic Province (i.e. predominantly deciduous forest; Figure 2-1).

Research on prehistoric agriculture in Michigan

Ideas and research on the use of agriculture in Michigan are necessarily constrained by the local environment. Michigan is an area with a northerly climate and maize had to already be adapted to a shorter growing season in order to be successfully grown. This shorter growing season included adaptation to rainfall, solarization, temperature, and number of frost free days. On average, maize requires 180 frost free growing days and is intolerant to cold, especially in its early stages of growth where cold growing conditions can stunt growth. Similar limitations occur with precipitation; too much water early in its growth will also stunt maize. As a result, maize not only needs warm climate conditions, but also well drained soils for ideal growing conditions (Krakker 1983).

In addition to maize plant adaptation, there are human behaviors that would have buffered against adverse environmental effects and aided in successful maize horticulture (Krakker 1983). These behaviors include cultivation techniques, such as using ridged fields or hills in which to plant crops, to garden plot location and soil selection (Gartner 1999; Krakker 1983). Planting cultigens in ridged fields or hills has a number of benefits. Ridges provide drainage and water storage by aerating planting surfaces and storing moisture at the base of ridge beds (i.e. in the field valleys). The cultivation techniques associated with raised fields also improve crop habitat by providing weed control as well as producing a loose well-aerated and fertile planting surface. Planting surface fertility was maintained by using sediment collected in the ridge ditches in conjunction with the burning of crop residues (in the case of maize, this would be stalk remnants). Use of ridged fields also helps to counteract the dangers of a deep spring frost, which can be more damaging to plants as they are in the initial stages of plant growth and germination. The likelihood of a deep spring frost is often more critical in terms of crop damage than the total number of frost-free days in a geographic area (Gartner 1999). Locating garden plots on areas of higher elevation and in conjunction with well-drained soils also guards against any subsequent growing season flooding which may occur and allows for warmer soil temperatures (Krakker 1983: 100).

The Carolinian biotic province is characterized by deciduous forest and temperate climate with moderate rainfall (Albert et al. 1986; Anderson and Winkler 2006; Barnes and Wagner 1981; Cleland 1966; Dice 1943; Harmon 2009). Most of ENA falls within this floristic tension zone and is considered to be very productive in terms of available wild food resources. Most importantly, this biotic zone falls within the 180 frost-free growing days maize requires (at a minimum). This is in contrast to the Canadian biotic province which is dominated by conifer forest and a less temperate climate with a shorter growing season.

The transition between these two zones within Michigan stretches from the southeastern edge of Saginaw Bay on the east side of the state to the mouth of the Muskegon River on the west side of Michigan. This transition zone stretches as far north as Charlevoix on the Lake Michigan side and to the mouth of the Ausable River on the Lake Huron side; the ameliorating climatic effects of Lake Michigan allow for the transition zone between the Carolinian and Canadian biotic provinces to be farther north on the west side of Michigan than the east side. As a result, the potential for maize horticulture is best found in the Carolinian biotic zone and the southern portion of the transition zone from the Carolinian to the Canadian biotic province. This expectation, in addition to the type of evidence found, guided early interpretations on the use of maize and maize agriculture.

The model advocated by Yarnell (1964), Cleland (1966), and Fitting (1969) mirrors the early model within ENA of a rapid transition from hunter-gatherer to reliance on maize agriculture. In this model the transition from the Late Archaic to the Woodland period is marked by rapid widespread change from hunting and gathering to an agriculturally based subsistence system (Egan 1990). Evidence for this rapid transition to maize horticulture was based on the discovery of maize storage pits located within large village sites such as Juntunen. Other evidence cited for the rapid transition from hunting and gathering to farming is based on the presence of open woodland species at sites such as Schultz and Moccasin Bluff. These types of species (examples include elk and woodchuck) appear in Middle and Late Woodland strata. Evidence for the exploitation of open woodland fauna is not found during the Early Woodland periods at these sites. As a result, Cleland (1966) interprets the presence of these open woodland species as evidence for the clearance of forest in conjunction with agricultural activities, primarily clearance for agricultural fields. In conjunction with the presence of open woodland fauna, Cleland also cites the decreased importance of hunting, based on the increased presence of fish remains coinciding with a decrease in mammalian remains, as evidence for a more plant based economy. It is inferred that this change means hunting was no longer the primary focus of subsistence during the Middle and Late Woodland periods which indicates that a shift in subsistence had occurred (Cleland 1966:210).

While this model of quick subsistence change is no longer accepted, it is the jumping off point for the two predominant models currently in use to explain the transition to low-level food production incorporating maize within Michigan. One model is that advocated by Lovis et al. (2001) and Egan (1993), which focuses on ecosystem factors while the other is put forth by O'Shea (2003) and Milner (1991) and places primacy on social relationships. Both models debate the mechanism for gradual intensification on domesticates and cultigens.

O'Shea (2003) suggests that there are two populations in Michigan, an inland forager group and a coastal dwelling maize horticulturalist population. He argues that social interaction between these two groups was important in affecting each other's subsistence decisions. When maize horticulture was adopted by these coastal groups, the inland population was cut-off from resource rich coastal zones (O'Shea 2003). In response to this minimization of resources, O'Shea (2003) hypothesizes that inland forager groups responded in two ways: 1) intensified exploitation of coastal-equivalent inland resource zones (i.e. large inland lakes and wetlands) and 2) creation of inter-regional social ties which enabled them to acquire both coastal resources and maize through exchange. This relationship would have been beneficial to the coastal populations since maize horticulture can vary in yearly production and this would have allowed them access to potentially more stable inland resources. Milner (1991) also argues for the importance of social dynamics in the western Great Lakes, in the form of trade alliances, marriage ties, and mortuary ritual. She argues for short-term fluidity in local group affiliation with longer term regional ties maintained via exogamous marriage with other sub-regions. In this way, local group control over productive fisheries was maintained while preserving access to inland resources (Milner 1991).

In the ecosystem and landuse model, (c.f. Egan 1993; Lovis 1990; Lovis et al. 2001; Robertson 1987) the focus is on factors such as reliability and abundance of wild resources, where those resources are located on the landscape and how this effects site location, and the intensified use of these reliable and abundant resources. In the Great Lakes, reliable and abundant plant resources are characterized by wetland resources and weedy annual EAC cultigens. Intensification on these plant resources sets up pre-adaptive behaviors conducive to expanded low-level food production which incorporates maize. Use of and planting and tending practices of EAC cultigens allows for a 'plug-and-play' type of system wherein these extent practices can be adapted for use with new types of cultigens; in this case maize.

Egan's (1993) work also takes into account issues of gender and the allocation of labor within the ecosystem model. However, cultigens were not included in her macrobotanical analysis of sites within the Saginaw River valley. The exclusion of these plant resources, under the assumption that they were not a large component of the hunter-gather diet, may have had a drastic impact on the model subsequently developed for settlement-subsistence patterns within the Saginaw drainage. For the time period analyzed by Egan, the populations within the Saginaw drainage are best characterized as mobile low-level food producers. Currently, there is ample evidence that domesticated squash was present as early as the Late Archaic and domesticated chenopod by the Middle Woodland (Lovis et al. 2001; Monaghan et al. 2006). The presence of these domesticates suggests they were being incorporated into the diet of the local population on some level. It is especially important that these were domesticates and not wild species of these plants as this indicates they were being cared for in some way. As such, we can characterize the population within the Saginaw drainage area as mobile low-level food producers. The incorporation of domesticated plants into what has traditionally been deemed a hunter-gather system also requires an explanation of which segment of the population were tending these plants and how this division of labor was divided when care for cultigens coincided with traditional hunting and gathering activities.

A combination of the two models presented above exists in the work of Howey (2006, 2007). Howey combines landscape factors such as waterways, slope, and vegetation cover in a GIS in order to model movement of different populations within Michigan to the Missaukee Earthworks (20MA11-12). Missaukee Earthworks is a late prehistoric ceremonial earthwork, in lower northern Michigan. Howey (2006, 2007) modeled pathways to Missaukee from various locations in Michigan including the Saginaw drainage, southeast Michigan, and southwest Michigan.

Pathways to Missaukee Earthworks from these various regions were modeled since this site was known as a ceremonial integration site. The interpretation of Missaukee as an area where dispersed populations convened is also supported through the presence of lithics and ceramics from disparate areas of Michigan. Lithic material includes Bayport chert (which outcrops in the Saginaw Basin) and Norwood chert (which outcrops in Antrim county on Lake Michigan) while ceramic styles such as Juntunen and Traverse Wares (northeastern Michigan), as well as what Howey terms Mixture Late Traits (i.e. a mix of decorative styles which are not typical of one ware) are present. Howey's interpretation follows the O'Shea and Milner models by positing that the different regional populations congregating at Missaukee represents coastal farmer and interior hunter-gatherer populations.

The research undertaken for this dissertation attempts to fill in gaps present in the ecosystem and landuse model for the Saginaw drainage. Data collected via phytolith and starch analyses of ceramic residues provides another line of evidence for various subsistence activities. Microbotanical data often provides evidence for plant use not seen in macrobotanical data due to different taphonomic processes undergone by microbotanical data. Microbotanical data directly derived from artifact surfaces (either ceramic or lithic artifacts) also provides direct evidence of which plants were utilized together. The utilization of ceramic residues in this study specifically provides data on plant mixes cooked together. These combinations not only provide dietary information but also potential information on seasonality through the use of plants which are known to be stored or those which are known to only be utilized during their season of availability.

Additionally, a social component may be relevant to the interpretation of microbotanical data if any exotic or non-local plants are identified. If such plants are identified, their presence is most likely due to either down-the-line, or perhaps direct exchange between populations. It is arguable, however, if this potential social interaction represents coastal farmers and inland hunter-gatherers. For the purposes of this dissertation, it is assumed that the various populations within Michigan do not represent a coastal-farmer, interior hunter-gatherer dichotomy but rather distantly related groups practicing mixed subsistence economies to varying degrees.

CHAPTER 3

Evidence for Plant Use

Introduction

As archaeological methods and techniques have become more refined and innovative, the lines of evidence, both direct and indirect, for plant use have also become more varied and refined. Direct evidence for plant use consists of the physical remains of the plants themselves and includes macrobotanicals, such as seeds, cobs, and rinds and microbotanicals such as pollen, starch, and phytoliths. While not all of these remains are visible to the naked eye, they are all some form of physical remain which can be extracted from various archaeological and environmental contexts. Included in direct evidence is accelerated mass spectrometry (AMS) dating, which has enabled the radiocarbon dating of small amounts of carbonized material (i.e. individual macrobotanical remains or carbon located within phytoliths). The development of AMS radiocarbon dating is what is most pertinent to the issue of diet since it has allowed for refining the timing of plant use.

Indirect evidence for plant use consists of evidence which would indicate the use of plants but does not come from the actual plant. Indirect evidence is most often derived from the refinement of scientific techniques which have come to be applied to archaeological data. The most important indirect dietary evidence is through stable isotope analysis. Stable isotope studies, especially when done on bone, provide an excellent indication for overall long-term diet composition. However, this is not always the case as various artifact classes, such as grinding stones, can indicate plant use without the physical remains of plants present.

When used in conjunction with each other, indirect and direct evidence for plant use act as complementary lines of evidence. This enables archaeologists to better interpret human behavior from the archaeological record and provide a more complete picture of activities taking place, which segments of the population were likely doing these activities, and the interaction between various groups on the landscape.

Direct Evidence

Macrobotanicals

To archaeologists studying the origins of agriculture in the early years of the discipline, it was clear domesticates had to have developed at some point in the past since modern industrial society is agriculturally based. As a result, macrobotanicals were the earliest form of evidence archaeologists had for plant use. Macrobotanicals are any plant part visible macroscopically (i.e. to the naked eye). These include seeds and seed cases, stems, leaves, roots, and fibers. However, methods of macrobotanical recovery have always been an issue.

In the case of macrobotanicals, evidence for paleodiet and subsistence is entirely dependent on the recovery of preserved floral remains. Initially, these remains were recovered during excavations only if an excavator encountered a large cache of remains or was sufficiently sharp-eyed enough to see various plant remains during excavation. Additionally, early screening techniques also posed problems to macrobotanical recovery. In early archaeological excavations, standardized screening techniques were varied. Excavations of the same site year to year could utilize ½" or ¼" mesh screens, or in the case of very early excavations, none at all. This resulted in many potential remains, both artifact and macrobotanical, going uncaptured. With the advocation for the use of (relatively) standardized excavation techniques by Binford (1965) and others in the 1960s, the switch to ¼" mesh as the standard for screening aided in some extent to counteract this recovery problem. However, it was not until the development of flotation that macrobotanical recovery became commonplace, regular, and standardized.

The 'flotation revolution' (Watson 1976), during the 1960s, led directly to the systematic recovery of macrobotanicals and allowed for quantitative analysis of plant remains (Pearsall 2000). Flotation started as a modification of a lab technique used by botanists to clean botanical samples still mixed with soil. It was modified into a field technique primarily by Struever for the express purpose of recovering small botanical and faunal remains (Pearsall 2000:20).

The overall principle behind flotation is that botanical remains will float and rise to the surface of water used in the flotation system while the soil is agitated through the fine mesh screen at the bottom of the flotation bucket. Botanical remains can then be collected, depending on the system in use, either by hand with a fine mesh screen or floated off into cheese cloth or other fine mesh screen. Assuming that standardized sampling for flotation samples was employed during field excavations, flotation recovery of botanicals allows then for systematic analysis of the recovered remains. Adding an exotic marker to each flotation sample, such as a standard number of charred poppy seeds in the case of New World excavations, also enables statistical analysis of recovery rates and acts as a check on the efficiency of flotation procedures (Pearsall 2000:93). The incorporation of flotation as an archaeological sampling method has caused a drastic increase in the number and types of macrobotanicals recovered as well as an increase in the variety of plants recovered.

The number and types of plants recovered also increases if flotation soil sampling during excavation is employed in all excavation contexts and is not simply limited to feature contexts (Pearsall 2000:66). Pearsall (2000:66) refers to this strategy as 'blanket sampling'. While sampling hearths and ashy deposits may seem the logical choice for the recovery of charred macrobotanical remains, this does not always result in macrobotanical recovery. Charred plant remains can occur through both deliberate and unintentional processes and the use of blanket sampling allows archaeologists to potentially capture both types of processes.

Charred remains can also be spread around and end up in secondary contexts through the cleaning behaviors of prehistoric peoples (Pearsall 2000:66). Examples of these secondary contexts include garbage middens and house floors. Sampling strategies need to account for these potential taphonomic processes in order to best obtain a representative sample. By utilizing blanket sampling, the ability to analyze and discuss paleodiet dramatically increases since the paleoethnobotanist now has maximum flexibility for interpretation since all contexts were sampled. This provides a means to evaluate various site contexts and site functions (Pearsall 2000:67).

As the discussion above should indicate, the recovery of macrobotanicals is not solely reliant on archaeological excavation techniques. Preservation of macrobotanicals is affected by a number of variables. The variability of macrobotanical preservation can be due to processing procedures (both in terms of initial food preparation prehistorically and, as already discussed, archaeological recovery methods), prehistoric storage techniques, soil acidity, and site formation and post-depositional processes (Pearsall 2000). Perhaps most importantly, the issues of prehistoric food preparation and storage techniques are central to the recovery of macrobotanicals by archaeologists.

Prehistoric food preparation techniques which result in the potential for macrobotanical preservation ubiquitously involve fire which to some extent chars the plant material (Pearsall 2000:247). Many historic and ethnographic accounts (c.f. *The Jesuit Relations*; Harrington 1908; Wilson 1987; others) describe the parching and drying of seeds in a shallow basket or clay bowl/pot over coals. The movement of seeds is required so as to prevent burning; this can be accomplished via continual movement of the parching basket or clay pot or by moving seeds with a stirring paddle or stick. Sievers and Wadley (2008) also describe experimental work wherein seeds are parched through burial 5-10cm directly underneath a fire. While their experimental archaeology project was undertaken to explain parched seeds found at Middle Stone Age sites in South Africa, it could be a method potentially used elsewhere. Burial of foods in a container or wrapped in leaves is a common cooking technique worldwide and it would not be unusual to assume that the parching and drying of seeds could be done in this manner. The use of indirect heat in this way would allow for an individual to participate or carry out other activities; similar arguments have been made for the heat treatment of lithic material (Raviele 2007). Other drying techniques, such as sun and air drying of parboiled seeds or mature seed pods/cobs would not result in preservation via fire. These macrobotanical remains could however, be preserved in cache/storage pits.

The storage technology utilized prehistorically is also a factor in the recovery of macrobotanicals. If subsistence items (plant and animal) were available year round, long-term storage would be a relatively unnecessary technology. However, in an area where drastic seasonal change occurs, as happens presently and prehistorically in the study area for this project, long term storage of various plant and animal foods is required to survive during the winter months. Storage pits encountered during excavation which are sampled for flotation often yield seed remains from the plants that had been stored in these pits or from the various grasses used to line storage pits. In these contexts evidence for the use of subsistence and non-subsistence flora is gained.

While storage pits and hearths can represent the most likely circumstances under which archaeologists can encounter plant remains, they do not account for all situations in which plants were utilized by people. Not all plant use is economic in nature nor are all economically important plants processed for storage. Fresh greens and berries are examples of foods which are more likely to be eaten immediately instead of processed for long-term storage. As a result, macrobotanical data produce variable interpretations of prehistoric human subsistence-settlement rounds since clearly not all economically important plants will be preserved. It is for this reason that multiple lines of evidence are required when reconstructing subsistence systems.

Pollen

Pollen studies, while predominantly focused on reconstruction of past vegetation and climate, have also been utilized in the reconstruction of paleodiet and plant, specifically when analyzing coprolites and soil samples taken within archaeological sites and anthropogenic contexts (Pearsall 2000:249-250). In addition to taking soil core samples from nearby lakes or swamps for pollen analysis, soil samples from archaeological sites can also be analyzed.

The best soil sampling technique for archaeological contexts is through the use of contiguous sampling. This type of sampling removes a vertical block of soil so that each soil horizon remains in contact with each other (Dimbleby 1985). Contiguous sampling is recommended over spot sampling, which takes samples at intervals throughout a profile, due to the likelihood of pollen accumulation of various ages within these soil samples (Dimbleby 1985:20-21). Spot sampling often results in pollen sequences which do not make sense in the context of known paleoenvironmental data. While pollen rain from the surrounding local environment will be present in these archaeological soil samples, pollen from subsistence plants utilized at the site is also likely to be present. This especially true if plants are gathered with their flowers attached and dried as in its whole form or if flowers are considered edible, as in the case of squash blossoms.

Pollen data does, however, present other problematic issues. Pollen cores are most often derived from nearby lakes and swamps rather than directly from soil samples at a given site (Bryant and Hall 1993; Bryant and Holloway 1983; Dimbleby 1985; Pearsall 2000). Thus, pollen data largely provides information on the regional environment. Pollen data derived from nearby lakes and swamps are also less likely to preserve pollen from important food plants. These plants may not be represented due to the distance of the lake or swamp from the archaeological site (Bryant and Hall 1993; Bryant and Holloway 1983; Dimbleby 1985; Pearsall 2000). Furthermore, if such pollen grains are preserved, their importance may be underrepresented due to more abundant pollen producers in the local environment (Pearsall 2000).

Related to where pollen cores are most likely to be taken from (lakes and wetlands), is pollen preservation. Pollen requires a continuously wet environment or an environment arid enough--as in desert caves--that it does not degrade. Fluctuations in temperature or moisture levels (cycles of wet and dry soils) will cause pollen grains to degrade, sometimes to the point that they are unidentifiable. This may mean that pollen grains from soil columns taken at archaeological sites may not be well preserved. The case is also true of seasonal wetlands located adjacent to archaeological sites. From personal experience taking a pollen core from a seasonal wetland adjacent to 20AN54 located in Antrim County, MI, the pollen grains recovered from this context were unidentifiable from such severe fluctuations in moisture.

Starch

Often paired with phytolith analysis (discussed below) is the study of starches. Starches are produced through photosynthesis as an energy store for the plant. All plants produce some form of starch, of which there are two varieties. The first type is transitory starch found in the leaves and stems and this is produced daily (Cortella and Pochettino 1994; Gott et al. 2006; Messner 2008). These starches generally do not have diagnostic features and are often used the day they are created. As a result they are not useful in archaeological starch grain analysis (Gott et al. 2006; Haslam 2004; Messner 2008).

The second type of starch produced by plants is reserve starch used as long term storage. These starches are primarily found in fruits, seeds, rhizomes, corms, bulbs, and tubers (Gott et al. 2006; Holst et al. 2007; Messner 2008; Messner and Dickau 2005; Pearsall et al. 2004; Perry 2001, 2002a, 2002b; Perry et al. 2007; Piperno and Holst 1998; Piperno and Holst 2004; Piperno et al 2000; Zarrillo and Kooyman 2006). It is these reserve starches that have diagnostic features which are useful in archaeological starch grain analysis. Perhaps most importantly, it is reserve starch that is found in those plant parts which are important prehistorically, either for medicinal or economic purposes. It is reserve starch that is likely to be preserved in residues found on stone tools or ceramic containers (Gott et al. 2006; Messner 2008).

Starch grains are composed of a semi-crystalline structure, containing both hard and soft layers. Grains are formed from glucose in two different forms, amylose and amylopectin. It is these molecules which form the alternating hard and soft layers of the starch granule. The ratio of amylose to amylopectin also aids in the resiliency of starch to environmental stressors and has an effect on physical properties such as gelatinization and reactions to staining (Gott et al. 2006). This ratio of amylose to amylopectin within a starch granule is controlled by both genetic and environmental factors and it is this semi-crystalline structure which has been demonstrated to preserve for long periods of time. Preservation is due to a number of factors including insolubility in cold water and under certain conditions, resistance to enzymic hydrolysis (Gott et al. 2006; Messner 2008). While not completely understood, it is these starch characteristics which allow for the recovery of starch granules from archaeological contexts.

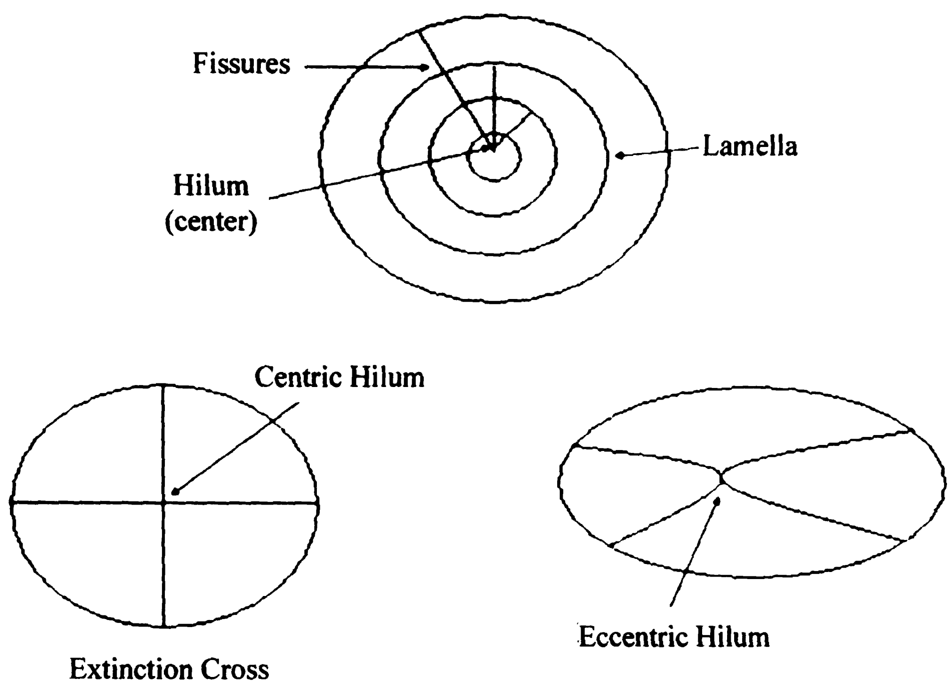
Examples of archaeological starch studies include the analysis of residues adhering to stone tools and ceramic sherds, recovery of starch from dental calculus, and the retrieval of starch from archaeological feature context soils (Fullagar 2006; Messner 2008; Samuel 2006; Torrence 2006). Importantly, organic residues adhering to ceramic sherd interiors can be processed for both phytoliths and starches. These samples can be split so there is separate processing for each type of microbotanical, or they can be processed together. In the case of processing for phytoliths and starch at the same time, some starch attrition may occur but this is likely to be negligible (Boyd personal communication 2008; Cummings 2006). In both cases, the processing for both starch and phytoliths for dual identification provides multiple lines of evidence in a relatively easy manner.

Diagnostic starches are identified via a number of starch grain features (see Figure 3-1 for features described below). These include the location of the hilum, the starch grain size and shape, fissures (if present and the type of fissure), lamellae (growth layers), and the type of birefringence (if and what type of extinction cross is present when the grain is viewed through cross polarized light). Included within the size and shape category for identifying starch, is the specific granule type: simple, compound, and semi-compound (Gott et al 2006:40-42).

The specific starch granule type is determined by how grains are formed in the amyloplast. Compound granules are composed of several parts deemed subgranules or granula; these form simultaneously during starch production. When ground, these granula will separate. Semi-compound granules start as compound forms but then each granula becomes fused together with a surrounding layer of amorphous starch. The result is that a semi-compound grain has a single exterior surface but multiple hila (Gott et al 2006:40-42). Simple granules are those that form independently of one another and are found as single starch grains.

Along with the granule type, starch granule shape can be part of the suite of diagnostic features. Diagnostic grains are found in a variety of shapes including the basic round spherical shape but other common shapes include discs, ovals, elongated, rounded,

Figure 3-1: Major starch grain features (recreated after Gott et al. 2006)



kidney, and polyhedral. Grain size is also influenced by the amount of water in the grain, age of the grain, and where in the plant it is formed. This last factor can also affect the shape of the starch granule (Gott et al 2006). As a result, plants may have multiple associated starch types, of which only some are diagnostic. Prehistorically, if multiple plant parts were economically useful, the variation in starch grains between them must be examined. Therefore, it is critical that researchers have access to comparative collections to aid in starch grain identification.

As stated previously, it is not well understood why some starch grains are resistant to processes which will cause other grains to degrade (even those grains from within the same plant species). However, this does mean that starch grains are left behind in archaeological contexts. In order to understand how starch is incorporated into the archaeological record, an understanding of not only which plants but which plant parts were utilized prehistorically is needed. In conjunction with this, how they were used and what types of processing (drying, grinding/milling, roasting, leeching, etc.) they may have been subjected to is also required.

Experiments with starch taphonomy have been performed by a number of researchers (cf. Babot 2006; Gott 2006; Lu 2006; Williamson 2006; Chapter 4 of this dissertation). These experiments confirm that starch grains can exhibit damage due to processing techniques (cracking, fractures, cavity-like depressions, clumping grains). This damage can aid archaeologists in identifying which human behaviors were most likely associated with plant use. Identification of starch on stone tool edges also provides more detailed and often new information on how those tools were used while also identifying which plants were processed. The analysis of starch from tool edges may also aid in confirming use-wear identification.

One other taphonomic issue in regards to starch studies is the potential for contamination from the surrounding soil matrix or contact with other artifacts. Bonny Williamson (2006) conducted a study wherein she buried a number of stone tools in flower pots (at varying levels and left outside for varying lengths of time) to determine under which conditions contamination would be most likely, if at all, to occur. Williamson found that starch from the surrounding soil matrix was highly unlikely to adhere to artifact surfaces and thus act as a source of contamination. However, when the stone tools were buried with whole vegetables nearby, a significant number of starch grains were found to have transferred from the vegetable material to the artifact surface.

As a result, the context of artifacts sampled for starch analysis should be taken into account and "...a comparison with use-wear would be required to distinguish use from contact," (Williamson 2006:90).

Phytoliths

The use of phytolith analysis in archaeology as a line of evidence for the identification of botanical remains has become increasingly common in the past 30 years. Phytoliths are microscopic deposits of silica that form in and between the cells of plants and can be found to varying degrees in each plant structure (Mulholland and Prior 1993; Pearsall 2000; Piperno 2006). Phytoliths have been known as important plant constituents since the mid-nineteenth century but were not widely used by American archaeobotanists as a fossil economic indicator until the late 1970s (Piperno 2006). The initial utilization of phytolith studies occurred in Meso- and South America where very poor macrobotanical preservation required the exploration and use of alternative methods for identifying domesticates and food plants (Piperno 2006). As of late, it is increasingly employed by North American archaeologists as an alternate means of identifying the early presence of domesticates (c.f. Boyd et al. 2008; Hart et al. 2003; Thompson et al. 2004).

Phytolith analysis offers direct evidence of plant use which may not exist in macrobotanical, palynological, or starch data (Hart et al. 2003; Piperno 2006; Thompson et al. 2004). The sources from which archaeological phytolith samples are derived includes either ceramic or lithic residues or from soil samples taken within and around a site. The result of sampling artifact residues or soil from directly underneath an artifact is that phytolith analysis allows for the identification of plant remains directly associated with an artifact(s). Direct artifact association enables paleoethnobotanists to identify plant processing (from stone tools), suites of plants that may have been cooked and eaten together (ceramic residues), and other human behaviors which may have only previously been hypothesized about or inferred based on ethnographic analogy.

Archaeological phytolith analysis has primarily been performed using soil samples taken within sites. One central assumption in the analysis of soil samples taken within archaeological sites is that the phytoliths present are primarily the result of direct human disposal of plants, resulting from a "decay-in-place mechanism" (Piperno 2006:81). Soil sampling methods for within site analysis occurs in two ways. One is through a vertical soil column removed from a finished, profiled wall while the other is a horizontal sampling of deposits during excavation. Vertical soil columns are ideal when a known chronology is in existence and the site represents multiple discrete occupations.

Horizontal sampling, however, is better suited for the study of various contemporaneous areas within a site. This is particularly useful in the understanding of different contemporaneous functional areas across a site and can add important data not represented through macrobotanical blanket sampling, soil sample derived starch grain data, or pollen analysis. However, even when horizontal sampling is being used, vertical soil columns should still be employed to act as a stratigraphic and depositional control (Pearsall 2006:82-83).

