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Richard Wynn Edwards
University of Wisconsin-Milwaukee

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THE CANINE SURROGACY APPROACH AND PALEOBOTANY: AN ANALYSIS OF WISCONSIN ONEOTA AGRICULTURAL PRODUCTION AND RISK MANAGEMENT STRATEGIES

by

Richard W. Edwards IV

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ABSTRACT:

THE CANINE SURROGACY APPROACH AND PALEOBOTANY: AN ANALYSIS OF WISCONSIN ONEOTA AGRICULTURAL PRODUCTION AND RISK MANAGEMENT STRATEGIES

by

Richard W. Edwards IV

The University of Wisconsin-Milwaukee, 2017
Under the Supervision of Robert Jeske

The goal of this research is to investigate the nature of Upper Mississippian subsistence systems (circa AD 1050-1450), to evaluate the role of agriculture, and to understand how these dietary choices are related to risk management systems and the development of cultural complexity in the Midcontinent. The research uses the Koshkonong Locality of southeastern Wisconsin as a case study and compares it to other Upper Mississippian groups throughout Wisconsin and northeastern Illinois, Middle Mississippian groups in Illinois and southeastern Wisconsin, and contemporaneous Late Woodland groups in southeastern Wisconsin.

This study uses two primary lines of evidence; macrobotanical remains and dietary isotopes ($\delta^{13}C$ and $\delta^{15}N$) from dogs. The dog values are interpreted as proxies for human food consumption though the lens of the canine surrogacy approach (CSA). Regionally, the data indicate maize was foundational to all examined Upper and Middle Mississippian populations, Upper Mississippians distributed food more equitably than Middle Mississippians, and each Upper Mississippian locality buffered maize in a unique manner. Locally, the data indicate that the Koshkonong residents were under stress from structural violence and that intralocality cooperation would have been essential for the subsistence system to have functioned effectively.

For Jacob, Emily, Mason, Connor, and baby Hill

You can do anything you want if you work hard and aim high

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As a friend and mentor, Bob Jeske has been the driving force in my professional development. As my advisor, he has literally read every conference paper, article draft, grant application, and thesis and dissertation chapter that I have ever written. For both our sakes, I do not want to know how many pages or hours that amounts to. His regular and detailed feedback has improved not only my writing style, but my research focus. He has provided me with more opportunities than I can count and has shaped my views and skillsets as an archaeologist. Last, but far from least, our "Oneota Fluid Dynamics" sessions at County Claire, Bar Louie, and elsewhere have helped me to understand and appreciate the archaeology of Oneota, the Midwest, and as a whole. For all of this I am eternally grateful. Given the amount of time he's spent, I'm sure that I owe Celi, Puffin and Boogie both my appreciation and apologies.

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1. Introduction

Between circa AD 1000-1650, people living in the northern part of the Prairie Peninsula combined maize agriculture with hunting and gathering as their subsistence strategy (Griffin 1948; Hall 1962; Overstreet 1978). What has been unclear to archaeologists is the extent to which maize contributed to the diet of these people (Brown 1982; Gibbon 1948, Jeske 2000). New approaches and techniques have recently helped to clarify this issue (Ambrose et al. 2003, Emerson et al. 2005). This dissertation is focused on adding to the discussion using a combination of paleobotany and isotopic data.

The 11th-17th centuries was a time of significant change in the Prairie Peninsula; both environmental and cultural (Baerreis and Bryson 1965; Baerreis et al. 1976; Griffin 1937, 1960). For this dissertation, I use the term Late Prehistoric to refer to the different archaeologically recognizable groups (e.g., Upper Mississippian, Late Woodland, Middle Mississippian) sharing the landscape on the Prairie Peninsula between ca. AD 1000-1650. This term is used when I reference more than one group for brevity and clarity. I also use the term Upper Mississippian to refer to sites containing Wisconsin Oneota, Fisher, and Langford material culture, which are generally thought to represent related and interconnected adaptions to a shared landscape. Other Upper Mississippian groups (e.g., Fort Ancient and Oliver) will not be investigated, as they are more geographically and culturally distant. Furthermore, this dissertation does not attempt to explain the co-existence of Fisher, Langford and Wisconsin Oneota. The nature of relationships among these Upper Mississippian groups (and contemporaneous Middle Mississippian groups) is beyond the scope of this research but has already been investigated by numerous authors (e.g., Berres 2001; Brown 1965; Fowler 1978; Griffin 1937, 1948, 1960; Hall 1960; Jeske 1992, 2003; Keys 1929; McKern 1945; Overstreet 1997; Pauketat 1994).

Historically, researchers identified shifting climates as the primary source of culture change in the Late Prehistoric (e.g., Griffin 1960). However, the focus has increasingly shifted to the role of warfare and agriculture in shaping Mississippian societies and their interaction (e.g., Emerson 1999; Jeske 1992; Kelly 1992; Karsten 2015; Milner 1992; VanDerwarker and Wilson 2016). This dissertation continues both violence and climate lines of inquiry by focusing on agricultural risk management strategies and adaptations during the Upper Mississippian occupation of southeastern Wisconsin (circa AD 1050-1400) (Figure 1.1). The Oneota occupation of the Koshkonong Locality acts as a case study for this research.

In this dissertation, I examine the degree of their reliance on agriculture, using a combination of botanical evidence and isotopic analysis of domestic dog bone, with dog diet serving as a proxy for human diet. I use a theoretical framework that borrows from human behavioral ecology (HBE) in general, and risk management strategies in particular.

The main research goals are: 1) identify the primary subsistence strategies and reliance on agriculture in the Koshkonong Locality; 2) compare Koshkonong subsistence strategies to other contemporaneous groups; 3) determine the nature of the Koshkonong risk management strategies; 4) examine the relationship of agriculture and the development of a ranked or stratified social system.

This dissertation applies both traditional and novel techniques to answer these research questions. Macrobotanical data, the first line of evidence, have been a staple of archaeological research for decades (Pearsall 2010). The canine surrogacy approach (CSA) acts as the second. CSA uses domestic dog isotopes as a proxy for human remains (see Guiry 2012). This approach

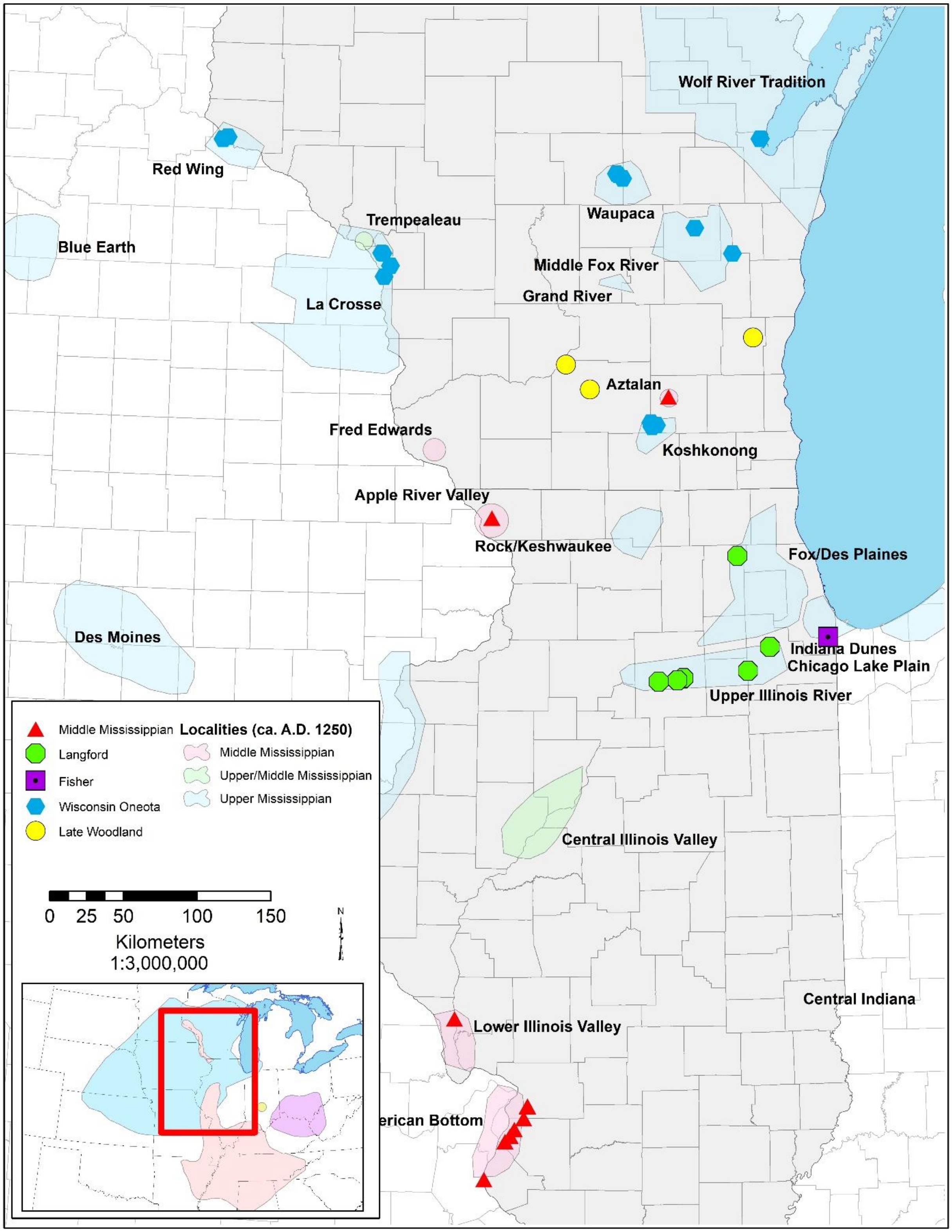


Figure 1.1: Locations of sites discussed in text, relative to localities ca. AD 1250

provides data that are comparable among sites, clear indicators of maize consumption levels, and do not require the destruction of human remains. This is the first application of this method in the western Great Lakes region and offers the potential to help reduce tensions between archaeologists and Native American communities (Edwards et al. 2017).

Social and Environmental Climate of the Late Prehistoric Western Great Lakes

Currently, the relationship between the Koshkonong Locality, its immediate non-Oneota neighbors (i.e., occupants of contemporaneous Late Woodland sites and Aztalan), and other Oneota localities is unclear. On a local scale, the use of shell tempering and vessel morphology distinguishes the Koshkonong potters from their Late Woodland neighbors (e.g., Hall 1960; McKern 1945; Richards and Jeske 2002; Schneider 2015), and vessel paste and morphology distinguishes them from their Middle Mississippian neighbors at Aztalan (e.g., Hall 1960; Richards 1992; Richards and Jeske 2002; Schneider 2015).

Schneider’s (2015) ceramic analysis indicates that Koshkonong groups were part of a larger Oneota social network. Schneider has demonstrated that the Koshkonong Oneota pottery recipes and styles are connected with trends in the Waupaca and Grand River Localities to the north. However, the residents of the Koshkonong Locality were at the edge of this network. Their pottery styles were distinct from these northern groups, and Koshkonong potters went out of their way to distinguish themselves by embellishing many of their pots with a grooved paddle surface treatment. Carpiaux (2018) and Carpiaux and Edwards (2017) suggest that this trend may increase through time, which could indicate the entrenchment of a local identity. The development of a distinct local identity within the Oneota world is supported by multiple lines of evidence, such as lithic procurement patterns (Sterner 2012; Wilson 2016) and appears to be the norm across Oneota localities in Wisconsin (e.g., O’Gorman 2010:589).

The absence of Woodland or Middle Mississippian pottery at Crescent Bay (Schneider 2015) and the Koshkonong Creek Village (Carpiaux 2018) is striking given the proximity of Aztalan and Late Woodland sites to the locality. While the ceramics and lithics at Koshkonong sites are indicative of isolation, the burial record suggests some degree of interaction with neighbors, albeit violently. Several individuals at Koshkonong sites exhibit evidence of trauma and violent death, possibly due to raiding or other forms of intergroup violence (Jeske 2014). If violence, or the threat of violence, was perceived as severe, this could have significantly altered the way that the Koshkonong residents moved about the landscape, procured food, and interacted with their neighbors (*sensu* Keeley 2016; Milner 1992; Pauketat 2009; Tung 2012).

The social stressors present in the Koshkonong Locality provide an important opportunity to gauge their impact on group organization, subsistence practices, and other cultural traits. However, these social factors were not the only stressors within the locality. The transition from relatively warm/wet to cold/dry climactic conditions shortly after the archaeological appearance of Oneota artifacts could also have created significant environmental stresses (Baerreis and Bryson 1965; Baerreis et al. 1976; McEnaney and Bryson 2005). Both social and environmental factors would have posed significant risks to the residents of the Koshkonong Locality and likely would have elicited very different responses (Hart 1993).

Evaluating Risk Management in Oneota Societies:

Given the combination of social and environmental conditions facing Oneota groups, we can expect that they made efforts to minimize their exposure to risk. Given the primacy of people's need for food, and the level of impact social and environmental stresses would have on the subsistence base, examinations of food should elucidate their stress responses (e.g., Milner 2007; VanDerwarker and Wilson 2016). Multiple lines of data identify Oneota subsistence systems' risk responses. First, macrobotanical data provide broad archaeological signatures for subsistence practices (see Hastorf and Popper 1988). Second, isotopic ($\delta^{13}C$ and $\delta^{15}N$) data more directly measure food consumption patterns (see Ambrose 1987). Together, the two lines of evidence can demonstrate what foods were eaten, and in the case of maize, in what proportions (e.g., Hart 1993; Halstead and O'Shea 1989). These data should display different patterns depending on the sources of risk, the chosen strategies to mitigate the risk, and the social institutions administering them.

A model of Oneota subsistence under social and environmental stress is presented based on models developed by Winterhalder and Goland (1997), and using assumptions of risk-aversion as defined and described by numerous authors (e.g., Cashdan 1990; Halstead and O'Shea 1989a; Hart 1990, 1993; Kipnis 2002; Marston 2011; Scarry 2003; Stone and Downum 1999; Winterhalder 1986, 1990). Risk management strategies are generally divided into five types: diversification, mobility, storage, exchange, and intensification. These strategies are neither mutually exclusive nor fully compatible, and the most appropriate strategy depends on the sources of risk. Exclusively environmental risks are usually best mitigated through increased mobility and increasing diet breadth (e.g., diversification). Social risks (e.g., threat of attack) are usually best mitigated through intensification and decreased mobility (Hart 1993), though highly aggregated resources (such as large bison herds) may allow for high mobility and defensibility under specific circumstances. However, risks are rarely single-sourced and therefore the most appropriate strategies are often nuanced and locally dependent (e.g., Hart 1990). Furthermore, because it is people who employ such strategies, the decisions to make them must be administered through social structures. The strategies also create real world repercussions; risk management strategies both shape and are shaped by social institutions (Halstead and O'Shea 1989b; O'Shea 1989).

In the models presented, for socially risky environments, Oneota groups should choose to reduce mobility and intensify agricultural pursuits. As sedentism is maintained or intensified, resource depression is expected and should force further intensification of agricultural resources and/or locally available aggregated resources. If environmental factors are the most significant, then the models predict Oneota groups should increase mobility and agricultural products should be a minor component of the diet. Wild resources should rank highly, though the types will depend on the nature of the risk (e.g.., local vs. regional and continuous or discontinuous). Environmental risks, particularly local ones, should magnify the importance of exchange with other groups. Regular violence should reorient exchange; the risk of attack should reduce the number of opportunities for trade (though not necessarily reduce the total volume), and military alliances are likely to become embedded within the system. Trading partners may not only be valued for the foods they can supply, but the military assistance they can offer.

Several statistical measures will be used to analyze the data, including principle component's analysis (PCA), traditional statistical tests (e.g., Mann Whitney U, Chi-Square tests, etc.), and traditional measures of macrobotanical assemblages (e.g., diversity indices). These types of statistical tests allow for multi-scalar analysis of the largely non-parametric datasets (Marston 2014; Smith 2014). By applying a combination of social/economic theory with these powerful statistical analyses on robust regional datasets, it is possible, not only to identify, but assess important trends and anomalies within the datasets. The theoretical approach allows for an interpretive framework that is both systematic and flexible. The HBE base of the risk management approach necessitates this because human behavior is expected to vary based on the social and environmental conditions. Using such a system allows for inferences about both sets of conditions; social and environmental (Hart 1993). It is through these environmentally specific inferences that we begin to assess and understand cultural responses. Because each group is situated in a distinct social and environmental context, it necessitates the recognition of intergroup variation while not obscuring similarities or shared traits among groups.

Previous Oneota Subsistence Research:

Macrobotanical Studies: Oneota subsistence research was limited prior to the introduction of flotation analysis (Struever 1968; Toll 1988; Wagner 1988; Watson 1976). After the rise of processual archaeology, zooarchaeological analyses were often incorporated into interpretations of Oneota (e.g., Fortier 1972; Gibbon 1969; Overstreet 1976). However, floral analyses were often hampered by extremely limited data. (e.g., Gibbon 1970; Hall 1962). After the introduction of flotation, significant gains were made in interpreting Oneota subsistence. A large proportion of the macrobotanical analyses have been conducted as part of cultural resource management (CRM) studies (e.g., Arzigian 1989; Arzigian and Boszhardt 1994; Brown and O'Brien 1990; Egan 1988, 1993a; Emerson 1999; Jeske 1990, 2000; Jeske and Hart 1988 O'Gorman 1993, 1994, 1995).