Phytolith analysis can also be used for a more direct line of data by analyzing residues from lithic and ceramic contexts as well as from human remains such as teeth. Phytoliths directly derived from artifacts can indicate plant processing functions and/or techniques as well as a more nuanced study of paleodiet since plant food-specific phytoliths are recovered together in a controlled context. One such context is ceramic residues which result from cooking; phytolith analysis allows for determine which plants may have been cooked and eaten together (Piperno 2006:83). If these artifacts are recovered in the field, control samples from the surrounding soil matrix should be taken in order to differentiate background "noise" from specific functional data. Otherwise careful examination of field notes to help determine artifact context can be used when analyzing museum-based collections.

An aspect of phytolith analysis from artifacts is the utilization of museum collections which may not have been reexamined since their initial recovery. While these artifacts will not have the corresponding control samples taken from the surrounding soil matrix, they can and do offer an important source of information not in use at the time of excavation. As has been demonstrated a number of times (c.f. Hart et al. 2003; Lovis 1990; Thompson et al. 2004), the reexamination of already excavated material in light of new analytical techniques offers the chance for new data from finite archaeological resources.

Another plus to phytolith analysis is that phytolith preservation is not subject to the same forces of decay as other botanical markers. Macrobotanicals and pollen both require specific environmental conditions in order to preserve. Pollen requires a stable wet or very dry environment, with minimal fluctuations between wet and/or dry conditions in order for good preservation to occur (Bryant and Hall 1993; Pearsall 2000). Generally good macrobotanical preservation also requires relatively stable environmental conditions. Such requirements are not necessary in order for phytoliths to preserve; they do not degrade as a result of climatic fluctuations.

Despite the number of drawbacks listed above for other lines of direct evidence of plant use, it is not suggested that phytoliths should act as a stand-alone source of data for paleodiet. One drawback to phytolith analysis is that the food plants in question must be phytolith producers. Systematic studies of various plant families have identified that not all plant families are phytolith producers (Piperno 2006). Some subsistence plants, such as amaranths and chenopods, fall into these families and so would not be identified during analysis. In addition to this familial limitation, the plants which are phytolith producers must have their phytolith producing parts (i.e. leaves, stem, roots, and inflorescence) utilized in some form. Even then the phytoliths present can vary due to inconsistent phytolith production between different plant parts; for example, a root will produce fewer phytoliths than a leaf (Mulholland 1993). As with all direct evidence for plant use, taphonomy plays a role in the recovery of these indicators.

Indirect Evidence

In conjunction with the direct lines of evidence for paleodiet and subsistence practices, indirect lines of evidence are also useful. Two of the most important in regards to subsistence and paleodiet are stable isotope analysis and AMS radiocarbon dating. This section provides an overview of each of these techniques, specifically focusing on aspects directly related to subsistence and paleodiet.

Stable Isotopes

In addition to direct botanical evidence, one indirect line of evidence for plant use can come from stable isotope studies. These studies have been performed on human remains (bone collagen) or residues present on either ceramic or lithic artifacts. Among the various isotopes stable isotope studies are able to identify, both carbon and nitrogen isotopes (^{13}C and ^{15}N) are two of the most important isotopes in regard to dietary studies and the identification of food sources (terrestrial versus aquatic/marine).

Analysis of carbon isotopes are used in examining the plant component of a prehistoric diet. Carbon isotopes can provide information on the use of C_4 versus C_3 plants. The distinction between C_3 and C_4 plants has to do with the process of photosynthesis used by a plant and how efficiently CO_2 is used in the photosynthetic pathway. Plants characteristic of the C_4 pathway tend to be tropical grasses, an example of which is maize. The C_3 pathway is what characterizes the majority of other plants. There is, however, an exception to the C_3 and C_4 photosynthetic pathways. CAM (Crassulacean Acid Metabolism) plants utilize both C_3 and C_4 photosynthetic pathways. They will switch depending on their environmental conditions; if the weather is cooler, a C_3 pathway is used while if the weather is hotter the plant will switch to the C_4 pathway. CAM plants are most often succulents such as agave (Barbour et al. 1999). Due to the differences in CO_2 use, the absorption of ^{13}C will vary between C_3 and C_4 plants. C_3 plants generally have a $\delta^{13}C$ index in the range of -22‰ to -35‰ while C_4 plants have a range of -9‰ to -20‰ for $\delta^{13}C$ (Barbour et al. 1999:422; O'Leary 1988). It is the difference between the $\delta^{13}C$ of C_3 and C_4 which allows for the identification of these plants based on carbon isotopes.

In addition to the use of carbon isotopes for plant identification, the ratio of nitrogen isotopes ($^{15}N/^{14}N$) can be used to distinguish marine versus terrestrial based animals (DeNiro 1987; Hastorf and DeNiro 1985; Heron and Evershed 1993; van der Merwe 1982). It is possible to distinguish marine versus terrestrial animals based on nitrogen isotopes due to the increased ^{15}N uptake of marine plants. This difference translates up the food chain so that marine animals have a higher $^{15}N/^{14}N$ ratio than terrestrial animals (Schoeninger et al. 1983:1381). The ^{15}N range for terrestrial animals is +1.9‰ to +10‰ $\delta^{15}N$ while the range for marine animals is +9.4‰ to +22.9‰ $\delta^{15}N$. It is presumed that this higher ^{15}N ratio will also be present in the bone collagen of humans who subsist on a diet heavy in marine resources (Schoeninger et al. 1983:1381).

Isotope studies on human bone collagen and/or carbonate provide information on both human consumption behaviors (i.e. dietary staples such as animal proteins and grains) and location/region of habitation (Buikstra 1992; Hart 1999; Schoeninger and Moore 1992; van der Merwe and Vogel 1978). These studies are useful in tracking dietary change (by time period, between contemporary populations and within populations) and population movement. One drawback to isotope studies on bone collagen is the sample size. Most studies use a few individuals from a few sites to extrapolate to an entire region (Hart 1999). As Rose (2008) demonstrates in her isotope study of individuals from Middle Woodland through Mississippian period sites in west-central Illinois, her results from contemporary populations demonstrate differential maize use ranging from heavy reliance to non-existent. While Rose's study demonstrates the need for a wider range of population sampling, isotope studies of human bone remain promising and extremely important. But, how do these isotope studies compare to those of ceramic or lithic residues?

Carbon and nitrogen stable isotope studies from residues can present a different picture than that seen in bone collagen studies. Ceramic residue isotope studies reflect the mixture of items which were cooked in the pot as well as probable accretion of residue over time; it is silly to assume a pot would be used once and then discarded—barring breakage or some other form of damage. These residues would then represent a combination of plant and animal species. How are the contributions of C_4 plants (if present), C_3 plants and their consumers, or aquatic species separated out from this mix?

Reber and Evershed (2004) discuss the combination of both stable isotope analysis with lipid analysis of absorbed ceramic residues to differentiate between the various components within a residue. The technique uses a combination of gas chromatography – combustion – isotope ratio mass spectrometry (GC–C–IRMS) which separates lipids while at the same time combusting the various compounds within the residue to produce a CO_2 gas. This gas is then subjected to stable isotope analysis to differentiate between C_3 and C_4 carbon isotopes (Reber and Evershed 2004:24).

For non-absorbed ceramic residues, i.e. those adhering to the surface of a sherd, Morton and Schwarcz (2004) used a combination of nitrogen and carbon isotopes to differentiate between potential residue contributors. Their findings from tests of a number of northern and southern Ontario Woodland period sites indicate minimal to zero amounts of maize contributing to the residue. This data does not corroborate the findings of earlier bone collagen studies from Ontario sites which indicated maize as a significant portion of the diet starting around AD 600 (c.f. Schwarcz et al. 1985). Morton and Schwarcz (2004) offer the explanation that different cooking techniques were used prehistorically and maize was only a minor component of those foods cooked in ceramic pots.

As a result, standard views on isotope studies using ceramic residues set the carbon isotope threshold for the presence of C_4 plants at -22‰ for $\delta^{13}C$ and anything below this represents C_3 (Hart et al. 2007, 2009). However recent work by Hart, Lovis, Urquhart, and Feranac (2007, 2009) challenge these thresholds. Systematic experiments performed at twenty percent increments of C_3 to C_4 (in this case maize) contributors indicate that C_3 plants and their animal consumers often mask the present of C_4 plants. There is not a perfect linear correlation of percentage of C_3 to C_4 as previously assumed. Hart et al.'s 2009 experiments further indicate that the use of carbon stable isotope analysis to identify the presence of maize, as well as the percentage of maize, in a ceramic residue is untenable.

From this discussion we see that the use of stable isotope analysis as a means for reconstructing paleodiet must be used judiciously. Bone collagen isotope studies reflect accurate representations of diet whereas residue isotope studies are more problematic. Lipid analysis of absorbed residues can provide useful information; however it is unclear if the use of GC–C–IRMS, as described by Reber and Evershed (2004), is also subject to C_3 masking of C_4 plants. This is an area in which further testing is required.

Radiocarbon Dating

The advent of radiocarbon dating in the 1950s caused a revolution in regards to dating archaeological sites. Besides having relative dates through the use of seriation and stratigraphy, absolute dates were now available. The availability of absolute dates now provided more time depth in which culture change, especially within North America, had occurred.

Refinement of radiocarbon dating through Accelerated Mass Spectrometry (AMS) has provided further time depth for archaeology. Since the carbon isotopes themselves are directly counted, instead of indirectly with a Geiger counter, a smaller amount of material is needed for radiocarbon dating (Thomas 1998). The direct result of only needing a small amount of dateable material is that artifacts and faunal and floral remains can be directly dated themselves; associated carbon from nearby hearths need no longer be used. The result of this direct dating of artifacts (example: residues adhering to ceramic sherds) and faunal and floral remains (example: a kernel of carbonized maize) once again provided time depth to North American archaeological chronologies. Maize was found to be older than previously assumed based on associated dates (c.f. Chapman and Crites 1987; Crawford et al. 1997; Crawford and Smith 2003; Ford 1987; Riley et al. 1994) as were/are some ceramic typologies (for Saginaw drainage specific examples c.f. Lovis 1990; Sommer 2003a; Chapter 5 this volume).

One drawback with radiocarbon dating is the need for calibration due to the lack of a one-to-one correlation of radiocarbon years to calendar years. The need for this calibration is due to varying levels of atmospheric carbon throughout the earth's history (Reimer et al. 2004). Calibration curves are determined through tree rings (dendrochronology) up until 12,400 years cal BP and after this period, through marine records (Reimer et al. 2004). The marine records are converted to atmospheric equivalents and are also subject to site-specific marine reservoir corrections. These records extend the terrestrial record up to 26,000 years cal BP (Reimer et al. 2004). All radiocarbon dates must be calibrated to ensure accuracy.

The combination of the various direct lines of evidence described above, used in conjunction with AMS dating, can yield data which help present a more robust understanding of paleodiet and the changes that occurred over time and with the introduction of domesticates. As presented later in this work, AMS dating of archaeological ceramic residues, used in conjunction with phytolith and starch analyses, provides new data on the timing of the use of maize, aquatic tubers and grasses. Previously known macrobotanical evidence and associated standard radiocarbon dates corroborate much of this data while some of it is challenged by the new findings.

CHAPTER 4

Experimental Work

Introduction

The experimental component of this research was initially undertaken to test if there is a noticeable difference in maize (*Zea mays*) phytolith production during the stage of plant development (i.e. younger versus more mature plants) and if so, was this also quantifiable based on phytoliths present in ceramic residues? In other words, would it be possible to determine at which stage of growth (green/ripe or young/mature) maize was utilized based on phytolith size and density found in ceramic residues?

Principles of Phytolith Production

There are a number of factors which control and account for the production of phytoliths in plants. Such factors include climate of growth environment, soil composition, water content of the soil, plant age, and plant taxonomic affinity. Soluble silica present in groundwater is absorbed by plants and carried into plant tissue. Some of this silica is eventually deposited as a solid in cell walls, cell interiors, and intercellular spaces. The mechanism for this deposition is not entirely understood but it does seem to be, at least in part, both genetically and metabolically controlled. Evidence for a degree of genetic control in phytolith deposition is demonstrated by evidence that indicates the patterns of silica accumulation and deposition are similar in plant species of closely related taxa (Piperno 2006:5-6). Various environmental factors and growing conditions do not appear to effect phytolith formation within a taxon. Phytolith formation has been found to be consistent despite widely varying environmental factors (Pearsall 2000:359). At the same time, non-producers taxa of phytoliths, such as the Amaranthacea and

Chenopodiaceae, do not produce phytoliths regardless of which areas in the world they grow.

Metabolic control over silica deposition and uptake occurs with active transport of monosilicic acid by the plant. In this process, the plant is expending energy to absorb silica, which seems to indicate a designated function for said silica (Piperno 2006:9). This soluble silica may then be converted into solid deposits of silica, or silicon dioxide. The process by which soluble silica is converted into solid deposits is also poorly understood but it may be related to transpiration. Active transpiration may result in plant cells becoming supersaturated with silica and as a result, silica accumulation and precipitation occurs within the plant cells (Piperno 2006:10). This is not to suggest that phytoliths only occur in cells associated with transpiration. High levels of phytoliths can be found in other plant cells including idioblasts (or short cells), pericarp, mesophyll, and epidermis cells (Pearsall 2000:363; Piperno 2006:10). Deposition of silica in non-transpiration cells indicates other metabolic mechanisms or cellular pathways may be at work. Currently these mechanisms are by and large poorly understood.

One of the most well studied plant groups in regards to phytolith production are the monocotyledons (or monocots). This focus on monocots in phytolith studies is due in part to the location of the true grass, or Poaceae, family within this monophyletic group. Grasses have been the focus of intense phytolith studies because of their economic importance both today and in the past. As a result of this intense study, plants in the Poaceae family, of which maize is one, are known to produce abundant and distinctive phytoliths.

For phytolith production in maize, there is recent evidence to suggest for some genetic control (Piperno 2006:11). It has been demonstrated that the same genes which control the deposition of lignin (a chemical compound which provides rigidity to plant cell walls and aids in providing overall structural support to a plant), also control phytolith production in maize. As a result of domestication, the genes which controlled for heavy lignification of the cob were selected against and a softer cob was favored. This genetic change also caused the formation of phytoliths of different types and numbers in maize (Piperno 2006:11).

Research Design

Since it is known that maize phytolith production can be genetically controlled and is not effected by environmental conditions, systematic experiments were designed involving green and mature maize to test if there was a difference in phytolith production or count between green and mature maize. It is hypothesized that green maize has lower phytolith production than mature maize due to its earlier stage of growth (Mulholland personal communication 2006). If there are differences in maize phytolith concentrations, this could indicate which stage of maize is being used in the archaeological record. A significant issue concerning the use of maize is its initial utilization in its green form. The initial use of green maize is a likely contributing factor to its low macrobotanical visibility in earlier contexts due its probable immediate use. Green maize is most likely not being processed and stored upon first introduction.

In addition to the issue of green versus mature maize use, the experiments were designed to also assess the potential of determining the percentage of a plant used to create a residue based upon phytolith density. The ability to quantify phytolith concentrations based on the percentage of maize in a pot would allow researchers to assess the 'importance' of maize in a prehistoric diet. This would alleviate problems of subjective descriptors assigned by paleoethnobotanists based on macrobotanical remains (Chilton 2002). As Chilton (2002) correctly points out, the number of kernels found in some archaeological contexts could come from one or two cobs. The overall importance of these experiments, if successful, would be to develop a baseline against which to analyze archaeologically derived materials.

Experimental Residues: Methods and Materials

A series of controlled experimental residues were created to test maize phytolith taphonomy. These residues utilized maize in various forms of processing and stages of development. The various forms with the type of processing used are listed in Table 4-1. Experimental residues were created in increasing 20% increments and the forms of maize utilized were separately combined with ground venison. This made for a total of 25 residues created, processed, and analyzed by the researcher. All experimental residues, except the hand ground maize flour, were carbonized in 100ml glass beakers in the researcher's kitchen cum laboratory. The hand ground maize flour residues were carbonized in aluminum cans over a charcoal grill. The difference in burning procedures was due to the season in which experiments were undertaken as all but the hand ground maize residues were created during the winter months.

Table 4-1: Maize form and processing used in experimental residues

Maize Form	Description of Processing Technique
Hand ground maize flour	Maize kernels removed from the cob and ground using a replica mano and metate
Dried whole kernels, removed from cob by hand	Maize kernels removed by hand from a dried cob (kernels split between this and lightly pounded, described below)
Lightly pounded dried kernels, removed from cob by hand	Split sample of maize kernels from dried whole kernels, lightly pounded with a hammer
Green kernels removed by hand	Maize kernels removed by hand with a chef's knife
Whole green cob	Maize cob left intact, but divided into segments using a chef's knife

Processing of Each Maize Form

<u>Hand ground maize flour</u>

The hand ground maize flour was ground using a replica mano and metate. Dried maize kernels from an ear of Iroquois White were removed by hand. Undergraduate student volunteers from my Anthropology 320 class took turns hand grinding the maize kernels (see Figure 4-1). Proportionate maize to venison (for example, 2g of maize to 8g of venison) mixtures were measured out on an analytic balance and placed in a cleaned aluminum can. A total of 10 mixtures (10-100% maize) were created. To better combine the maize-venison mixtures, 30ml of water was added to each can and stirred to combine. The cans were then placed on a charcoal grill, and allowed to carbonize (see Figure 4-2). In order to ensure total carbonization, the mixtures were allowed to burn for 5 hours. Once the experimental residues cooled, they were removed and placed in separate labeled plastic sample bags. A sample of non-carbonized maize flour was taken as well in order to assess phytolith taphonomy prior to burning.

Figure 4-1: Student volunteers hand grinding maize (photo taken by author)

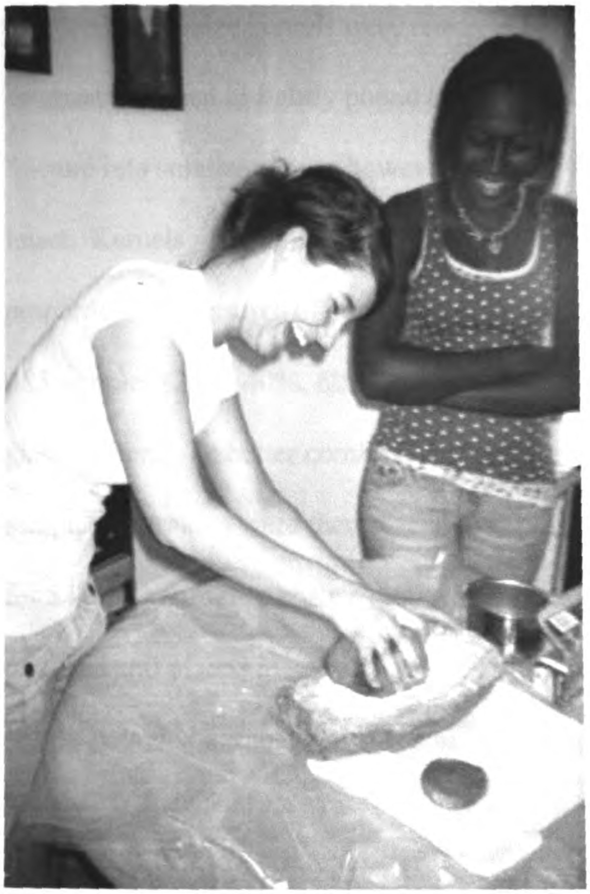


Figure 4-2: Carbonization of experimental residues, in progress (photo taken by author)

Lightly-pounded dried maize kernels

Dried maize kernels were removed by hand and placed on a baking a sheet. A hammer was used to lightly pound the kernels in order to crack them. Some kernels did fracture into smaller pieces, however most only cracked slightly while a few did remain intact. Kernels were then weighed out on an analytic balance and combined with proportionate measures of venison (for example 2g maize kernels to 8g venison). A total of 5 samples (20%, 40%, 60%, 80%, 100%) were created and placed separately in 100ml glass beakers. To better combine the mixtures, 30ml of water was added to each. The samples in beakers were then placed in a 232°C (450°F) oven and allowed to carbonize for 5 hours in order to ensure total carbonization. Once samples had cooled, they were removed and placed in separate labeled plastic sample bags. A sample of non-carbonized lightly-pounded kernels was taken as well in order to assess phytolith taphonomy prior to burning.

Whole dried maize kernels

Half of the dried maize kernels from the lightly-pounded dried maize kernel experiment were reserved and utilized for the whole dried maize kernel experiment. These were set aside prior to processing the kernels for the lightly-pounded maize residues. Kernels were weighed out on an analytic balance and combined with proportionate measures of venison. A total of 5 samples (20-100%) were created and placed separately in 100ml glass beakers. Thirty millimeters of water was added to each to better combine the mixtures. The samples in beakers were then placed in a 232°C (450°F) oven and allowed to carbonize for 5 hours in order to ensure total carbonization. Once samples had cooled, they were removed and placed in separate labeled plastic sample bags. A sample of non-carbonized whole dried kernels was taken as well in order to assess phytolith taphonomy prior to burning.

Green maize kernels removed by hand

Green ears of maize were bought at a local Meijer grocery store. Kernels were removed by hand from the cob using a chef's knife in the researcher's kitchen. Kernels were weighed out on an analytic balance and combined with proportionate measures of venison. A total of 5 samples (20-100%) were created and placed separately in 100ml glass beakers. Thirty millimeters of water was added to each to better combine the mixtures. The samples in beakers were then placed in a 232°C (450°F) oven and allowed to carbonize for 5 hours in order to ensure total carbonization. Once samples had cooled, they were removed and placed in separate labeled plastic sample bags. A sample of non-carbonized green kernels was taken as well in order to assess phytolith taphonomy prior to burning.

Whole cob green maize

Green ears of maize bought in the same trip as that used in the green kernels removed by hand were used for this set of residues. Green maize cobs were cut into pieces using a chef's knife in the researcher's kitchen. The green cob pieces were weighed out on an analytic balance and combined with proportionate measures of venison. A total of 5 samples (20-100%) were created and placed separately in 100ml glass beakers. To better combine the mixtures, 50ml of water was added to each sample. The amount of water was increased in this set of experiments to ensure total coverage of the cob pieces. The samples contained in beakers were then placed in a 232°C (450°F) oven and allowed to carbonize for 5 hours in order to ensure total carbonization. Once samples had cooled, they were removed and placed in separate labeled plastic sample bags. A sample of non-carbonized green maize cob was taken as well in order to assess phytolith taphonomy prior to burning.

Laboratory Processing Procedures

Experimental residues were processed in the Pollen Laboratory of Dr. Catherine Yansa, Department of Geography, Michigan State University. A sample of each experimental residue was taken using a separate, clean disposable scalpel for each residue and weighed on an analytic balance. The entire residue was not processed for phytoliths in order to replicate the procedure for sampling archaeological ceramic residues. Taking the entire archaeological residue for phytolith processing would be avoided if possible and so I felt the same circumstances should be replicated for the experimental residues. The weight of the samples was determined by first weighing the test tube each sample would be placed in, then adding the sample and weighing the tube again. Subtracting the original tube weight from the combined sample and tube weight provided the weight of the sample.

After each sample had been weighed, processing procedures for phytolith extraction followed the protocol developed by Rapp and Mulholland at the Archaeometry Laboratory, University of Minnesota—Duluth. A complete description of the processing protocol can be found in Appendix A. Schulze solution (a 3:1 mixture of nitric acid to dissolved potassium carbonate) was added to each test tube in the quantity of 10ml. Test tubes containing samples were then placed in a hot water bath (heated to 90°C) and allowed to sit for 24 hours to ensure complete dissolution of carbon in the sample. If any carbon remained after 24 hours, the samples were centrifuged, supernatant decanted and

10ml of nitric acid added to the samples. Samples were then placed in the hot water bath for another 24 hours. Extra processing time was unusual for the experimental samples. If extra processing time was needed only nitric acid was used in order to provide a different caustic environment.

Once the carbon in the samples had dissolved, water rinses were performed to remove the chemicals from the samples. Samples were centrifuged for 15 minutes at 3000 rpm, the supernatant decanted, and samples agitated with a stirring rod. Distilled water was used to rinse the stirring rod into the test tube to ensure phytoliths did not adhere to the stirring rod. Extra water was added to the tube as needed to ensure similar water levels in all tubes for balance purposes within the centrifuge. Once each sample had gone through this procedure, samples were centrifuged again (for 15 minutes at 3000 rpm) and this process was repeated until the liquid in the samples was clear. The number of water rinses ranged from 4 to 8, depending on how large (i.e. the original weight) the original sample was.

After water rinses were completed, an ethanol rinse was performed. The supernatant was decanted and samples were transferred to labeled 1dr storage vials using a disposable pipette. A final rinse of the test tube and pipette with ethanol was performed to better ensure total collection of phytoliths in each sample. If too much ethanol ended up in the storage vials, these were centrifuged for 15 minutes at 3000 rpm (to ensure sample material remained at the bottom of the vial) and the extra ethanol was removed with a clean disposable pipette.

Microscope slides were made by placing three drops of the processed material suspended in ethanol on a 3x1 inch slide and placing this on a slide warmer to allow the ethanol to evaporate. Once the ethanol had evaporated, 4-6 drops of Permount was added to mount slides for analysis. Slides were scanned using a Leica DM2500 microscope with dark field and phase contrast capabilities at 40x magnification.

Experimental Residue Results

A summary of the experimental residue results are presented in Table 4-2. The results were initially surprising and unexpected. The hand ground maize flour residues were the first set experimental residues processed and analyzed by the researcher. It was due to these residues that the researcher discovered the presence of starch remaining in the residues after processing. Further discussion with other phytolith researchers, chiefly Dr. Deborah Pearsall of the University of Missouri and Dr. Matthew Boyd of Lakehead University, ON, proved that this was a fairly common occurrence. According to Dr. Boyd (personal communication 2009), while there is very likely some starch attrition due to the acidic nature of the Schulze processing procedure, starch is also left behind in the residue. As a result, starch identification was added as another microbotanical component to the residue analyses of both the experimental and archaeological samples.

The residue results presented in Table 4-2 portray some interesting trends. The majority of phytolith occurrence found in a residue occurs with the use of whole green cob maize. While at first surprising, it makes sense when one thinks about where and how phytoliths form in maize. Phytoliths are created through silica deposition both in between and within plant cells. This deposition can vary between species and also between various plant parts (roots, leaves, stem, and inflorescence). In the case of maize, most diagnostic phytoliths are found in the leaves, tassels, and cob and glumes. Diagnostic phytoliths are not found in the kernel itself. This means then that the maize

kernel pericarp will only have basic body cell phytoliths that are non-diagnostic. Well, so what? Why does that matter?

Table 4-2: Microbotanical results of experimental residues

Maize Form	% Maize in Experimental Residue Mix	Phytolith Count	Starch Count
Whole Green Cob	20%	73	0
	40%	156	2
	60%	50	7
	80%	11	0
	100%	63	5
Whole Green Kernel	20%	0	1
	40%	1	20
	60%	0	0
	80%	0	5
	100%	0	0
Lightly Pounded Dried Kernel	20%	0	84
	40%	0	44
	60%	0	25
	80%	0	22
	100%	1	117
Whole Dried Kernel	20%	1	56
	40%	0	18
	60%	0	18
	80%	1	53
	100%	0	53
Hand Ground Maize Flour	20%	0	53
	40%	0	24
	60%	0	11
	80%	0	27
	100%	0	19

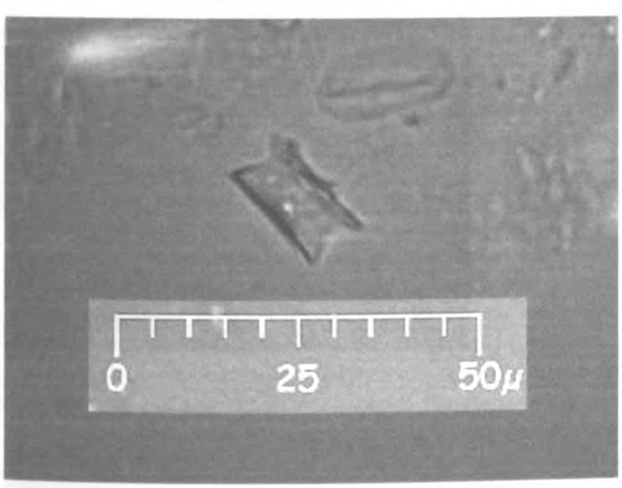
The “so what?” speaks to issues of the form of maize being utilized, as well as to issues of maize processing prior to cooking and to consumption. I will address the issue of which form of maize is utilized first. In the experimental residues analyzed, all but one form required removal of the maize kernel from the cob. Removal of kernels from the cob means any diagnostics that would have shown up in these removed forms would have been incorporated accidentally from any maize glumes that remained attached to the kernels after removal. These ‘accidental’ inclusions can be seen in the single maize phytolith counts from the whole green kernel, lightly pounded dried kernel, and whole dried kernel residues. As the phytolith counts in Table 4-2 demonstrate, significant phytolith counts occur with whole green cob. Therefore, any significant phytolith identification in residues is most likely from the use of whole green maize on the cob.

The flip side to the phytolith count data is the starch count data. As Table 4-2 demonstrates, maize starch is much more likely to occur in residues when maize kernels, whether dried or green, are removed from the cob. Dried forms of maize (lightly pounded whole kernel, whole dried kernel, and maize flour) will also have a greater abundance of starch than the green forms. Once again, this is not as surprising as it might initially seem. Diagnostic forms of starch come from long term storage organs of plants; in the case of maize, this long term storage is in the kernels. These storage organs have a seasonal build-up of starch; starch will be more abundant in the fall and winter than in the spring and summer (Messner 2008). Dried forms of maize represent the mature plant and therefore starch in maize kernels will be at its peak. Lower starch production in the green form of maize is to be expected since it would have been harvested early and starch production would not have been at its peak. The experimental starch counts for the green forms reflect this expectation; whole green kernel and whole green cob have minimal starch counts.

Discussion: Phytolith and Starch Taphonomy

Location of diagnostic phytolith and starch production leads directly to the issue of processing. Which human behaviors will most likely result in the incorporation of either maize phytoliths, maize starch, or both in a residue? The results of the experimental samples indicate that diagnostic maize phytoliths (Figure 4-3) found in ceramic residues are more likely to be a result of the use of green maize when in its whole form. This is not to suggest, however, that phytoliths from the cob and glume could not be accidentally included via hand removal in the other forms of processed maize. Based on the low to zero counts of the dried forms, however, it is most likely the green form of maize that is utilized when maize phytoliths are found in early dated archaeological ceramic food residues.

Figure 4-3: Diagnostic maize rondel



This likelihood is further corroborated when combined with the starch data. Starch was present in abundance with the experimental residues created from the dried

forms of maize (Figure 4-4). The presence of only maize starch in a sample more likely indicates a dried form of maize utilization while the presence of starch and phytoliths together, is more likely indicative of a green form of maize utilization. Further processing information can potentially come from damage to the starch granule itself (Figure 4-5). Current evidence suggests there is specific damage to maize starch if it is ground or pounded in the preparation of maize for flour (Pearsall conference paper; Piperno 2006; others). Identification of maize starch that has been ground or pounded could further indicate the use of maize flour. While somewhat crude at a scalar level, this data does allow us to identify how people were potentially utilizing maize, and therefore make statements on behavior, based on the presence or absence of diagnostic maize phytoliths and starch in residues (see Table 4-3).

Figure 4-4: Undamaged diagnostic maize starch

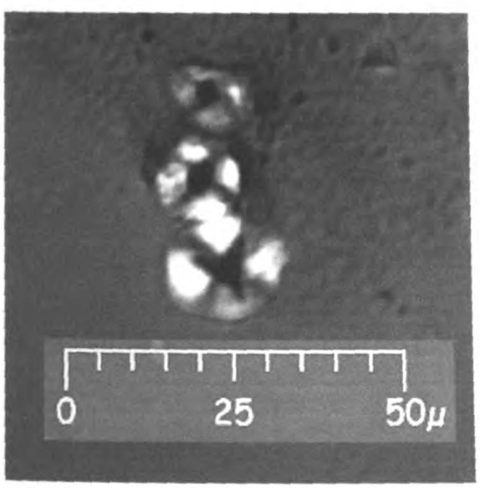


Figure 4-5: Maize starch with evidence for grinding

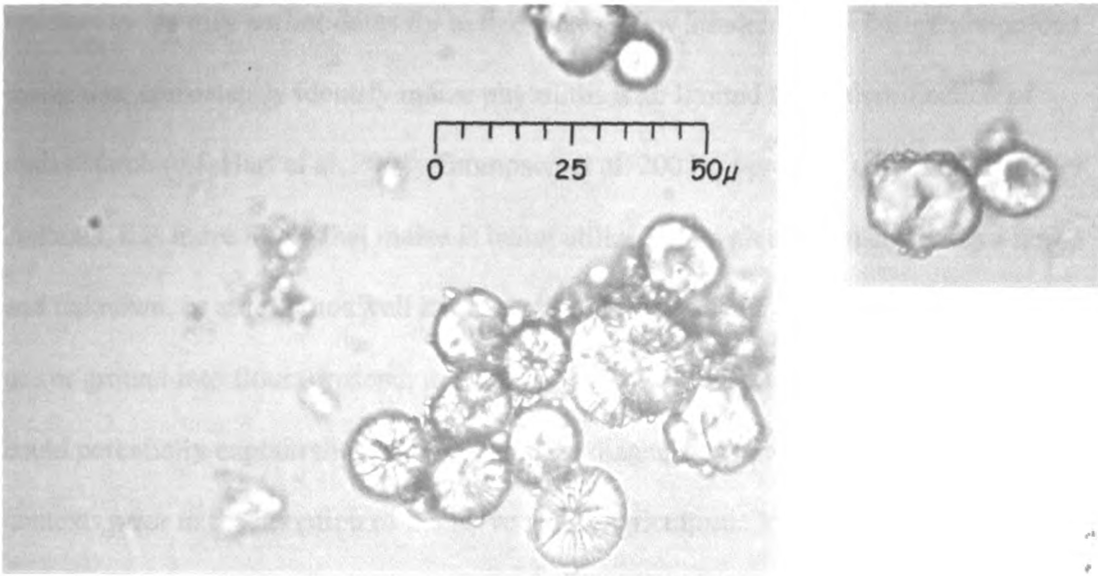


Table 4-3: Probable utilization of maize based on presence/absence of diagnostics

Probable behavior	Residue Evidence
Utilization of maize in green form	Diagnostic cob phytoliths OR diagnostic cob phytoliths and starch
Utilization of maize in dried form	Diagnostic starch only
Utilization of maize in flour form	Diagnostic starch only; some starch may show grinding or pounding damage

Conclusion

While it is entirely probable that a combination of green and dried forms could result in the presence of diagnostic phytoliths and starch in the same residue, this is unlikely until maize use has become more ubiquitous. Current studies utilizing ceramic residues to identify earlier dates for maize, dates a few hundred years before ubiquitous maize use, consistently identify maize phytoliths with limited to no identification of maize starch (c.f. Hart et al. 2004; Thompson et al. 2005). I propose that in these earlier contexts, it is more likely that maize is being utilized in its green form since it is a new and unknown, or at least not well known, plant. It is not being dried and stored for later use or ground into flour. Instead, it could very well be boiled whole. Such processing could potentially explain the presence of maize diagnostics in residues from earlier contexts prior to the adoption of intensive maize agriculture. Intensive maize agriculture is associated with large scale drying and storage of surpluses and is corroborated by the presence of maize macrobotanicals in conjunction with storage pits. It is far more likely that in these recently identified earlier contexts, some portion of the whole cob was being cooked rather than an accidental incorporation of glume material coinciding with the removal of dried maize kernels from the cob.

Returning to the issue of quantification of maize phytolith density based on the percentage of maize used to create a residue or quantification of maize phytolith density based on the use of green or mature maize, at this point quantification of either of these scenarios has found to be untenable. The presence of diagnostic phytoliths primarily occurring in only the whole green cob set of experimental residues made it pointless to attempt phytolith quantification of green versus mature maize.

Quantification of maize phytoliths based on the percentage of maize used to create a residue is also moot for the same reason. While it may have been possible to quantify maize phytoliths to percentage of maize in the pot with the whole green cob form, there appear to be other potential taphonomic factors not currently accounted for in this study. One would expect a general trend of more diagnostic maize phytoliths coinciding with a greater percentage of maize utilized in residue creation, however this does not appear to be the case. If quantification based on percentage of maize cooked in a pot had been successful, there is also the issue of how applicable this quantification would have been to archaeological residues. Are archaeological residues adhering to ceramics the result of one episode of accidental burning or is it a result of repeated use of the pot and the residue represents an accretion of burned and charred food? If a residue is created due to accretion, repeated cooking of a smaller percentage of maize over time could mimic a cooking episode of a higher percentage of maize.

Since quantification of maize phytolith density was found to be flawed, the possibility of quantifying maize starch density still remains. The processing procedures utilized in this study however make such an endeavor unwise. It is assumed that some starch attrition occurred with the Schulze solution processing. There are also a number of as yet unknown taphonomic issues with starch production and incorporation into ceramic residues (Barton and Matthews 2006). Starch is both a highly durable but also fragile compound and is susceptible to dissolution and gelatinization from the cooking process (Barton and Matthews 2006; Messner 2008). A firmer understanding of these issues is required before attempting any quantification of starch based on the percentage of a plant used to create a residue. If and/or when these issues are clarified, the reuse of a pot archaeologically, and how reuse effects residue taphonomy will likely remain an issue.

Similar taphonomic issues with ceramic residues were found by Hart et al. (2007, 2009) in regards to the use of stable isotopes to identify maize in ceramic residues adhering to ceramic vessel walls. In the Hart et al. studies, controlled cooking experiments utilized various forms of maize individually mixed with various individual C_3 components (wild rice, chenopod, and deer). These residues were created to test the threshold of $\delta^{13}C$ and $\delta\ ^{14}C$ isotopes for maize use in ceramic residues that had been proposed by Morton and Schwarz (2004). The Hart et al. studies found that maize was overwhelming masked by C_3 producers and that maize might not be identifiable via the stable isotope analysis of residues until maize represents 80-90% of a mix. From the experimental work undertaken for this dissertation, in conjunction with the experiments performed by Hart et al. (2007, 2009), it is clear then that quantification of these types of variables through a number of different proxies may be difficult for multiple reasons and may not be feasible beyond presence/absence identification of maize.

The application of these results to the archaeological data are discussed in chapter six. The next chapter provides background on the sites used in this research, especially the existing subsistence data. The data provided by the microbotanical analyses of the archaeological residues and how they add to or complement the existing data is also presented in the following chapter.

CHAPTER 5

Archaeological Residue Analysis

Introduction

A total of 79 sherds from various archaeological sites in the Saginaw Drainage were sampled. Appropriate collections were identified from site inventories at Michigan State University (MSU), University of Michigan Museum of Anthropology (UMMA), the Michigan Historical Center (MHC), and the Saginaw Archaeological Commission (SAC) at the Castle Museum. Once sites dating to the desired time periods (Middle to Late Woodland; 200BC-AD 500 and AD 600-AD 1400 respectively) were identified (see Table 5-1 for a list of sites), I went through each collection to determine the number ceramic sherds with residues were present. After this information had been collected from each suitable site in the study area, I determined which residues to sample based on time period and date range, and obtained formal permission for destructive sampling from each institution to do so.

Sampling of each sherd took place in the Pollen Laboratory of Dr. Catherine Yansa, Department of Geography, Michigan State University. Prior to sampling, the ceramics were photographed to record where the residue was located on the sherd. Residues were sampled by taking a clean, disposable scalpel and scraping it against the sherd to remove a portion of the residue. Since a subsample of these sherds were going to be radiocarbon dated, all scalpels were labeled with the site name and ceramic ID and put back in their original packaging for storage. This was done to ensure that the same scalpel would be used if it was decided to sample that sherd for ^{14}C dating. Due to the possibility of radiocarbon dating and to ensure the possibility of future studies, a minimum amount of residue was sampled from the sherd. The amount of residue taken varied based on how much residue was adhering to the ceramic but ranged from .00010g to .0290g. Sample weights were calculated indirectly by weighing the piece of weigh paper used, scraping off a portion of the residue onto the weigh paper, weighing the combined weigh paper and sample, and then subtracting the weigh paper weight from the weigh paper plus residue weight. A Cole Parmer Symmetry PA analytic digital balance was used to determine the weight of all samples. After the sample was weighed, it was immediately funneled into a labeled centrifuge tube by creating a funnel from the weigh paper used in determining the sample weight.

Archaeological residue samples were processed in sets of 16; this reflects the capacity of the centrifuge used in the laboratory. The same processing techniques used for the experimental residues were used to process the archaeological residues (see Appendix A). Depending on the size of the sample, some archaeological residues required a second day of processing in the Schulze solution for all of the carbon to dissipate. The same procedure in making slides for the experimental residues was also followed for the archaeological residue samples.

Slides were scanned for the presence of both phytoliths and starches since it was determined via the experimental residue results that starches remained in samples, albeit probably with some attrition. A comparative phytolith collection was obtained by photographing diagnostic forms from samples at Dr. Deborah Pearsall's laboratory at University of Missouri as well as by creating slides of comparative material from the laboratory of Dr. Susan Mulholland at University of Minnesota—Duluth. Due to a lack of comparative starch samples in my possession, the dissertation of Timothy Messner

(2008), "Woodland Period People and Plant Interactions: New Insights from Starch Grain Analysis," proved invaluable. Messner (2008) describes and photographs starch grains for both medicinal and subsistence plants in the Delaware River Watershed (DRW). Many of the plants described overlap in both their range and use prehistorically for the DRW and the Saginaw Drainage of Michigan. Messner also provided further assistance with starch identification via email.

Table 5-1: Middle and Late Woodland sites examined for residues; x denotes presence

Site	Time Period	Residue Present
Liberty Bridge (20BY77)	Middle Woodland	x
Dutch Creek (20BY200)	Middle Woodland	
Miller (20SA7)	Middle Woodland	
Satchell (20SA33)	Middle Woodland	
Fletcher (20BY28)	Middle and Late Woodland	x
Marquette Viaduct (20BY28)	Middle and Late Woodland	
Kantzler (20BY30)	Middle and Late Woodland	x
Schultz (20SA2)	Middle and Late Woodland	x
20SA1276	Middle and Late Woodland	x
20SA1251	Middle and Late Woodland	x
Bridgeport Township (20SA620)	Middle and Late Woodland	
East Oxbow (20MD490)	Middle and Late Woodland	
Stroebel (20SA14)	Middle and Late Woodland	
Cook (20SA31)	Middle and Late Woodland	
Cassasa (20SA1021)	Late Woodland	
Slavik (20GR221)	Late Woodland	
Tobico (20BY192)	Late Woodland	x
Weber I (20SA581)	Late Woodland	x
Simons 249 (20SA665)	Late Woodland	x
Trombley House (20BY70)	Late Woodland	
Solms (20SA57)	Late Woodland	x
Mahoney (20SA193)	Late Woodland	
Stadelmeyer (20SA195)	Late Woodland	x
20BY210	Late Woodland	x
Foster (20SA74)	Late Woodland	x
Butterfield (20BY29)	Late Woodland	
20BY192	Late Woodland	x
Clunie (20SA722)	Late Woodland and Late Prehistoric	x

Site and Ceramic Descriptions

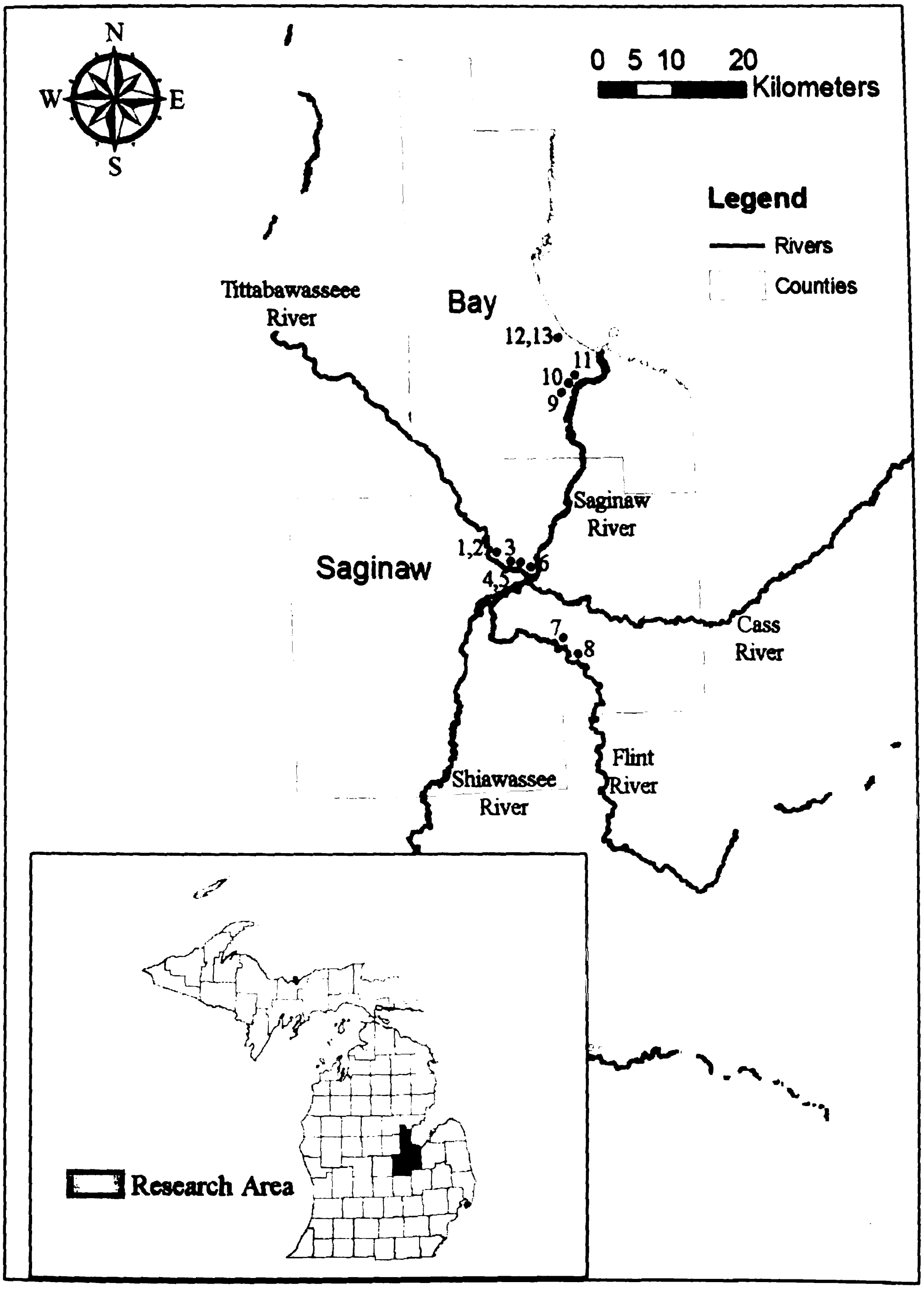
Locations of the sites in the following discussion are presented in Figure 5-1. These sites reflect those from Table 5-1 which were found to have ceramics with residue. It should be noted that for the Saginaw Drainage, the Middle Woodland period coincides with the presence of Hopewell ceremonial traits. Hopewell expression throughout the Midwest, Great Lakes, and Southeast varies but is characterized by significant mound construction (examples include sub-conical, elongate, and geometric earthwork enclosures), exotic raw materials (obsidian, Gulf coast shell, copper, minerals such as galena and mica), and elaborate burial customs including log-lined tombs, inclusion of exotic artifacts, burial 'houses', and post-mortuary processing (Maxwell 1952; Morgan 1952; Seeman 1992; Wymer 1987). In the Saginaw Drainage, Hopewell expression appears to be a variant of Illinois Hopewell (Kingsley 1999; Brashler et al. 2006). This is not to suggest, however, that contact with other regional groups did not occur.

Liberty Bridge (20BY77): Middle and Late Woodland

Site 20BY77 is a Woodland period occupation of the Liberty Bridge locale. The site was located as a result of excavations conducted in association with the Third Street Bridge right of way project in Bay City, MI (Egan 1993; Lovis 1993a). During excavations conducted by Lovis in 1984, a total 117m^2 of the site was excavated (Lovis 1993a). This includes a portion of site 20BY79 (Block 1) which was found to be identical to 20BY77 in regards to depositional sequence and cultural material. Delineation of site boundaries between 20BY77 and 20BY79 was placed at the railroad tracks which cut through the area under investigation; it is likely that the eastern portion of 20BY79 represented in Block 1 is a part of 20BY77 based on the sequence of soil

S
4
9
1

Figure 5-1: Site Locations



Sites: 1, 2: Stadelmeyer (20SA195) & Solms (20SA57); 3: Clunie (20SA722); 4, 5: 20SA1276 & 20SA1251; 6: Schultz (20SA2); 7: Foster (20SA74); 8: 20SA665; 9: Kantzler (20BY30); 10: Liberty Bridge (20BY77); 11: Fletcher (20BY28); 12, 13: Tobico Marsh sites (20BY192 & 20BY210) deposition and cultural material recovered (Lovis 1993a; Robertson 1993). Site 20BY77 is located within Bay City on the west bank of the Saginaw River. The site itself sits on a ridge just above modern lake levels at approximately 183m asl (Monaghan 1993).

Activities conducted at 20BY77 appear to include hide working, hunting and butchering activities and associated lithic tool manufacture for these activities and ceramics present at the site increase in density over the Woodland period (Lovis and Davis 1993; Robertson 1993). Features present at 20BY77 do little to illuminate site functionality since none of the eight cultural features identified were hearths or roasting pits despite the presence of fire-cracked rock throughout the site (Lovis 1993b). According to Lovis (1993b:194), "All features appeared midden filled and empty, suggesting they were used for short-term, task-specific activities and then emptied." Site 20BY77 appears to represent a short-term residential occupation given the suggested use for pit features, presence of ceramics, and extent of lithic manufacture and tool use.

The Middle Woodland component of 20BY77 appears to be a summer occupation, although this determination is tenuous. The faunal evidence for warm weather seasonality is based on a young white-tailed deer (age approximately six months), painted turtle, and freshwater mussels. Other faunal evidence for summer occupation is tentative; painted turtle are more easily caught in the summer months and warmer water facilitates mussel collection (Franz 1993). Despite its proximity to the Saginaw River, there are a limited number of fish species represented at 20BY77, in contrast with other Middle Woodland occupations in the vicinity where fish remains dominate the faunal assemblage.

The Late Woodland occupation of 20BY77 is more difficult to identify due to its sparse nature. No macrobotanical remains from the Late Woodland occupation at 20BY77 were identified. However at nearby site 20BY79, both chenopod and sumac were recovered in the Late Woodland occupation (Cleland 1993). Faunal remains are also poorly represented in the Late Woodland component and much of what was recovered was too fragmentary to be identified (Franz 1993).

The botanical remains recovered from 20BY77 do not clarify site seasonality much either. A list of macrobotanical remains is found in Table 5-2. Chenopod and nutshell from hickory and walnut were recovered. Chenopod seeds are commonly stored but their greens are available in the spring while hickory and walnut are available in the fall (Cleland 1993).

A total of three sherds with residue from Liberty Bridge (20BY77) were sampled for this project. The sherds sampled date to the late Middle Woodland (Green Point ware) and early Late Woodland periods (Appendix B, Figures B1-B3). Phytolith and starch results are found in Table 5-3. A radiocarbon sample from a sherd stylistically typed as Green Point ware was sent to Beta Analytic for dating. Unfortunately this was determined to be undateable due to insufficient material for radiocarbon analysis.

Phytolith and Starch Results

For the Middle Woodland occupation, maize starch was the only identifiable microbotanical. This new data does little to clarify site seasonality. During the Late Woodland, the combined presence of maize, wild rice, and acorn could indicate a late summer to fall occupation since this is their peak harvest time. However all of these plants are storable and could potentially be used year round. These data can be considered consistent with a short-term residential occupation of the site since they could have been temporarily stored in the pit features discussed above.

Table 5-2: Macrobotanical Data for Liberty Bridge; x denotes presence

Scientific Name	Common Name	Middle Woodland	Late Woodland
Chenopodium sp.	Chenopod	x	
Carya sp.	Hickory	x	
Juglans sp.	Walnut	x	

Table 5-3: Phytolith and Starch Data for Liberty Bridge; x denotes presence

Scientific Name	Common Name	Middle Woodland		Late Woodland	
		Phytolith	Starch	Phytolith	Starch
Zea mays	Maize		x	x	x
Zizania aquatica	Wild Rice			x	
Quercus sp.	Oak (Acorn)				x

Fletcher (20BY28): Middle and Late Woodland

The Fletcher site (20BY28) is located in Bay City, MI, on the west bank of the Saginaw River at an elevation of approximately 178m asl (Lovis 1985). Periodic professional excavation of the Fletcher site occurred from 1967 to 1987, while previous surface collection by amateur archaeologists had also occurred (Brashler 1973; Egan 1993; Lovis 1985). The initial 1967 excavation, performed by Dr. Moreau Maxwell (MSU), was undertaken after the U.S. Army Corp of Engineers came upon human remains and artifacts during excavation for a sediment retention basin in the northern portion of the site (Egan 1993). Subsequent excavations of Fletcher occurred in 1968 (also by Dr. Maxwell), in 1970 by Dr. James Brown (then of MSU), and lastly in 1988 by Dr. William Lovis (MSU) when construction threatened the site.

The Fletcher site represents continuous occupation from the Terminal Archaic to the Late Woodland and into the historic period as late as the 19^{th} century. Major occupation of Fletcher occurred during the late Middle Woodland and Late Woodland periods based on lithic and ceramic assemblage concentrations (Lovis et al. 1996). One problem encountered during excavations at Fletcher was the erosion, redeposition of material, and disturbed areas of the site, especially those areas relating to the Middle and Late Woodland components, due to fluctuating lake levels and flooding (Lovis et al. 1996).

Subsistence remains found at Fletcher indicate a mixed-subsistence economy. There is little Early Woodland subsistence data available but Middle and Late Woodland subsistence data is abundant. During the Middle Woodland, a variety of both terrestrial and aquatic resources are present. Faunal remains present include deer, bear, wapiti, beaver, otter, muskrat, waterfowl, and fish (sturgeon, channel catfish, northern pike, drum, perch/walleye). Floral remains identified by Egan (1993) include nuts (hickory, black walnut, acorn), seeds (chenopod, hawthorn, huckleberry), and both aquatic and terrestrial tubers (see Table 5-4). Taken together, the faunal and floral remains indicate a spring-summer occupation. However, due to post-depositional disturbance, the intensity and duration of the Middle Woodland occupation of Fletcher is unclear (Egan 1993:191).

According to Lovis (1985), the Late Woodland occupation of Fletcher represents peak occupation due to the presence of a full range of lithic reduction activities as well as division of space across the site. Habitation areas and specialized activities marked by hearths and storage pits are clearly separated from each other and cluster in specific areas of the site (Lovis 1985). There is also significant and overlapping midden accumulation during the Late Woodland occupation which supports intensive site occupation at this point in time (Lovis 1985). Faunal remains identified to the Late Woodland occupation suggest spring to autumn seasonality; floral remains were not identified.

Given the extent of resources exploited both during the Middle and Late Woodland occupations of Fletcher, site function has been interpreted as a long-term collective resource extraction site with more intensive occupation occurring during the Late Woodland (Egan 1993). Faunal and floral remains identified indicate multiple seasonality of use. Extensive pit features excavated at Fletcher support this interpretation; most pit features appear to have been used for storage of items that were later removed (Lovis 1985). The presence of spatially segregated patterns of postmolds also indicates designated areas for residential activities separate from that of storage features and various processing activities (Lovis 1985).

Table 5-4: Macrobotanical Data for Fletcher; x denotes presence

Scientific Name	Common Name	Middle Woodland	Late Woodland
Quercus sp.	Oak (Acorn)	x	
Carya sp.	Hickory	x	
Juglans nigra	Black Walnut	x	
Chenopodium sp.	Chenopod	x	
Crataegus sp.	Hawthorn	x	
Vaccinium sp.	Huckleberry	x	
NA	Aquatic and/or Terrestrial Tubers	x	

The Fletcher site material was used in a pilot study I conducted in order to determine the feasibility of deriving phytoliths from ceramic residues. Three sherds with residue were identified and sampled in this analysis conducted under the supervision of

Dr. Susan Mulholland (University of Minnesota—Duluth). Unfortunately these rims were not photographed prior to their return to the MSU Museum Repository. Only rimsherds were assessed for the presence of residue and as a result, it is not possible to state which percentage of sherds was sampled from the total ceramic assemblage. Based on observations of residues on the rims, however, it appears that residues are rare, perhaps due to post-excavation processing for museum storage.

Phytolith and Starch Results

While phytoliths were identified in all three residues, none of them were diagnostic. They were all identified to be a generic wild grass rondel form. Starch was also not identified in any of the three residues as well. This is surprising given the identification of tubers in the macrobotanical remains from Fletcher. Currently, these results do not add to interpretation of the site.

Kantzler (20BY30): Middle and Late Woodland

The Kantzler site was excavated by the Saginaw Drainage Chapter of the Michigan Archaeological Society in 1965 and by the University of Michigan Museum of Anthropology in 1966. Kantzler is located within Bay City, MI on an Algoma terrace on the western bank of the Saginaw River, at an elevation of approximately 183m. Due to its location in the estuarine area of the Bay City moraine, and as a former floodplain for the Saginaw River, flooding has been a feature of the site location throughout its history (Crumley 1973).

The earliest occupation of Kantzler dates to the Early Woodland, where site occupants utilized the area for fishing. Most of the fish species recovered, such as walleye, catfish, gar, and drum, are present in the Saginaw River year round (Crumley

1973). However the presence of young deer as well as whistling swan, ring-necked duck, and passenger pigeon indicate a spring-summer occupation of the site. Only one ceramic sherd dating to the Early Woodland was recovered during excavations. Upon examination of the collection in the UMMA, no residue was present on the sherd.

The Middle Woodland occupation of Kantzler can be divided into Early Middle Woodland and Hopewell (middle to late Middle Woodland) occupations based on the ceramics present (Crumley 1973). The ceramics sampled for this project, including both Tittabawassee and Greenpoint wares, correspond to the Hopewell-related portion of the Middle Woodland occupation. Evidence for occupation during the entirety of the Middle Woodland suggests the site may have been in use for all economic seasons. During the early Middle Woodland, fish species captured indicate spring and fall spawning fish (cod and trout respectively), as well as those available year round. The mammal species recovered at the site support use of the site for all economic seasons with the presence of beaver, which is usually hunted during the winter (Crumley 1973).

Occupation during all economic seasons of Kantzler is surmised for the Hopewell-related occupation period as well. The presence of beaver, elk, and muskrat indicate winter hunting while the remains of young deer and acorns are indicative of summer and fall resource exploitation (Crumley 1973). Macrobotanical remains were sparse; two acorns and a modern grape seed were recovered (Table 5-5). The grape seed reflects intrusion from the historic period occupation of the site area. The presence of acorn could also be indicative of fall occupation; however these nuts were often stored as well.

The Late Woodland occupation at Kantzler is difficult to tease out since throughout this stratum it is mixed with historic material (Crumley 1973). Ceramics present in the Late Woodland stratum appear to have stylistic indicators which may show affinities with Point Peninsula wares from southern Ontario as well as wares commonly found in Ohio (Crumley 1973). There is a known historic period Algonquin camp at Kantzler sometime in the late 17th century and this material is mixed with more modern historic material (Crumley 1973).

A total of 14 sherds with residue were identified from the Kantzler collection of materials located at UMMA. Four of these sherds (29%) were sampled for this project (Appendix B, Figures B4-B7). All three sherds date to the Middle Woodland period and are either Greenpoint or Tittabawasse wares.