To date, the bulk of research has been sub-regional or locality focused. Limited information is available concerning the dietary variation among localities, particularly floral. This type of comparison has largely been hindered by the lack of complete or comparable datasets (Brown 1982; Edwards et al. 2017), and the difficulty of comparing macrobotanical assemblages among sites (Hastorf and Popper 1988; Pearsall 2010). Most regional analyses have focused on tracking the introduction of certain taxa (e.g., Fritz 1992; Hart and Lovis 2013; Monaghan et al. 2014), or looking for broad-scale identity markers in food (e.g., Egan-Bruhy 2014). The latter research has helped to understand variation in the overall diet, but a solely macrobotanical or microbotanical approach cannot answer most of the lingering questions posed decades ago (e.g., Brown 1982). For this, macrobotanical research would need to be coupled with isotopic research.

Isotopic Bone Chemistry: Isotopic research has been even more limited than macrobotanical research. Only a handful of isotopic studies have been conducted using human isotopes on Late Prehistoric sites in the study area (Ambrose 2003; Bender et al. 1981; Buikstra et al. 1994; Emerson et al. 2005, 2010; Hedman 2002; Pratt 1994; Schurr 1992). Even fewer have been conducted on Upper Mississippian sites in the western Great Lakes (Emerson et al. 2005, 2010; Pratt 1994). To date, the research shows that Middle Mississippians consume highly variable amounts of maize, and that Langford maize consumptions are on par with many Middle Mississippians. The Langford levels are higher than many Oneota researchers predicted (e.g., Brown 1982; Jeske 1990, 2000; Michalik 1982), and it is unclear if Langford is representative of Upper Mississippian groups in Illinois and Wisconsin. This dissertation will provide comparable dog isotope values from five Upper Mississippian localities to determine if the Langford values are outliers.

Organization of the Dissertation:

The dissertation is organized to first provide readers with contextual and theoretical background to the research topics. The data are presented one data-type at a time and the analysis of each data type is held until the end so that both lines of evidence can be considered together. Chapter 2 presents the culture history of the study region, the history of archaeological investigations at the primary study sites, and generally in the Koshkonong Locality. It ends with a brief discussion of each of the comparative sites.

Chapter 3 provides a discussion of the theoretical considerations of the research. It discusses the concept of risk, how groups attempt to mitigate it, and how we can expect to see risk management strategies archaeologically. Halstead and O’Shea’s (1989) discussion of risk management is discussed. It includes a discussion of how physical violence, rather than environmental considerations can affect subsistence systems. Winterhalder and Goland’s (1997) theoretical HBE/risk management model of domesticate adoption is also provided, as it provides the base for the theoretical model used in the dissertation. The chapter ends with a theoretical model of predicted Koshkonong subsistence given the social and environmental contexts of the sites.

Chapter 4 provides a discussion of the methods used in the data collection and analysis. Macrobotanical and isotopic techniques and quantitative metrics are discussed. Chapter 5 is dedicated to the macrobotanical remains identified in the Koshkonong Locality. Chapter 6 provides a description and discussion of the isotopic data. It includes a discussion of previously obtained data and compares it with the samples collected for this dissertation. Chapter 7 provides analysis of the data and discusses its implications for the research questions. Chapter 8 concludes the dissertation, summarizing the implications of the research, and suggests potential future courses for research.

2. Cultural History and Archaeological Background

Introduction: In the Midwest Taxonomic System, the term Upper Mississippian was originally created as a phase within the Mississippian pattern due to the prevalence of shell-tempered ceramics, triangular points, and several other traits that it shared with Middle Mississippian sites (McKern 1939, 1945). Within Upper Mississippian, the two main aspects are Oneota and Fort Ancient (Griffin 1943; McKern 1939).

As the term is used today, Upper Mississippian typically includes groups labeled as Oneota, Langford, Oliver, and Fort Ancient. Oneota is an Upper Mississippian material culture manifestation present throughout much of the western Great Lakes and eastern Plains regions (Figure 2.1) during the Late Prehistoric (Brown 1965; Hall 1962; Overstreet 1997). The term Oneota was coined by Keyes (1929) to refer to sites and assemblages in the Oneota River (now known as the Upper Iowa River) valley of Iowa. More specifically he used it to differentiate sites with shell-tempered ceramics from the more ubiquitous grit-tempered Woodland sherds. Early researchers noted that a suite of other material culture often accompanies Oneota ceramics. McKern (1931) argued that the Oneota Aspect also included triangular arrowheads (typically Madison Points) and snub-nosed scrapers.

Researchers throughout the northern midcontinent quickly began using the term to refer to sites with similarly shell-tempered ceramics that were not consistent with Cahokia-style vessels (McKern 1931). At a 1935 conference, archaeologists formally defined the “Oneota Aspect” of the Upper Mississippian Archaeological Culture to include the three foci in northern Illinois, two foci exclusively in Wisconsin, 7and the Orr focus (which included southwest

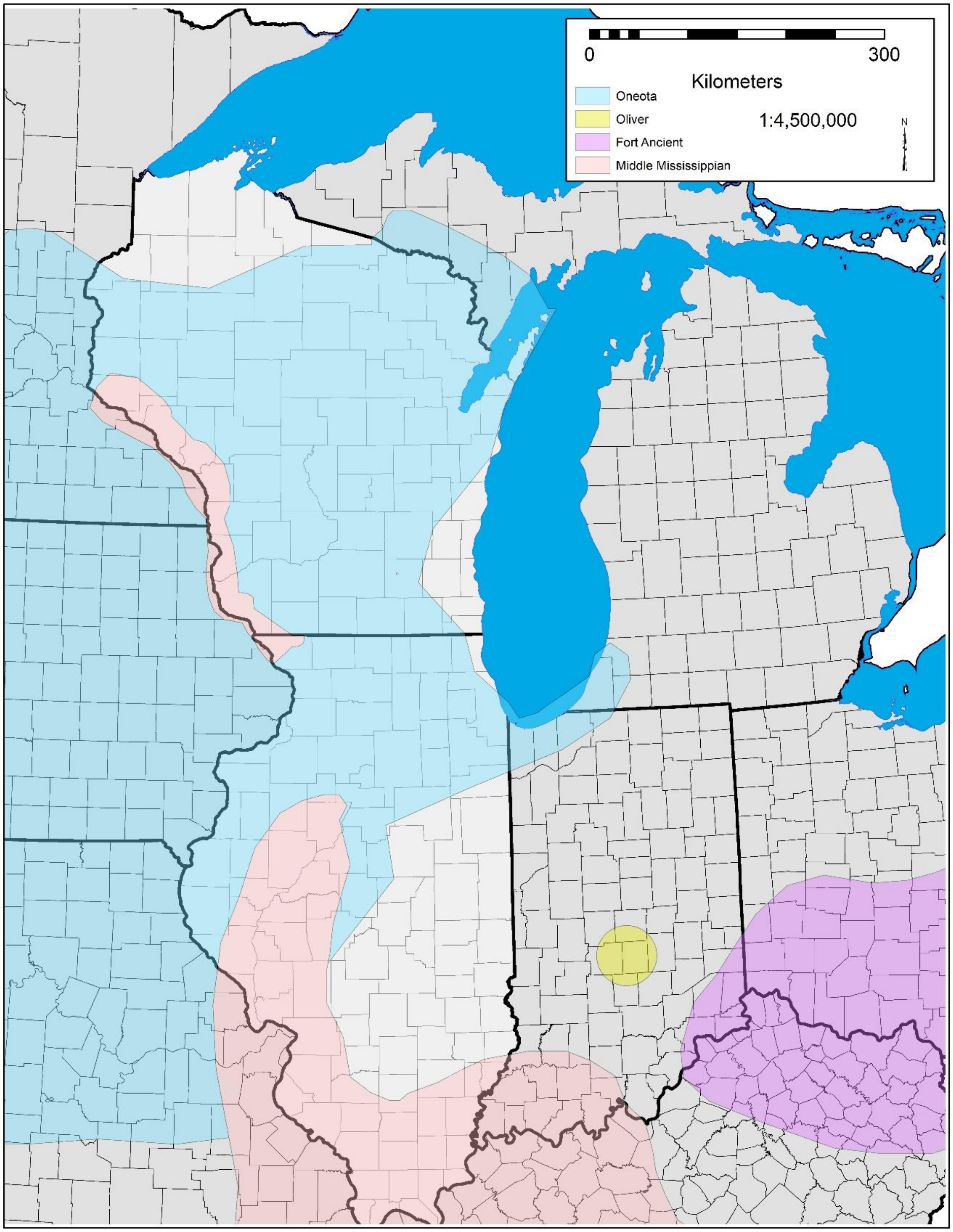


Figure 2.1: Middle and Upper (Oliver, Fort Ancient, Oneota) Mississippian Culture Areas in the Midwest

Wisconsin, Iowa, and Minnesota) while acknowledging that there were also materials far to the west that were likely connected to Oneota (Griffin 1937). Brown (1965:113) described Oneota as the “dominant stylistic complex in the Prairie Peninsula.” Similar related cultural manifestations have been noted with connected ceramic styles and general lifeways, but different combination of grit and shell common among northern Wisconsin groups (R. Mason 1966; Overstreet 2009).

Today, Oneota is often recognized not just as a particular assemblage, but representing a similar suite of lifeways. These lifeways are generally described as being focused on a mixed foraging/agriculture economy that included a diverse suite of resources including maize, Eastern Agricultural Complex (EAC) plants, wetland flora and fauna, large mammals, and fish (e.g., Brown 1982 among others). Given this large geographic range, significant variation is present across space. Therefore, Oneota cannot practically be discussed as a whole; it is usually treated on a regional basis (e.g., Logan 1998; Overstreet 1997). However, even regional treatments of Oneota can obscure significant variation in subsistence, settlement, social organization, etc. (Jeske and Edwards 2015). Failure to acknowledge inter and intra-regional variation has been a source of several debates in the literature. In Wisconsin, debates have most notably been related to chronology (e.g., Boszhardt 1998; Boszhardt 2004; Overstreet 2001). As a result, several scholars have called for discussions of Oneota to recognize that each locality has its own history and unique, though not totally independent, cultural trajectory (e.g., Edwards and Jeske 2015; Jeske and Edwards 2015). To further this end, general trends will be initially discussed, with more detailed regional descriptions to follow.

Relevant Regional Expressions

Oneota sites are not evenly distributed across the landscape (Figure 2.2). Rather, the sites are clustered into what is known as localities (Hall 1962; McKern 1945; Overstreet 1997, 2000). The landscapes separating the localities appears to have been unoccupied – at least by Mississippian (Upper or Middle) sites (Richards and Jeske 2002). Sites within these localities are often seen as more tightly connected with each other than to sites in other localities (Gibbon 1972a; McKern 1945; O'Gorman 2010), though the degree to which localities vary is not clear (Jeske and Edwards 2015; Jeske et al. 2016; Schneider 2015). Due to a lack of fine-scale comparative data, many researchers have often focused more on regional differences. Within Wisconsin, we can see two broad divisions (e.g., Egan-Bruhy 2014; Henning 1998; McKern 1945; Overstreet 1997) – Eastern and Western – with at least three sub-regions within eastern Wisconsin: northern; central; and southern (e.g., Jeske and Edwards 2015).

Eastern Wisconsin Oneota: Oneota research in eastern Wisconsin has a long history, dating back to the early 20th Century (Gibbon 1972a; Hall 1962; McKern 1931, 1945). The Grand River area was among the first to be studied (Jeske 1927), followed shortly by sites near Lake Winnebago (McKern 1945) and Lake Koshkonong (Hall 1962). Further localities have been identified in the Green Bay/Door Peninsula region (R. Mason 1966), Waupaca (Hamilton et al. 2010), and northern Wisconsin (Buckmaster 1979). Southern ceramic assemblages are dominated by shell-tempering (Hall 1962; McKern 1931, 1945; Schneider 2015). Assemblages from northern sites are known as Mero, including those on the Door Peninsula, and tend to have both grit and shell tempered ceramics, (R. Mason 1966; Overstreet 2009). Several lines of evidence suggest that there are significant differences among localities, in terms of ceramics,

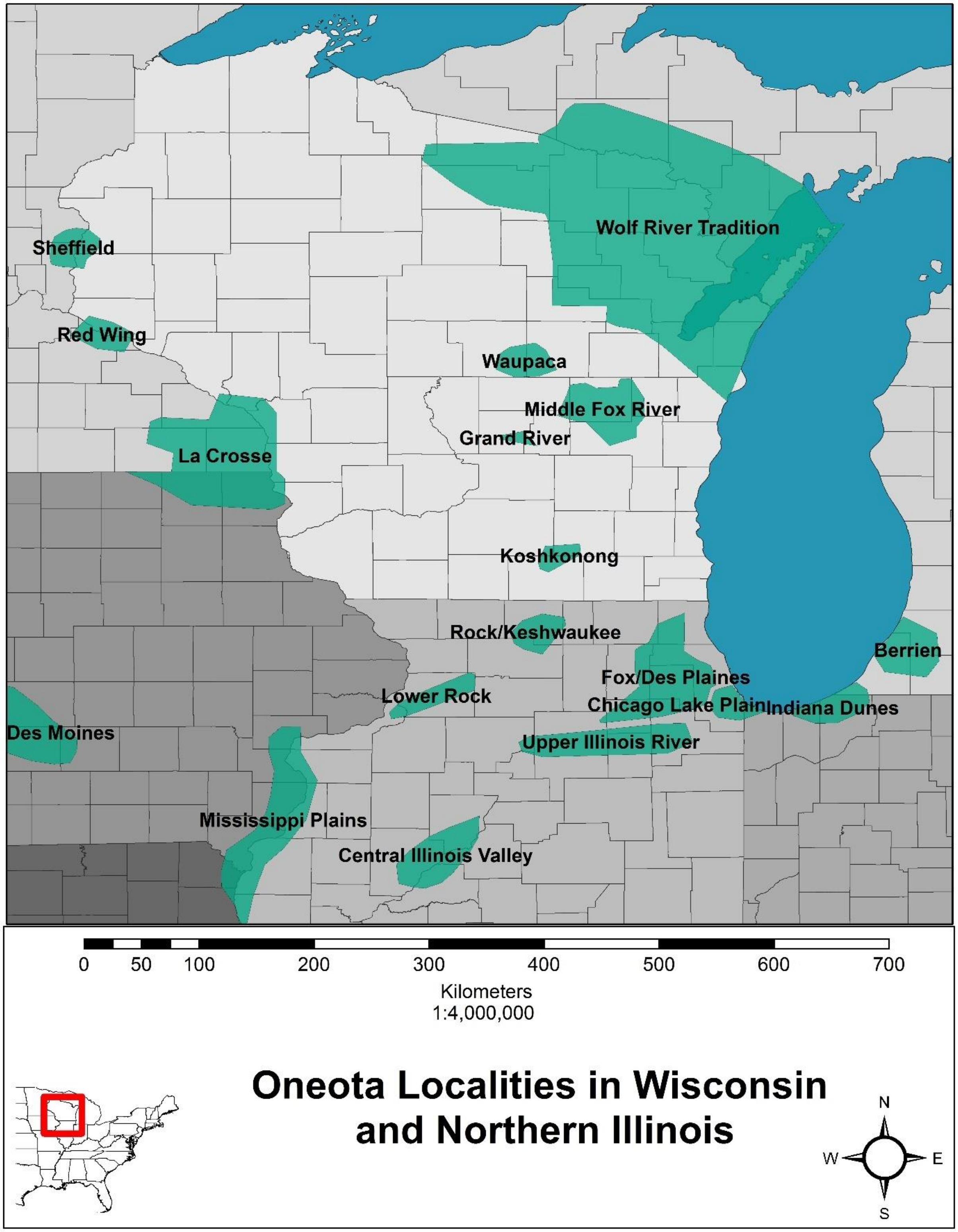


Figure 2.2: Oneota Localities in and adjacent to the study area

diet, raw material acquisition patterns, and political relationships (Edwards and Jeske 2015; Jeske et al. 2016; Schneider 2015). Most localities appear to be occupied starting around AD 1050 but are abandoned by AD 1400. The Lake Winnebago region is the one exception; it was occupied until AD 1600 (see Jeske et al. 2016; Overstreet 1997).

Western Wisconsin: There are two primary localities within Western Wisconsin; Red Wing/Lake Pepin and La Crosse. The Red Wing locality extends across the Mississippi into Minnesota and has a long history of research (see Gibbon and Dobbs 1991; Rodell 1991 for a discussion of the history of research in the region). It appears that the area was possibly occupied by both Oneota and Middle Mississippian groups (Gibbon and Dobbs 1991; Lawshe 1947; Maxwell 1950). Oneota groups resided in the locality from approximately AD 1000-1400 (Schirmer 2002 Table 3).