Phytolith and Starch Results

Results of the phytolith and starch analysis are presented in Table 5-6. Maize and wild rice were both identified from Middle Woodland sherds. The possibility of maize during the Late Woodland is from the presence of a phytolith which could be maize diagnostic. The identification as definitively maize is not possible since the phytolith was not able to be rotated during analysis to view all sides. The identification of maize and wild rice during the Middle Woodland occupation of Kantzler also supports an interpretation for use during all economic seasons. These resources are available in the late summer to early fall and can be processed for long-term storage.

Table 5-5: Macrobotanical Data for Kantzler; x denotes presence

Scientific Name	Common Name	Middle Woodland	Late Woodland
Quercus sp.	Oak (Acorn)	x	

Table 5-6: Phytolith and Starch Data for Kantzler; x denotes presence

Scientific Name	Common Name	Middle Woodland		Late Woodland	
		Phytolith	Starch	Phytolith	Starch
Zea mays	Maize		x	possible	
Zizania aquatica	Wild Rice	x			

20SA1276: Middle and Late Woodland

Site 20SA1276 is located within the Shiawassee National Wildlife Refuge, in Saginaw County, MI. Site excavations have been conducted by Mr. Jeffrey Sommer of the Historical Society of Saginaw County. The site is 250m north of the Shiawassee River and the main extent of the site is bordered on the west by an old drainage or channel which runs between the Shiawassee and Titabawassee rivers (Sommer 2002, 2003b, 2005). Based on the ceramic and projectile types recovered, 20SA1276 dates to the Middle and Late Woodland periods. Floral remains recovered from flotation and encountered during excavation include hickory and walnut (Sommer 2002, 2003b, 2005). Faunal remains include deer, fish (catfish, sturgeon, gar), muskrat, and beaver (Sommer 2002, 2003b, 2005). Taken together the faunal and floral remains seem to indicate a fall to spring occupation. Sturgeon is a spring spawning anadromous fish while muskrat, beaver and nuts (hickory and walnut) are available during the fall and winter months. Feature descriptions indicate burning activities from the presence of ash, reddened soil, calcined bone, and charcoal (Sommer 2002, 2003b, 2005). Storage features have also been identified and it is likely that 20SA1276 represents a winter camp (Sommer 2002, 2003b, 2005)

Phytolith and Starch Results

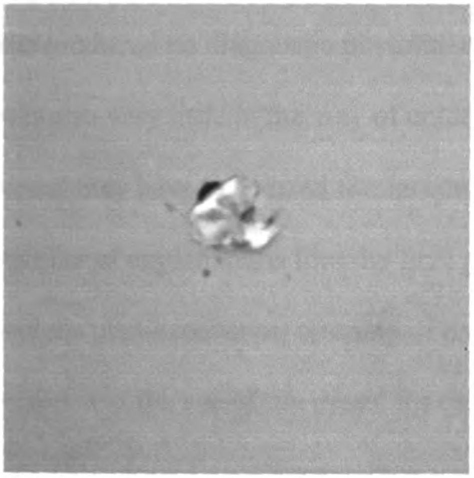
Results of the residue analyses for the sherds from 20SA1276 produced minimal diagnostic phytolith and starch bodies. The only diagnostic forms were found in two sherds which date to the Middle Woodland (see Table 5-7). The other Middle Woodland sherd examined did not produce diagnostic forms and the Late Woodland sherd examined had no phytoliths or starches present in the residue. Two sherds from this site were AMS dated. One sherd was not stylistically identifiable while the other was identified as Tittabawassee Ware, which dates to the early Middle Woodland (Appendix B, Figures B8-B13). Both radiocarbon dates derived from these samples are early in the Middle Woodland period; the unidentifiable sherd dated to Cal BC 50-Cal AD 90 (2 sigma) while the Tittabawassee Ware dated to Cal AD 10-140 (2 sigma; Sommer 2003a).

The plants identified through microbotanical analysis are available in late summer and early fall. The best time to harvest wild rice is generally early September to October (Vennum 1988). Acorns become available during the fall, and the presence of maize starch (Figure 5-2), which likely indicates mature maize, would also be available late summer-early fall. The plants identified also represent resources which are conducive to long-term storage, are easily collected, and can occur in abundance. This data supports the interpretation that 20SA1276 is likely a fall to early spring occupation and represents a winter camp.

Table 5-7: Phytolith and Starch data for 20SA1276; x denotes presence

Scientific Name	Common Name	Middle Woodland		Late Woodland	
		Phytolith	Starch	Phytolith	Starch
Zea mays	Maize		x		
Quercus sp.	Oak (Acorn)		x		
Zizania aquatica	Wild Rice	x			

Figure 5-2: Maize starch with possible evidence for grinding



20SA1251: Middle and Late Woodland

Site 20SA1251 is located along the Shiawassee River, within the Shiawassee National Wildlife Refuge, near Saginaw, MI. Excavations have been undertaken by Mr. Jeffrey Sommer, of the Historical Society of Saginaw County. An AMS date derived from residue adhering to the inner rim of a Green Point Incised vessel produced a date range of 40 BC-AD 120 (Sommer 2004). In addition to the dated Middle Woodland component of 20SA1251, diagnostic artifacts provide evidence of Late Archaic, Early Woodland, and Late Woodland occupations (Sommer 2002, 2003, 2005). The faunal assemblage consists of bird, turtle, drum, sturgeon, catfish/bullhead, other fish, muskrat, beaver, raccoon, deer, probable elk, bear, bobcat, fox, and other mammal (Sommer 2002, 2003b, 2005). Macrobotanicals have yet to be identified. Based on the artifact assemblage consisting of ceramic sherds, bifaces and debitage, and fire-cracked rock, Sommer interprets 20SA1251 as a site where lithic tool manufacture, on-site butchery, ceramic manufacture, and food preparation took place (Sommer 2002, 2003, 2005, 2007).

Phytolith and Starch Results

The results of the phytolith and starch study from the sherd examined from this site produced no diagnostic phytolith or starch forms (Appendix B, Figure B14). There was also very little in the way of unidentifiable forms. It appears that whatever this vessel may have been used for, its contents included little plant material. There are a number of explanations for why little plant material was found in these vessel. These include post-excavation cleaning of the artifact, the minimal use of plants cooked in this vessel, and the use of the vessel for cooking meat and/or fish.

Schultz (20SA2): Middle and Late Woodland

The Schultz site is located within the city of Saginaw, at the confluence of the Tittabawassee and Shiawassee rivers where they converge to form the Saginaw River. The site's proximity to upland, riverine, and wetland resources made it an ideal settlement location. Systematic excavation of Schultz was undertaken by UMMA from 1959 to 1965. The most intensive period of excavation occurred from 1962-1965. During this period UMMA crews identified a number of significant cultural features including a stratified Early through Late Woodland midden, three burial mounds and a circular stockade. Importantly, throughout the site, trenches were excavated during the UMMA excavations to aid in understanding the site's complicated stratigraphic record;

the result of a number of flooding and erosional episodes. These periodic flooding episodes played a significant role in the duration and intensity of occupation at Schultz. Excavations at Schultz were also undertaken in 1999 by Lovis on a smaller scale. The goal of these excavations was the recovery of more fine-grained subsistence data through the use of systematic flotation samples, a method not utilized during the original UMMA excavations.

Occupational history:

During the Early Woodland, initial occupation of the area occurred after the levee first forms. During site occupation the area around Green Point is initially swampy, at c. 600BC, but becomes less so by 400BC. However, the general area around the site does remain marshy (Fitting 1972). Floral remains for this time period consist of squash, hickory, black walnut, butternut, and walnut as well as one aster seed (Allison 1972; Egan 1993; Ozker 1982). Faunal remains are more abundant than floral remains and include deer, muskrat, beaver, bear, otter and a variety of fish (sturgeon, drum, walleye, channel catfish, bowfin). Human occupation during the Early Woodland at Schultz is extensive but of short duration and the site is abandoned after a flooding episode (Fitting 1972).

The early Middle Woodland period at Schultz demonstrates an increase in flooding at Green Point around 2000 years ago (Speth 1972). Occupation of the site at this time occurs along the levee and on the edge of a filled-in channel. Season of occupation varied, but warmer weather species increase. A variety of floral remains have been identified (Allison 1972; Egan 1993; Lovis et al. 2001) and are listed in Table 5-8. Terrestrial faunal remains during this time period are similar to that of the Early

Woodland but new species include elk, wolf, woodchuck, and mink. Fish species exploited are also similar to the Early Woodland but more extensive fishing behaviors are indicated by the presence of gar, perch, bass (large and smallmouth), sucker, and trout. The circular stockade at Schultz is built towards the end of this occupation and artifact densities and types suggest the presence of specialized activity areas (Fitting 1972).

During the late Middle Woodland, the rate of flooding which occurs at Schultz decreases and, as a result, the overall area around the site becomes less swampy. Occupation during this time period is on a stable levee which has a seasonal backswamp. Towards the end of this occupation, environmental data provided by Brose's (1972) mollusk analysis suggests a drier and possibly cooler climate. Faunal (aquatic and terrestrial) and floral exploitation during the late Middle Woodland is similar to that of the early Middle Woodland, however there is an increase in the potential reliance of Schultz occupants on aquatic species compared to terrestrial fauna (Fitting 1972; Egan 1993; Lovis et al. 2001). An increase in reliance on aquatic species is an overall trend from the Early through Late Woodland periods at Schultz.

Late Woodland occupation of Schultz declines in intensity and Fitting (1972: 264) characterizes these occupations as "...sporadic [and] seems to have taken place many times between AD 600-AD 1300." An increase in flooding episodes appears to occur between AD 700 and AD 900 which caused the area to become marshy again. It is perhaps due to this increased flooding that Late Woodland occupation at Schultz appears to be so sporadic. However by AD 1100, the site is drier once again (Fitting 1972:264). Overall, seasonality of these occupations is varied although the importance of aquatic species, especially various types of fish, indicates warm weather.

A total of 42 sherds with residue from the Schultz (20SA2) site were sampled for this project. This reflects approximately a 10% sample of the number of sherds (total count 421) with residues identified in the UMMA collection. The sherds sampled from Schultz for this project primarily date to the Middle Woodland but also include some transitional Middle to Late Woodland ceramics as well as one possible Early to Middle Woodland sherd (Appendix B, Figures B15-B53).

Phytolith and Starch results:

The results of my phytolith and starch analyses confirm the macrobotanical evidence, as well as add to it. Table 5-8 presents the macrobotanical data for the Middle and Late Woodland periods at Schultz while Table 5-9 presents the phytolith and starch data for the same time periods. Further evidence for the use of wild rice (Figure 5-3) and aquatic tubers during the Middle Woodland is identified. Egan (Lovis et al. 2001) had identified the presence of tubers at Schultz in the small-scale re-excavations undertaken by Lovis in 1991 but was unable to identify them to the genus or species level. The starch analysis performed here was able to identify a specific species of tuber (duck potato) exploited prehistorically and also demonstrated evidence for the presence of maize (Figure 5-4). The microbotanical data also supports the interpretation that the Middle Woodland occupation at Schultz occurred during all economic seasons. The plants identified in this analysis are all available in late summer to early fall and represent resources that can be processed for long-term storage.

Table 5-8: Macrobotanical data for Schultz; x denotes presence

Scientific Name	Common Name	Middle Woodland	Late Woodland
Amphicarpa bracteata	Hog-peanut	x	
Celtis occidentalis	Hackberry	x	
Chenopodium sp.	Chenopodium	x	x
Gaylussacia baccata	Huckleberry	x	
Polygonum sp.	Knotweed	x	
Sambucus canadensis	Elderberry	x	
Viburnum sp.	Nannyberry	x	
Iva annua	Sumpweed	x	
Zizania aquatica	Wild Rice	x	
Carya sp.	Hickory	x	
Corylus americana	Hazelnut	x	x
Juglans sp.	Walnut	x	
Juglans cinerea	Butternut	x	x
Juglans nigra	Black Walnut	x	x
Quercus sp.	Oak (Acorn)	x	
Juglandaceae	Walnut Family	x	x
Cucurbita pepo	Squash	x	
Zea mays	Maize		x

Table 5-9: Phytolith and Starch data for Schultz; x represents presence

Scientific Name	Common Name	Middle Woodland		Late Woodland	
		Phytolith	Starch	Phytolith	Starch
Zea mays	Maize		x		x
Zizania aquatica	Wild Rice	x			
Quercus sp.	Oak (Acorn)		x		x
Sagitaria latifolia	Duck Potato		x		

Figure 5-3: Diagnostic wild rice sheath phytolith from Schultz

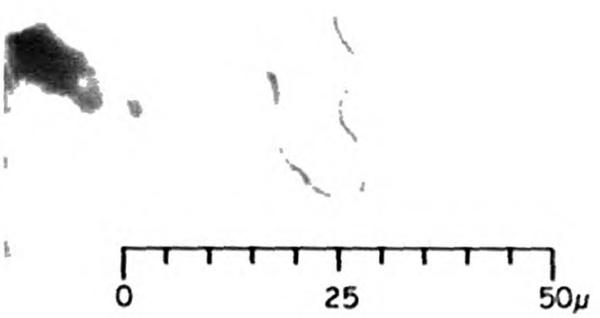
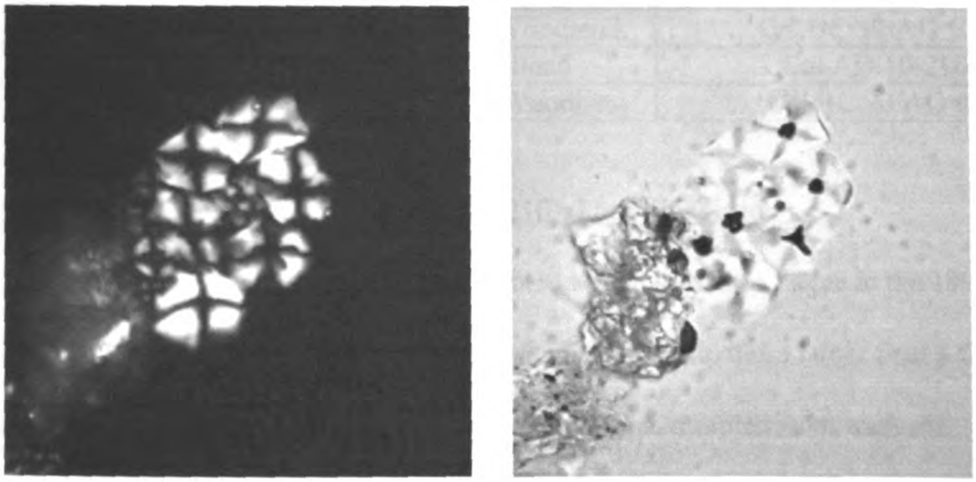


Figure 5-4: Maize starch, polarized and bright field views



The vast majority of radiocarbon dates obtained in this study come from the Schultz site assemblage. This was primarily due to a number of factors including the number of sherds where maize was identified in Middle Woodland wares, the presence of sufficient residue on sherds for both AMS sampling and phytolith and starch analysis, and the sherds from Schultz comprising most of the samples analyzed. The dates derived from these samples are all early and in the range of Cal BC 300-AD 130. Table 5-10 provides specific dates and corresponding stylistic identification for sherds sampled for AMS dating.

Table 5-10: Radiocarbon samples from Schultz

Lab Number	Stylistic Time Period	Radiocarbon Date (2 sigma calibration)
Beta-261449	Middle Woodland, possible Early Woodland	Cal BC 170-AD 50
Beta-261454	Green Point, Middle Woodland	Cal BC 160-AD 60
Beta-261455	Middle Woodland	Cal BC 90-AD 80
Beta-261456	Possible Tittabawassee, early Middle Woodland	Cal BC 350-300; Cal BC 210-40
Beta-261459	Green Point, Middle Woodland	Cal BC 190-AD 10
Beta-261460	Woodland	Cal BC 100-AD 120
Beta-261463	Tittabawassee, early Middle Woodland	Cal BC 170-AD 30
Beta-262038	early to late Middle Woodland	Cal BC 30-AD 130
Beta-262039	late Middle Woodland	Cal AD 10-210
Beta-262040	Green Point, Middle Woodland	Cal BC 90-AD 80

Tobico Marsh sites (20BY192 and 20BY210): Late Woodland

Of the sites identified within Tobico Marsh by James Payne in the 1990s, sites 20BY192 and 20BY210 both had large enough sherds (i.e. those larger than a fingernail) and sherds with residues. One sherd with residue was sampled from each site. The sherd from 20BY210 (Appendix B, Figure B54) was temporally unidentifiable since the exterior was too exfoliated. The sherd from 20BY192 (not photographed due to fragility) is thought to date post-1200AD due to its fine paste and the visibility of a fabric impressed exterior when viewed under direct light.

Tobico Marsh itself is located on the southwestern side of Saginaw Bay in Bay County, Michigan. The marsh contains a number of low parallel ridges, upon which a number of sites within the marsh, including 20BY192 and 20BY210, are located (Payne 1994).

Site 20BY210 (Tobico #21/Sharon's Scourge) was discovered during a shovel test survey in 1990. Finds from the shovel test pits and subsequent excavations indicate that 20BY210 probably represents a series of early and late Late Woodland occupations (Payne 1994). Diagnostic ceramic decoration, in conjunction with diagnostic lithics (including a Levanna-like biface), indicate Late Woodland occupation. Floral remains recovered from 20BY210 include acorn fragments, a possible maize kernel, and an unidentified tuber (Sommer 1994). Faunal remains found during excavation indicate fish and mammal exploitation. Fish species, identified by Sommer (1994), include bowfin, gar, perch, walleye, bullhead, drum, and sucker. Mammal remains include white-tailed deer, dog or coyote, muskrat, fox, raccoon and squirrel. Migratory waterfowl included duck, and a small number of amphibians, such as toad and turtle, were also identified (Sommer 1994).

The variety in size of fish species found at 20BY210 indicates the likely use of netting or trapping. Many of the perch recovered are smaller in size which would make spearing or line fishing inefficient capture techniques. The wide variety of species present at the site also indicates a non-discriminatory fishing technique; netting or trapping best represents this (Sommer 1994:58). The presence of walleye is a good seasonal indicator of early spring since walleye is a spring spawning species and can be found in shallower waters at this time of year.

Site 20BY192 (Tobico #8/Chris' Crossroads) is located on a ridge approximately 35-40m wide and was first identified during survey in 1988 (Payne 1994).

Cultural material recovered from 20BY192 indicates a late prehistoric occupation. Diagnostic artifacts include Madison points and shell-tempered pottery. What Payne (1994) identifies as an acceptable ^{14}C date from one of the pit features at the site, provides a date of AD 1400-1633, which corresponds to the time period represented by the Madison points and shell-tempered pottery. A date of AD 1220-1395 was derived from acorn fragments on the site but Payne rejects it for being too old (Payne 1994). Little floral material was recovered other than the acorn already discussed. Faunal remains include a variety of fish and mammal species. White-tailed deer, dog, elk, and muskrat are among the mammal species identified. Fish species include catfish and perch (Sommer 1994). Shallow stratigraphy and potential intrusion of historic activity into prehistoric deposits provide some problems in associating certain of the faunal remains with a time period. Both the dog and elk could be from historic activities rather than prehistoric (Sommer 1994).

Both sites 20BY210 and 20BY192, likely represent resource extraction camps. The large number of fish and aquatic mammals identified at both sites, along with Sommer's supposition of netting and/or trapping for fish capture strongly suggest specialized collective resource extraction (à la Egan 1993). This is also supported by the presence of tubers which are another collective resource and could easily be extracted during fishing activities.

Phytolith and Starch Results

The results of the phytolith and starch analyses are listed in Table 5-12. These results add to the few macrobotanical remains recovered from 20BY210 (Table 5-11). No diagnostic phytoliths or starches were identified in the residue derived from the sherd found at 20BY192. The phytolith and starch results confirm the macrobotanical data. Maize is positively identified in conjunction with a specific species of aquatic tuber, duck potato. The identification of duck potato supports the interpretation of 20BY210 as a resource extraction camp. The presence of maize is probably the result of maize being carried with individuals as a field food source (Raymond and DeBoer 2006).

Table 5-11: Macrobotanical remains from 20BY210; x denotes presence

Scientific Name	Common Name	Late Woodland
Zea mays	Maize	possible
Quercus sp.	Oak (Acorn)	x
NA	Unidentified tuber	x

Table 5-12: Phytolith and Starch Data for 20BY210; x denotes presence

Scientific Name	Common Name	Late Woodland	
		Phytolith	Starch
Zea mays	Maize		x
Sagitaria latifolia	Duck Potato		x

Simons 249 (20SA665): Late Woodland

Site 20SA665 was discovered by Mr. Donald Simons in the 1970s and surface collected by him throughout the 1970s and 80s (Beld 1993). A formal excavation was undertaken in May 1990 by Alma College as a field school under the direction of Dr. Scott Beld. 20SA665 is located in an agricultural field on the Flint River floodplain in Taymouth Township (Beld 1993). Based on two ^{14}C dates from the Alma excavations, as well as pottery and lithic diagnostics, the site dates to the Late Woodland period (Beld 1993). Radiocarbon dates from two features excavated during the Alma field school resulted in dates of cal. AD 1323-1490 (2-sigma) and cal. AD 434-1146 (2-sigma; note that the large standard deviation is due to a small sample size). These dates represent occupation during the entire Late Woodland.

Site seasonality for 20SA665 is hypothesized to occur during the summer due to the recovery of many fish bones and scales (Beld 1993). Other faunal and floral remains are not discussed due to ongoing analysis at the time of Beld's (1993) article. Features identified during site excavation represent a probable storage pit and shallow hearth (Beld 1993). Lithics from the site include bifaces, debitage, cores, and scrapers which indicate some tool manufacture and probable butchering activity associated with fish processing. Site 20SA665 could represent a short term resource extraction camp.

In his report on 20SA665, Beld (1993) includes Simons' surface collected materials. The sherd sampled for residue analysis (labeled vessel 92; Appendix B, Figure B55) was part of Simons' surface collection and is discussed by Beld (1993) as part of his Moccasin Bluff exterior modified lip section. Beld (1993) describes this vessel as similar to material found at Moccasin Bluff due to the finger grooves on the exterior and presence of one vertical and one horizontal row of circular punctates. When this sherd was assigned a type for this study, with the aid of Dr. William Lovis, it was not assigned a specific type but it was placed in the Late Woodland or later due to its being well fired and having a hard fabric. This corresponds time-wise to Beld's observation that it is similar to material present at Moccasin Bluff.

Phytolith and Starch Results

Phytolith and starch results are presented in Table 5-13. The data provided from these analyses support a summer occupation but could also indicate early fall through the presence of acorn. Maize can be harvested green during the summer.

However, mature maize is harvested in the fall so the presence of maize does not add much to detail to occupation seasonality or function.

Table 5-13: Phytolith and Starch Data for 20SA665; x denotes presence

Scientific Name	Common Name	Middle Woodland		Late Woodland	
		Phytolith	Starch	Phytolith	Starch
Zea mays	Maize	NA	NA	x	x
Quercus sp.	Oak (Acorn)	NA	NA		x

Solms (20SA57): Late Woodland

The Solms site is primarily known from surface collections although salvage excavations were undertaken by Fel Brunett in 1978. The report on file with the Office of the State Archaeologist provides little detail on the excavation and materials recovered other than a list of artifacts. The only macrobotanical data known for Solms is in the recovery of squash seeds from a late Middle Woodland stratum. Floral data derived from phytolith and starch analysis of Late Woodland material (see Table 5-14) denote the presence of maize, aquatic tubers (Figure 5-5), nuts, and wild rice. A total of seven sherds, from subsurface contexts, were sampled for residue analysis (Appendix B, Figures B56-B62).

Table 5-14: Phytolith and Starch results for Solms; x denotes presence

Scientific Name	Common Name	Middle Woodland		Late Woodland	
		Phytolith	Starch	Phytolith	Starch
Zea mays	Maize	NA	NA	x	x
Zizania aquatica	Wild Rice	NA	NA	x	
Quercus sp.	Oak (Acorn)	NA	NA		x
Nuphar lutea	Yellow Pond Lily	NA	NA		x

Figure 5-5: Yellow Pond Lily

Stadelmeyer (20SA195): Late Woodland

Stadelmeyer is located in the southwestern portion of Saginaw, MI, on the north bank of the Tittabawassee River approximately 5.8km from the confluence of the Tittabawassee and Shiawassee Rivers (Bigony 1970). The site is located on a sandy ridge at an elevation of approximately 181masl. The prehistoric component of the Stadelmeyer site was initially found in the 1960s by amateur archaeologists associated with the Saginaw Valley Chapter of the Michigan Archaeological Society. The Saginaw Drainage Chapter undertook a number of excavations until 1967 when the UMMA conducted their own fieldwork (Bigony 1970).

Based on the pottery recovered from the UMMA excavations, as well as the inclusion of the collections of two local amateur archaeologists, Messrs. Arthur Graves and Cleve Pomranky, the site was determined to date to two periods of the Late Woodland (Bigony 1970). The earlier Late Woodland occupation dates to AD 800-1100 based on the presence of Riviere au Vase ware. The later phase dates to AD 1200-1400 due to Upper Mississippian influence pottery. These Upper Mississippian influenced sherds are well-fired and use shell or grit temper (Bigony 1970).

Season of occupation for the Late Woodland component of Stadelmeyer seems to represent a late fall to early spring period of habitation. Fish remains, pike, perch, sturgeon and bowfin, are indicative of those caught in the early spring, based on their spawning season, while walnut and butternut hull remains are suggestive of fall. Other identifiable macrobotanical remains (see Table 5-15) were not recovered (Bigony 1970). Features at the site support this interpretation through the identification of hearths and storage pits, which would have been necessary for a winter occupation, and what Bigony calls a living floor. The living floor is described as a shallow lens of darker soil than the surrounding matrix which contained pottery, bone, clay daub, and charcoal (Bigony 1970:121).

A total of 14 sherds with residues were identified in the Stadelmeyer collection at the UMMA. Of these, six sherds (43%) were sampled for this project. From these six sherds (Appendix B, Figures B63-B68), three dated to the later Late Woodland period (post-1200AD), one was a generic Woodland ceramic, and two were a stylistic toss-up between the Middle and Late Woodland periods. The latter had paste which looked Middle Woodland but the rims had characteristics more consistent with the Late Woodland.

Phytolith and Starch results

The data derived from the phytolith and starch studies for Stadelmeyer significantly increased the number of known plant taxa. Macrobotanical data had only identified acorn, walnut and butternut as plant species present (see Table 5-15). Plant taxa identified through the residue analysis performed in this study (see Table 5-16) now include maize and aquatic tubers. This new data also supports the interpretation of a fall to early spring occupation at Stadelmeyer.

Table 5-15: Macrobotanical Data for Stadelmeyer; x denotes presence

Scientific Name	Common Name	Middle Woodland	Late Woodland
Juglans sp.	Walnut/Butternut	NA	x
Juglans cinerea	Butternut	NA	x
Juglans nigra	Walnut	NA	x
Quercus sp.	Oak (Acorn)	NA	x

Table 5-16: Phytolith and Starch data for Stadelmeyer; x denotes presence

Scientific Name	Common Name	Middle Woodland		Late Woodland	
		Phytolith	Starch	Phytolith	Starch
Zea mays	Maize	NA	NA	x	x
Quercus sp.	Oak (Acorn)	NA	NA		x
Sagitaria latifolia	Duck Potato	NA	NA		x
Nuphar lutea	Yellow Pond Lily	NA	NA		x

Foster (20SA74): Late Woodland

Formal excavations of Foster were undertaken by the UMMA in the summer of 1967. Foster is located in Taymouth Township of Saginaw County, MI on the northeastern side of the Flint River (Bigony 1970). Foster is dated to the Late Woodland period on the basis of diagnostic ceramic and lithic artifacts. The small ceramic assemblage present is described as, "...suggestive of Mackinac ware which has been dated to ca. AD700-1100..." while the presence of shell-tempered pottery is indicative of a post-AD1300 occupation (Bigony 1970:208). The presence of stemmed and small triangular points at Foster also speaks to a Late Woodland occupation since these are typical of the period for the Saginaw Drainage. Bigony (1970) determines site seasonality to be fall/winter on the basis of walnut and butternut shell and the preponderance of mammal bone in the faunal assemblage. Fish bone, of drum and catfish, in the faunal assemblage do not narrow down seasonality since they are available year round. The identification of hearths and storage pits would also be consistent with a fall/winter occupation and Foster is likely a winter camp.

Three of the four identified sherds (75%) with residue were sampled from the UMMA collections of Foster. Two of these sherds date to the later Late Woodland while one was unidentifiable due to its exfoliated exterior (Appendix B, Figures B69-B71).

Phytolith and Starch Results

Data from the phytolith and starch analyses are presented in Table 5-17. Analysis of residues provides more detailed floral information than originally reported. Both maize and yellow pond lily, add to the subsistence data for Foster. Bigony (1970) proposes that Foster is a fall/winter occupation based on the presence of nuts such as walnut and butternut. Given the identification of only maize starch, this likely indicates use of a dried form of maize. Tubers such as yellow pond lily are available year round but are best harvested in the late summer or early fall. Both maize and yellow pond lily are storable resources and support Bigony's (1970) suggestion of Foster as fall/winter occupation.

Table 5-17: Phytolith and Starch Data for Foster; x denotes presence

Scientific Name	**Common Name**	**Middle Woodland**		**Late Woodland**	
		Phytolith	**Starch**	**Phytolith**	**Starch**
Zea mays	Maize	NA	NA		x
Nuphar lutea	Yellow Pond Lily	NA	NA		x

Clunie (20SA722): Late Woodland

The Clunie site is currently undergoing excavation by Mr. Jeffrey Sommer of the Historical Society of Saginaw County at the Castle Museum. There have been three field seasons of excavation thus far, all of which have yielded a wealth of information. Clunie is located on the banks of the Tittabawassee River in the Shiawassee National Wildlife Refuge in Saginaw County, MI (Sommer 2005, 2006, 2007). Excavations take place every summer under the direction of Sommer with volunteer archaeologists from the local community.

Ceramic material at the site indicates the primary occupation as Late Prehistoric (AD 1400-1650). This time period assignment is also supported by four radiocarbon dates derived from charcoal samples at Clunie (Sommer 2005, 2006, 2007). However other ceramic material also indicates an early Late Woodland component as well. One of these Late Woodland sherds (Appendix B, Figure B72) was sampled for this study and radiocarbon dated. The date derived from residue on this ceramic, however, dates the sherd to the Late Prehistoric with a date of Cal AD 1440-1640 (2-sigma).

Sommer has encountered numerous prehistoric features at Clunie and has utilized intensive flotation sampling as part of his excavation strategy (Sommer personal communication). Analysis of flotation material in conjunction with excavation-encountered floral and faunal remains has yielded a variety of species. Floral remains include acorn (both nut and meat remains) as well as maize cob and individual kernels (see Table 5-18). Faunal remains from the site are comprised of mussel, fish bone and scales (including sturgeon and walleye), elk and deer, snapping turtle, beaver, muskrat, porcupine, and various species of bird (Sommer 2005, 2006, 2007). The faunal remains indicate extensive use of the available surrounding habitat. Walleye and sturgeon are both spring spawning fish while beaver is most often hunted in the winter. The presence of maize is indicative of late summer while acorn is harvested in the fall. The combination of this seasonality data indicates Clunie may well have been occupied either year round or nearly year round (Sommer 2005, 2006, 2007). Deer and elk are available year round while acorn and maize are very commonly stored food resources, which would have made year round occupation feasible.

Table 5-18: Macrobotanical Data for Clunie; x denotes presence

Scientific Name	Common Name	Late Woodland	Late Prehistoric
Zea mays	Maize		x
Quercus sp.	Oak (Acorn)		x

Phytolith and Starch Results

Phytolith and starch results for Clunie are given in Table 5-19. Residue analysis did not add any new subsistence data but does confirm the presence of maize in the Late Prehistoric occupation of Clunie. This new data is consistent with the interpretation that Clunie was likely occupied during all economic seasons.

Table 5-19: Phytolith and Starch Data for Clunie; x denotes presence

Scientific Name	Common Name	Late Woodland		Late Prehistoric	
		Phytolith	Starch	Phytolith	Starch
Zea mays	Maize				x

Summary of New Phytolith and Starch Subsistence Data

The phytolith and starch data presented in this chapter confirms previously known subsistence behaviors, as well as providing significant new data that extends and adds to our knowledge of subsistence for the Middle and Late Woodland period of the Saginaw Drainage. A summary table of phytolith and starch data with the associated radiocarbon dates for split residue samples is found in Table 5-20; the detailed results for each residue analyzed can be found in Appendix C, and the full results for the AMS dates can be found in Appendix D. Phytolith and starch data on Middle Woodland wild rice and aquatic tuber use provides more detail than the existing macrobotanical data. Evidence for the earlier use of maize is demonstrated through identification of maize starch in conjunction with a number of AMS dates which place this use of maize significantly earlier, by approximately 600 years, than a previous early date of AD 400 derived from a maize kernel at 20SA1043 (Parker 1996). What this data means, especially the evidence for such earlier use of maize, is discussed in the next chapter.

Table 5-20: Radiocarbon dates with plants identified from split residues

Lab Number	Radiocarbon Date (2 sigma calibration)	Site Name and Number	Plant Species Identified
Beta-261462	Cal AD 1440-1640	Clunie (20SA722)	Maize
Beta-261451	Cal AD 880-1020	Solms (20SA57)	Maize, Wild Rice
Beta-261452	Cal BC 50-AD 90	20SA1276	Maize, Wild Rice
Beta-261457	Cal AD 10-140	20SA1276	Acorn
Beta-261449	Cal BC 170-AD 50	Schultz (20SA2)	Possible sedge family species
Beta-261454	Cal BC 160-AD 60	Schultz (20SA2)	Possible wild rice
Beta-261455	Cal BC 90-AD 80	Schultz (20SA2)	Maize
Beta-261456	Cal BC 350-300; Cal BC 210-40	Schultz (20SA2)	Maize
Beta-261459	Cal BC 190-AD 10	Schultz (20SA2)	Wild Rice
Beta-261460	Cal BC 100-AD 120	Schultz (20SA2)	Possible maize starch determined to be generic form
Beta-261463	Cal BC 170-AD 30	Schultz (20SA2)	Maize, Wild Rice
Beta-262038	Cal BC 30-AD 130	Schultz (20SA2)	Maize
Beta-262039	Cal AD 10-210	Schultz (20SA2)	Possible maize starch determined to be generic form
Beta-262040	Cal BC 90-AD 80	Schultz (20SA2)	Maize

CHAPTER 6

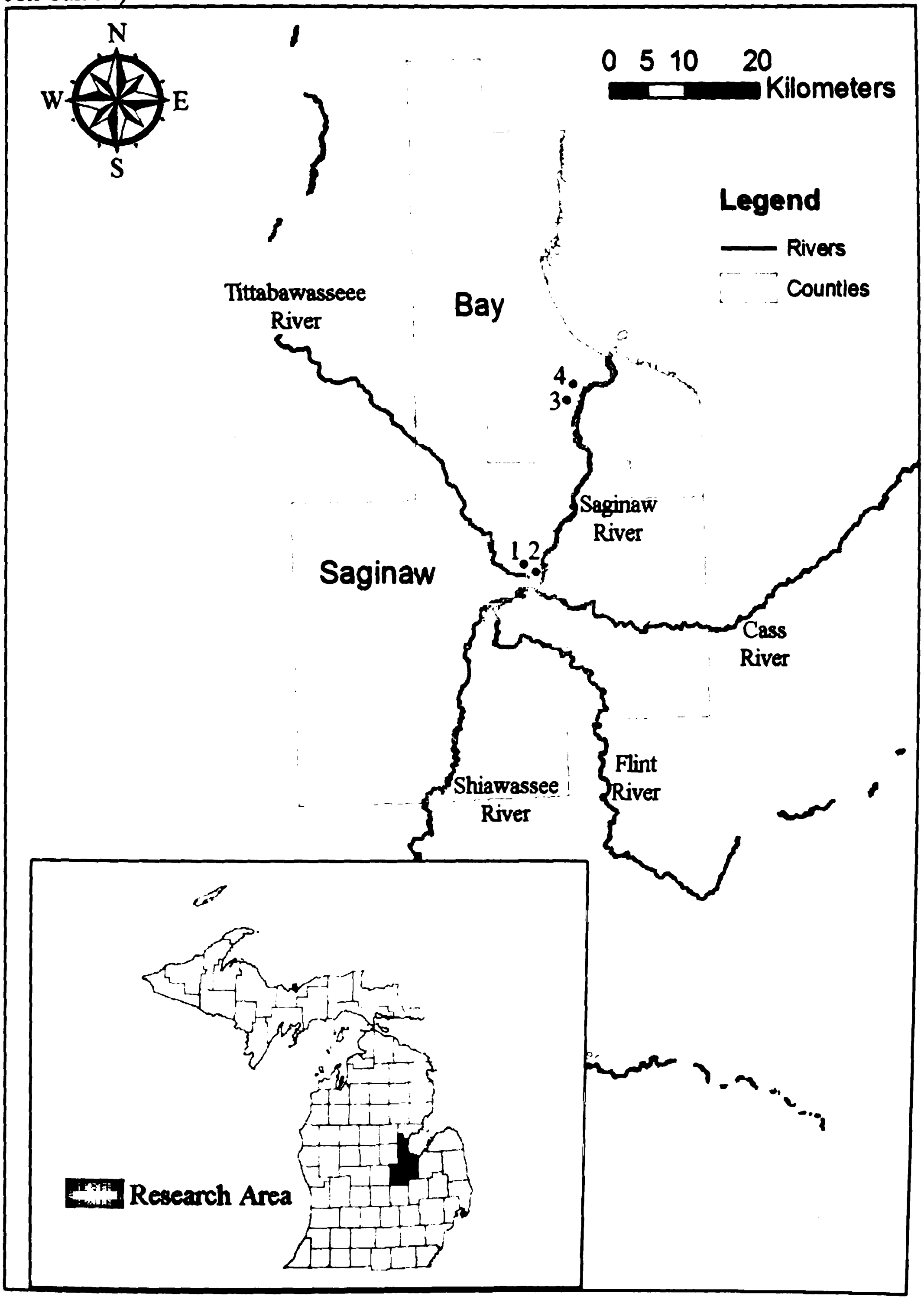
Saginaw Drainage Connections to the Great Lakes Region

Introduction

Results from the archaeological analysis indicate the earlier use of maize in the Saginaw Drainage as well as confirming the accepted hypothesis of maize utilization by c. AD 1000. The new data provided by the starch and phytolith analyses present some interesting questions. The earlier use of maize during the Middle Woodland in the Saginaw Drainage coincides with the expression of Hopewell-related traits both in Michigan and throughout the Midwest. Is the earlier use of maize somehow connected to the spread of Hopewell traits? What does the presence of maize starch, indicative of a form of dried maize, prior to the presence of maize phytoliths, i.e. evidence for the use of green maize, potentially mean? According to the behavioral table created from the experimental residues in Chapter 4, the presence of maize starch is most likely indicative of dried whole kernel or maize flour. The lack of maize phytoliths identified in residues prior to the Late Woodland period indicates that green maize was not being utilized before this point in time. If, as discussed in Chapter 4, part of the potential 'invisibility' of early maize use is its use in a green form, how can we explain the use of a dried form prior to a green form of maize? A summary of those sites in the Saginaw Drainage that were detected to have early maize is needed.

The identification of the presence of maize during the Middle Woodland (200 BC-AD 500) for sites in this study is limited to the following: 20SA1276, Liberty Bridge (20BY77), Kantzler (20BY30), and Schultz (20SA2) (Figure 6-1). It is interesting that all of these sites are thought to have either year-round economic activity (Kantzler and

Figure 6-1: Sites with maize dating to the Middle Woodland period (figure courtesy of Jon Carroll)



Sites: 1=20SA1276; 2=Schultz (20SA2); 3=Kantzler (20BY30); 4=Liberty Bridge (20BY77)

Schultz) or represent smaller short term seasonal occupations, either warm weather (spring/summer at Liberty Bridge) or cold weather (fall to early spring at 20SA1276) occupations. The occupations at Kantzler and Schultz also have significant evidence for Hopewell ceremonial affiliations while Liberty Bridge and 20SA1276 have more limited manifestations of Hopewell material culture such as slate pendants (Liberty Bridge) and engraved turtle carapace bowls (20SA1276). The following section discusses potential mechanisms for how maize may have been incorporated into these earlier dated residues.

Explanations for Maize in Residues

Contamination

One explanation for the identification of maize starch in residues is through contamination. Many of the collections utilized in this study have been curated in repositories for up to 40 years. Corn starch (i.e. maize starch) is a very common additive to packing materials and laboratory gloves. There is the possibility for the transfer of starch from these types of sources to artifact surfaces if collections are being rehoused, reanalyzed, or repackaged.

While a possibility, I do not think this is the source of corn starch found in my samples. Many samples were curated at the same institution. One such example are the samples from the Schultz site which were all housed in the Great Lakes Range at the University of Michigan Museum of Anthropology. Yet despite this common factor, maize starch was not identified in all residues derived from samples at Schultz. It would be expected that all, or at least most samples, would have maize starch present if contamination from packaging materials had been a factor.

The other possibility is the transfer of corn starch from powdered gloves. Since

I was aware of the potential for sample contamination with the use of powdered gloves, these types of gloves were not used when performing my analyses. If powdered gloves were used by museum staff at the institutions where the collections used in this study were housed, I do not know. However, if contamination from this source was a factor, I would once again expect maize starch to be present on all or most samples analyzed. To reiterate, this was not the case. Overall, I think contamination is an unlikely explanation.

Low-level Cultivation of Maize in the Saginaw Drainage

The explanation I expected (see Chapter 1) is that the early presence of maize would be due to its cultivation as a supplement to both extant Eastern Agricultural Complex (EAC) crops and wild plant foods already in regional economic use. However, I do not think planting of maize can be explained only through the presence of maize starch. The presence of only maize starch in these early residues does not support the hypothesis that initial maize utilization in its green form accounts for the invisibility of early maize use in terms of macrobotanical remains. The experimental data generated in this study also reveals that the best indicator of green maize utilization is in the identification of diagnostic cob phytoliths and not through the presence of starch. This finding is supported by the recovery of maize cob phytoliths from other residue studies (c.f Hart et al. 2003; Thompson et al. 2004) which indicate significantly earlier maize use. The early evidence for maize in the Saginaw Drainage derived from this study only identifies maize in its dried form (i.e. maize starch).

As determined from the experimental residues, maize starch is an overwhelming indicator for a dried form of maize. This could mean that at this earlier point in time, maize was under cultivation in the Saginaw Drainage. However, if maize were being cultivated and dried for storage during the Middle Woodland, one would also expect the recovery of macrobotanicals or cob fragments as well as tools associated with cultivation such as hoes. Recovery of maize macrobotanicals has not been the case despite the widespread and systematic use of flotation in Saginaw Drainage research for the past thirty years; evidence for tools associated with cultivation is also lacking.

Additional evidence which argues against the early cultivation of maize in the Saginaw Drainage is the increase in flooding documented during the early Middle Woodland (Monaghan and Lovis 2005; Speth 1972). This increase in flooding is a result of higher lake levels in Lake Huron which would have had a dramatic effect on river flow and would have inundated the flood plain (Monaghan and Lovis 2005). Additionally, GIS modeling currently undertaken by Cheruvelil (personal communication 2010) corroborates extensive flooding during the early Middle Woodland due to the higher lake levels in Lake Huron.

Evidence for wetter conditions is also demonstrated in environmental reconstruction via pollen analysis undertaken by Hupy and Yansa (2009) in the ecotone transition between deciduous and coniferous forest. Their analysis demonstrates an increase in mesic tree species such as beech, maple, elm, and basswood in the deciduous ecotone transition at c. 250 AD (Hupy and Yansa 2009:218). The residues with maize AMS dated for this study all date to the early part of the Middle Woodland (BC 200-AD 300) and the potential for maize cultivation would have been affected by these wetter conditions.

While flood plain cultivation was common during the Late Woodland and Late Prehistoric periods, it would probably not have been viable during the early Middle

Woodland. Increased early Middle Woodland flooding episodes would most likely have inhibited sufficient drainage of the flood plains, especially due to the already low-lying topography of the area. A reexamination of Figure 6-1 demonstrates that the four sites with early maize are at most 200m asl. All four sites would have been prone to flooding during an episode of increased flooding due to higher lake levels in Lake Huron. The area these sites are located in were prone to floods throughout the historic period and up to today (Krakker 1983). It is more than likely that these areas near site locations would have remained marshy and too wet to allow for successful maize cultivation (c.f. Lovis and Bogdan-Lovis 2004 on the effects of copious precipitation during the planting season and Chapter 2 of this work on the requirements for successful maize cultivation).

The use of ridged fields in gardens could have aided in the successful cultivation of maize during flood periods (Gallagher et al. 1985; Gartner 1999; Sasso 2003), and while there are garden beds identified in both Saginaw and Shiawassee Counties (Hinsdale 1931), their identification is farther downstream on the Shiawassee River. A review of Figures 5-1 and 6-1 (maps of site locations) demonstrates that the sites used in this study, are all located farther upstream along the Saginaw River and at the convergence of the Shiawassee, Tittabawassee, and Cass Rivers. According to Hinsdale's (1931) maps, garden beds have not been identified in this area. Ultimately the environmental conditions for this part of the Middle Woodland period were not conducive to maize cultivation, even for low-levels of production.

Exchange of Maize in Dried Form(s)

Another explanation for the presence of maize is its exchange between populations. It is well known that hunter-gatherer populations participate in gift exchange to reinforce social ties (Cashdan 1985; Hegmon 1991; Holman and Kingsley 1996; Kelly 1995; O'Shea 1981 and many others). It would be reasonable to assume that this type of behavior also applies to low-level food producers. Utilizing a mixed-subsistence economy still requires the maintenance of social ties to act as a buffer if one resource group (wild or cultivated) should fail. This would still require maintenance of social ties via gift exchange; maize, as an exotic food source, could be a potential type of gift. The gift aspect of exchange does not have to be included in this scenario as well. Sharing of food resources is a daily occurrence among hunter-gatherers and is a behavior which could be extrapolated to low-level food production (Keeley 1995; Kelly 1995; Knauft 2010; Lee 2003).

A study undertaken by Fie (2006) to determine which type of exchange best characterizes Middle Woodland (i.e. Hopewell) exchange networks also supports the idea of subsistence based exchange. Fie's (2006) study looks at the exchange of everyday, non-exotic items in the Lower Illinois River Valley. Fie's analysis of everyday item exchange during the Hopewell is important since so much emphasis is placed upon the exchange of exotic items during this period. Fie tests four models using ceramic composition and stylistic data, to determine which best characterize Middle Woodland interaction. For the Lower Illinois Valley, Fie finds that the most congruent model is based on socially motivated exchange for subsistence-maintenance materials (Fie 2006:445). Exchange of lithic raw material and food stuffs were important aspects of Middle Woodland exchange; Hopewell ceremonial items were not the sole focus. A subsistence-maintenance materials model supports the hypothesis of maize being utilized in subsistence exchange form. In fact, maize identified at Schultz, which has a significant Hopewell ceremonial component associated with a stockade, does not occur in these ceremonial contexts. Maize identified in residues from Schultz occurs in areas outside the stockade and are not affiliated with Hopewell-related ritual. If maize is being utilized as an exchange item, this now brings up the question of transport.

Maize in its dried form (whole kernel or flour) is easily transportable. It would not be unduly burdensome to transport maize longer distances in the form of kernels or flour. Transportation prehistorically would have most likely occurred in skin bags and baskets or birch bark containers; transportation of maize in ceramic jars would have been cumbersome and the ceramics prone to breakage, especially if transport was occurring over long distances. However, this is not to assume that transport of materials via ceramic jars never occurred.

If we suppose that maize is being exchanged in to the Saginaw Drainage, the next question to ask is, where is it coming from? The assumption made here is that any exchange of maize to the Saginaw Drainage is through down-the-line exchange and not direct exchange or trade between maize producing populations and non-maize cultivators. Based on artifact typologies and lithic raw material sources, the likely areas of interaction between the Saginaw Drainage and Great Lakes/Midwest region, either individually or collectively, are with Illinois, Indiana, Ohio, and southern Ontario.

Evidence for Middle Woodland Maize

Southern Ontario

Early evidence for maize in southern Ontario dates to c. AD 230/260-670/610 (2-sigma; Crawford and Smith 2003) from the Grand Banks site located in eastern southern Ontario. The Middle Woodland component of southern Ontario is characterized by the Couture (western southern Ontario), Saugeen (central western Ontario), and Point Peninsula (eastern Ontario) Complexes. For the purposes of this discussion, the most relevant, geographically speaking, Middle Woodland Ontario cultural manifestations are the Couture and Saugeen complexes. The Grand Banks site is a Middle to Late Woodland site and is best characterized by Point Peninsula and subsequently Princess Point material culture. The site is located on the isthmus between Lakes Ontario and Erie and is approximately 257 km from the Finger Lakes region where Hart et al. (2003, 2004) identified early maize in ceramic residues. The approximate distance to the Saginaw Drainage from Grand Banks would be around 360 km. Early maize has yet to be identified at Couture or Saugeen complex sites.

Ohio

Extensive paleoethnobotanical studies have been conducted on Middle and Late Woodland Ohio sites. Out of those studies, early maize has been identified at the Harness Mound site (Smith 1992). It was hypothesized early on (Braun 1987; Brose and Greber [eds.] 1979; Morgan 1952) that Hopewell manifestation (and even possibly the Early Woodland Adena cultural complex) in Ohio was not possible without maize agriculture (Hall 1976). As Eastern Agricultural Complex (EAC) cultigens became recognized as an independent agricultural manifestation within ENA, a shift from maize agriculture as the basis of Hopewell society to cultivation of EAC crops as the basis for Hopewell subsistence occurred (Dancey and Pacheco 1997; Wymer 1987, 1993, 1994; Wymer and Abrams 2003).

In part this shift in hypothesizing reliance on maize to EAC cultigens was due to the paucity of maize macrobotanicals identified through the systematic use of flotation on many Ohio Hopewell projects (Wymer 1993, 1994, 1996, 1997). Stable isotope studies of human bone have also not identified the presence of maize in Ohio Hopewell diets (Redmond 2007; Tankersley and Tench 2009; Yerkes 2005). Yerkes (2006) also notes a lack of dental caries, which would be associated with a high carbohydrate, agricultural diet, on Ohio Hopewell skeletal remains. The extant paleoethnobotanical and skeletal data in Ohio overwhelmingly points to the use of EAC cultigens used in combination with wild food resources (both faunal and floral) rather than reliance on maize horticulture during the Middle Woodland (Cowan 2006; Wymer 1994; Yerkes 2006).

Indiana

The area of Indiana archaeology pertinent to Michigan is located in northwest Indiana. The cultural manifestation in this area is known as the Goodall Tradition and is the local Hopewell variant (Brashler et al. 1999, 2006; Garland et al. 2006; Quimby 1941, 1943, 1944; Schurr 2009). The Goodall Tradition is located primarily in northwestern Indiana as well as extending northwards into southwestern Michigan and, relative to other Hopewell manifestations, is poorly understood. Studies by Schurr and Mangold (Ketchum et al. 2009; Mangold and Schurr 2006) have attempted to identify Goodall Tradition subsistence practices; however, very little floral and faunal data have been identified. Chenopod and hazelnut was identified at the Bellinger (12SJ6) site while bottle gourd was found at the Goodall (12LE9) site. Site locations on "dunal islands" (Ketchum et al. 2009) and in the uplands of the Kankakee River seem to indicate a mixed subsistence system of aquatic and upland terrestrial resources. Currently there is little evidence to suggest plant cultivation, whether EAC or maize, for the Goodall Tradition. A survey of the published literature also failed to identify any early evidence for maize within other regions of Indiana.

Illinois

Evidence for early maize within Illinois is present in both macrobotanical and stable isotope data. Maize macrobotanicals, two of which were AMS dated, were recovered from the Holding site (11MS118), located in the American Bottom in Illinois. These AMS dates were derived from a cob fragment and kernel recovered from two different feature contexts at Holding (Fritz 1993). The respective dates (kernel and cob) are 2017±50 BP (67 BC) and 2077±70 BP (127 BC) (Fritz 1993; Riley et al. 1994). For the Illinois archaeological chronology, this is squarely in the Middle Woodland (200 BC-AD 300) period. Other occurrences of Middle Woodland maize macrobotanicals in Illinois have also been recovered from Peisker, Smiling Dan, 11SA86, and Console (Asch and Asch 1985; Jefferies and Butler 1982; Struever and Vickery 1973). The maize remains from these latter contexts are all dated via artifact association and does not represent an absolute date.

Recent stable isotope studies (Rose 2008) of Middle Woodland to Mississippian skeletal populations in west-central Illinois have identified maize consumption at some early Late Woodland (AD 400) sites. Maize was identified in skeletal material at the Knight and Joe Gay burial mounds. The evidence from the Joe Gay site is especially compelling since the Late Woodland component of this site is presumed to be continuous from the Middle Woodland component on the basis of ceramic style continuity (Rose 2008:424).

The Illinois sites with Middle Woodland maize present are all located between the Illinois and Mississippi River Valleys in west-central Illinois. These are also sites with substantial Hopewell components. Ceramics at Smiling Dan, for example, are characteristic of a range of Middle Woodland forms including Havana, Pike, Baehr, and Hopewell vessels. Other evidence for Hopewell material culture is in the presence of blades, obsidian, cut mica, and slate gorgets. Importantly, Smiling Dan also has evidence for tools associated with plant cultivation in the form of manos (n=134), metates (n=2), and hoes (n=24). Cultivation of EAC plants is known to occur at Smiling Dan; the presence of Middle Woodland maize, however, also indicates the incorporation of maize into the extant subsistence system.

Evidence for Interregional Influence in Michigan

If one accepts the premise that the early maize identified in Michigan is a result of down-the-line exchange, there are only two geographic regions which could be the likely sources for the exchange of maize based on the evidence presented above. These areas are southern Ontario and Illinois. There is evidence from both regions for contact between populations in both the presence of lithic raw material and projectile point styles. From the southern Ontario/Northeast region Onondaga chert is a common exotic lithic raw material found in the Saginaw Drainage. Other Ontario chert sources found to varying degrees in Michigan also include Kettle Point and Collingwood. Meadowood points are one of the most common projectile point types for the Late Archaic/Early Woodland period in Michigan and these have a distribution throughout the Northeast and into Ontario and Michigan. Other projectile point examples following a Northeast distribution into Michigan include Genesee, Snook Kill, and Lamoka (Justice 1987).

Examples of Archaic period bifaces with Illinois affinities found in Michigan are Turkey Tails and a variety of stemmed points falling into the Table Rock Cluster

(Justice 1987). In regards to lithic raw material originating from Illinois, Burlington chert would be the most likely source. However there is very little Burlington chert found in the Saginaw Drainage of Michigan. Sommer (2004) reports one flake of Burlington from 20SA1276 and Crumley describes a high quality non-local white chert at Kantzler but does not identify it. Burlington is characterized as high quality and is white in color; the chert described at Kantzler could be Burlington based on the description but visual confirmation is required.

Projectile point continuity with Illinois continues into the Early and Middle Woodland. The characteristic Hopewell Snyders point originates in Illinois (Justice 1987) and has a Michigan variant known as Norton Corner Notched, primarily found in southwestern Michigan. Snyders points found outside of Illinois are predominately in Indiana and Michigan but are less frequent in Ohio (Justice 1987). Interestingly, Snyders points identified in southwestern Michigan appear to be related to the extension of the Goodall Tradition into Michigan and are often made on Burlington or Wyandotte (an Indiana lithic material) cherts (Brashler et al. 2006; Garland and DesJardins 2006). Brashler's excavations (1996-97, 1999) at the Prison Farm site near Grand Rapids, MI identified Burlington chert as part of the lithic assemblage and Garland and DesJardins (2006) characterize Burlington as an important exotic lithic in the St. Joseph and Portage River drainages. To a lesser extent, Snyders points in Michigan are also found made on Onondaga, Flint Ridge and Upper Mercer cherts which does at suggest ties of some kind in terms of lithic raw material exchange to Ohio and southern Ontario. The southwestern Michigan variant of Snyders, Norton Corner Notched points, are commonly made on Bayport chert, which is 'exotic' to southwestern Michigan, but local to the Saginaw River drainage (Brashler et al. 2006; Garland and DesJardins 2006).

Based on the lithic information, both southern Ontario and Illinois seem to be equally likely areas of interaction. However the ceramic typology of the Saginaw Drainage provides a different set of information. Ceramics first appear in Michigan during the Early Woodland period. Early Woodland Saginaw Drainage ceramics, particularly Schultz Thick and Shiawassee Ware, are Illinois variants of Marion Thick and Dane Incised respectively (Brashler 1973; Fischer 1972; Fitting 1970; Ozker 1982). These Early Woodland Schultz Thick ceramics have also been identified at southwestern Michigan sites such as Spoonville, Norton Mound, and Moccasin Bluff (Brashler 1973).

Evidence for ceramic affinities with Illinois continues into the Middle Woodland (and Hopewell manifestations) of both southwestern Michigan and the Saginaw Drainage. Tittabawassee and Green Point Wares are characterized by nodes, punctates, dentate stamping, and rocker stamping (Brashler 1973). These two wares correspond to the expression of Havana and Hopewell wares for the Saginaw Drainage. Tittabawassee Ware has affinities with Havana ceramics from Illinois (Brashler 1973; Fischer 1972). Research occurring on Hopewell manifestations in southwestern Michigan has also identified Illinois Havana wares (Brashler et al. 2006; Kingsley et al. 1999; Mangold and Schurr 2006). Illinois Havana wares have been identified at the Moccasin Bluff, Hart, Norton Mounds, Jancarich, Sumnerville, Toft Lake, and Brooks Mound sites (Brashler et al. 2006; Garland and DesJardins 2006; Kingsley et al. 1999).

In regards to southern Ontario ceramic styles, there is little evidence for interaction between Saginaw Drainage and southern Ontario populations during the Early and Middle Woodland periods (Brashler 1978; Fischer 1972). In general, there is very little evidence for any sort of Hopewell cultural manifestation in either Saugeen or Couture Middle Woodland complexes. The evidence for any kind of Hopewell influence in southern Ontario is seen in a couple of caches of Hopewell bifaces and prismatic blades made on Flint Ridge chert found at Couture Complex sites in southwestern Ontario (Spence and Fox 1986; Spence et al. 1990; Crawford and Smith 2003). Other evidence for Hopewell influence that has been found is in ceramics with dentate and rocker stamping which have been characterized as influenced by Ohio Hopewell and some Hopewell burial goods present in Saugeen complex burials (Deller et al. 1986; Spence et al. 1990; Wright 1967).

Apparent interaction for southern Ontario at this point in time is most likely with points in Ohio instead of the Saginaw Drainage. Interaction between the Saginaw Drainage and southern Ontario, as manifested via ceramic styles, does not appear until the Late Woodland period which appears to coincide with a shift in population density and focus (Krakker 1983). This particular phenomenon will be addressed in the concluding chapter.

Summary

Given the evidence presented above, the best candidate for where this maize may have originated is currently in Illinois. This is primarily based on the number of early occurrences (i.e. Middle Woodland) for maize that have been identified in Illinois as well as the evidence for cultural influence in the Saginaw River drainage and throughout southwest Michigan. Cultural manifestations in the Saginaw Drainage demonstrate continuous affinities with Illinois-based material culture up through the Middle Woodland period and Hopewell-related manifestation of the Saginaw Drainage.