The primary Oneota occupation of the La Crosse terrace began circa AD 1300 and the region was abandoned shortly after AD 1600 (Boszhardt 1989). Boszhardt (1994) divided the chronology into three phases, Brice Prairie (AD 1300-1400), Pammel Creek (AD 1400-1500), and Valley View (AD 1500-1625). The Pammel Creek phase marks an apparent large-scale migration to the La Crosse region (Boszhardt 1994); the density of post AD 1400 sites is significant, and suggests that it was a major population center (Boszhardt 1994).

Illinois Oneota/Upper Mississippian:

The situation in northern Illinois is even more complicated. Researchers have long postulated that there were at least two separate contemporaneous Upper Mississippian groups: Langford and Fisher. Huber is a third Upper Mississippian tradition in the region later in time – it may represent the cultural descendant of Fisher (Bluhm and Liss 1961; Brown 1990). However, Emerson et al. (2015) argue that the two groups are not related. The relationship between Huber and the preceding groups is unclear, but because of its late date, it is beyond the scope of this dissertation.

McKern (1943) noted that both Langford and Fisher vessel types were similar to the Grand River Focus Oneota ceramics in Wisconsin. Fisher sites can still be identified by unique aspects ceramic assemblages. These unique characteristics include a combination of shell-tempering with a distinct set of decorative motifs and surface treatments (e.g., cord marking) (Faulkner 1972; Griffin 1946, 1948; Langford 1927). Fisher territory largely coincided with Langford; however, site placement was distinct indicating each group had different criteria for habitation placement (e.g., Jeske 1989). Fisher sites are common occurrences on terraces overlooking large rivers (e.g., Illinois River), but rarely extend into the smaller river valleys. In general, Fisher sites are placed in locations with access to arable floodplain soils (Jeske 1989). Excavations at large sites (e.g., Hoxie Farm) indicate that Fisher site occupants relied heavily on wild resources and cultivated plants, including EAC cultigens (e.g., Jackson and Emerson 2013).

Mafic grit-tempered globular vessels with everted rims characterize Langford tradition assemblages (Bird 1997; Brown 1961; Faulkner 1972; M. Fowler 1940; Griffin 1948). Langford sites are ubiquitous in northern Illinois river valleys including the Kishwaukee, Lower Rock, Upper Illinois, Fox, Des Plaines and DuPage (Bird 1997; Birmingham 1975; Brown 1961; M. Fowler 1940; Hart and Jeske 1987; Jeske 1989, 2003b; Jeske and Hart 1988). Smaller Langford sites are also found remote upland settings providing access to a different suite of resources (Jeske 1989, 2003b). Langford groups appear to rely on a diverse suite of foods – with maize and wild starchy seeds apparently among the most important floral resources (Egan-Bruhy and Nelson 2013; Egan 1988; Simon 1999). Isotopic evidence suggests that maize may have been as an equally important dietary contributor to Langford groups as it was for Middle Mississippians (Emerson et al. 2005).

The relationship between Langford and Fisher has been debated; Berres (2001) suggests that they represent different moieties of the same society, Jeske (2003b) argues that Berres' own data indicate Fisher and Langford ceramics differ in 9 of 10 measured variables. Even when sites contain the material remains of both groups, they are recovered in distinct contexts. For example, excavations at the Fisher site recovered both Langford and Fisher ceramics, but were stratigraphically separated at the site (Langford 1927). John Griffin (1948) noted that the deepest strata contained Fisher materials, while the upper two strata contained Langford ceramics. Overall, the two groups generally occupied and used distinct parts of the landscape, different agricultural technologies, different ceramic technologies, and distinct subsistence resources (Jeske 1989; 1990, 2003b).

Origins:

The reason for the sudden arrival of Oneota material culture at approximately AD 1050-1100 is unclear. Numerous researchers have postulated explanations; however, to date no published accounts are widely accepted or sufficiently account for regional variation. For decades, many scholars have suspected that Middle Mississippians, Cahokia, in particular, may have played a significant role – an idea still popular with many scholars (e.g., Green 2014). James Griffin (1960) initially felt that Oneota represented Middle Mississippians that had moved north, and after the onset of the Little Ice Age devolved into Oneota when they could no longer support large aggregated populations. When radiocarbon data discounted this possibility, numerous theories were devised. Overstreet (1989, 1995) has also argued for a non-local origin of Oneota groups.

Gibbon (1972a) argues that Oneota groups represent local Late Woodland populations that fused in reaction to the more organized Middle Mississippians on their southern flank. Many authors have built related arguments – that contact with Middle Mississippians and some driving factor led Late Woodland groups to adapt new practices that we call Oneota or Langford (Emerson 1999; Fowler 1949; Jeske 1990). Theler and Boszhardt (2000, 2006) argued that Mississippian influence mixed with increased population pressures and declining deer populations were the catalysts for the shift of western Late Woodland populations; Green (2014) argues that the shift occurred after Mississippian religious proselyting. Emerson (1999) has argued that the increased military threat of Middle Mississippians caused desperate Late Woodland groups in Northern Illinois to unify into Langford through a process of tribalization. While these Middle Mississippian-centered hypotheses may be reflective of the events in some localities, they lack broad explanatory power as they do not fit the data across the Oneota landscape.

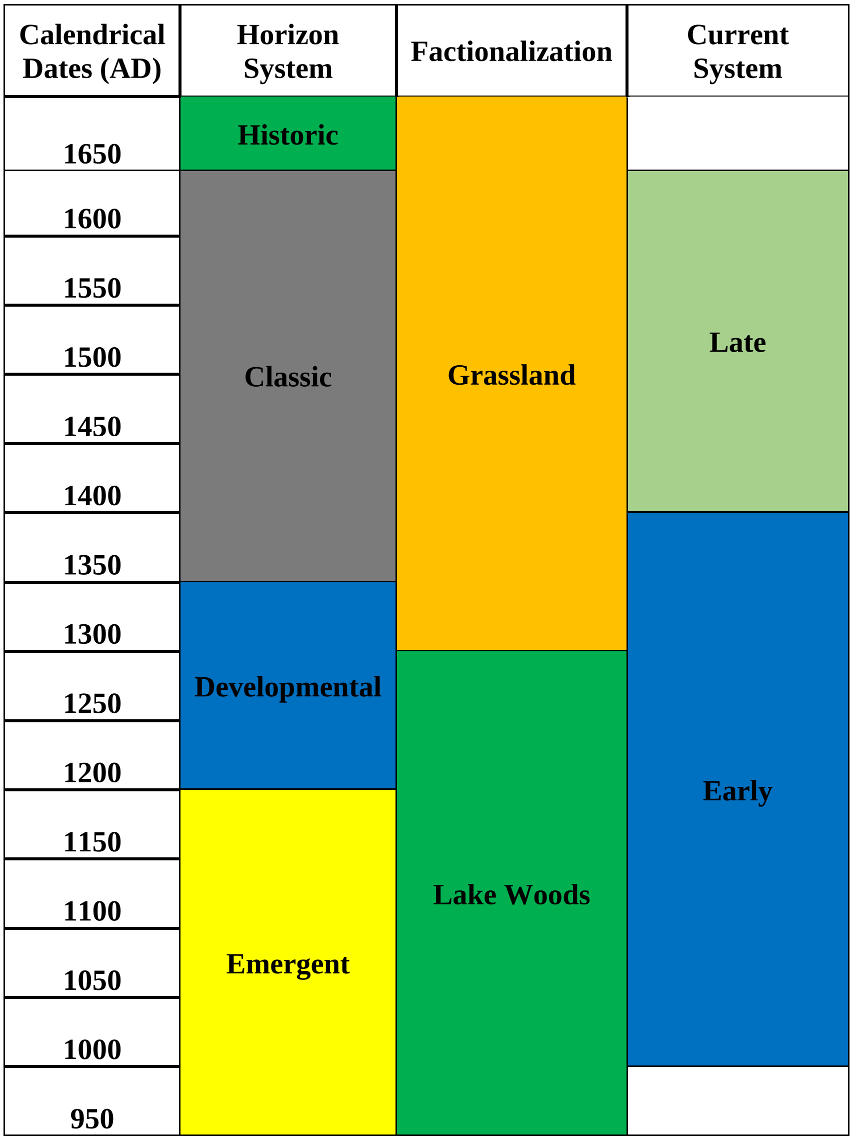
Following regional arguments made by many (e.g., Brown 1982), Jeske and Edwards (2015) and Edwards and Jeske (2015) illustrate that there is insufficient time for Middle Mississippians to have affected such a change in the local Late Woodland population in the area around the Koshkonong Locality. Moreover, Richards and Jeske (2002) show the coeval nature of Middle Mississippians, Oneota, and Late Woodland in Wisconsin. The earliest evidence of Middle Mississippians in the region occurs after the Oneota groups were already established. Furthermore, there is no indication of any significant interaction between Lake Koshkonong Oneota groups and Aztalan despite the short distance between them (see also Overstreet 1995:60). Given the variation among localities, it is likely that no single answer will fully or sufficiently explain the origins of all Oneota.

Chronology:

Several Oneota chronologies have been suggested. The most pervasive has been used extensively in Wisconsin from the 1960s until recently, and divides Oneota occupation into horizons. Several other chronologies have been suggested, including by Gibbon (1972a; 1986) and Jeske (Figure 2.3).

The original Horizon system was developed by Hall (1962) and later amended by Overstreet (1976). Hall's used a three-division system, and the amended version included a fourth. Hall's work, as updated by Overstreet, posited various Oneota horizons – widespread, contemporaneous distribution of distinct material culture across a broad landscape. Hall initially defined the Emergent (circa AD 950-1200), Developmental (AD 1200-1350) and Classic Horizon (AD 1350-1650). In addition to refining and updating the descriptions of each Horizon, Overstreet (1976, 1981, 1995, 1997) also added the Historic Horizon (post-1650). Gibbon (1972a, 1986) has argued for a different chronology with a major cultural shift occurring at AD 1300. He argues that from circa AD 900 until 1300, Oneota economies were focused on agriculture and local resources in what he termed the Lake-Woods adaptation.

In recent years, new data have necessitated that we call into question both Hall/Overstreet's Horizon and Gibbon's Factionalization systems. There does not appear to be significant cultural or artefactual changes at AD 1200 as suggested by the Horizon system or 1300 suggested by the Factionalization. In fact, research into ceramic attributes in the Koshkonong, Waupaca, and Grand River localities showed no significant changes during the Oneota occupations (Schneider 2015). What the analysis did show is significant differences among localities. Furthermore, other predicted artifactual shifts have not been identified. For example, Sterner's (2012) analysis did not indicate a shift point to scraper ratio at Crescent Bay. This indicates there was no shift in hunting practices as Gibbon (1972a, 1986) suggested



Calendrical Dates (AD)	Horizon System	Factionalization	Current System
1650	Historic	Grassland	
1600	Classic		Late
1550			
1500			
1450			
1400			
1350			Early
1300	Developmental		
1250		Lake Woods	
1200			
1150	Emergent		
1100			
1050			
1000			
950			

Figure 2.3: Alternate Chronological Models discussed in text (after Hall, Overstreet, Gibbon, Jeske et al. 2016)

Simon (1999), Egan-Bruhy and Nelson (2013) among others (e.g., Arzigian 1989; Arzigian et al. 1994; Hollinger and Pearsall 1994) do suggest that there are temporal shifts in floral subsistence patterns; however, these shifts appear to be gradual rather than episodic and vary by region. For the Horizon system to be applicable, the shifts should be sudden and occur simultaneously across a large region; neither are appropriate given the currently available data

(Hollinger 1998; Willey and Phillips 1958:33). Likewise, Gibbon's system no longer conforms to the available data.

A big shift in Oneota lifeways across the entire region does occur at AD 1400 (Jeske et al. 2016). Jeske et al. (2016) argue that the beginning of the 15th century AD marks a reorganization of political boundaries and overall social organization (Figure 2.3). Formerly disparate groups spread across the landscape are either pulled or pushed together. At roughly the same time, we see the abandonment of the Koshkonong, Waupaca, and Grand River localities in Wisconsin. Other areas of the state may have also abandoned; however, we lack sufficient chronological clarity in several areas, particularly northern Wisconsin. We also see the disappearance of Langford ceramics in Northern Illinois shortly after AD 1400 (Bird 1997; Jeske 1990, 2000b; Strezewski et al. 2012) and the replacement of Fisher ceramics with Huber, though it is unclear if the Fisher/Huber replacement represents an *in-situ* transition (Brown 1990; Faulkner 1972) or a population replacement (Emerson and Emerson 2015). Many authors (e.g., Overstreet 1997) have noted a significant increase in the number and density of sites in the Lake Winnebago/Middle Fox and La Crosse terrace regions, suggesting that groups began to aggregate in these two locations, in addition to the Huber groups in the Chicago area.

I avoid using the phase or component terminology. There appears to be local variation, but the ability to distinguish assemblages among localities is unclear, and it is unlikely that the definitional requirements of a phase can be met (see Boszhardt 2004; Hollinger 1998; Willey and Phillips 1958). It appears that no Oneota locality, from the Upper Illinois River Valley north into Wisconsin, was unaffected by changes ca. AD 1400 (Figure 2.4). Therefore, and when speaking of chronologies intended for a wide geographic focus, an early (pre-AD 1400) and late (post AD 1400) dichotomy seems most appropriate (Jeske et al. 2016). However, it is also

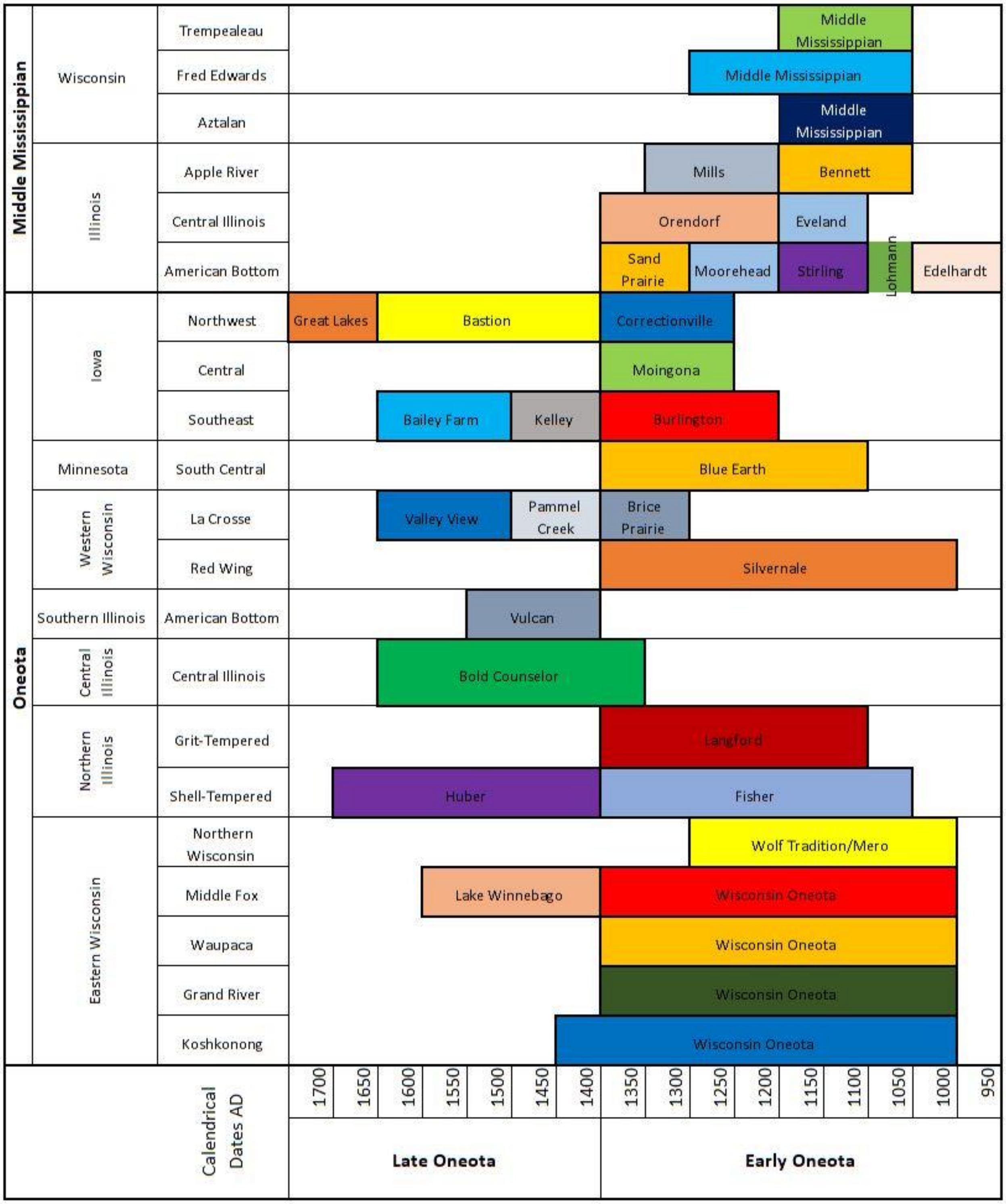


Figure 2.4: Mississippian Chronologies after Schneider 2015:52

important to realize that localities were, to varying extents, isolated and independent (Edwards and Jeske 2015; Gibbon 1972a; R. Jeske et al. 2015; Jeske et al. 2016; O’Gorman 2010). Therefore, we should expect to see smaller-scale changes within some localities not reflected in others. Thus, the early/late dichotomy is only relevant for large-scale analyses. Internal chronologies for each locality need to be locally defined, such as that proposed by Boszhardt (1994) for La Crosse or by Schermer (2017) for Red Wing. These chronologies need to account for the effects of local historical trajectories and interactions among groups. In sum, given that fine-grained analyses are now possible and increasingly available, broad generalizations about Oneota culture through time and space have limited explanatory value.

Subsistence:

Brown (1982) argued that Oneota subsistence practices were diversified, relying on domesticated plants, wetland resources, and hunting. He also argued that the subsistence systems were highly flexible to the local conditions. Hart (1990) made a similar point about the agricultural systems stating that:

> The relationship between climate, population density, and agricultural management indicates that Oneota agricultural production should not be thought of as a unitary phenomenon. Population densities and climatic variables were not constant throughout the upper Midwest during the Mississippian period. It follows from microeconomic theory that there should be regional and even local variation in agricultural production as a result of varying population density and climatic conditions. Hart 1990:575

While Brown’s (1982) arguments were made prior to most flotation-based paleoethnobotanical analyses, his general arguments are still generally thought to hold true. An examination of faunal materials from western Wisconsin indicate that aquatic resources were a vital aspect of the diet. Theler (Arzigian et al. 1994; Arzigian et al. 1989; Theler 1989, 1994) has regularly argued for the importance of fish and mollusks in the Oneota diet. Tubbs and O'Gorman (2005) have estimated the dietary contribution of faunal resources and suggest that fish and mollusks provided from 55-75% of the assemblages. Wetland plants were also important. In northern localities, wild rice (*Zizania sp.*)[1] appears to have played a measurable role in the Oneota diet (Arzigian 2000; Egan-Bruhy 2014; Hunter 2002) while aquatic tubers were more important to Langford groups in Northern Illinois, though their dietary contribution was likely limited (Egan-Bruhy and Nelson 2013).

Some degree of an agricultural base for Oneota groups is unquestioned. While there appears to be considerable variability in the reliance on domesticates such as maize (*Zea mays*), beans *(Phaseolus vulgaris*), and squash (*Cucurbitaceae*), all major Oneota habitations sites appear to rely on maize, if not all three to a high degree (Egan-Bruhy 2014; Egan-Bruhy and Nelson 2013; Jeske et al. 2016; Simon 2014). The high rate of scapulae hoes in La Crosse and Lake Winnebago/Middle Fox noted by numerous researchers (e.g., Gallagher and Arzigian 1994; Gallagher and Sasso 1987; Jeske 1989; Overstreet 1997; Sasso 2014) is also suggestive of the high importance of agriculture. The presence of bison scapulae, which were apparently acquired at significant cost through trade, and/or during long-distance hunting trips to the Plains, helps to underscore the effort invested in agricultural pursuits. (Gallagher and Arzigian 1994; Sasso 2014; Theler 1989). Isotopic analyses taken from human remains at several Langford burial sites also suggest a high reliance on maize, consistent with many Middle Mississippian groups (Emerson et al. 2010).

Hunting, the third of Brown's (1982) criteria, also still appears to be a significant component of the Oneota diet. La Crosse terrace sites indicate a heavy reliance on white-tailed

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[1] I refer to wild rice as *Zizania sp.* because there is debate among botanists about the historic ranges of the two extant species: *Zizania aquatica* and *Zizania palustris.* Today, Wisconsin is in the range of both plants. There is nothing to suggest a difference in economic potential between the two.

deer (*Odocoileus virginianus*) in the subsistence system (Theler 1989; Tubbs and O'Gorman 2005). Deer and elk (*Cervus elaphus*) were likely of vital importance in the Koshkonong Locality, providing as much as 70% of the faunal diet, though a full-scale analysis of Koshkonong fauna is still underway (Agnew et al. 2016; Edwards 2013; Hunter 2002; Jeske et al. 2016; Picard and McTavish 2015; Van de Pas et al. 2015). Northern Illinois groups also appear to have a had strong focus on upland-game hunting (Emerson 1999; Hunter 2002; Jeske 2002, 2003b; McTavish 2015).

The diversified nature of the Oneota subsistence has been often been interpreted as a risk-management strategy (Gallagher and Arzigian 1994). By focusing on a wide array of resources, failure in one can be easily mitigated by increased use of others (Halstead and O'Shea 1989b; O'Shea 1989). However, this idea has generally been used as a heuristic device and has rarely been tested in any rigorous sense. In some areas, it has been noted that there is a strong emphasis on local resource acquisition (Edwards and Jeske 2015; McTavish 2015) and that it may be part of a defensive strategy to minimize the risk of ambushes from opposing groups (Milner 1992; 2007). In northern Illinois, this can be seen in the extreme with a high degree of resource processing (e.g., marrow extraction and use of bone as fuel) at several sites – notably Washington Irving, Robinson Reserve (McTavish 2015), La Salle County Home (Cross and Jeske 1988; Martin 2002), and Hoxie Farm (T. Martin 2013).

Intergroup Violence in Oneota Societies:

In the last 25 years, increased attention has been paid to the effects of intergroup violence in shaping Oneota lifeways. Some of the best early evidence comes from the Central Illinois River Valley where expanding Oneota groups came into conflict (Milner 1992; Milner et al. 1991; Milner and Smith 1990). Milner et al. (1991) note that the high rate of violent encounters is consistent with a raiding style warfare, where small groups would enter enemy territory, and lay in wait for the opportunity to ambush a small group as they went about their daily routine away from the village. Approximately 16% of the cemetery population show evidence for violent deaths (Table 2.1). When children are excluded, that number rises to roughly 30% of the cemetery population. More than 42% of those who died violently appear to have survived a previous attack, only to have been killed in a subsequent encounter. An additional 2% of the total cemetery population survived attacks, and eventually died deaths that were apparently non-violent. Milner (2005) makes clear that the skeletal evidence underrepresents the actual number of war-related deaths, as not all wounds will impact bones (e.g., arrow wounds to the stomach). Therefore, the estimate of 30% of the population dying from enemy attacks should be considered conservative.

*Table 2.1: Markers of osteological violence and associated type of violence as used by Milner et al. (1991 - * consistent with raiding style intergroup conflict*

Osteological Markers	**Non-Violent Incident**	**Interpersonal Violence**	**Intergroup Violence**
Perimortem blunt-force trauma (e.g., cranial impact)	x	x	x
Perimortem trauma consistent with defensive injury (e.g., forearms)		x	x
Perimortem sharp-force trauma		x	x
Projectile point imbedded in bone		x	x
Trophy Taking/Mutilation (e.g., removal of hands, scalping, etc.)			x
Scavenger gnaw marks (i.e., away from site ambush led to scavenging)			x
Mass Graves			x
Male to Female ratio relatively even			x

This high rate of warfare does not appear to be an isolated occurrence. A comparative study along the western margins of Lake Winnebago showed similar levels of violence in central Wisconsin (Karsten 2015). Karsten (2015) analyzed 126 individuals from six sites and found that 21% showed evidence of violent deaths. The proportion rises to roughly 30% when children are excluded. He concluded that a similar pattern of violence was likely occurring in Middle Fox Passageway as at Norris Farms. Jeske (2014) notes that many individuals within the Koshkonong Locality also suffered violent deaths. However, because of smaller sample sizes and most human remains have been recovered as isolated finds, there is less demographic detail. Human remains recovered from Upper Mississippian sites in northern Illinois also regularly show evidence of intergroup violence (e.g., Berres 2001 Emerson et al. 2010; Fowler 1949, Jeske 2003; Langford 1927; Jackson and Emerson 2013), as do many in Iowa (Benn 1995).

The data show that throughout much, if not all, of Oneota history, warfare was a significant fact of life. Everyone would have known someone that was killed in a raid. Cultural practices to ameliorate its effects would have been required. Milner (2007:199) argues that groups facing this type of threat would have had to “modify subsistence practices or move to safer, but less productive, places.” Anyone leaving the safety of the village could potentially be at risk, requiring shifts in group size (both village and work party), composition, and range. Groups would leave the protection of the village less often, in larger groups, and would be less likely to travel longer distances. This would almost certainly reduce productivity. Except with the most aggregated resources, large groups would be less efficient at exploiting resources, particularly if a portion of the group is focused on defense. Leaving the site less often may preclude groups from accessing certain wild resources while they are most viable, and will increase the opportunity for competing animals to obtain a larger portion of the yield. Finally, fewer and shorter trips will restrict the range of resources (see Chacon and Mendoza 2007; Keeley 1996; Maschner and Reedy Maschner 1998; Rice and LeBlanc 2001). VanDerwarker and Wilson (2016) have illustrated that groups living in the Central Illinois River Valley were forced to restrict their hunting ranges and reduced foraging forays. Meanwhile, these groups were unable to offset the reduction in food, thereby increasing the likelihood of food shortages. These issues would only be exacerbated if stored foods or agricultural fields were also destroyed in an attack (Milner et al. 1991).

Historical Connections:

The disappearance of Oneota is also a point of contention. Several different tribes have been suggested as the descendants of Oneota. Most suggested connections are to Chiwere-Siouan speaking groups (Griffin 1937; McKern 1945; Springer and Witkowski 1982). In eastern Wisconsin, many archaeologists (Hall 1993, 1995; Overstreet 1993; Richards 1993) believe that the Ho Chunk are the most likely descendants; however, the lack of historic components on Oneota sites creates a gap between the historic and prehistoric groups that cannot be easily explained (Mason 1993). Overstreet (2009) has also suggested that the Menominee may be the descendants of the northern Mero producing Oneota-like ceramics, though these sites also lack a clear transition or overlap between historic and prehistoric components. No clear connection has been made for Huber ceramics in northern Illinois, although Cremin makes a case for a Potawatomi connection to Berrien ware of Michigan and northwest Indiana, (Cremin 1996). Berrien ware is extremely similar to Huber ware (Cremin 1996). Danner pottery – which appears similar to Fort Ancient styles from Ohio (Brown 1990) is clearly associated with the historic Illini occupations at both the Illiniwek Village site in Missouri (Grantham 1993) and the Zimmerman site, also referred to as the Grand Village of the Kaskaskia (Brown 1961; Brown 1975) and the Grand Village of the Illinois (Stelle et al. 1993). Zimmerman is on the northern bank of the Illinois River, across from Starved Rock in the Upper Illinois River Valley (Park 2010; Stelle et al. 1993). In the west, archaeologists have had better luck connecting prehistoric Oneota groups to historically known tribes – in Iowa, the Ioway have been linked to Orr Phase Oneota sites (Wedel 1959, 1976, 1981, 1986).

Detailed Descriptions of Primary Study Sites:

The Crescent Bay Hunt Club (47JE904) and Koshkonong Creek Village (47JE379) are both habitation sites in the Koshkonong Locality (Cowell et al. 2008; Gibbon n.d.; Jeske 2000a; Musil 1987). They are two of six known Oneota villages along the northwest shore of Lake Koshkonong. The Carcajou Point 47JE002 (Brubaker and Goldstein 1991; Hall 1962; J. Richards et al. 1998), Crab Apple Point 47JE093 (Spector 1975), Schmeling 47JE0833 (Edwards 2010; Foley Winkler 2006, 2008, 2011), and Hearthstone/Purnell 47JE089/813 (Rodell 1984; Stout and Skavlem 1908; Torgerson et al. 2014) sites are also in the locality (Figure 2.5). Increase Lapham (1855) and Stout and Skavlem (1908) conducted the earliest archaeological surveys of the region. Stout and Skavlem (1908) were the first to report many of the Oneota sites (e.g., KCV, Carcajou Point, Hearthstone/Purnell).

History of Archaeological Research in the Koshkonong Locality:

Since the mid-20th Century, the area has intermittently been a hub of Oneota research. In the late 1950s Robert Hall (1960) began excavations at the Carcajou Point site; he used the ceramic assemblage to define Oneota ceramics and chronology. In 1968 David Baerreis led a UW Madison field based-course at the Crescent Bay Hunt Club, though the results were never formally published (Gibbon n.d.). Janet Spector (1975) did her dissertation work at the Crabapple Point site; however, she focused her research on the historic component. In the 1980s and 1990s Lynn Goldstein’s Southeast Wisconsin Archaeological Program conducted several surveys as part of the Crawfish Rock Archaeological Project, relocating multiple sites and identifying several new ones (e.g., Rodell 1984). In 1998, Robert Jeske began a biennial field school through UWM’s Program in Midwestern Archaeology. The field school conducted

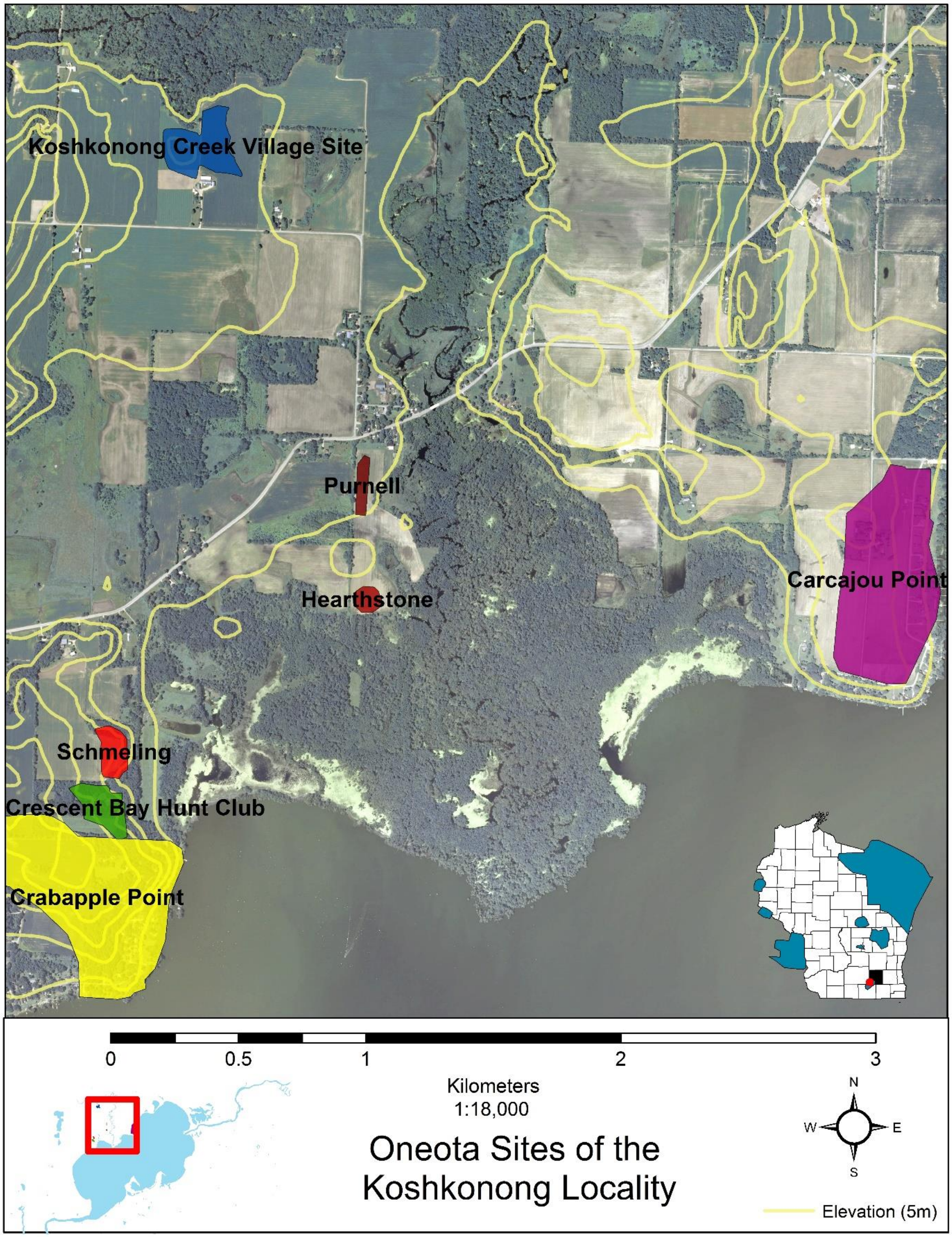


Figure 2.5: Oneota sites in the Koshkonong Locality

excavations and surveys at several sites in the region – though most work has been conducted at Crescent Bay, Schmeling, and Koshkonong Creek Village sites.