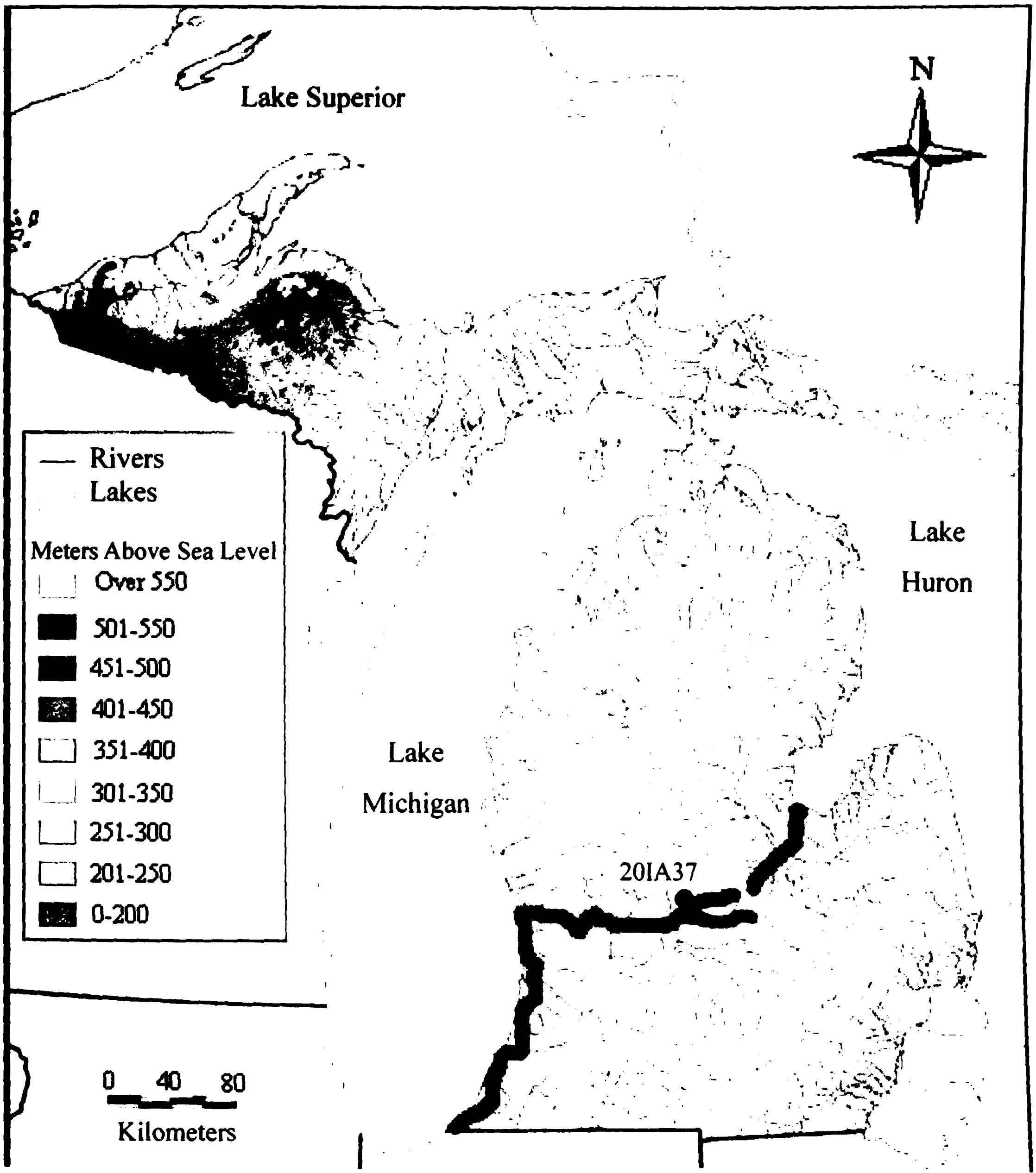
In fact, it is probably through interaction between the occupants of the Saginaw Drainage and populations in southwestern Michigan that Illinois stylistic and cultural influence is manifested. Saginaw Drainage Hopewell-related manifestations have been characterized as 'doing Hopewell out of context' (Fitting 1975; Kingsley 1999:152). There is good evidence to suggest that certain Hopewell characteristics were adopted by a local population through diffusion. Hopewell mortuary treatments for the Saginaw Drainage are characterized as truncated and there is a higher proportion of decorated ceramics in the ceramic assemblage for Saginaw Hopewell than is seen in other Hopewell manifestations (Kingsley et al. 1999:152). The evidence for diffusion and/or acculturation of Hopewell in the Saginaw Drainage is from southwestern Michigan, which has evidence for connections to Illinois Hopewell.

There is ample evidence for interaction between southwestern Michigan and Indiana with the Goodall Tradition. The Goodall Tradition has direct connections and ties to Illinois Hopewell cultural manifestations (Garland and DesJardins 2006; Kingsley et al. 1999; Mangold and Schurr 2006). Goodall appears to be directly related to Illinois Hopewell in decorative ceramic motifs such as dentate stamping and rocker decoration. Importantly, Burlington chert is also found on Goodall Tradition sites and in larger percentages on these sites. Besides lithic raw material, bifacial blades found at Goodall Tradition sites are more similar to Illinois Middle Woodland bifacial blade production, than that seen in Ohio (Mangold and Schurr 2006).

As discussed above, there is also evidence for Illinois-produced Havana wares at southwest Michigan sites. Whether the presence of these ceramics is due to direct population migration from Illinois into this area of Michigan, or through diffusion and down-the-line exchange with Goodall Tradition populations as 'intermediaries' is currently a question up for debate. Previous research (Brashler et al. 1999; Kingsley et al. 1999; Mangold and Schurr 2006) had argued for Hopewell migration into the area. Based on more recent research (Brashler et al. 2006; Garland and DesJardins 2006) into Hopewell manifestations in southwestern Michigan, however, it appears that diffusion is the more likely scenario. The diffusion hypothesis is also supported by the presence of some Ohio material, such as Flint Ridge chert and a vessel found at the Schilling site with a herringbone decorative pattern that is reminiscent of Ohio Hopewell (Garland and DesJardins 2006). The presence of other Hopewell manifestations, such as Ohio Hopewell, would be unexpected if southwest Michigan Hopewell was derived from a population migration into the area. The likely method of diffusion of Illinois Hopewell into southwest Michigan and subsequently into the Saginaw Drainage is likely via river routes.

Hinsdale's (1931) map of river portages for Michigan and northern Indiana and Ohio identify portages between the Kankakee to the St. Joseph River. From this point, there are a number of paths (both overland and via waterways) from southwestern Michigan to the Saginaw Drainage. The most prominent portage from western Michigan to the Saginaw Drainage is between the Maple and Looking Glass Rivers to the Shiawassee River (see Figure 6-2 for a reconstruction based on Hinsdale 1931 and Howey 2007). Along the Grand River, at its confluence with the Maple River in Ionia County, there is also an Early Woodland earthwork enclosure site, Arthursburg Hill (20IA37; Figure 6-2) which Beld (1993b) characterizes as a population aggregation site for social integration purposes.

Figure 6-2: River routes from southwest Michigan to the Saginaw Drainage



Arthursburg Hill is considered to have served some type of population integration function not only because of the presence of the earthwork enclosure, but also due to the presence of numerous types of lithic material, both local and non-local;

examples include Bayport, Norwood, Onondaga, Flint Ridge, and Wyandotte/Indiana Hornstone (Beld 1993b; Garland and Beld 1999). Areas of origin for these raw material types include the Saginaw Drainage, Northwest Michigan, Ontario, Ohio and Indiana. Arthursburg Hill also has evidence for both domestic and ritual activities conducted at the site (Garland and Beld 1999). Evidence for domestic activities such as stone tool manufacture, cooking, and plant and animal processing are present while evidence for its integrative function is due to its location on a major river confluence and presence of exotic materials (lithics, copper, slate pendant). The presence of black bear, beaver, turtle and bobcat in the faunal assemblage could also speak to the possible ritual function of the site. All of these are common figures in Great Lakes Native American mythology and items such as fur, teeth, claws, and turtle carapaces for rattles often play a role in ritual ceremonies (Clifton 1978; Densmore 1929; Howey and O'Shea 2006; Lovis 2001). Exchange of exotic materials, including maize, could have been conducted at social integration sites such as Arthursburg Hill.

The presence of Illinois influenced material culture in the Saginaw Drainage, as well as the presence of Bayport chert, the most common lithic raw material utilized in the Saginaw Drainage, found on Middle Woodland southwest Michigan sites, argues for some kind of interaction between the two areas. Social integration sites located between the Saginaw Drainage and southwest Michigan, such as Arthursburg Hill, could have acted as point for exchange between these two areas. How this data ties in with other evidence for down-the-line exchange of maize, as well as a discussion of why there is this shift to maize cultivation during the Late Woodland period, documented both macro- and microbotanically, are provided in the next (and last) chapter.

CHAPTER 7

Conclusion

Based on the existing evidence for early maize, ceramic decoration, and lithic raw material and projectile point styles, the current best explanation for the presence of maize in the Saginaw Drainage at c. 0 AD is due to down-the-line exchange. The most likely area from where this maize originates, based on the information presented, is within Illinois. This is not the first microbotanical analysis which has concluded the earlier presence of maize in an area to derive from down-the-line exchange. Phytolith and starch studies conducted by Boyd and Surette (2010) and Zarillo and Kooyman (2006) make arguments for down-the-line exchange of maize as well.

The Zarillo and Kooyman (2006) study examined residues derived from a grinding slab and grinding stone found on a site located in Calgary, Alberta on the Northern and Canadian Plains. Due to the informal nature of these tools, a use wear analysis was performed prior to sampling the artifacts for starch grain analysis. The use wear analysis confirmed these artifacts as being utilized for plant processing (Zarillo and Kooyman 2006:483). The results of this analysis identified a number of plant species including choke cherry, saskatoons, and maize. Zarillo and Kooyman explain the presence of maize through trade, due to environmental limiting factors in the Northern Plains. Based on ethnographic and early historic accounts, Zarillo and Kooyman (2006:490) identify the Middle Missouri region as the origin for trade items into the Canadian Plains. Throughout prehistory, especially c. AD 1000 and later, there was contact and influence between populations within the Missouri River valley and farther east toward the Mississippi and Illinois Rivers which does exert some influence on more peripheral regions and populations (Brown and Sasso 2001; Mainfort 2001; Theler and Bozshardt 2006).

Boyd and Surette's (2009) study of a series of Northern Plains and Boreal Forest Middle Woodland Laurel Tradition (300 BC-AD 1100) sites also demonstrates the earlier presence of maize. Out of their sample, ten Laurel sherds derived from ten different sites produced evidence for early maize (Boyd and Surette 2009:124). Microfossils recovered include only maize starch, only maize phytoliths, and both maize phytoliths and starches. Boyd and Surette (2009) argue that the presence of this earlier maize is most likely due to down-the-line exchange and indirect influence from upper Mississippi River Valley (i.e. Illinois) Hopewell groups. The timing for the presence of maize at these Boreal Forest and Northern Plains sites coincides with the earliest evidence for maize at the Holding site in Illinois (Boyd and Surette 2009:129). Importantly, Boyd and Surette view this down-the-line exchange of maize as a primarily social occurrence (i.e. gift exchange) rather than subsistence based.

Both studies demonstrate the presence of maize in unexpected contexts. The Northern Plains and Boreal Forest are not conducive to maize cultivation, although microclimate areas such as the Lake of the Woods in northwestern Ontario may have allowed for low-level cultivation of maize. In both cases, however, down-the-line exchange would have played some role in the presence of maize prior to the ubiquity of maize cultivation in the Midwest.

There are, however, some questions raised in using down-the-line exchange as an explanatory mechanism for the presence of early maize in the Saginaw Drainage. First and foremost is the question "Is there evidence for maize cultivation along the

Illinois, Kankakee, St. Joseph, Maple, and Looking Glass River valleys?" Presently the answer is no. Early maize macrobotanical remains have not been identified in these areas. Most subsistence information seems to indicate wild resource utilization with varying degrees of Eastern Agricultural Complex (EAC) cultigen incorporation into the diet. However, taphonomy and differential recovery issues also play a role in what has been recovered so far from these other areas. To test this hypothesis of down-the-line exchange, the sampling of residues from artifact surfaces (either ceramic or lithic) is required. The next logical step is to test materials from southwestern Michigan and northwestern Indiana for the presence of maize.

As a countermeasure, materials from southeastern Michigan, southeastern Ontario, and northeastern Ohio also need to be analyzed. While the exchange of maize from southern Ontario was discounted due to the lack of ceramic style affinity, the exchange of lithic raw material does indicate contact. While I do believe that there is likely a secondary mechanism operating for the exchange of lithic raw material from this area into the Saginaw Drainage, that of access proximity and efficiency of transport, this region around Lake Erie cannot be discounted in regards to future testing of residues.

In fact, due to the apparent restructuring of both subsistence and settlement patterns during the Late Woodland, in both the Saginaw Drainage and southeastern Michigan, which clearly indicate affinities between the two areas, analysis of materials from this region is critical. A major question in the past thirty to forty years of research around the western shore of Lake Erie is how these materials relate to one another and why there is such a dramatic shift in Saginaw Drainage subsistence and settlement towards this region at c. AD 1000 (Brashler et al. 2000).

One potential explanation is environmental change occurring between the Middle and Late Woodland periods. While the early Middle Woodland demonstrates an increase in flooding of the Saginaw Drainage, the Late Woodland period appears to coincide with a 'drying out' of the area. The Medieval Warm Period, which begins c. AD 1000, is manifested across the northern hemisphere with a trend of warmer and drier temperatures. Causes for the onset of the Medieval Warm Period are uncertain but it appears to be related to increased solar activity and/or a decrease in volcanism which may have amplified other climatic factors elsewhere (Booth et al. 2006; Crowley 2000). Other factors which appear to be affected by or have an effect on the drying trend occurring during the Medieval Warm Period include sea surface temperatures (in the Tropical Pacific, North Pacific, and North Atlantic) which had a combined effect on circulation patterns in the atmosphere. These modified circulation patterns appear to have played a role in the drought and drying trend seen across the western Great Lakes and elsewhere (Booth et al. 2006:423-425).

Evidence for drought during this time period is seen at both Hole-in-the-Bog in Minnesota and Minden Bog in southeastern Michigan. Paleohydrological reconstruction from these two bog sites, located approximately 1000 km apart, correlate to drought during the Medieval Warm Period at AD 1000 and AD 1200 (Booth et al. 2006). This correlates with other evidence for drought and a general drying trend post-AD 1000 as demonstrated in the growth of sand dunes on the shores of Lake Michigan and Lake Huron and in other areas of the Midwest (Hanson et al. 2009; Lovis et al. 2009).

Finally, there is also evidence for a drop in water levels in Lake Huron and the Saginaw Bay. Fluvial changes manifested in the Shiawassee River indicate that at this point in time, the river shifts its channel and there is also evidence for both vertical and lateral erosion (Lovis et al. 2001; Monaghan and Lovis 2005; Speth 1972). This pattern of erosion is consistent with a faster stream flow and is indicative of a drop in water levels for Saginaw Bay. This change in stream flow is indirectly corroborated with the drop off in identification of wild rice phytoliths during the Late Woodland. Wild rice has very specific ecological niche requirements including clear slow moving water and muddy river bottoms (Vennum 1988). An increase in stream flow would more than likely shrink any existing stands of wild rice, possibly to the point where this carbohydrate-rich grain could no longer be relied upon as a staple.

Cumulatively, these environmental changes especially the evidence for drought in conjunction with faster stream flow, indicates that the wetlands so characteristic of the Saginaw Drainage, were likely decreasing in size and/or in productivity. All subsistence evidence prior to the Late Woodland period indicates heavy reliance on aquatic and wetland species (Lovis et al. 2001). Drought would have forced a shift in subsistence. This shift is corroborated by the fine-grained recovery and analysis of sediments, flora and fauna at Schultz in a small-scale re-excavation by Lovis in 1991; reliance on aquatic species drops significantly (Lovis et al. 2001). Incorporating the subsistence data derived from the residue analyses conducted in this study, residues from Middle Woodland pottery demonstrate the presence of wild rice. Wild rice is a nutritious grain, high in carbohydrates which is and was extensively utilized by Native American populations in the Great Lakes region (Vennum 1988).

While the current range of wild rice is limited to the Upper Peninsula of Michigan, northern Wisconsin, Minnesota and Ontario, there is good prehistoric evidence that it occurred farther south within the Great Lakes. Moffat and Arzigian (2000), Egan (2001), Ford and Brose (1975), and Parker (1996) have all recovered wild rice macrobotanicals from sites in southern Michigan and Wisconsin. An important characteristic of wild rice is its ecological sensitivity to habitat requirements. It prefers clear, slow moving, sandy bottomed streams, lakes, and rivers (Vennum 1988). These environmental conditions were present during the late Middle Woodland, once lake levels had stabilized and intensive flooding in the Saginaw Drainage was no longer an issue (Lovis et al. 2001; Monaghan and Lovis 2005).

However, once water levels in Lake Huron and Saginaw Bay dropped and the drying trend brought on by the Medieval Warm Period intensified, these conditions for wild rice would no longer have existed or would have been significantly diminished. These conditions would have made reliance on wild rice as a carbohydrate source untenable. The likely result is that maize, which had been incorporated in low levels in the previous subsistence regime, intensification occurred. The ubiquity of maize cultivation at around AD 1000 is most likely a response due to this onset of drier conditions.

The realignment of settlement in the Saginaw Drainage with areas to the southeast is also apparent at this point in time. Brashler's (1978 and 1981) study of ceramic types in southern lower Michigan demonstrates that while three distinct cultural traditions (Allegan, Spring Creek, and Wayne Traditions) exist for the early Late Woodland period, there is also substantial fluidity in social boundaries, especially for the late Late Woodland (Brashler 1978:347). Brashler (1978:347) cites the later integration of Younge and Western Basin Traditions into southeastern Michigan and the unclear boundary relationship between southeastern Michigan and Saginaw Drainage groups as evidence for this social fluidity. Younge Tradition ceramics appear to have stylistic affinities to Glen Meyer ceramic types in southern Ontario and sharing of decorative motifs and techniques is evident on Younge and Wayne Tradition ceramics (Brashler 1981:334). Finally Brashler (1981) also provides evidence that Western Basin Tradition groups may have cultivated crops. Maize found at the Sissung site, which has clear Western Basin affinities, has an associated ^{14}C date of AD 700 (Brashler 1981; Prahl 1969; Prahl et al. 1976). Further inquiry into southern Michigan social boundaries and subsistence is continued by Krakker (1983).

Krakker (1983) examines ceramic and settlement system change during the Late Prehistoric period for southeastern Michigan. Krakker's specific focus in this study is on post-Wayne Tradition wares, specifically Riviere au Vase, Younge, Springwells, and Wolf wares. These wares represent a temporal sequence starting c. AD 900 and continuing until c. AD 1400 and, importantly, also demonstrate continuity from one stylistic tradition to the next; transitional forms are present and abrupt changes in ceramic styles do not appear to exist (Krakker 1983:184).

In Krakker's settlement analysis, he finds there is evidence for an increase in community size over time and that this occurs at a rate which suggests population aggregation (Krakker 1983:521). Krakker (1983:522-525) attributes this trend towards an increase in settlement size due to maize cultivation and the selection of sites which have optimal characteristics such as well-drained arable soil, access to water, and are (potentially) easily defensible locations. However the onset of the Medieval Warm Period at c. AD 1000, and the climatic changes caused by it, could have also spurred on community aggregation as a means to conserve resources and buffer risk. This is further supported by the realignment seen in the Late Woodland period with areas in southern Ontario and northeastern Ohio. These regions may not have been affected in the same way as the Saginaw Drainage, and hence had resources which may have become scarce or were not usually available in abundance. Southern Ontario groups may have also had more experience with maize cultivation due to its early incidence in southwestern Ontario and the nearby Finger Lakes region of New York and its likely spread east towards southeastern Ontario.

To sum up the changes in subsistence discussed above, subsistence during the Middle Woodland is based on intensification of wetland and riverine resources, the use of Eastern Agricultural Complex (EAC) crops, and some use of maize likely present through down-the-line exchange. Late Woodland subsistence demonstrates a decline in the reliance on wetland and riverine resources, the ubiquity of maize cultivation, and a shift in settlement patterns towards southeastern Michigan. With the data generated from this study incorporated into the above summary, how does this new data answer the research questions initially posed?

Research Results

Q1: How much earlier is maize being 'plugged into' traditional subsistence practices and does this have any effect on the seasonal settlement-subsistence round? Earlier use of maize was found to be present as early as 500 years prior to the current maize macrobotanical evidence for the Saginaw Drainage. However, it's probable presence through down-the-line exchange rather than low-level cultivation is not consistent with the idea of maize being 'plugged into' the existing subsistence system.

Due to my current hypothesis that maize was not undergoing cultivation in the Saginaw Drainage its presence via down-the-line exchange most likely did not have a drastic impact on the settlement-subsistence round. If anything, the incorporation of maize in a dried form may have enabled Saginaw Drainage inhabitants to remain more effective foragers by allowing for more prolonged foraging and/or hunting trips (Raymond and DeBoer 2006; Wills 1988).

Raymond and DeBoer (2006) discuss the use of maize in Amazonia among various hunter-gatherer groups as a supplement to a collected diet. Examples of Gé linguistic populations, especially the Shavante, provide evidence of highly mobile hunter-gatherers who grow maize in fields along travel routes (Raymond and DeBoer 2006). Maize harvest for the Shavante coincides with community rituals and as a result, fits into their prescribed settlement-subsistence pattern. While some maize is used ceremonially, it is also eaten daily after harvest, stored on the stalk, hung from hut rafters, stored in baskets or ground into meal (Raymond and DeBoer 2006:340). This mixed use of maize in regards to context, daily versus ritual, is also demonstrated in eastern North America (Callendar 1978; Trigger 1969; Trigger and Day 1994).

The use of maize in dried form as a travel and trade food is also seen throughout the ethnographic and ethnohistoric literature of eastern North America. Accounts of the Huron, Iroquois, Cherokee, Choctaw, Hidatsa, Sauk, and Ottawa (among many others) all mention the growing of maize and its use in trade (green, mature, or dried kernels) or as ground meal taken on long-distance trips (Bushnell 1909; Callendar 1978; Feest and Feest 1978; Perdue 1998; Quimby 1962; Rogers 1994; Trigger 1969; Trigger and Day 1994; Wilson 1987). While many of these accounts identify European trading posts as the centers for where exchange of maize for other goods occurs, these posts sometimes acted as areas for social aggregation in ways comparable to what is hypothesized for prehistoric earthwork sites (Garland and Beld 1999; Howey and O'Shea 2006; Milner and O'Shea 1998; Nassaney et al. 2007; Thwaites 1896-1901).

Q2: Is this earlier use of maize continuing the trend of greater reliance on collective resources? This is probably true since there seems to be little impact on the subsistence system with the earlier presence of maize. As a result, the continuing trend of reliance on collective resources remains unchanged. If exchange of early maize is occurring at social integration sites like Arthursburg Hill, then this could potentially be viewed as a collective resource. Sharing of maize during social integration rituals or as a means to buffer risk between regions could have been a means to solidify group identity and/or alliance (Howey and O'Shea 2006; O'Shea 1989; Raymond and DeBoer 2006).

Q3: To what extent does the use of maize overlap with the utilization of Eastern Agricultural Complex domesticates in the western Great Lakes? The overlap between maize and EAC plants is not seen in the manner I originally expected. The earlier presence of maize does not appear to represent an overlap in the cultivation of maize with EAC cultigens at this point in time (AD 0-200). However, this earlier presence of maize does indicate potential overlap of use in terms of cooking and its incorporation into the diet. Based on the location within the site context of sherds identified with early maize, these appear to be daily and not special use contexts. However, further residue testing may prove otherwise. The site with greatest potential to do so is Schultz; the stockade present at the site is interpreted as having a ritual function and could demonstrate differential use of maize (Fitting 1972).

Q4: Is the low incidence of maize macrobotanicals anomalous? Most likely the low incidence of maize macrobotanicals in the Saginaw Drainage is not anomalous. Based on the interpretation of the archaeological data provided by the experimental results, it appears that the earliest regional use of maize is in a dried form. If this dried form is being both transported and used off the cob, and possibly ground into flour, experimental results indicate that it is unlikely that any maize macrobotanicals would be found or incorporated into the archaeological record.

Future Research

Clearly much work remains to be done in order clarify the origins of early maize in the Saginaw Drainage. Down-the-line exchange is the most feasible explanation for the presence of early maize, and while Illinois as an origin is the best explanation given the current subsistence and cultural affinity data, further testing of ceramic residues and from areas to the southeast and southwest is required. Additionally, I want to incorporate lithic material for testing as well. Ideally this would be ground stone, such as mortars and pestles, but formal and/or informal tools used for cutting could also have potential for microbotanical recovery. Testing of lithics, in conjunction with ceramic residues, would allow for the incorporation of more sites within the Saginaw Drainage that were previously discounted either due to lack of ceramics or lack of ceramics with residue present.

Southwest Michigan sites which could best elucidate connections between the Saginaw Drainage and Illinois are those with evidence for Illinois Havana wares, such as Moccasin Bluff, Jancarich, Sumnerville and Toft Lake. Testing of residues on these wares for maize could potentially provide direct evidence for maize exchange into

Michigan. Other southwest Michigan sites which could be tested, due to evidence for interaction between Illinois and Michigan, include Eidson, Prison Farm, Elam, Armintrout-Blackman, and Simpson. However, this is just a handful of potential sites.

Testing of ceramic residues for evidence to the southeast would include sites not only from southeastern Michigan but also southern Ontario and northeastern Ohio. The realignment which occurs during the Late Woodland does have precursors, primarily in the exchange of lithic raw material, in the Middle Woodland which must be considered. The Middle Woodland period in southeastern Michigan is not well known but one site which could be targeted for residue analysis is Fort Wayne (Monaghan and Lovis 2005). Examination of the significant collections from southeastern Michigan of Late Woodland material to assess for the presence of material from earlier time periods would be required.

Finally, testing of materials from sites 'in-between' southwest Michigan and the Saginaw Drainage is warranted. These sites could represent possible exchange points between the two regions. Potential sites for testing include Ayen and Arthursburg Hill, which both have Middle Woodland components. Given the probable function of Arthursburg Hill as a social integration site, testing of ceramic residues here would especially prove beneficial. In obtaining the ^{14}C dates from Arthursburg Hill, Beld utilized residues from two ceramic rims (Garland and Beld 1999); whether any residue remains is unknown.

While the working hypothesis for this future work is that the early presence of maize is due to down-the-line exchange from Illinois, it is also entirely possible that low-level maize cultivation was occurring in these regions. The presence of maize phytoliths in residues from these areas would be indicative of low-level cultivation, rather than down-the-line exchange of maize in a dried form. Testing of lithic material for microbotanical remains from Saginaw Drainage sites could also prove low-level cultivation if maize phytoliths were identified to the same time period as the early dated ceramic residues. There could also be implications for seasonality depending on where in the Saginaw Drainage these sites occurred and possibly indicate the presence of 'trail fields' as discussed in Raymond and DeBoer (2006).

Appendix A: Laboratory Protocol for Phytolith Extraction

Modified from the Archaeometry Laboratory, University of Minnesota—Duluth

Digestion procedure was used on samples taken from ceramic residues and for processing plant material and experimental material. Methods for removing residues adhering to ceramics discussed in Chapter 5.

<u>Schulze Digestion Procedure</u>

Part A: Water bath digestion

1) Prepare Schulze solution

-Prepare $KClO^3$ solution by adding powdered potassium chlorate to distilled water until saturated. Note: 10ml of water to 0.7g $KClO^3$ is a saturated solution.

-Add 3 parts of concentrated nitric acid (HNO^3) to 1 part saturated potassium chlorate ($KClO^3$) solution. Be sure $KClO^3$ dissolves completely; stirring by hand or using a stirring plate aids in faster dissolution.

-Allow 15 to 20ml Schulze solution per sample for the initial digestion. If a second digestion (after centrifuging) is required, allow 10 to 12ml per sample.

-ALWAYS ADD ACID TO OTHER CHEMICAL. Wear gloves and apron for protection while preparing solution; a mask and breathing apparatus are also available. Measure chemicals in graduated cylinder; pour from small containers only. Transfer from large bottles to beaker if necessary. Glass rods control flow and prevent drips. SCHULZE SOLUTION MUST BE MADE FRESH FOR EACH DIGESTION SET

2) Add 10-12 ml of Schulze solution to each tube.

-Set varipet to desired volume. To avoid contamination, tip must not come in to contact with the sample.

- If there is a lot of plant material or sample, place a slender glass rod in each test tube and stir to remove any air pockets that may develop.

-Place tubes in preheated water bath. The bath should be approximately 90-95°C. Water may need to be added to the bath as digestion occurs since low water levels may cause bumping and potential sample contamination.

-Submerge sample in acid with glass rod. The samples must be monitored very closely for the first hour in the bath, since convection currents often cause undigested material to rise to the top of the tube and occasionally overflow (especially during the first half hour).

-As digestion continues, less constant attention is necessary. The acid level in the tubes should be maintained at the 13ml level (1-2ml of the lip).

-Check water level and samples every half hour. Submerge samples and agitate with rod to enhance digestion.

-Continue digestion, stirring frequently, until the sample has been completely digested, or until additions of acid fail to produce a reaction (approximately 10 hours). **Note: for small samples (often those characteristic of charred material taken from ceramic residues) the water bath can be turned off after an hour or two and the reaction will continue overnight. Small samples usually do not need a change of acid. NEVER CENTRIFUGE HOT SAMPLES

3) Change acid

-Examine labels; if smudged, check against records and relabel.

-Remove completed samples from water bath and cover with parafilm.

-Prepare fresh Schulze solution (step 1).

-Submerge all plant material below liquid level; rinse rods and equalize tube levels with excess Schulze. Remove rods. Centrifuge at 3000rpm for 15 minutes. If material remains floating, return the tube to the water bath. If all plant material has settled, decant, refill with fresh Schulze solution, agitate with glass rods, and return tube to water bath.