Previous research has suggested the Koshkonong Oneota groups chose village location based on many factors – but economics was consistently ranked high (Edwards 2010; Hunter 2002). Oneota sites throughout Wisconsin, Minnesota, Iowa, and Illinois were typically placed with access to preferential resources, though the exact pattern is unique from locality to locality (Dobbs and Shane III 1982; Gallagher and Stevenson 1982; Michalik 1982; Tiffany 1982). Koshkonong sites were primarily placed in a middle ground – between two diverse sets of resources: in one direction, upland resources, and arable land; wetland and aquatic resources in the other (Edwards 2010). Furthermore, the sites were placed atop high ground overlooking the aquatic resources.

The Crescent Bay Hunt Club:

The Crescent Bay Hunt Club was first excavated by David Baerreis and students from the University of Wisconsin-Madison in a limited project during the fall of 1968. Through the course of investigations, they excavated several pit features and uncovered a structure similar to the dome-shaped wigwams (hereafter referred to as wigwams) reported historically throughout the western Great Lakes (Gibbon n.d.). The University of Milwaukee field school, under the direction of Robert Jeske, returned to excavate the site in 1998. Jeske has conducted 10 field school seasons there through 2017 (Jeske 2000a, 2001, 2003a, 2010; Jeske et al. 2015; Jeske et al. 2003; Jeske et al. 2013; Jeske et al 2017).

These excavations uncovered more than 100 pit features and six additional structures (Jeske et al. 2015; Moss 2010). In total, three types of structures have been identified (Figure 2.6). Two additional rectangular wigwam-like structures, including the one from 1968, have been

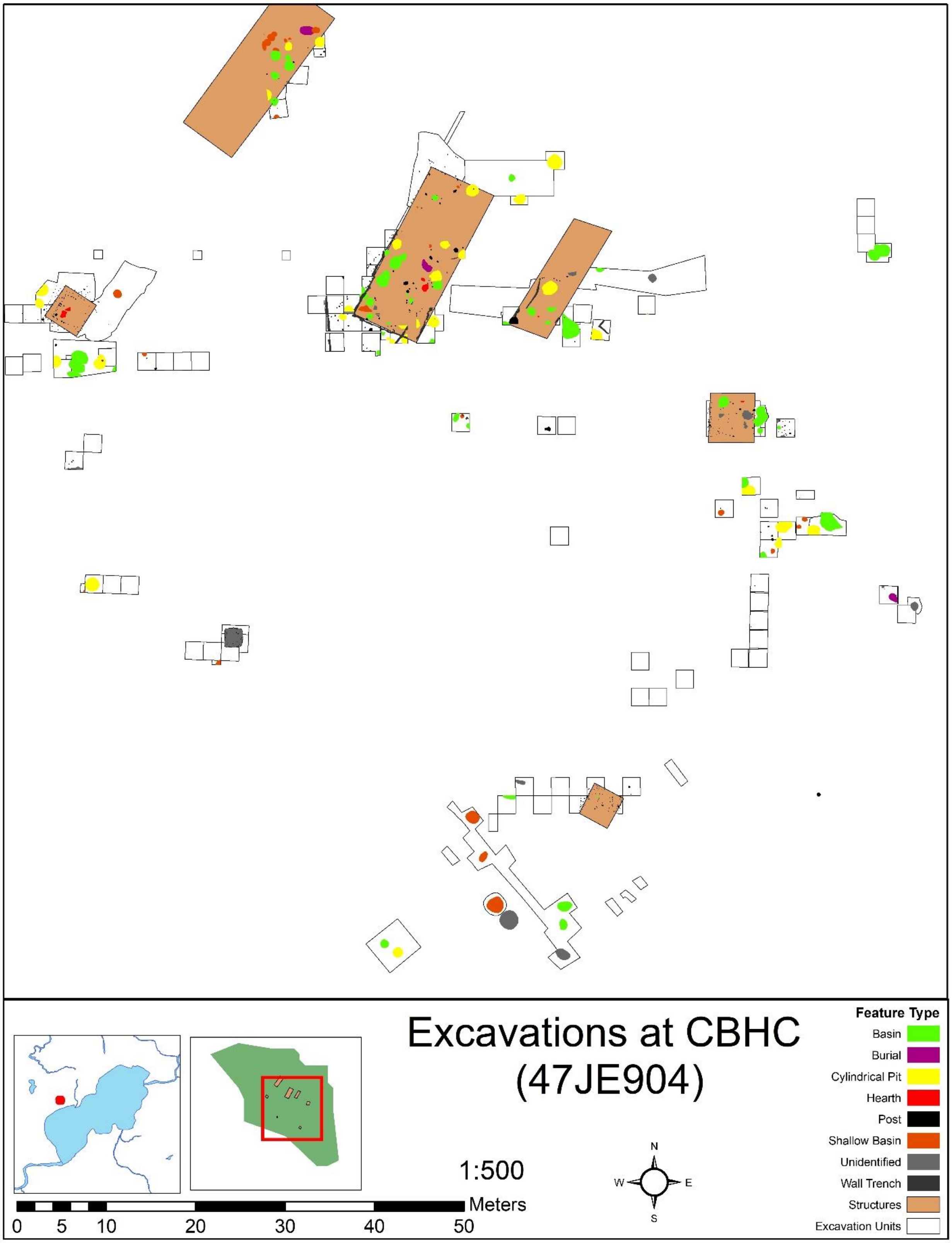


Figure 2.6: Excavation and Feature Locations at CBHC (47JE904)

uncovered. They have a double wall construction and average about 20 m^2 (Jeske 2010; Moss 2010). Three longhouses were also identified at the site. These structures were built using the post-in-trench- construction technique. Only one longhouse structure has been sufficiently excavated to accurately estimate size – 140 $m^{2.}$ Radiocarbon dates suggest that they are contemporaneous with the wigwam structures (Jeske 2011; Jeske et al. 2017; Moss 2010). Features within and near the longhouses have contained buds indicating that the longhouses may have been used in the winter (Edwards and Pater 2011). The third structure type was identified in 2014. The structure consists of a half meter deep basin, with posts placed on a ledge around the margin. The entire basin measured approximately five square-meters, and is too small to be a house structure; its function remains unclear, and analysis is still underway (Jeske et al. 2015).

The site appears to have been occupied throughout the entire year (Edwards and Pater 2011), in contrast to many villages in the La Crosse terrace (Sasso 1989) where separate summer and winter villages seem to be the norm, or northern Illinois (Jeske 1989, 1990, 2000) where many villages appear to be multi-seasonal but not necessarily year around. Faunal evidence suggests that animal food sources were highly diversified but relied more heavily on mammals than other single source; fish was also a significant proportion of the diet (Edwards 2013; Van de Pas et al. 2015). Previous floral analyses conducted by Jean Nelson, Lee Olsen, and the author, under the supervision of Dr. Katie Egan-Bruhy were conducted on several features from the site. These analyses all showed a similar subsistence pattern – one that included an emphasis on three plants: maize; wild rice; and chenopodium – but also included other EAC plants and an array of wild resources including nuts, berries, and aquatic plants (Edwards and Pater 2011; Egan-Bruhy 2001a; Olsen 2003).

Environmental reconstructions of the region have allowed for the subsistence data to be contextualized (Edwards 2010; Hunter 2002; Jeske and Edwards 2012). This diversified subsistence strategy fits well with its location on the landscape (Edwards 2010). The site sits atop an eight-meter ridge overlooking what would have been extensive wetlands to the east – providing easy access to the aquatic and wetland resources. Most the arable land and upland hunting grounds were to the west of the site.

Koshkonong Creek Village:

The Koshkonong Creek Village was first identified by Stout and Skavlem (1908) but was not subjected to professional research for many decades. Skavlem identified the site based on the dense scatterings of refuse present in the plowed fields – including large amounts of ceramics and mussel shell. They also noted that there were several mounds in the immediate vicinity of the village and that human remains had been recovered by the land owner, which Brown (1909) notes are associated with the village. In 1987, The University of Wisconsin-Milwaukee's Southeast Wisconsin Archaeological Program surveyed the area, though they referred to it as the Twin Knolls (Musil 1987). The walkover survey identified the site as primarily Oneota; most ceramics were shell tempered, though a minority of the materials appeared to be Woodland or older.

Beginning in 2008, field schools under the direction of Robert Jeske began research at the site. In 2008, a walkover survey relocated, expanded the boundaries, identified two large artifact concentrations, and confirmed the Oneota occupation at the site (Cowell et al. 2008). In 2010, additional survey work located the north and east boundaries of the site, and four units were placed in the Woodland portion of the site along the bluff overlooking the creek. A modest concentration of Late Woodland ceramics and projectile points were recovered, but no features

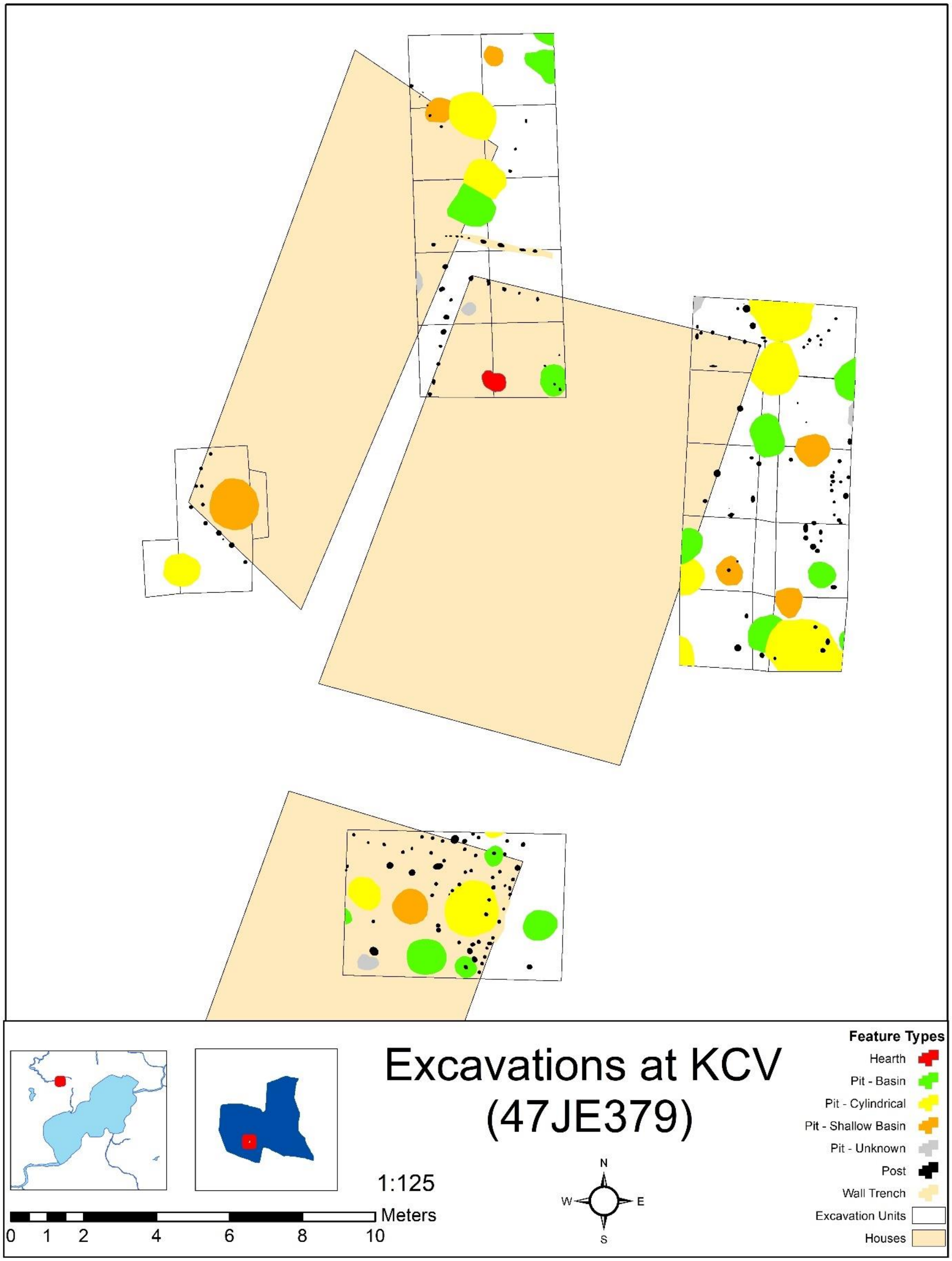


Figure 2.7: Location of Features and Excavation units at KCV (47JE379)

were identified (Pater et al. 2010). Beginning in 2012, biennial excavations began in the Oneota portion of the site. Between 2012 and 2016, a total of 88 m^2 were excavated, and portions of both longhouse and wigwam style structures have been identified. Approximately 25 pit features (Figure 2.7) have been excavated (Edwards 2014a; Edwards and Spott 2012; Jeske et al. 2015; Jeske et al. 2013).

Environmental reconstruction suggest that the site was placed in an atypical location for the locality (Edwards 2010). While most sites were situated along the lake and its associated wetlands, KCV was placed inland along Koshkonong Creek. The site's residents had significantly less access to the wetland/aquatic resources than their regional neighbors. However, they did have greater access to arable land and upland resources. Preliminary faunal analyses indicate that different food procurement strategies were used at KCV than CBHC; a different suite of fish were exploited and large mammals made up a much higher proportion of the overall diet (Agnew et al. 2016; Edwards and McTavish 2012; McTavish and Edwards 2014; Van de Pas et al. 2015). No prior floral analyses have been conducted at the site.

Regional Chronology:

Radiocarbon assays from the two sites indicate that they were both occupied from approximately AD 1050 to 1400 (Table 2.2, Figure 2.8). Dates from Schmeling and Carcajou Point align with the assays from KCV and CBHC, indicating that the Oneota occupation of the locality lasted from the 11th through the 15th Centuries AD. However, the error ranges of the radiocarbon dates make it impossible to determine if the sites were all occupied simultaneously or concurrently.

Table 2.2: Radiocarbon Dates from Koshkonong Locality

Site	Context	Material	Age BP	Error Term	1σ	%	2σ	%	Reference
KCV	F12-06 zL	Bean	520	20	1410-1427	100%	1399-1438	100%	Edwards 2016
CBHC	F04-14 Z2	Maize/ Nut	530	40	1329-1340	17%	1312-1359	30%	Richards and Jeske 2015
					1369-1434	83%	1387-1444	70%	
CBHC	F12-53	Maize Cob	580	15	1322-1347	72%	1314-1357	68%	Jeske et al 2017
					1392-1403	28%	1388-1409	32%	
KCV	F12-06 zB	Residue	605	20	1307-1328	41%	1299-1370	78%	Edwards 2014
					1341-1362	40%	1380-1403	22%	
					1385-1395	19%			
CBHC	F04-14 z6	Residue	590	40	1310-1360	73%	1296-1415	100%	Richards and Jeske 2015
					1387-1405	27%			
KCV	F14-29 zb	Residue	610	30	1302-1328	40%	1296-1403	100%	Edwards 2016
					1341-1367	40%			
					1382-1395	20%			
CBHC	F00-06	Maize/ Nut	600	40	1306-1363	79%	1294-1411	100%	Richards and Jeske 2015
					1385-1400	21%			
CBHC	F00-11	Maize/ Nut	600	70	1300-1368	74%	1279-1432	100%	Richards and Jeske 2015
					1381-1406	26%			
CBHC	F00-26	Maize/ Nut	620	80	1294-1333	39%	1262-1438	100%	Richards and Jeske 2015
					1337-1398	61%			
Carcajou	F15	Wood	660	80	1275-1327	50%	1222-1423	100%	Richards et al. 1998
					1342-1395	50%			
CBHC	F02-01	Residue	690	15	1280-1292	100%	1275-1299	93%	Richards and Jeske 2015
							1370-1380	7%	
CBHC	F0-14	Residue	700	20	1277-1290	100%	1269-1299	95%	Richards and Jeske 2015
							1370-1379	5%	
Carcajou	F12	Wood	700	70	1255-1318	65%	1195-1195	<1%	Richards et al. 1998
					1352-1390	35%	1206-1410	99%	
CBHC	F00-21	Maize/ Nut	720	40	1257-1297	99%	1222-1308	89%	Richards and Jeske 2015
					1375-1375	1%	1361-1386	11%	
CBHC	F04-35	Residue	745	20	1264-1278	100%	1247-1286	100%	Richards and Jeske 2015
KCV	F14-29	Residue	740	25	1263-1281	100%	1226-1232	2%	Edwards 2016
							1244-1290	98%	
CBHC	F04-14	Residue	730	40	1254-1296	100%	1218-1304	94%	Richards and Jeske 2015
							1365-1384	6%	
SCH		Residue	765	15	1257-1273	100%	1224-1234	6%	Richards and Jeske 2015
							1242-1278	94%	
CBHC	F10-29	Residue	765	15	1257-1273	100%	1224-1234	6%	Jeske 2010

Site	Context	Material	Age BP	Error Term	1σ	%	2σ	%	Reference
							1242-1278	94%	
CBHC	F02-40	Residue	750	40	1227-1231	6%	1208-1298	99%	Richards and Jeske 2015
					1245-1284	94%	1371-1378	1%	
CBHC	F04-03	Residue	785	15	1225-1232	21%	1222-1269	100%	Richards and Jeske 2015
					1224-1264	79%			
SCH		Residue	785	20	1224-1234	28%	1220-1271	100%	Richards and Jeske 2015
					1242-1265	72%			
CBHC	F68-01	Wood	760	50	1224-1280	100%	1166-1299	98%	Bender et al. 1970
							1370-1379	1%	
CBHC	F10-98	Residue	795	15	1224-1235	37%	1219-1265	100%	Richards and Jeske 2015
					1241-1259	63%			
CBHC	F68-06	Wood	780	50	1217-1277	100%	1159-1293	100%	Bender et al. 1970
CBHC	F06-63	Residue	800	40	1213-1268	100%	1166-1277	100%	Richards and Jeske 2015
CBHC	F68-10	Wood	800	50	1192-1997	4%	1055-1076	2%	Bender et al. 1970
					1205-1272	95%	1153-1287	98%	
CBHC	F68-26	Wood	810	50	1189-1266	100%	1051-1082	4%	Bender et al. 1970
							1128-1133	1%	
							1151-1284	95%	
CBHC	F10-14	Dog bone	854	21	1169-1177	20%	1156-1228	96%	This dissertation (Appendix B)
					1181-1214	80%	1231-1247	5%	
CBHC	F10-11	Dog bone	856	24	1168-1216	100%	1058-1065	1%	This dissertation (Appendix B)
							1066-1074	1%	
							1154-1252	98%	
CBHC	F04-14	Residue	880	40	1050-1082	27%	1037-1225	98%	Richards and Jeske 2015
					1228-1135	5%	1234-1243	2%	
					1151-1216	68%			
Carcajou	-	Wood	890	80	1043-1103	38%	1016-1271	100%	Hall 1960
					1118-1216	61%			
CBHC	F04-15	Residue	920	40	1043-1104	60%	1026-1192	98%	Richards and Jeske 2015
					1118-1158	40%	1197-1205	2%	
KCV	F12-01	Residue	1000	20	999-1001	3%	989-1044	93%	Edwards and Spott 2012
					1013-1035	97%	1100-1119	6%	
							1144-1145	0%	
Crabapple	Oneota Feature	Wood	980	55	999-1002	1%	909-911	<1%	Spector 1975
					1012-1053	38%	969-1190	99%	
					1079-1152	61%	1198-1203	<1%	
CBHC	F04-22	Residue	990	20	1016-1040	92%	994-1047	78%	Richards and Jeske 2015
					1110-1115	8%	1089-1122	19%	
							1139-1148	3%	
Carcajou	F17	Wood	990	250	777-791	3%	581-1428	100%	Hall 1960

Site	Context	Material	Age BP	Error Term	1σ	%	2σ	%	Reference
					804-842	7%			
					860-1259	90%			
Carcajou	F5	Wood	1010	70	969-1053	60%	887-1190	99%	Richards et al. 1998
					1079-1152	40%	1199-1202	<1%	
Carcajou	F8	Wood	1020	80	900-921	9%	778-790	1%	Richards et al. 1998
					950-1051	61%	810-810	<1%	
					1082-1128	22%	826-840	1%	
					1134-1115	8%	863-1211	98%	
Carcajou		Wood	1020	250	771-1224	99%	557-1415	100%	Hall 1960
					1239-1240	1%			
Carcajou		Wood	1520	250	237-731	95%	-4-1018	99%	Hall 1960
					735-769	5%			

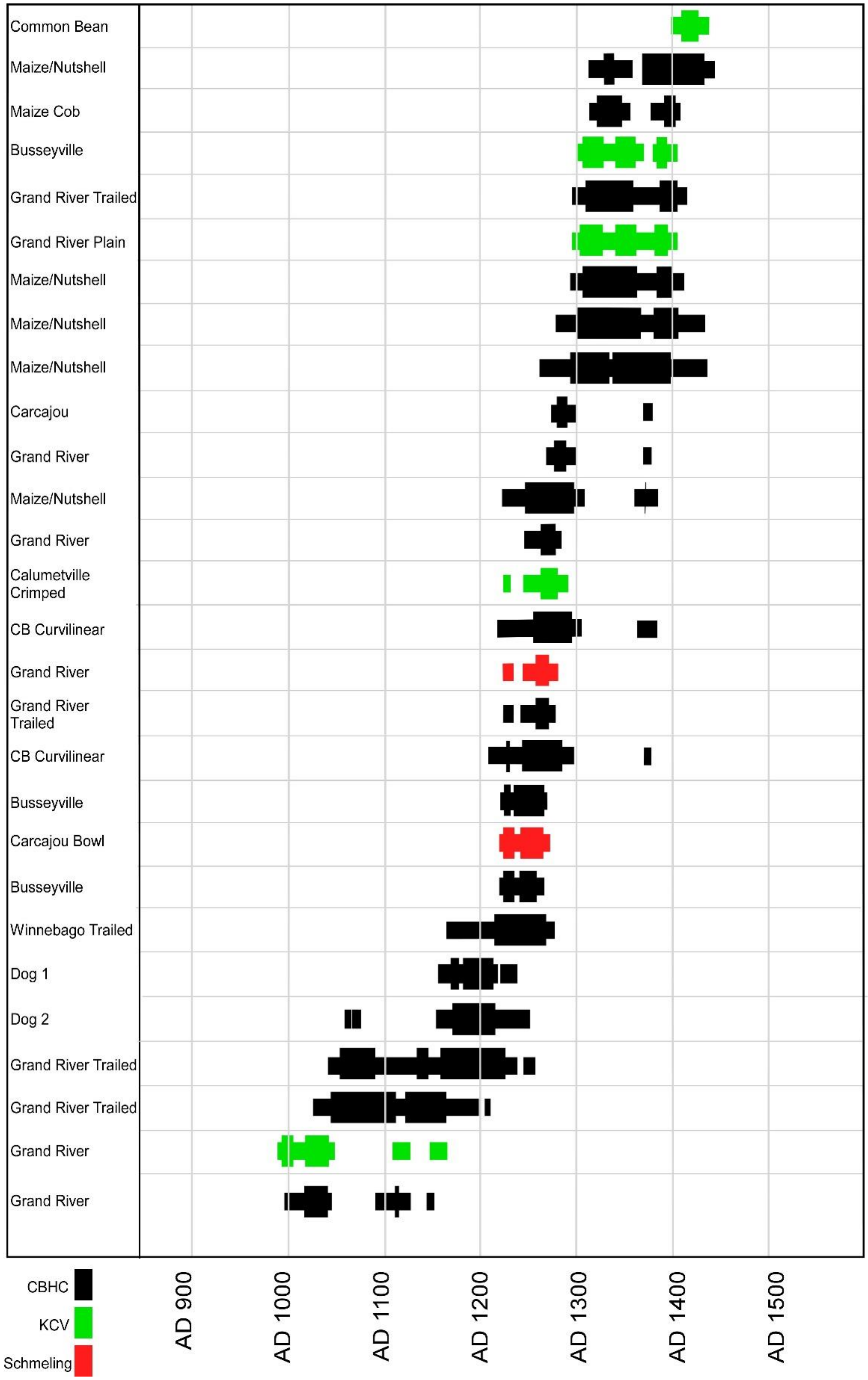


Figure 2.8: 2σ Calibrated AMS dates from CBHC, KCV, and Schmeling (after Edwards 2014a; Edwards and Spott 2012; Jeske 2008)

Descriptions of Comparative Sites:

The following section provides the essential background information for the comparative sites. This includes sites with comparative paleoethnobotanical data, as well as sites where dog isotopic data was collected. The section will discuss sites based on their archaeological culture, and sub-divided by regions/localities.

Upper Mississippian Sites: The sites in this category are both the most numerous and the geographically diverse. A total of 20 comparative sites across three states and nine localities compose this category (Table 2.3). These sites also include the full time-span of Oneota, from circa AD 1050 to 1650.

*Table 2.3: Upper Mississippian Comparative Sites - * 2σ Calibrated Dates - ** No radiocarbon dates available*

Locality	**Site Name**	**Site Number**	**Occupation Range***	**References**
Koshkonong	Carcajou Point	47JE002	AD 1190-1425	Hall (1962) Richards et al. (1998)
Middle Fox	Schrage	47FD581	AD 1000-1380	Schneider and Richards (2010) Egan-Bruhy (2010a)
	Soggy Oats	47WN595		Egan-Bruhy (2001b)
Waupaca	Blinded by the Light	47PT191	AD 950-1350	Hamilton et al. (2010) Egan-Bruhy 2010b
	Dambrowski	47PT160	AD 1000-1400	
	Burley Brew	47PT159	AD 950-1350	
Green Bay	Citgo	47BR460	**	Egan-Bruhy (2012)
	Pamperin Park	47BR389	**	Egan-Bruhy (2012)
Red Wing	Bryan	21GD004	AD 1020-1440	Schirmer (2002)
	Diamond Bluff	47PI002	AD 1020-1450	Rodell (1997)
La Crosse	Tremaine	47LC095	AD 1275-1650	O'Gorman (1995)
	OT	47LC262	AD 1320-1650	O'Gorman (1993)
	Filler	47LC149	AD 1420-1650	O'Gorman (1994)
	Pammel Creek	47LC061	AD 1290-1640	Arzigian (1989); Arzigian et al. (1989); Boszhardt (1989)
	Valley View	47LC034	AD 1020-1650	Stevenson (1994); Stevenson (1985)
	Sanford District	47LC394	AD 1040-1440	Arzigian et al. (1994); Holtz-Leith (2006, 2011)
Northeast Illinois Langford and Fisher	Fisher	11WI5	AD 1045-1400	Emerson et al. (2006); Griffin (1948); Parmalee (1962); Strezewski (2006)
	Zimmerman	11LS13	AD 1050-1385	Brown (1961); Egan (1993); (Jeske and Hart 1988)
	Washington Irving	11K52	AD 1110-1440	Jeske (2000b), Richards and Jeske (2015)
	Hoxie Farm	11CK4	AD 1220-1620	Brown and O'Brien (1990); Jackson and Emerson (2013)

Middle Fox Locality Sites: The Schrage (47FD581) and Soggy Oats (47WN595) sites compose the comparative sites from the Middle Fox Locality (Figure 2.9). Schrage (Schneider and Richards 2010) was excavated in 2009 and is located on the east side of Lake Winnebago. Excavations were restricted to the modern extent of US Highway 151. In total, 86 pit features were identified and excavated. Based on the density of features and the density of the materials they contained, the site has been interpreted as a village site. Calibrated AMS dates range from AD 1000-1380. The site appears to have been occupied year around based on the flora (Egan-Bruhy 2010a).

Dr. Egan-Bruhy at Commonwealth Cultural Resources Group (CCRG) (now Commonwealth Heritage Group) conducted floral analysis. The sample included 35 samples from 29 features. The analytical methods match those used in this dissertation (described in Chapter 4). The results indicated that the population was highly reliant on maize. It was highly ubiquitous (present in 89% of samples) and present in moderate densities (16 ct./10 liters). The high proportion of cupules, glumes, and cob fragments indicates that maize was heavily processed on site, and may have been intentionally used as a fuel source. Nuts were apparently a major secondary resource. Nuts were present in 51% of samples and found in high densities (53 ct./10 liters). Grains were also cultivated as a secondary resource, including chenopodium, barnyard grass, and wild rice.

Soggy Oats is a much smaller site with only five features identified (Egan-Bruhy 2001b). Three of the pit features are interpreted as hearths/roasting pits. A single storage pit and a post mold were also identified. The site has been interpreted as an autumn nut-processing camp. Dr. Egan-Bruhy used the same analytical methods as those used in this dissertation to analyze the

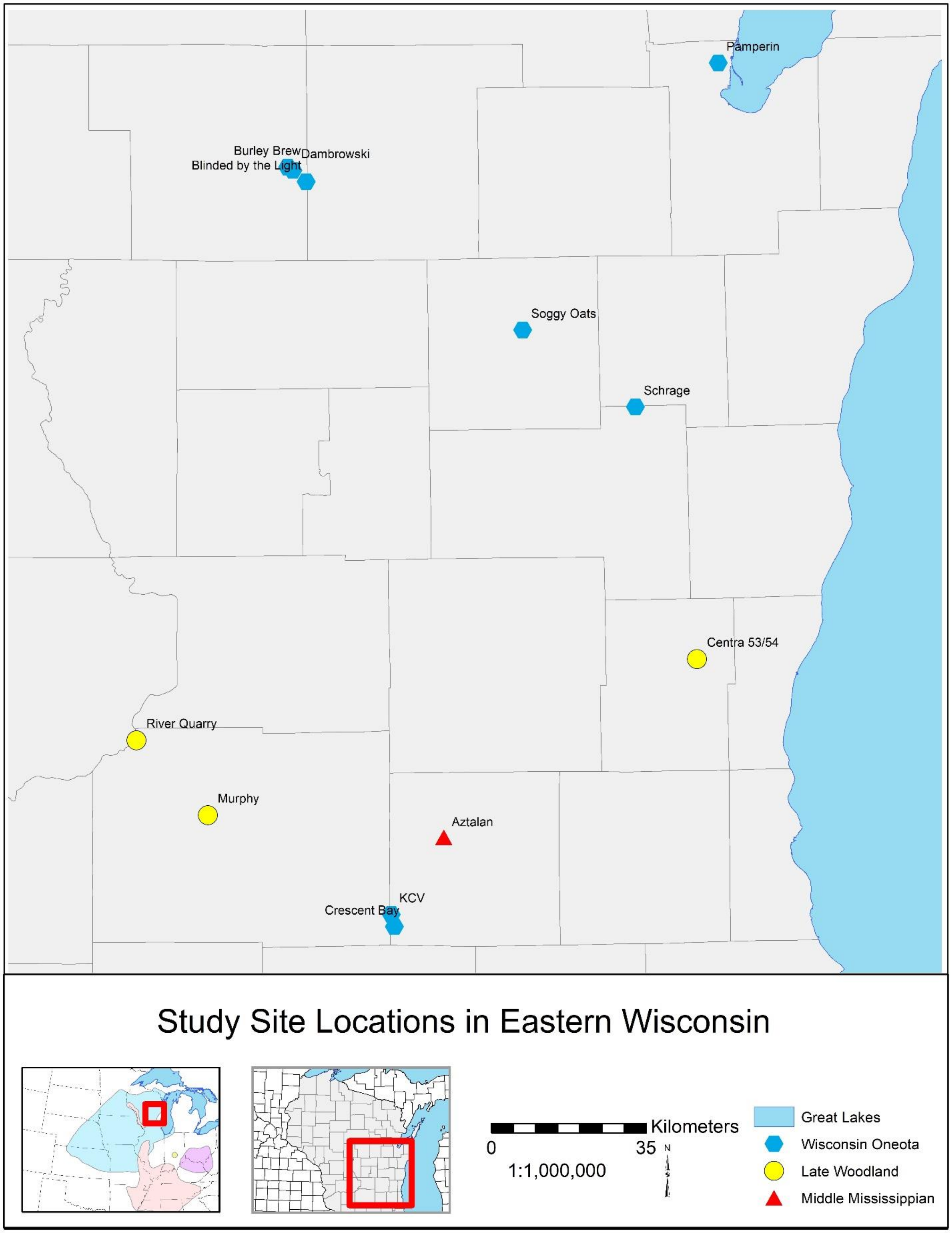


Figure 2.9: Location of study sites in eastern Wisconsin

flora. The sample indicates that maize was an important aspect of the diet, even at campsites. It was found in two of the four pit features. Squash was also present in the sample. Nutshell was found in three of the four pit features, as well as a sampled post mold. Little Barley and Chenopodium were also found at the site. Nutshell was generally present in moderate densities, though Feature 8 contained significantly greater amounts. Despite the site's short occupation, the general dietary patterns are still like Schrage's. Overall, the assemblage is less diverse, though it appears maize was a major component of the diet in the locality regardless of the situation. At Soggy Oats, it is not known if it was brought as a provision, or if there were dispersed agricultural fields near the processing site. Given the six-to-one ratio of cupule/cob fragments to kernels, it is possible that the site also served as a maize field processing location as well. The site does show less diversity of seeds, which is understandable considering the short-term nature of its occupation.

Waupaca Locality Sites: Three sites were chosen for comparison from the Waupaca Locality. Burley Brew (47PT159), Dambrowski (47PT160), and Blinded by the Light (BBTL, 47PT191) are all interpreted as Oneota villages that were occupied from the 11th through 14th centuries (Figure 2.9). The sites were all excavated by the Museum Archaeology Program of the Wisconsin Historical Society as part of the US Highway 10 project. Therefore, the areas excavated were limited to the areas of impact and may not be fully representative of the large sites (Hamilton et al. 2010).