-Fresh acid increases the speed of digestion greatly. Additional changes of acid should be done as needed to complete digestion efficiently.

-Do NOT digest all organics completely (i.e. until a clear liquid remains). A small amount of plant material is desirable to aid centrifugation of phytoliths.

4) Rinse samples.

-Wear gloves for the first wash in this step.

-Centrifuge samples at 3000rpm for 15 minutes. Decant supernatant.

-Agitate remaining liquid and sample material with a glass rod. Rinse glass rod with distilled water while removing it from the centrifuge tube.

-Equalize liquid levels and centrifuge samples again (3000rpm, 15 minutes).

-Repeat water wash until liquid in the centrifuge tubes is clear

-Rinse with 95% ethanol, centrifuge and decant. DO NOT MIX ETHANOL WASTE WITH SCHULZE SOLUTION AS A VIOLTENT REACTION WILL OCCUR.

5) Sample storage

-Rinse 1 dram storage vials with 95% ethanol. Label vials with sample number and date and cover with scotch tape. Ethanol smudges labels; keep outside of vials dry.

-Using a disposable pipette, transfer sample material from the centrifuge sample tube to the vial. Spray inside of centrifuge tube with ethanol. With the same disposable pipette, suck up ethanol and squirt back into centrifuge tube. Suck ethanol back into the disposable pipette and transfer to storage vial.

-If vials are too full, place stoppers at the bottom of each centrifuge well and place vials in the centrifuge. Centrifuge at 3000rpm for 15 minutes. Tweezers may be required to remove vials from the centrifuge. Use a new disposable pipette to remove the extra liquid.

-Cover vial with parafilm to prevent evaporation and cap. Twist parafilm down over vial top to reduce tearing.

Part B: Slide Preparation

1) Set slide warming tray at low to medium heat. Ethanol should evaporate quickly but organic residue should not burn.

2) Label slide with information on storage vial and cover label with scotch tape. Place on slide warming tray.

3) Using a disposable pipette, transfer 3-4 drops of material from bottom of storage vial to the slide. Let residue dry.

4) Add 3-4 drops of either Permount or Canadian Balsam (either mounting medium is acceptable) to dried sample material. Remove slide from heating unit and carefully place cover slip over mounting medium. Gently press bubbles to one edge using toothpick. Place flat in storage to dry.

List of Equipment

Scalpel

Kimwipes

Balance

Weighing paper

Centrifuge tubes

Test Tube Rack

Wax Pencil

Beakers (50ml and 100ml)

Graduated cylinder (25ml and 100ml)

Funnel

Chemical spoon

Watch glass

Gloves (non-powdered)

Apron

Lab Coat

Face Shield

Water Bath

Fume Hood

Nitric Acid

Saturated $KClO^3$

Distilled Water

Ethanol

Permount

Canadian Balsam

Glass rods

Varipet

Disposable Pipettes

Centrifuge

Labels

Vials

Slides (3x1)

Cover slips

Toothpicks

Appendix B, Figures B1-B72: Artifact Photographs

Note: All scales in photographs are equal to 10 centimeters

<u>Liberty Bridge (20BY77):</u> Figures B1-B3

Figure B1: N10E8.1SE-4

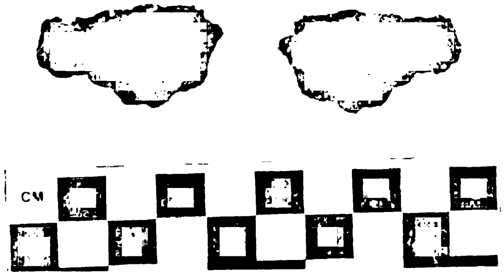


Figure B2: 2.N0E0.2SE-3

Figure B3: 2.N0E0.2NE-2

<u>Kantzler (20BY30)</u>: Figures B4-B7

Figure B4: 77127

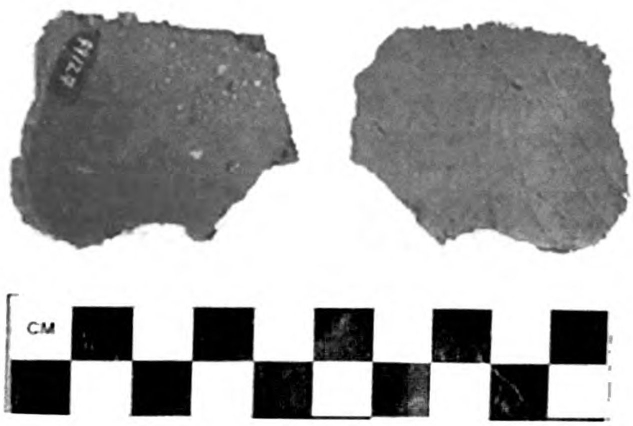


Figure B5: 77112

Figure B6: 77102

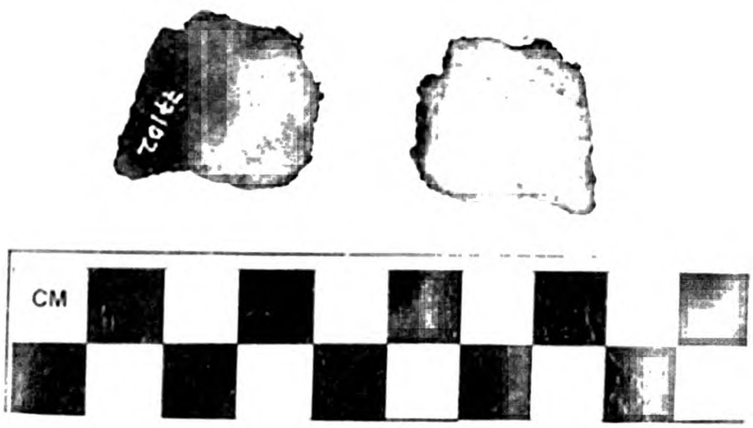
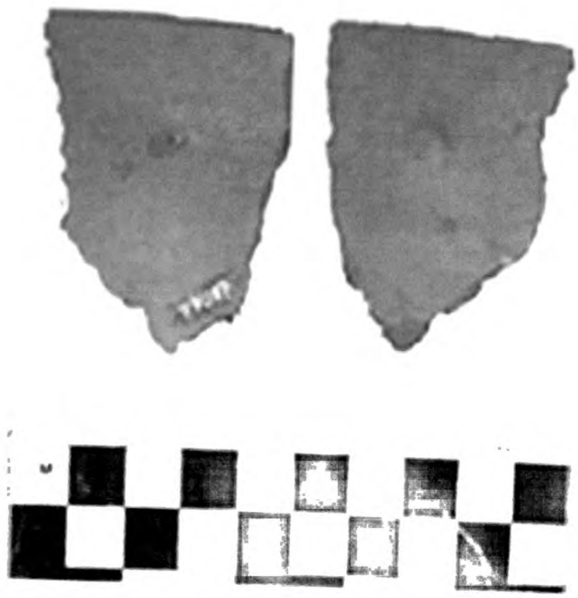


Figure B7: 77087



20SA1276: Figures B8-B13

Figure B8: FS 394

Figure B9: FS 390

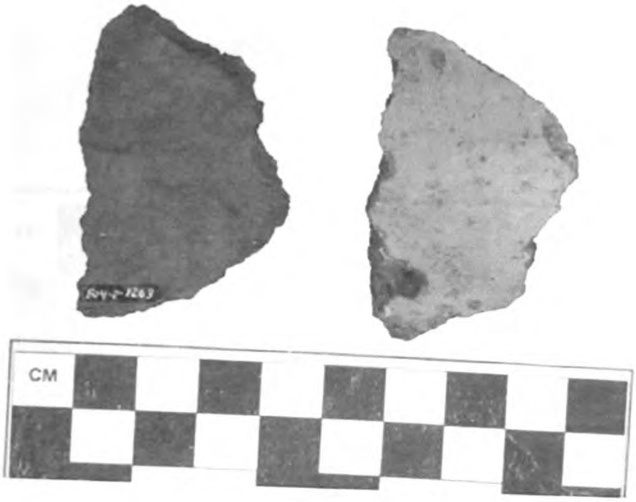


Figure B10: FS 356

Figure B11: FS 305

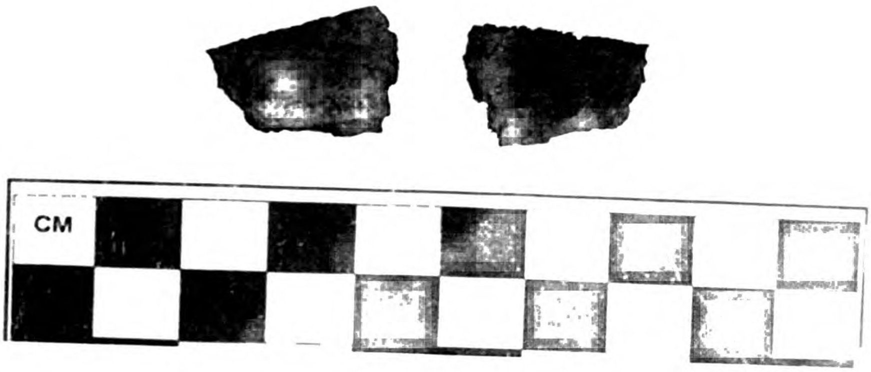
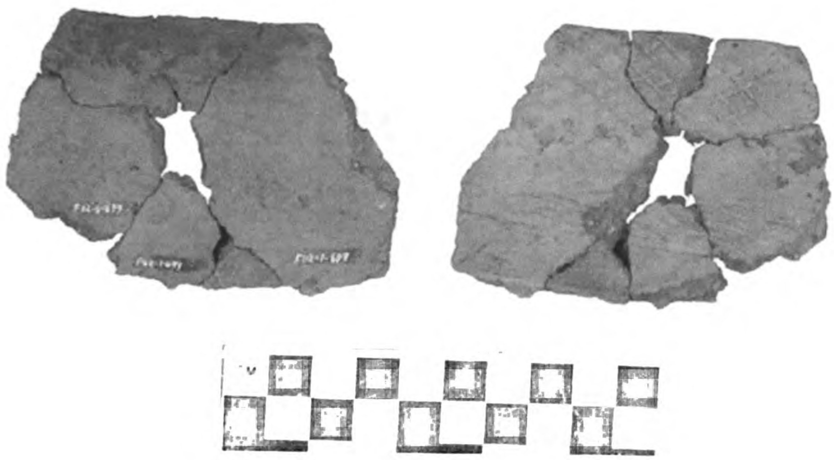