Each of the sites is located near the Waupaca/Tomorrow River in Portage County, southeast of modern Stevens Point. Despite the general proximity, the sites appear to have been differentially placed on the landscape. BBTL, the easternmost site, is roughly 2.5 km north of the river valley, on relatively low ground (20-30 feet lower than the adjacent bluff), and is immediately adjacent to an intermittent stream (Hamilton et al. 2010:3-5). Dambrowski is immediately adjacent to Waupaca River, on high ground, overlooking the river valley. The site is close to the river on three sides; it is largely within the inside curve of an oxbow. Where BBTL occupies the lowest land in the immediate vicinity of the site, Dambrowski occupies nearly the highest. Immediately to the east, a hill overlooks the site, and the village sat 30-40 feet above the river (Hamilton et al. 2010:6-7). Burley Brew, the westernmost site, is less than two kilometers from Dambrowski. The site is multi-component and covers a large area, both along and inland from the Waupaca river. Much of the site is on relatively flat ground (Hamilton et al. 2010:29-30).

The floral analysis at all three of the sites was completed by Egan-Bruhy (2010b) using the same methods as this dissertation. The Burley Brew assemblage included 10 samples, each from a different feature for a total 126 liters. Blinded by the Light contained 58 samples from 39 features for a total of 408 liters. The floral assemblages from all three sites support a warm-season occupation of the villages, from late Spring through early Fall. Blinded by the Light and Dambrowski also contain buds, indicating they were also occupied during the cold seasons, and were likely occupied year around. The lack of cold season indicators at Burley Brew may represent actual seasonal differences, or it may be sampling bias.

Green Bay Locality Sites: The Citgo and Pamperin Park sites are both located in mainland Wisconsin near the west shore of Green Bay, across from the Door Peninsula (Figure 2.9). The sites are along the north shore of the Suamico River. The two sites are separated by less than 500 meters. Pamperin Park directly overlooked the river, Citgo was slightly further inland, approximately 200 meters from the river. Dr. Egan-Bruhy conducted the analysis from the Citgo site, using comparable methods. A total of seven contexts from three features totaling 25 liters of soil were analyzed from the Oneota component of the site. The bulk of the assemblages (excluding wood/bark charcoal) is nutshell. Given the large number of aquatic tubers, the site was likely occupied from during the late spring, and perhaps longer (Egan-Bruhy, personal communication). The relatively high importance of nutshell supports a cold season occupation, with nuts used as a buffer resource to get through the winter.

Pamperin Park was occupied from Early Woodland through Oneota. The density and permanence of the site is ambiguous, "the Late Woodland and Oneota occupations appears to be longer-term occupations characteristic of village sites, although interestingly the range of resources represented suggests a seasonal occupation," (Egan-Bruhy 2012:1). Jean Nelson conducted the floral analysis under the supervision of Dr. Egan-Bruhy using methods comparable to those in this analysis. Approximately 270 liters of soil from 28 Oneota features were analyzed. The presence of buds and the overall floral assemblage is consistent with a cold season occupation of the site. Maize does not appear to be a significant component of the diet, as it is found in low ubiquities and densities. Nutshell is found in much higher densities and ubiquities, which is indicates that nuts were an important aspect of the winter diet at the site, and potentially in the region as a whole (Egan-Bruhy 2012).

Red Wing Locality: The Red Wing locality occupies both sides of the Mississippi River, between modern Minneapolis and La Crosse where the Cannon and Trimbelle rivers join the Mississippi (Figure 2.10). Numerous Oneota sites have been identified in the region, including seven notably large Oneota villages (Dobbs 1984; Fleming 2009; Gibbon and Dobbs 1991; Schirmer 2002). Sites in the region generally date from between AD 1000 to 1450 (Schirmer

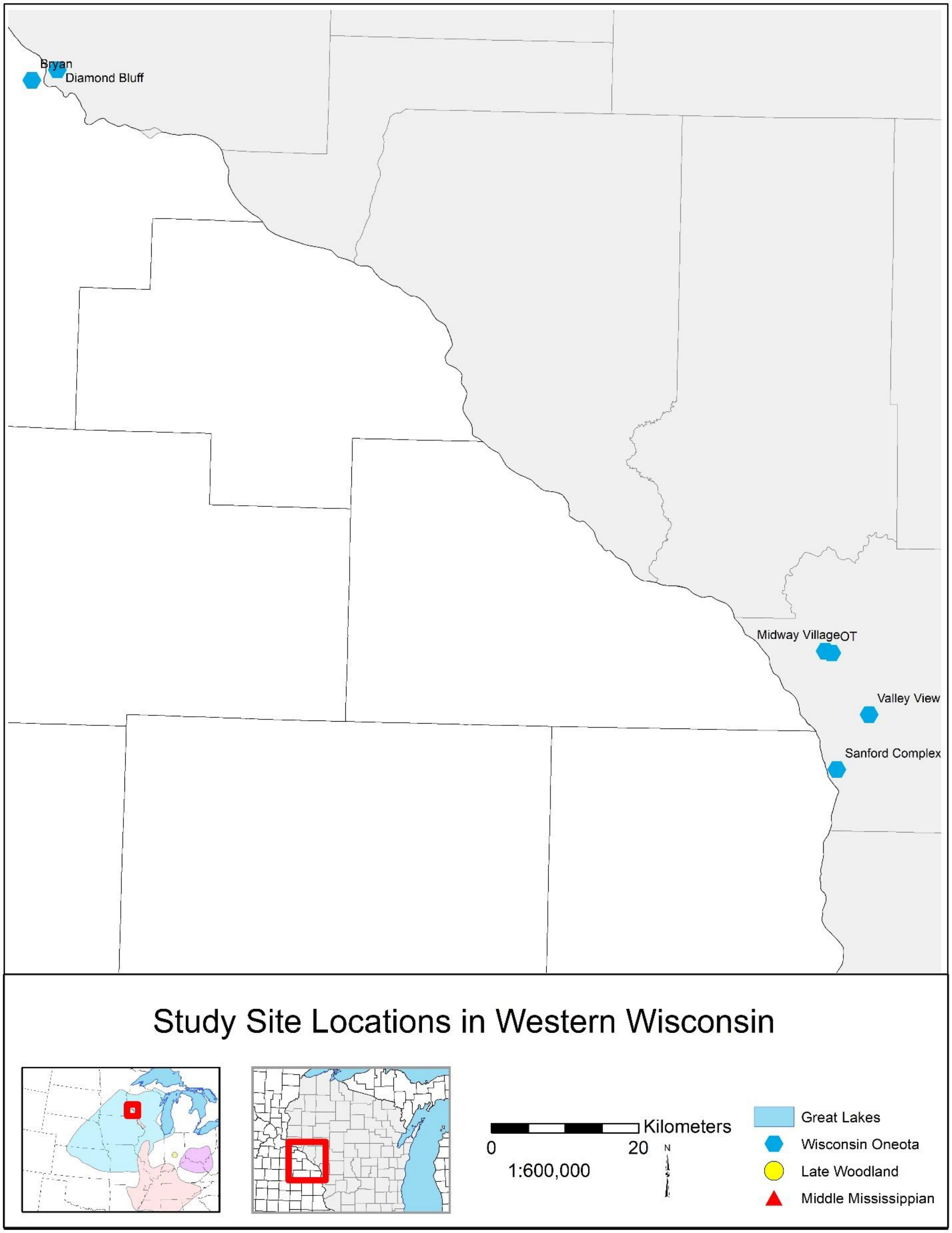


Figure 2.10: Location of study sites in western Wisconsin

2002:56 Table 4.3). Most, if not all the major villages were likely occupied simultaneously (Fleming 2009:151; Rodell 1997:34). Village sites are generally located atop glacial outwash terraces and are often associated with large mound complexes. Fleming (2009) argues that, while interconnected, villages separated by the Mississippi were less connected with one another than with villages on the same side. He attributes the differences in connectedness to distinct resource catchments and different trade networks. Essentially, each site was more connected with trade networks on its own side of the river (e.g., east/Wisconsin side for Diamond Bluff vs. west/Minnesota side for Bryan) and its resource catchment rarely crossed the Mississippi River.

Two village sites from Red Wing were chosen for comparison because they had comparable datasets. The Bryan site, on the west side of the Mississippi includes comparative floral data conducted by Schirmer (2002) and human isotope data (Pratt 1994). His methods were generally similar to those used in this dissertation. The site has a long history of excavation and is the most thoroughly investigated site in the Locality (Schirmer 2002:129). It sits atop a terrace overlooking the Cannon River, includes an associated mound complex, and the village covered approximately eight hectares. Diamond Bluff (also referred to as Mero I), a large village on the east side of the river, includes two dogs, which were submitted for isotopic analysis. The site sits atop the north end of a large terrace, and like Bryan, is associated with many mounds. Also like Bryan, the site has a long excavation history (Rodell 1997). One dog was identified from square G, and the other in square Z (Alex n.d.).

La Crosse Locality: The La Crosse Locality contains a dense concentration of Oneota sites, that primarily postdate AD 1200 (Boszhardt 1994; Overstreet 1997). The site settlement system in this region is multi-layered and dynamic, consisting of seasonal villages of multiple sizes, and associated hamlets, mortuary sites, and logistical camps (Sasso 1989). The primary comparative sites, Tremaine, Filler, and OT (Figure 2.10), are part of what is commonly referred to as the Tremaine Complex as each of the sites are in close proximity to one another near Halfway Creek (O'Gorman 1994). The Museum Archaeology Program, under the direction of Dr. Jodie O'Gorman, excavated each of the sites (O'Gorman 1995). Multiple analysists conducted the floral analyses, but all used the Illinois Department of Transportation method designed by Wagner and are comparable to the methods used in this dissertation (Hunter and Berg 1993). Generally, most of the sites were occupied towards the end, or after, the Koshkonong Locality occupation. The earliest of the three sites is Tremaine which appears to have first been occupied starting between AD 1300-1400. The site was most heavily occupied between AD 1400-1500, with evidence of a minor occupation after AD 1500 (O'Gorman 1995). The bulk of the OT occupation was also during the Valley View phase, primarily in the early AD 1400s, with portions of the site occupied in the earl-to-mid 1600s (O'Gorman 1993). The Filler site was occupied the latest, post AD 1600 (O'Gorman 1994).

A total of eight dog samples from four La Crosse area sites were selected for isotopic analysis. Two were from the previously described OT site, and were recovered from O'Gorman's (1993) excavations in two different levels of Feature 3. Samples were obtained from the Wisconsin Historical Society with the assistance of Angela Glasker. Two dog mandibles were obtained from the Valley View site, one from Pammel Creek, and one from the Sanford Archaeological Complex (generally near/within the Gunderson site).

The Pammel Creek site was excavated several times, but Mississippi Valley Archaeological Center (MVAC) conducted the most significant excavations in the 1980s. These excavations uncovered a large portion of the site, including numerous pits, houses, and other features from the AD 15th century village site (Arzigian and Boszhardt 1989). Using the radiocarbon dates and ceramics Boszhardt (1989) argues that the site was primarily occupied in the first half of the AD 15th century. Arzigian and Boszhardt (1989:33) argue that the site occupation was “relatively short-term.” The exact size of the site is unclear, but is at least 2.5 hectares. The site is named for the artificial creek it abuts, and is within one kilometer of the Mississippi River and its associated wetlands (Arzigian and Boszhardt). The site shows definitive evidence of occupation from late spring through to early fall (Arzigian et al. 1989).

The floral remains were analyzed from the site by Arzigian (1989); however, the domesticates (e.g., maize) were not quantified in the same manner as used in this dissertation so they were not included in the macrobotanical comparison. Radiocarbon dates from the site range from AD 1280-1640, but most have large two-sigma ranges making it difficult to narrow the range with radiocarbon dates alone. Permission to do destructive testing on dog remains from the site was granted by MVAC. Dr. James Theler identified the single dog from the site. Theler removed a sample from the mandible, with the assistance of myself and Dr. Constance Arzigian. The sample was then sent to the University of Utah.

The Valley View site overlooks the La Crosse River, about 6.5 kilometers northeast of its confluence with the Mississippi River (Stevenson 1994:237). The site was excavated by MVAC as a CRM project, and the University of Wisconsin-La Crosse as a field school. The bulk of the occupation was between AD 1500-1600; however, a small number of early radiocarbon assays have been obtained that range from AD 1020-1330. These early dates are generally discarded as erroneous because they are earlier than all other previously reported Oneota dates in the region and the ceramics were consistent with a later-dated assemblage (Stevenson 1994) based on the La Crosse ceramic chronology (Boszhardt 1994). Theler identified a total of two dog mandibles.

Like Pammel Creek, MVAC gave permission for the destruction of the mandibles. Samples were removed in La Crosse prior to being sent to Utah.

The Sanford Archaeological district is in southern La Crosse, within the city boundaries. Due to the density of modern occupation, numerous construction projects have required periodic archaeological investigations, most notably by MVAC. They have found a large-scale Oneota occupation dating roughly between AD 1300-1500 (Holtz-Leith 2006, 2008). Much of the Sanford Archaeological District is atop a terrace, running from the base of large bluffs to the east of the site, and overlooking the Mississippi River to the west (Holtz-Leith 2008). During the excavations of the Seventh Street Project in 1999, dog remains were identified in Feature 37 (Holtz-Leith 2006). One mandible was selected for analysis. Two additional dogs were identified from the 1991 excavations in features 59 and 516 (Arzigian et al. 1994), and used for this analysis. Identification, sampling, and permissions for both samples are the same as described for Pammel Creek.

Illinois Sites: Comparative floral material was used from three Upper Mississippian sites in northern Illinois (Figure 2.11), and comparative dog remains were identified from one additional Upper Mississippian site in northern Illinois. These sites span nearly the entire geographic range of Upper Mississippian in northern Illinois, and include sites from the Fox/Des Plaines (Washington Irving), Chicago Lake Plain (Hoxie Farm), and Upper Illinois River localities (Fisher and Zimmerman). The only area major habitation area without any comparative sites is the Rock/Kishwaukee Locality. The sites also encompass both archaeological cultures present in the region that were contemporaneous with the Oneota occupation of the Koshkonong Locality, Fisher and Langford.

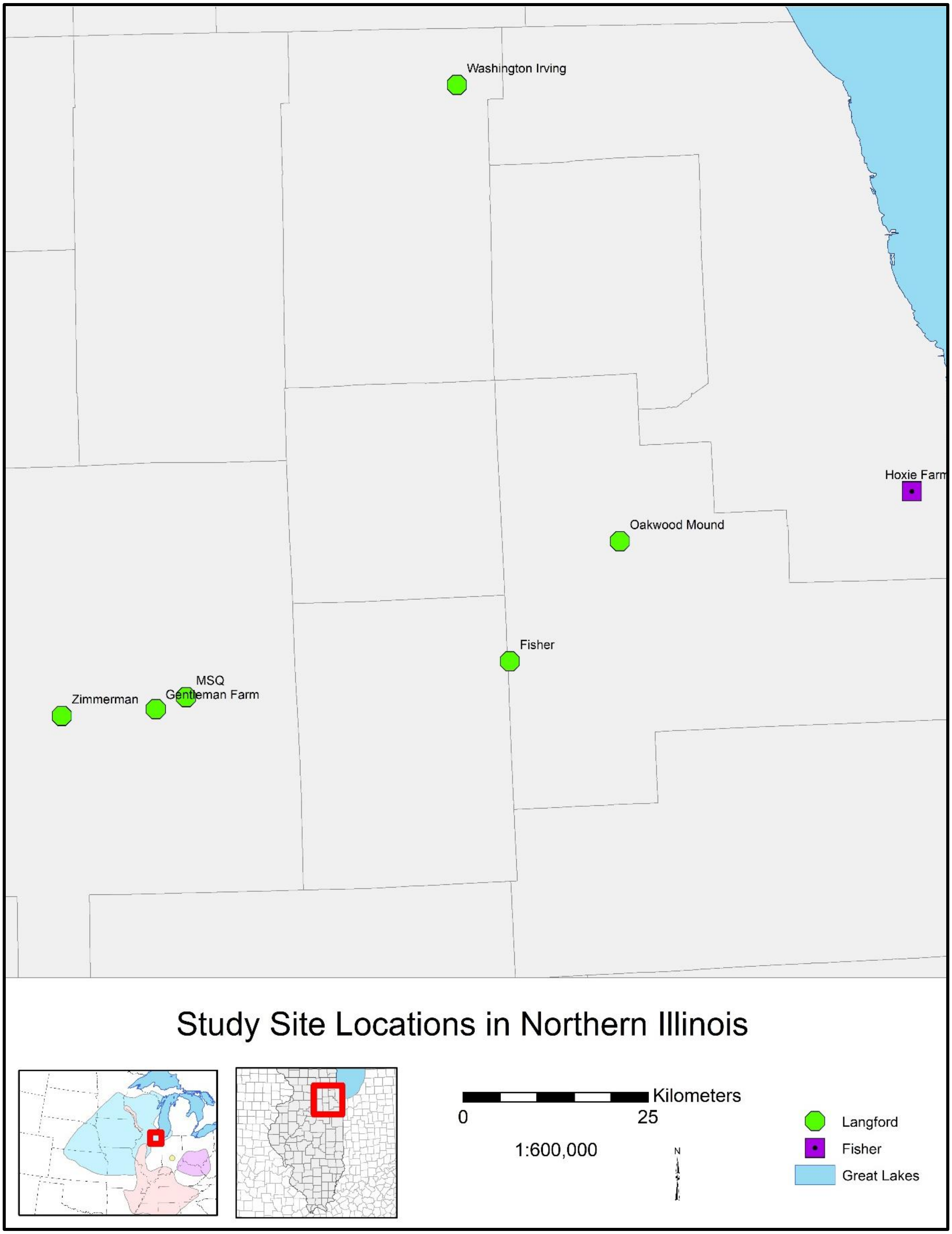


Figure 2.11: Location of study sites in northern Illinois

The Washington Irving site sits on a terrace overlooking Jelkes Creek, a tributary of the Fox River. The site boundaries cover approximately 4 hectares (Jeske 1990, 2000). The site was noted historically by an American expedition that crossed the region in 1817, and again by the General Land Office surveyor in 1838 (Jeske 1990). The explorers described likely earth lodges while the GLO surveyor simply noted the presence of mounds. Excavations conducted by a field school under the direction of Jeske confirmed that these were not mounds but the remnants of earth lodges. A series of 13 radiocarbon assays date the site between cal AD 1000 and 1440 (Jeske 1990; Richards and Jeske 2015). The site is normally described as a multi-seasonal site, with direct evidence of occupation for spring through the fall (Jeske 1990, 2000). The insulated nature of the earth lodges would have been ideal for winter heating, so it is likely that the site was occupied year around (Jeske, personal communication). Floral remains from 35 features excavated in 1984-1985 were examined by Egan-Bruhy using methods comparable to those in this dissertation. Flotation volumes from three features (F28, 30, and 31) are not known. Because the density of floral remains could not be determined from these contexts, they were discarded from the comparative analysis (Jeske 2000).