Figure B12: FS 192

Figure B13: FS 153

20SA1251: Figure B14

Figure B14: Shiawassee #2



Schultz (20SA2): Figures B15-B53

Figure B15: 65888

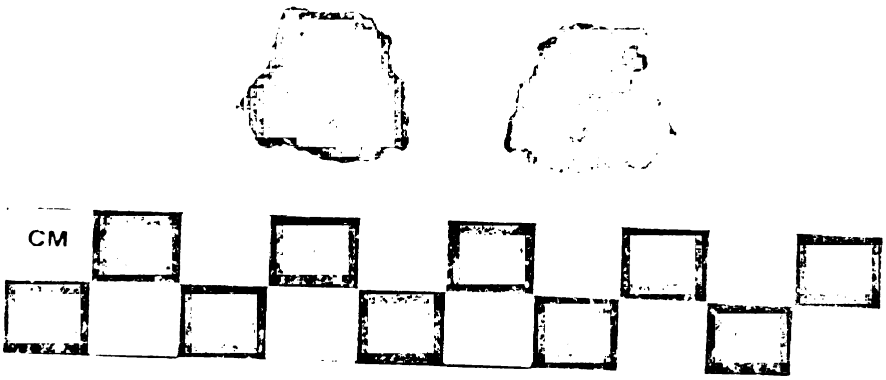


Figure B16: 65826

Figure B17: 65557

Figure B18: 65409

Figure B19: 64718

Figure B20: 64676

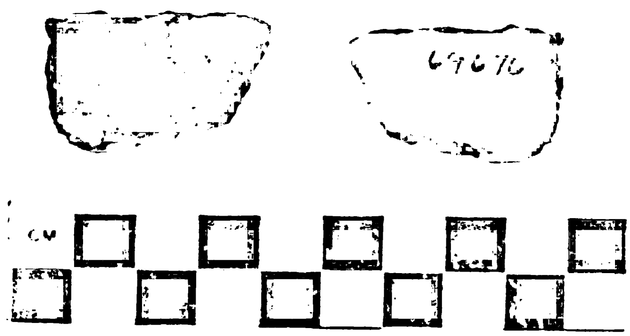


Figure B21: 64622

Figure B22: 66361

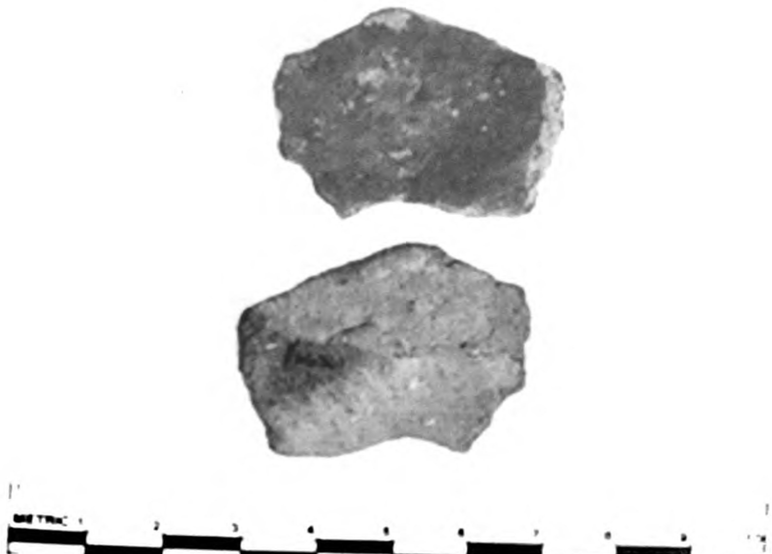


Figure B23: 66160

Figure B24: 66020

Figure B25: 66004

Figure B26: 66003

Figure B27: 65961

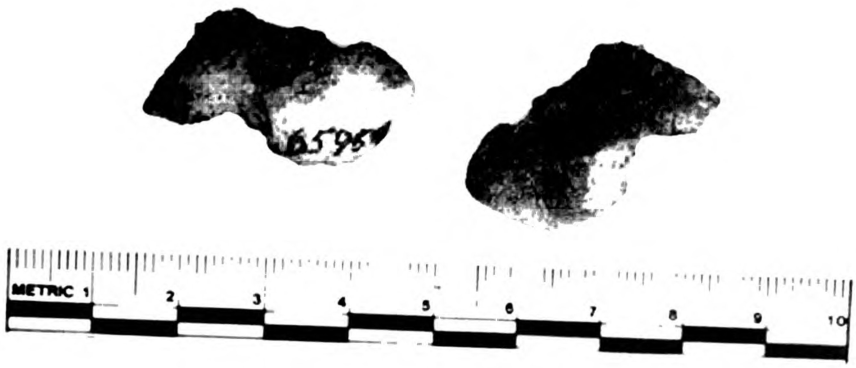


Figure B28: 65920

Figure B29: 65908

Figure B30: 67878

Figure B31: 67845

Figure B32: 67674

Figure B33: 67469

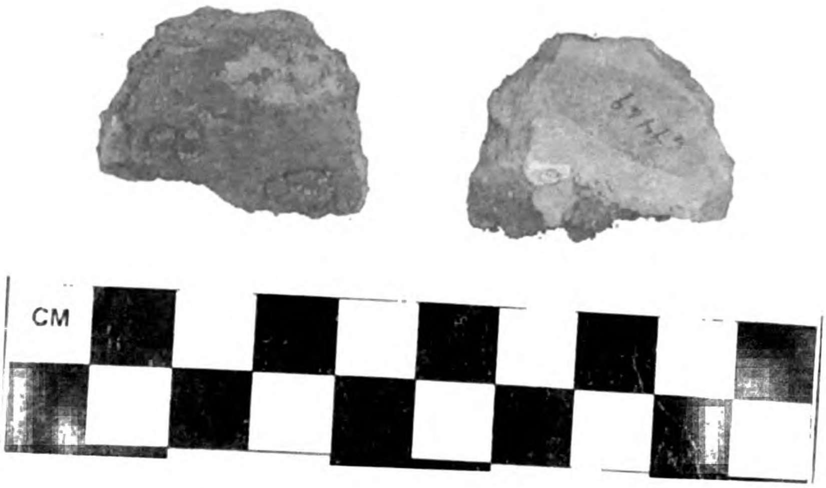


Figure B34: 67275

Figure B35: 67207

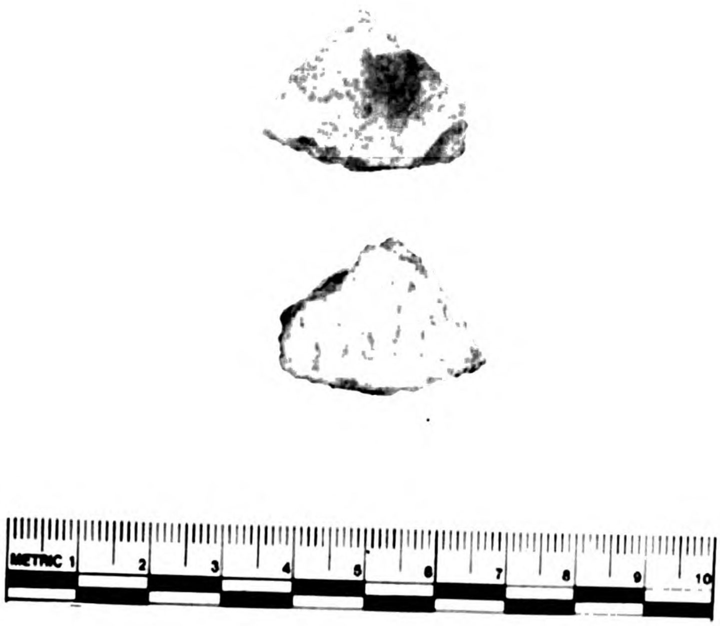


Figure B36: 66839

Figure B37: 66656

Figure B38: 66656

Figure B39: 69552

Figure B40: 69477

Figure B41: 69276

Figure B42: 69080

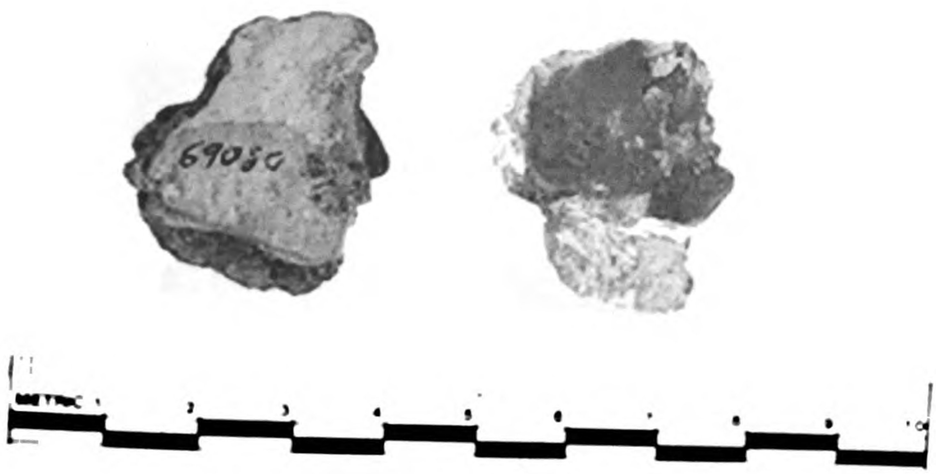


Figure B43: 68567

Figure B44: 68559

Figure B45: 67916

Figure B46: 67896

Figure B47: 67232

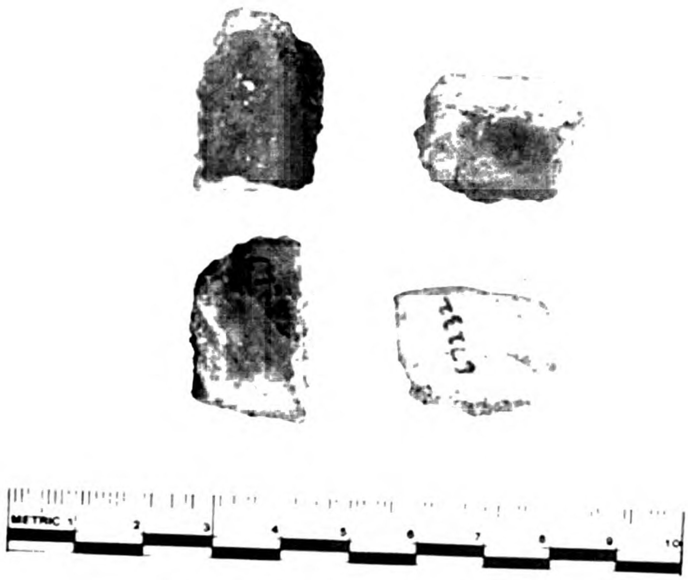


Figure B48: F29

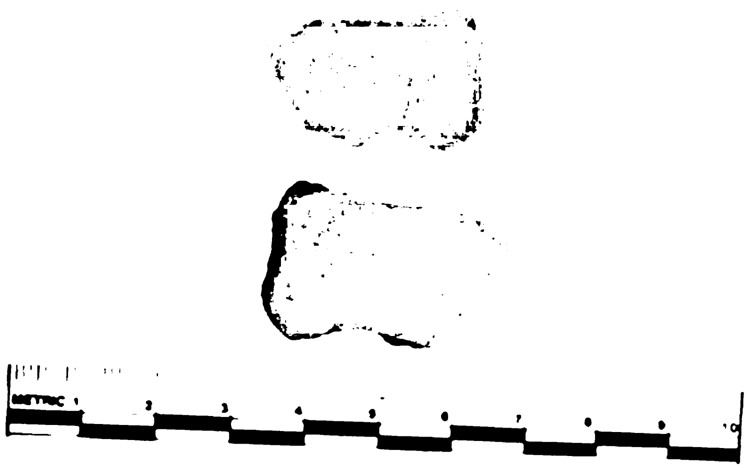
Figure B49: 69771

Figure B50: 69743

Figure B51: 69760

Figure B52: 69666

Figure B53: 69606



Tobico Marsh Sites (20BY192 and 20BY210): Figure B54

Figure B54: 20BY210

<u>Simons 249 (20SA665)</u>: Figure B55

Figure B55: Vessel 92

<u>Solms (20SA57)</u>: Figures B56-B62

Figure B56: SAC 70 #1

Figure B57: SAC 70 #2

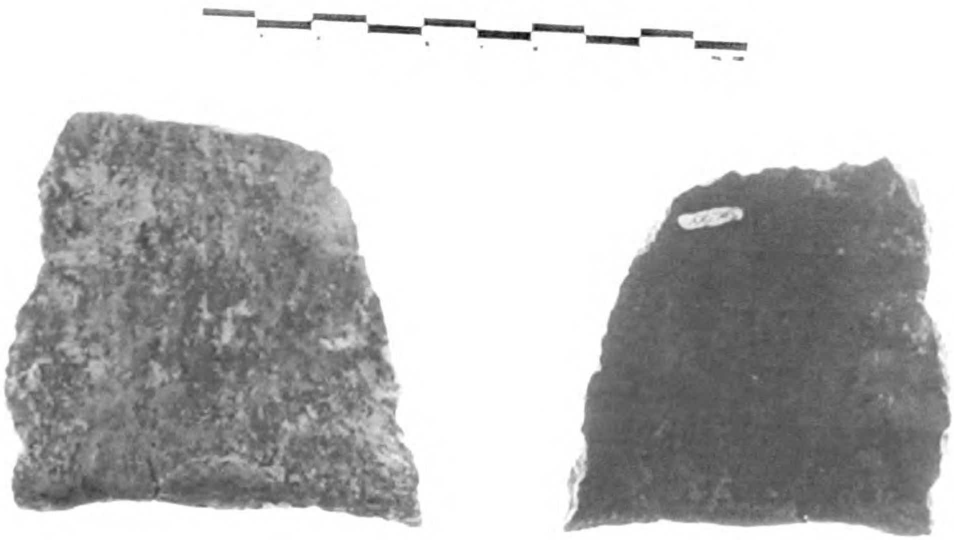


Figure B58: SAC 35

Figure B59: Vessel 435

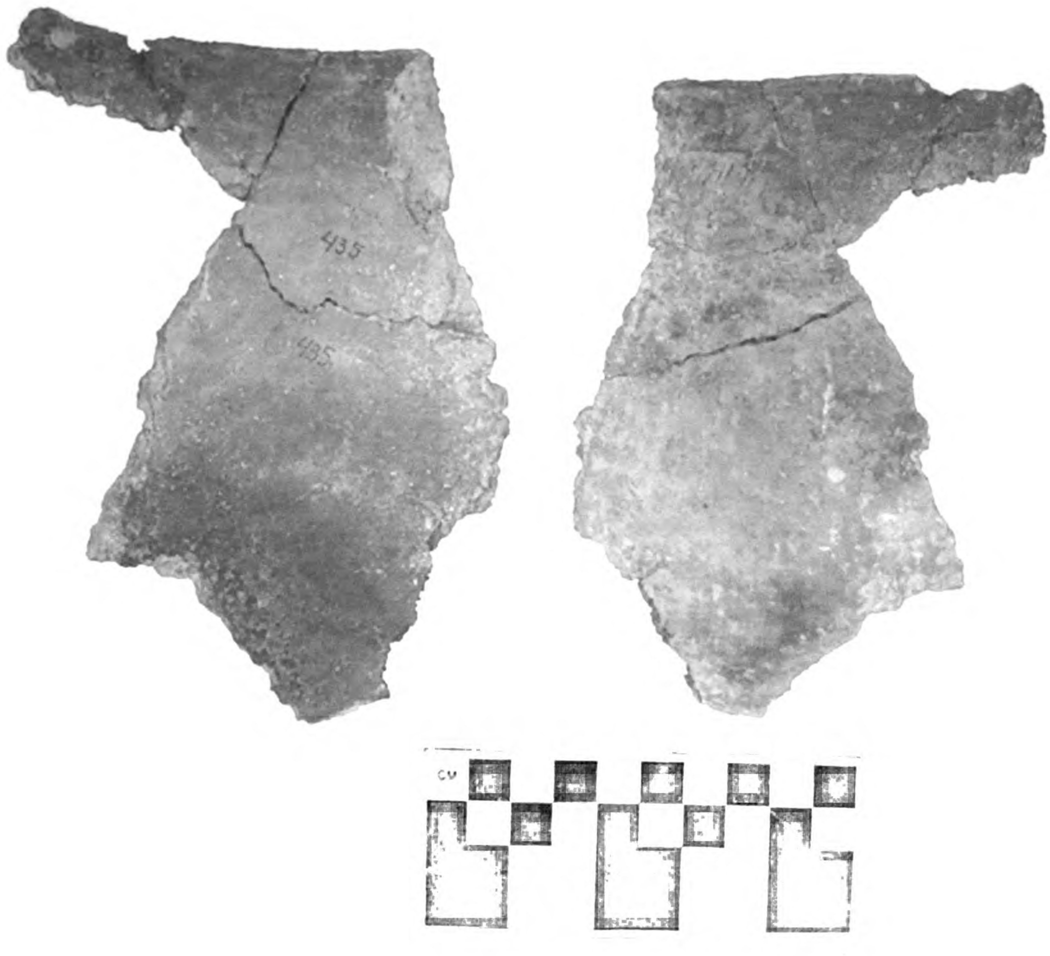


Figure B60: SAC 31

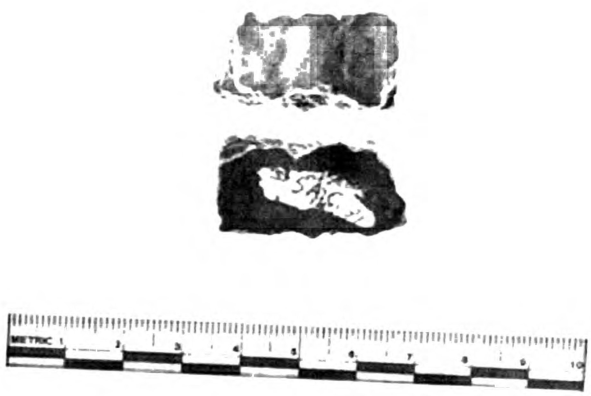


Figure B61: SAC 15 #1

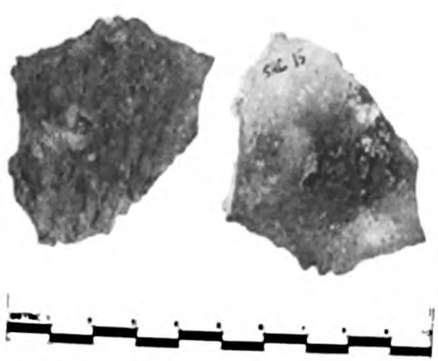


Figure B62: SAC 15 #2

Stadelmeyer (20SA195): Figures B63-B68

Figure B63: 76986

Figure B64: 73995

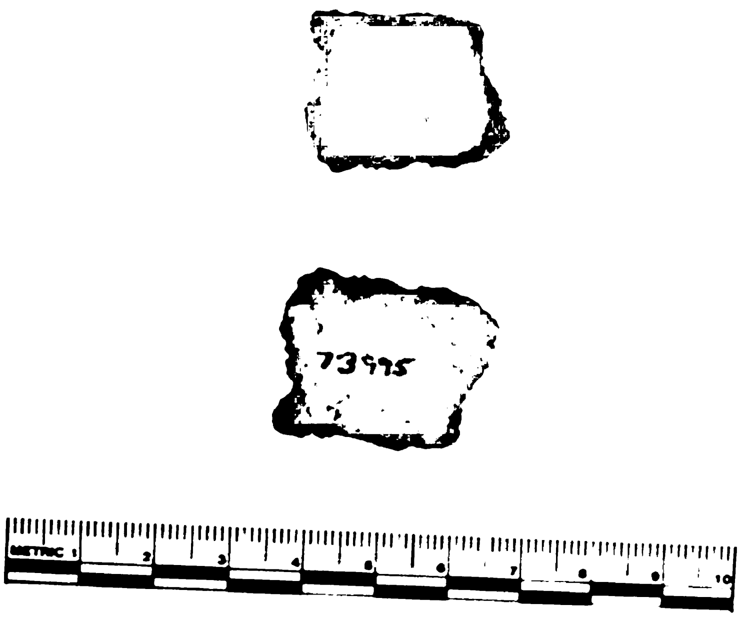


Figure B65: 73970

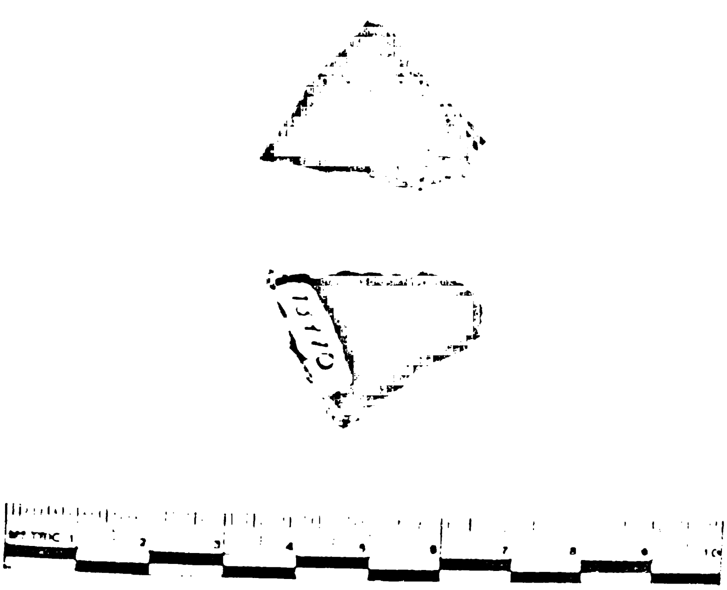


Figure B66: 73949

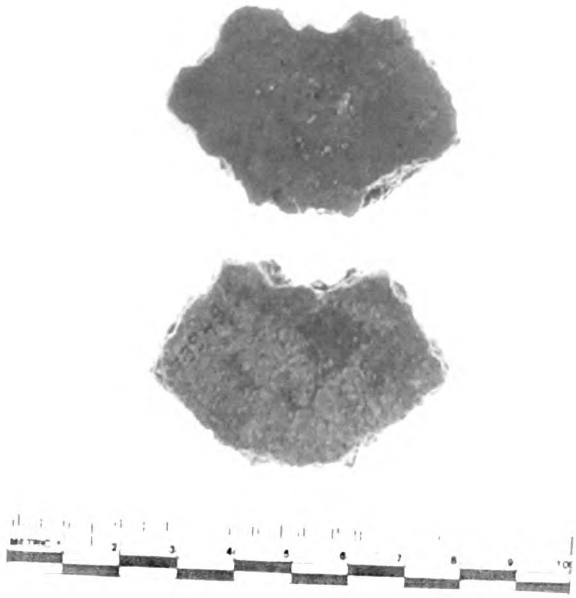


Figure B67: 73942

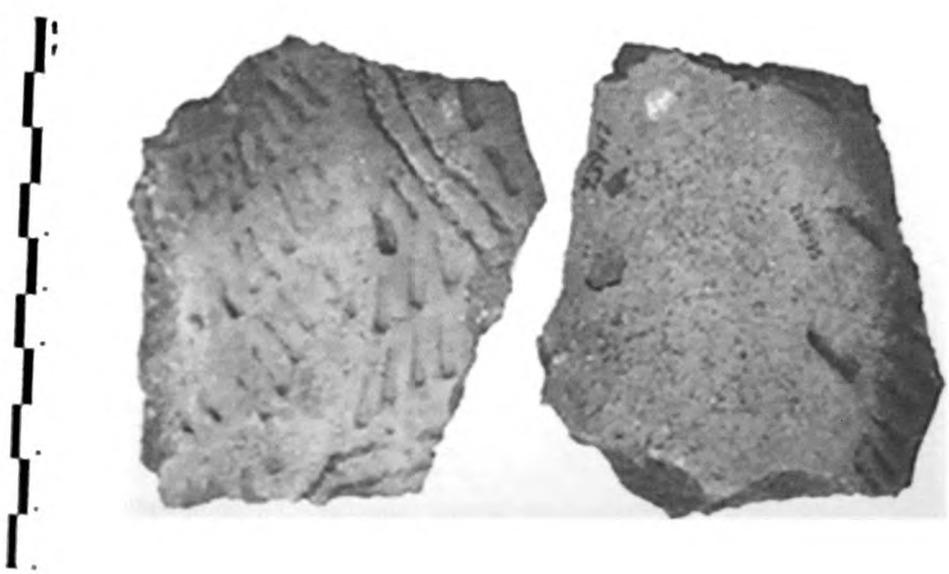
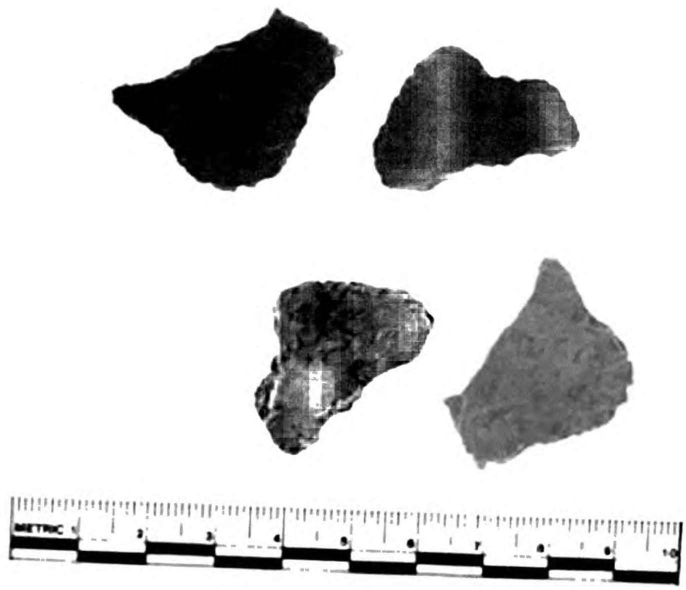


Figure B68: 73931



Foster (20SA74): Figures B69-B71

Figure B69: 76639

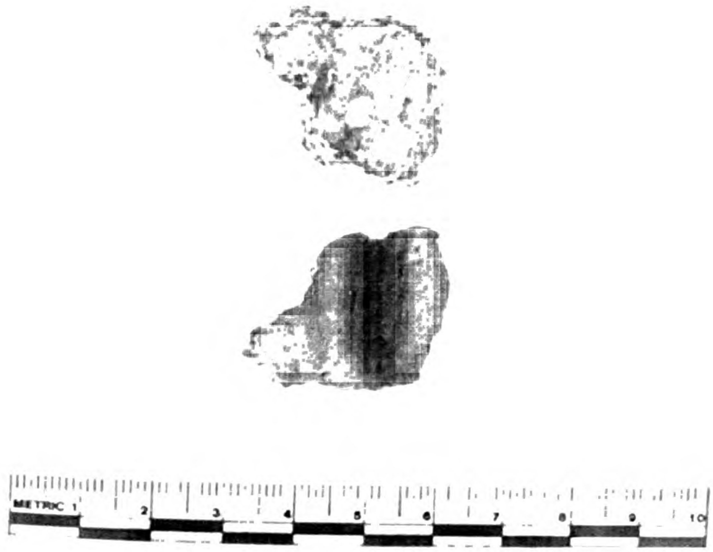


Figure B70: 76643

Figure B71: 2861

Clunie (20SA722): Figure B72

Figure B72: FS 433

Appendix C

Table C-1: Phytolith and Starch Analysis Results

Site	Sherd #	Time Period	Ceramic Type	AMS Date (2-Sigma)	Maize Phytoliths	Maize Starch	Wild Rice Phytoliths
20SA75	FS 433				cf maize (1)	0	0
20SA1276	FS 192	unknown		Cal BC 50-Cal AD 90 (Cal BP 2000-1860)	0	4	1
20SA1276	FS 390	early MW	Tittabawassee	Cal AD 10-140 (Cal BP 1940-1810)	0	0	0
20SA1276	FS 305	early LW	probable Saginaw Variant		0	0	0
20SA1276	FS 356	MW	Green Point		0	0	0
20SA1251	F-02-1-699	MW	Green Point	Somers date	0	0	0
20SA722	FS 433	early LW		Cal AD 1440-1640 (Cal BP 510-310)	0	2	0
20SA57 (Solms)	Vessel 435		possible late Green Point	Cal AD 880-1020 (Cal BP 1070-930)	0	4	3

Table C-1 continued

Site	Sherd #	Duck Potato	Yellow Pond Lily	American Lotus	Acorn Starch	Generic Starch	Generic Phytolith	Generic Grass Phytolith
20SA75	FS 433	0	0	0	0	0	1	0
20SA1276	FS 192	0	0	0	0	0	0	1
20SA1276	FS 390	0	0	0	1	0	0	0
20SA1276	FS 305	0	0	0	0	0	0	0
20SA1276	FS 356	0	0	0	0	0	1	2
20SA1251	F-02-1-699	0	0	0	0	0	1	0
20SA722	FS 433	0	0	0	0	2	0	0
20SA57 (Solms)	Vessel 435	0	0	0	0	0	0	0

Table C-1 continued

Site	Sherd #	Unidentifiable Phytolith	Diatoms (Y/N)	Sponge Spicules (Y/N)
20SA75	FS 433	0	N	N
20SA1276	FS 192	0	N	N
20SA1276	FS 390	0	N	N
20SA1276	FS 305	0	N	N
20SA1276	FS 356	0	N	N
20SA1251	F-02-1-699	1	Y	Y
20SA722	FS 433	0	N	N
20SA57 (Solms)	Vessel 435	0	N	N

Table C-1 continued

Site	Sherd #	Time Period	Ceramic Type	AMS Date (2-Sigma)	Maize Phytoliths	Maize Starch	Wild Rice Phytoliths
20SA75	FS 433				cf maize (1)	0	0
20SA1276	FS 192	unknown		Cal BC 50-Cal AD 90 (Cal BP 2000-1860)	0	4	1
20SA2	66526	early MW	Tittabawassee	Cal BC 170-Cal AD 30 (Cal BP 2120-1920)	cf maize (1)	0	3
20SA2	69080	early-late MW		Cal BC 30-Cal AD 130 (Cal BP 1980-1820)	0	4	0
20SA2	65557	late MW-early LW	Green Point	Cal AD 10-210 (Cal BP 1940-1740)	0	0	0
20SA2	66656	late MW-early LW	Green Point	Cal BC 90-Cal AD 80 (Cal BP 2040-1870)	0	10	0
20SA2	69743	early MW			0	9	0
20SA2	65920	early LW	Wayne and Saginaw Thin		0	16	0

Table C-1 continued

Site	Sherd #	Duck Potato	Yellow Pond Lily	American Lotus	Acorn Starch	Generic Starch	Generic Phytolith	Generic Grass Phytolith
20SA75	FS 433	0	0	0	0	0	1	0
20SA1276	FS 192	0	0	0	0	0	0	1
20SA2	66526	0	0	0	0	0	3	0
20SA2	69080	0	0	0	0	0	0	0
20SA2	65557	0	0	0	0	0	0	0
20SA2	66656	0	0	0	0	0	0	0
20SA2	69743	0	2	0	0	27	1	0
20SA2	65920	0	0	0	0	15	0	0

Table C-1 continued

Site	Sherd #	Unidentifiable Phytolith	Diatoms (Y/N)	Sponge Spicules (Y/N)
20SA75	FS 433	0	N	N
20SA1276	FS 192	0	N	N
20SA2	66526	2	N	Y
20SA2	69080	0	N	N
20SA2	65557	0	N	N
20SA2	66656	0	N	N
20SA2	69743	2	N	N
20SA2	65920	0	N	N

Table C-1 continued

Table C-1 continued

Site	Sherd #	Time Period	Ceramic Type	AMS Date (2-Sigma)	Maize Phytoliths	Maize Starch	Wild Rice Phytoliths
20SA2	660020/ 66020	generic MW			0	8	0
20SA2	64622	early-late MW	Green Point or Tittabawassee		0	21	0
20SA2	69666	early MW	possible Tittabawassee	Cal BC 350-300 (Cal BP 2300-2260) and Cal BC 210-40 (Cal BP 2160-1990)	0	4	0
20SA2	65706	MW	Green Point	Cal BC 190-Cal AD 10 (Cal BP 2140-1940)	0	0	1
20SA2	67674	Woodland		Cal BC 100-Cal AD 120 (Cal BP 2050-1830)	0	0	0
20SA2	66839	late MW-early LW	Green Point		0	0	0
20SA2	65888		Saginaw Thin		0	0	0

Table C-1 continued

Site	Sherd #	Duck Potato	Yellow Pond Lily	American Lotus	Acorn Starch	Generic Starch	Generic Phytolith	Generic Grass Phytolith
20SA2	660020/ 66020	0	0	0	0	9	0	0
20SA2	64622	0	0	0	0	8	0	0
20SA2	69666	0	0	0	0	0	0	0
20SA2	65706	0	0	0	0	0	4	0
20SA2	67674	0	0	0	0	0	0	0
20SA2	66839	0	0	0	0	0	0	0
20SA2	65888	0	0	0	0	0	0	0

Table C-1 continued

Site	Sherd #	Unidentifiable Phytolith	Diatoms (Y/N)	Sponge Spicules (Y/N)
20SA2	660020/ 66020	0	N	N
20SA2	64622	0	N	N
20SA2	69666	0	N	Y
20SA2	65706	3	N	Y
20SA2	67674	0	N	N
20SA2	66839	0	N	N
20SA2	65888	0	N	N

Table C-1 continued

Site	Sherd #	Time Period	Ceramic Type	AMS Date (2-Sigma)	Maize Phytoliths	Maize Starch	Wild Rice Phytoliths
20SA2	66003	generic MW		Cal BC 90-Cal AD 80 (Cal BP 2040-1870)	0	3	0
20SA2	F29	early MW	Tittabawassee		0	0	0
20SA2	65908	early MW	Tittabawassee		0	2	0
20SA2	69760	early MW	Tittabawassee		1	7	0
20SA2	66004	MW	Green Point	Cal BC 160-Cal AD 60 (Cal BP 2110-1890)	0	0	0
20SA2	67845	MW			0	0	0
20SA2	69552				0	0	0
20SA2	67469	MW, possible EW		Cal BC 170-Cal AD 50 (Cal BP 2120-1900)	0	0	0
20SA2	64676	early-mid MW			0	0	0
20SA2	64718	early MW	Tittabawassee		0	0	0

Table C-1 continued

Site	Sherd #	Duck Potato	Yellow Pond Lily	American Lotus	Acorn Starch	Generic Starch	Generic Phytolith	Generic Grass Phytolith
20SA2	66003	0	0	0	0	0	0	0
20SA2	F29	0	0	0	0	0	0	0
20SA2	65908	0	0	0	0	0	0	0
20SA2	69760	0	0	0	0	16	7	0
20SA2	66004	0	0	0	0	0	0	0
20SA2	67845	0	0	0	0	0	0	0
20SA2	69552	0	0	0	0	0	0	0
20SA2	67469	0	0	0	0	0	0	0
20SA2	64676	0	0	0	0	0	0	0
20SA2	64718	0	0	0	0	0	0	0

Table C-1 continued

Site	Sherd #	Unidentifiable Phytolith	Diatoms (Y/N)	Sponge Spicules (Y/N)
20SA2	66003	0	N	N
20SA2	F29	0	N	N
20SA2	65908	0	N	N
20SA2	69760	3	N	N
20SA2	66004	0	N	N
20SA2	67845	0	N	N
20SA2	69552	0	N	N
20SA2	67469	1	N	N
20SA2	64676	0	N	N
20SA2	64718	0	N	N

Table C-1 continued

Site	Sherd #	Time Period	Ceramic Type	AMS Date (2-Sigma)	Maize Phytoliths	Maize Starch	Wild Rice Phytoliths
20SA2	65409	MW	Green Point		0	0	0
20SA2	69606	Woodland			0	0	0
20SA2	67275	MW	Green Point (rocker)		0	0	0
20SA2	67896	early MW	Tittabawassee		0	0	0
20SA2	67878	MW			0	0	0
20SA2	66655	MW			0	0	0
20SA2	66524	MW	Green Point		0	0	0
20SA2	69771	Woodland	rocker stamped		0	0	0
20SA2	67358	MW			0	0	0
20SA2	67232	MW	Green Point		0	0	0
20SA2	68567	late MW	Saginaw Thin		0	0	0
20SA2	66160 (66960)	Woodland			1	7	0
20SA2	69477		no ID		0	10	0

Table C-1 continued

Site	Sherd #	Duck Potato	Yellow Pond Lily	American Lotus	Acorn Starch	Generic Starch	Generic Phytolith	Generic Grass Phytolith
20SA2	65409	0	0	0	0	0	0	0
20SA2	69606	0	0	0	0	0	0	0
20SA2	67275	0	0	0	0	0	0	0
20SA2	67896	0	0	0	0	0	0	0
20SA2	67878	0	0	0	0	0	0	0
20SA2	66655	0	0	0	0	0	0	0
20SA2	66524	0	0	0	0	0	0	0
20SA2	69771	0	0	0	0	0	0	0
20SA2	67358	0	0	0	0	0	0	0
20SA2	67232	0	0	0	0	0	0	0
20SA2	68567	0	0	0	0	0	0	0
20SA2	66160 (66960)	0	0	0	0	16	7	0
20SA2	69477	0	0	0	0	15	0	0

Table C-1

Table C-1 continued

Site	Sherd #	Unidentifiable Phytolith	Diatoms (Y/N)	Sponge Spicules (Y/N)
20SA2	65409	0	N	N
20SA2	69606	0	N	N
20SA2	67275	0	N	N
20SA2	67896	0	N	N
20SA2	67878	0	N	N
20SA2	66655	0	N	N
20SA2	66524	0	N	N
20SA2	69771	3	N	N
20SA2	67358	0	N	N
20SA2	67232	0	N	N
20SA2	68567	0	Y	N
20SA2	66160 (66960)	3	N	N
20SA2	69477	0	N	N

Table C-1 continued

Site	Sherd #	Time Period	Ceramic Type	AMS Date (2-Sigma)	Maize Phytoliths	Maize Starch	Wild Rice Phytoliths
20SA2	67916		no ID		0	39	1
20SA2	69276		no ID		2	22	0
20SA2	66361		no ID		1	11	0
20SA2	65826		no ID		0	4	0
20SA2	65961		no ID		0	25	0
20SA2	68558	MW			0	7	0
20SA2	67207	LW	probable Wayne Ware		0	6	0
20SA581	5664.90.1-1	early LW	Wayne Punctate		0	48	0
20SA57 (Solms)	SAC 70 #1	early LW	Wayne Punctate		6	5	2
20SA57 (Solms)	SAC 70 #2				3	6	2
20SA57 (Solms)	SAC 15 #1				0	8	2
20SA57 (Solms)	SAC 15 #2				2	3	0
20SA57 (Solms)	SAC 35				1	6	0

Table C-1 continued

Site	Sherd #	Duck Potato	Yellow Pond Lily	American Lotus	Acorn Starch	Generic Starch	Generic Phytolith	Generic Grass Phytolith
20SA2	67916	0	0	0	0	20	6	0
20SA2	69276	0	0	0	1	20	18	0
20SA2	66361	2	0	0	0	12	6	0
20SA2	65826	0	0	0	1	19	0	0
20SA2	65961	0	0	0	0	2	0	0
20SA2	68558	0	0	0	0	4	0	0
20SA2	67207	0	0	0	1	5	0	0
20SA581	5664.90.1-1	1	0	1	0	44	1	0
20SA57 (Solms)	SAC 70 #1	0	0	1	1	18	2	0
20SA57 (Solms)	SAC 70 #2	0	0	0	0	22	6	0
20SA57 (Solms)	SAC 15 #1	0	0	0	0	3	1	0
20SA57 (Solms)	SAC 15 #2	0	0	0	0	4	8	0
20SA57 (Solms)	SAC 35	0	0	0	0	13	10	0

Table C-1 continued

Site	Sherd #	Unidentifiable Phytolith	Diatoms (Y/N)	Sponge Spicules (Y/N)
20SA2	67916	0	Y	Y
20SA2	69276	2	Y	Y
20SA2	66361	2	Y	N
20SA2	65826	0	Y	Y
20SA2	65961	0	N	N
20SA2	68558	1	N	N
20SA2	67207	0	N	Y
20SA581	5664.90.1-1	0	N	N
20SA57 (Solms)	SAC 70 #1	1	Y	N
20SA57 (Solms)	SAC 70 #2	9	Y	Y
20SA57 (Solms)	SAC 15 #1	2	N	N
20SA57 (Solms)	SAC 15 #2	7	Y	Y
20SA57 (Solms)	SAC 35	4	Y	Y

Table C-1 continued

Site	Sherd #	Time Period	Ceramic Type	AMS Date (2-Sigma)	Maize Phytoliths	Maize Starch	Wild Rice Phytoliths
20SA57 (Solms)	SAC 31				0	6	0
20SA1276	FS 394	generic Woodland			1	2	0
20SA1276	FS 153	generic Woodland			0	5	0
Stadelmeyer	73942	late LW	Macomb Linear		5	7	0
Stadelmeyer	76986	MW or LW			0	0	0
Stadelmeyer	73949				0	7	0
Stadelmeyer	73931				0	0	0
Stadelmeyer	73970				0	0	0
Stadelmeyer	73995				0	0	0
20BY77	N0E0	probable LW			2	3	0
20BY77	.2.N0E0.2 SE 3				2	3	2
20BY77	.2.N0E0.2 NE-2		probable LW		0	4	0
20BY77	N10E8	MW	Green Point		0	3	0
Kantzler	77087	early MW	Tittabawassee		0	0	0

Table C-1 continued

Site	Sherd #	Duck Potato	Yellow Pond Lily	American Lotus	Acorn Starch	Generic Starch	Generic Phytolith	Generic Grass Phytolith
20SA57 (Solms)	SAC 31	0	0	0	0	13	0	0
20SA1276	FS 394	0	0	0	0	5	1	0
20SA1276	FS 153	0	0	0	0	4	0	0
Stadelmeyer	73942	0	0	0	7	10	7	0
Stadelmeyer	76986	0	0	0	0	0	3	0
Stadelmeyer	73949	1	0	0	1	9	5	0
Stadelmeyer	73931	0	0	0	0	6	1	0
Stadelmeyer	73970	0	0	0	0	1	0	0
Stadelmeyer	73995	0	1	0	2	0	0	0
20BY77	N0E0	0	0	0	0	0	0	0
20BY77	.2.N0E0.2 SE 3	0	0	0	2	16	6	0
20BY77	.2.N0E0.2 NE-2	0	0	0	0	8	1	0
20BY77	N10E8	0	0	0	0	0	0	0
Kantzler	77087	0	0	0	0	0	0	0

Table C-1 continued

Site	Sherd #	Unidentifiable Phytolith	Diatoms (Y/N)	Sponge Spicules (Y/N)
20SA57 (Solms)	SAC 31	0	Y	Y
20SA1276	FS 394	0	N	Y
20SA1276	FS 153	0	N	N
Stadelmeyer	73942	4	Y	Y
Stadelmeyer	76986	0	N	N
Stadelmeyer	73949	0	N	N
Stadelmeyer	73931	0	N	N
Stadelmeyer	73970	0	N	N
Stadelmeyer	73995	0	N	N
20BY77	N0E0	0	N	N
20BY77	.2.N0E0.2 SE 3	5	N	Y
20BY77	.2.N0E0.2 NE-2	1	N	N
20BY77	N10E8	0	N	N
Kantzler	77087	0	N	N

Table C-1 continued

Site	Sherd #	Time Period	Ceramic Type	AMS Date (2-Sigma)	Maize Phytoliths	Maize Starch	Wild Rice Phytoliths
Kantzler	77112	MW	Green Point		0	4	1
Kantzler	77127				cf maize (1)	0	0
Foster	2861		probable Wayne Ware		0	0	0
Foster	noted item 1	post 1200			0	8	0
Foster	76639				0	0	0
Acc 13	305		possible Skegemog		0	0	0
20BY210 (Tobico)	FS 13		no ID		0	14	0
20BY28 (Fletcher)	sample 4 pot reconstruc-tion				0	0	0
20BY28 (Fletcher)	sample 3 pot reconstruc-tion				0	0	0
20BY28 (Fletcher)	sample 1 #323437.1				0	0	0
20SA665	Vessel 92	LW			cf maize (1)	33	0

Table C-1 continued

Site	Sherd #	Duck Potato	Yellow Pond Lily	American Lotus	Acorn Starch	Generic Starch	Generic Phytolith	Generic Grass Phytolith
Kantzler	77112	0	0	0	0	3	0	0
Kantzler	77127	0	0	0	0	0	1	0
Foster	2861	0	0	0	0	1	0	0
Foster	noted item 1	0	0	0	0	0	0	0
Foster	76639	0	3	0	0	0	0	0
Acc 13	305	0	0	0	0	0	0	0
20BY210 (Tobico)	FS 13	4	0	0	0	24	1	0
20BY28 (Fletcher)	sample 4 pot reconstruc-tion	0	0	0	0	9	0	0
20BY28 (Fletcher)	sample 3 pot reconstruc-tion	0	0	0	0	0	1	0
20BY28 (Fletcher)	sample 1 #323437.1	0	0	0	0	0	9	0
20SA665	Vessel 92	0	0	0	4	22	7	0

Table C-1 continued

Site	Sherd #	Unidentifiable Phytolith	Diatoms (Y/N)	Sponge Spicules (Y/N)
Kantzler	77112	0	N	N
Kantzler	77127	1	N	N
Foster	2861	0	N	N
Foster	noted item 1	0	N	N
Foster	76639	0	N	N
Acc 13	305	0	N	N
20BY210 (Tobico)	FS 13	0	N	N
20BY28 (Fletcher)	sample 4 pot reconstruction	0	N	Y
20BY28 (Fletcher)	sample 3 pot reconstruction	0	N	Y
20BY28 (Fletcher)	sample 1 #323437.1	0	Y	N
20SA665	Vessel 92	4	N	N

Appendix D

Table D-1: Radiocarbon Date Results

Beta Analytic Code	Sample Name	Site	Ceramic Museum ID	Ceramic Time Period	Measured AMS Date	Conventional C14 Age	2 Sigma Calibration (Calendar Calibrated)	Delta ^{13}C
Beta-261449	raviele01	Schultz	67569	MW, possibly EW	2060±40 BP	2040±40 BP	Cal BC 170-Cal AD 50 (Cal BP 2120-1900)	-26.1
	raviele02	Schultz	69743	early MW, possibly Tittabawassee	problem sample	problem sample	problem sample	
Beta-261451	raviele03		Vessel 435	late Green Point, MW	NA	1100±40 BP	Cal AD 880-1020 (Cal BP 1070-930)	NA
Beta-261452	raviele04	20SA1276	FS192	undetermined	2020±40 BP	1980±40BP	Cal BC 50-Cal AD 90 (Cal BP 2000-1860)	-27.5
	raviele05	Schultz	66020	generic MW	problem sample	problem sample	problem sample	
Beta-261454	raviele06	Schultz	66004	Green Point, MW	NA	2030±40 BP	Cal BC 160-Cal AD 60 (Cal BP 2110-1890)	NA

Table D-1 continued

Beta Analytic Code	Sample Name	Site	Ceramic Museum ID	Ceramic Time Period	Measured AMS Date	Conventional C14 Age	2 Sigma Calibration (Calendar Calibrated)	Delta ^{13}C
Beta-261455	raviele07	Schultz	66003	generic MW	2080±40 BP	2000±40 BP	Cal BC 90-Cal AD 80 (Cal BP 2040-1870)	-29.8
Beta-261456	raviele08	Schultz	69666	possibly Tittabawassee, early MW	NA	2120±40 BP	Cal BC 350-300 (Cal BP 2300-2260) and Cal BC 210-40 (Cal BP 2160-1990)	NA
Beta-21457	raviele09	20SA1276	FS390	Tittabawassee, early MW	NA	1920±40 BP	Cal AD 10-140 (Cal BP 1940-1810)	NA
	raviele10	20BY77	N10E8.1	Green Point, MW	problem sample	problem sample	problem sample	
Beta-261459	raviele11	Schultz	65706	Green Point, MW	2090±40 BP	2070±40 BP	Cal BC 190-Cal AD 10 (Cal BP 2140-1830)	-26.2
Beta-261460	raviele12	Schultz	67674	generic Woodland	2020±50 BP	1990±50 BP	Cal BC 100-Cal AD 120 (Cal BP 2050-1830)	-26.9
	raviele13	Schultz	68567	Saginaw Thin, late MW	problem sample	problem sample	problem sample	

Table D-1 continued

Beta Analytic Code	Sample Name	Site	Ceramic Museum ID	Ceramic Time Period	Measured AMS Date	Conventional C14 Age	2 Sigma Calibration (Calendar Calibrated)	Delta ^{13}C
Beta-261462	raviele14	20SA722	FS433	possibly early LW	NA	370±40 BP	Cal AD 1440-1640 (Cal BP 510-310)	NA
Beta-261463	raviele15	Schultz	66526	Tittabawassee, early MW	NA	2050±40 BP	Cal BC 170-Cal AD 30 (Cal BP 2120-1920)	NA
Beta-262038	raviele16	Schultz	69080	early-late MW	NA	1940±40 BP	Cal BC 30-Cal AD 130 (Cal BP 1980-1820)	NA
Beta-262039	raviele17	Schultz	65557	late MW	NA	1910±40 BP	Cal AD 10-210 (Cal BP 1940-1740)	NA
Beta-262040	raviele18	Schultz	66656	Green Point, MW	2010±40 BP	2000±40 BP	Cal BC 90-Cal AD 80 (Cal BP 2040-1870)	-25.8

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