Two sites from the Upper Illinois River Valley were included in the analysis. The Zimmerman site was used for its comparative floral data. The Fisher site has dog remains for isotopic testing as well as previously published human isotopic data (Emerson et al. 2010). Zimmerman is a multi-component site with a long history of archaeological investigation dating back to 1947 (Brown 1961; Brown 1975; Jeske and Hart 1988). The site extends over a mile on a terrace along the northern banks of the Illinois River; however, the various components are largely separated via horizontal stratigraphy (Brown 1961). The prehistoric components include Late Woodland and Langford, while the historic Danner components is associated with the Illini village first encountered by Marquette and Jolliet in 1673, and is where Marquette returned to found the Mission of the Immaculate Conception in 1675 (Brown 1961).

While the historic Illini occupation has been a major focus of investigations (e.g., Brown 1961, Brown 1975), its late prehistoric Langford occupation is of relevance for this research (Brown 1961; Jeske and Hart 1988). The site is situated near many other important sites in the Upper Illinois River Valley, including Material Service Quarry (MSQ), Gentleman Farm, and others (Brown and O'Brien 1990; Brown 1967; Emerson et al. 2010). The floral materials all come from the Langford component of the site, located in Grid D (Brown 1961). Five of the twelve samples come from Northwestern University 1987 excavations conducted under a grant from the National Park Service (Jeske and Hart 1988). The remainder comes from 1991 field school excavations, under the direction of James. A. Brown (unpublished). Katie Egan-Bruhy conducted both analyses with comparable methods to those used in this analysis (Egan 1993a; Jeske and Hart 1988).

The Fisher site was first excavated by the George Langford (1927) in the early 20th Century and has been subjected to intermittent, yet considerable archaeological research (Emerson et al. 2006; Griffin 1946, 1948; Horner 1947; Langford 1927; Parmalee 1962; Strezewski 2006). The site is multi-component and was occupied by both Langford and Fisher groups sequentially (Griffin 1946, 1948). It is located atop a roughly 10m tall terrace overlooking the Des Plaines River, near the confluence of the Des Plaines and Kankakee Rivers, which forms the headwaters of the Illinois River (Langford 1927). In total, 50 houses and 12 burial mounds have been identified; many of them have been excavated and analyzed (Griffin 1948). The sample from the site includes two definitive dogs and one potential dog from Langford deposits (Edwards et al. 2017). Additionally, 29 individuals from the mounds were analyzed isotopically by the Illinois State Archaeological Survey and provide greater understanding of the dietary range at the site (Emerson et al. 2010). The site is contemporaneous with the Oneota occupation of Koshkonong (Edwards et al. 2017; Emerson et al. 2006).

The Hoxie Farm site has a long history of archaeological inquiry (e.g., Brown and O’Brien 1990; Jackson and Emerson 2013; Jackson 2017). It overlooks the Little Calumet River southeast of modern-day Chicago. The area surrounding the site was reported to have included a mixture of wetlands, forests, and prairies (Meyer 1952) (Figure 2.16). Marshes were abundant east of the site, and prairie to the south (Brown and O’Brien 1990). The most recent radiocarbon assays from the site range from the 13th through 17th centuries (Jackson and Emerson 2013) and include both Fisher and Huber components (Brown and O’Brien 1990; Jackson and Emerson 2013). The Fisher component, excavated by the Illinois Transportation Archaeological Program (ITARP) and uncovered a significant portion of a large prehistoric fortified village (Jackson and Emerson 2013). Jean Nelson and Dr. Egan-Bruhy conducted the floral analysis of 31 features, totaling more than 500 liters. Feature types include hearths, earth ovens, and trash pits. Analysis was conducted using methods comparable to this dissertation (Egan-Bruhy and Nelson 2013). The Illinois State Archaeological Survey (ISAS, formerly ITARP) recently completed analysis on a larger portion of the site, including Fisher and Huber components (Jackson 2017). Their analyses included both radiocarbon and dietary isotopes; however, 20 out of 43 samples were rejected for differing reasons. Given the high failure rate, these materials are not included in this analysis.

Summary: All the Langford and Fisher sites in this study appear to have been occupied year around based on house type; all appear to be villages; and to have been occupied (or reoccupied) for a similar length of time as the Koshkonong sites. The combined datasets are geographically representative of three distinct localities, covering most of the Upper Mississippian territory in northeastern Illinois. They also include both distinct archaeological cultures that were present in the region concurrent with the Koshkonong Occupation.

Late Woodland: Several Late Woodland sites were selected to provide comparative data (Figure 2.9). To fully contextualize the Koshkonong subsistence strategy, both collared and non-collared ware sites in southeastern Wisconsin were sought. However, there are relatively few sites with available macrobotanical or isotopic data available.

Two non-collared ware sites were selected; one with macrobotanical data, and the other with isotopes. Nitschke Mounds, an Effigy Mound site, is in Dodge County near the Horicon Marsh (Kaufmann 2005) was first excavated by W. C. McKern (1930). A single dog, buried in Mound 21, was subjected to isotopic testing and has been previously reported (Edwards et al. 2017).

Centra 53/54 is a small habitation site located in Washington County. Commonwealth Cultural Heritage Group (CCRG) excavated this multicomponent site as part of a Phase III mitigation. The limited excavations identified both Late Archaic and Late Woodland components (Egan 1993b). The site is clearly Late Woodland, but the two rim-sherds make precise identification difficult. Neither of the identified rims contained collars. The identifiable body sherds were of the Madison type, often associated with non-collared ware sites; however, sites with both have been noted (Clauter 2003, 2012). The site was situated in a diverse environment near the Milwaukee River; multiple swamps, lakes, and other wetlands were present in the immediate vicinity of the habitation. The single radiocarbon-date, taken from wood charcoal, indicates that the site was occupied contemporaneously with the Koshkonong Locality (2σ range: cal AD 1300-1625). The floral analysis of eight units including two definitive features were analyzed by Egan-Bruhy using comparable methods. There are few indicators of seasonality, and Egan-Bruhy argues that the assemblage, with little very low densities, is not inconsistent with winter storage (Egan 1993:45). I tentatively identify this site as a low-intensity non-collared ware warm season occupation.

Two collared-ware camps were also used for comparison. Murphy and River Quarry were both excavated by the Museum Archaeology Program (MAP). The sites are multi-component, but include a substantial Late Woodland component, denoted by the presence of collared ceramic vessels. Radiocarbon dates span from Murphy span from cal AD 400- 1300. River Quarry dates are more constrained, between cal AD 1000-1300, so both sites are contemporaneous with Koshkonong. Both sites are in Dane County, but Murphy is adjacent to a wetland near Lake Mendota. River Quarry is near the Wisconsin River (Hawley 2011). Floral analysis was conducted by Egan-Bruhy using comparable methods. Faunal and floral data both clearly indicate a fall through winter occupation of the sites (Hawley 2011:286).

Middle Mississippian: Two Middle Mississippian sites were chosen for comparison to Koshkonong. The first, Aztalan (Figure 2.9), has been excavated for decades starting with Barrett (1933) in the early 20th century. Aztalan is in Jefferson County, along the banks of the Crawfish River. The Crawfish is a tributary of the Rock and Aztalan is only 25km up river from the Koshkonong sites (Richards and Jeske 2002:34). The site has been occupied since the Paleoindian period (Goldstein and Richards 1991; Sampson 2008), but it is best known as a large Late Woodland site occupied by Middle Mississippians (e.g., Barrett 1933; Goldstein and Richards 1991; Richards 1992). Zych (2013) has argued that the manner in which the northeast mound was constructed, and associated ceremonies, indicates a creolization or merging of a Mississippian group from the American Bottom and a local Late Woodland group that was already living at the site. The site was heavily fortified with a palisade, built with substantial posts (Barrett 1933; Goldstein and Freeman 1997; Birmingham and Goldstein 2005). Recent radiocarbon dates make clear that the Middle Mississippian occupation occurred between AD 1100 and 1250 (Richards and Jeske 2002).

Picard (2013) analyzed the paleoethnobotanical data from the site. Her dataset contains samples from two different field seasons, and from before and after the arrival of the Middle Mississippians and the subsequent restructuring of the site. Picard's methods followed the same procedure as this dissertation. The Late Woodland context samples from the 1984 field season do not have associated soil volumes, making them incomparable to other sites. However, the Middle Mississippian occupation samples are directly comparable to other sites in this dissertation. Also, the Aztalan Late Woodland data can still be used for diversity indices because they are based on raw counts, rather than density.

Lundy is the other Middle Mississippian site. Set in the Apple River Valley of northwestern Illinois, the site is approximately 1.2 hectares in area, and has been excavated intermittently since the 1980s (Emerson et al. 2007:1-5). The site is situated above the Apple River, just north of its confluence with the Mississippi River, and its Mississippian occupation ranges from AD1100-1350 (Emerson et al. 2007:11-12). Botanical analysis of samples from Center for American Archaeology excavations was conducted by the Illinois State Museum on behalf of the Illinois State Archaeological Survey. The methods used were broadly comparable to my own. The results of the analysis were published in a comprehensive interpretation and overview of the site (Emerson et al. 20007).

Summary:

KCV and CBHC, two Oneota sites from the Koshkonong Locality, are compared to contemporaneous Middle and Upper Mississippian and Late Woodland sites in southern Wisconsin and northern Illinois. The two Koshkonong sites are clustered along Lake Koshkonong in southeastern Wisconsin. Radiocarbon evidence indicates that both sites were occupied from ca. cal AD 1050 until 1400. Oneota subsistence systems are generally described as diversified with emphases on maize agriculture, EAC cultigens, wild plants, hunting and fishing (e.g., Brown 1982; Egan 1988; Egan-Bruhy 2014; Hart 1990; Simon 1999; Theler 1989, 1994). To test this inference, macrobotanical and isotopic data have been collected from other Upper Mississippian sites in eight localities (two in western Wisconsin, three northern Illinois, three in eastern Wisconsin), as well as three Late Woodland and two Middle Mississippian sites. Except for La Crosse, each of the comparative sites is largely contemporaneous with the Koshkonong Locality, though several have shorter occupational spans (e.g., Aztalan). The Middle Fox Locality was occupied longer than the Koshkonong sites, but Schrage and Soggy Oats are contemporaneous with KCV and CBHC.

3. Risk Management and Other Theoretical Considerations

Introduction:

Cultural and environmental instability instills a risk for failure into all subsistence systems (e.g., Kipnis 2002). When insufficient food is obtained for the entire population, some level of starvation and death follow. However, through cultural adaptations, humans make efforts to mitigate and buffer against such occurrences and embed these practices into several cultural systems beyond just subsistence (Cashdan 1990a; Halstead and O'Shea 1989b; Winterhalder 1986). Halstead and O'Shea (1989b) argue that the study of these cultural constructions can inform on an array of anthropological questions, from the functional, about the nature of economic systems, to questions concerning long-term cultural change. In their seminal volume, Halstead and O'Shea (1989a) highlight several ways that investigations into risk management strategies can help to explain large-scale cultural shifts. For example, O'Shea (1989) highlights the role of trade and warfare in early historic North American groups. He stresses that the nature of the risk buffering activities, their effectiveness, and the cost to implement them is in part responsible for shaping relationships with neighboring groups and impacts the direction of regional politics. Garnsey and Morris (1989) argue that redistribution of stored surpluses played an important role in the development of early Greek city-states. Minc and Smith (1989) argue that regular changes to risk buffering mechanisms eventually created conditions where social mechanisms had sufficiently developed to allow for large communal hunts in northern Alaska. They contrast this risk buffering strategy to the development of Alaskan coastal groups’ reliance on whaling, which led to increased territorial defense and competing networks of alliances.

The sources and the nature of variation in food productivity are an important factor to consider. Predictability, scale, and the severity of variation are of particular importance.

Following Halstead and O’Shea’s (1989) definitions, predictability refers to the ability of prehistoric groups to foresee variation in productivity or output accurately. For example, winter in temperate climates is predictable. Anyone living in a temperate climate knows that there will be certain times of the year where low temperatures and snow make plant resources scarce, many animals migrate or hibernate, the remaining animals become leaner. Furthermore, most tasks become more difficult (e.g., transportation increases with snowfall, greater amounts of firewood are needed for heating purposes, etc.). While the exact timeline may vary from year to year, the overall pattern is well known and easily predicted. In regions like Wisconsin, regardless of severity, winter will be a lean time. While the severity may vary, the same general plan of provisioning food and firewood will generally hold true. The best way to survive winter is to already have all the resources you need before it starts. However, the success of these plans is often determined by the level of productivity during the warmer seasons, and typically must be bolstered by winter hunts, ice fishing, and other activities. These buffering actions are subject to unpredictable weather events, like storms or atypical temperatures. Some form of these events can occur year around.

These other factors are less predictable. For example, droughts or blizzards occur with little warning, which makes planning for them difficult. Taking steps to mitigate drought every year may be a costly endeavor. If so, it is less likely that everyone in a group would be willing to maintain the costly behavior after several good years, or during years where other unpredictable events necessitate alternate actions. Furthermore, the severity and scale of a drought may vary from event to event. While droughts may be relatively unpredictable, in many regions they can be expected to occur at least a few years each decade. If a particularly bad drought (extremely dry, extremely long, or a combination of both) occurs, typical mitigation tactics may not be successful. Furthermore, the range of areas affected can vary from event to event. A drought may extend over an entire region, or it can affect a much smaller area. The scale will greatly affect the range of viable mitigation options. Each source of variation has its own parameters for scale, severity, and predictability. Hail storms, for example, are extremely unpredictable, highly variable in severity, and tend to be very localized in their effects. The result, regardless of steps taken, food returns will not be consistent annually. Since, in any given year, the final food yields cannot be predicted, it is essential for all group to attempt to employ mechanisms that will reduce the overall likelihood of food scarcity the most. Since different threats may require contradictory strategies, there is often no way to know if the appropriate strategy was used until it is too late. Risk buffering strategies are essentially wagers. Like any gambling, understanding the probability of various outcomes is key (Cancian 1980; Cashdan 1990; Fleisher 1990; Gladwin 1980; Halstead and O'Shea 1989b)

Risks are often divided into two types based on their source: social (typically threat of warfare) and environmental (long-term: climate shifts; short-term unexpected weather patterns or seasonal variation) (Hart 1993). These two types of risks are usually mitigated with opposing strategies. Environmental stress can be mitigated through mobility; people can move to an area less affected by the current conditions or expand their range so that they can access resources that are less affected. Both forms of mobility tend to reduce the importance of agriculture because people are less capable of investing in the landscape (Jones 2005), whereas the threat of warfare tends to increase it. As outside groups become more threatening, pulling in to a defendable territory and intensifying agriculture can allow the population to remain relatively safe and fed (Hart 1990; 1993). Marston (2011) makes a similar argument; he argues that agricultural groups tend to focus on one of two primary strategies: diversification and intensification.

Hart (1993) points out that many strategies can operate in conjunction with each other to bolster their effect. For example, modifications to local kin-networks (Minnis 1985), and/or regional alliance and trading networks (O'Shea 1989) together can have a stronger effect than either alone. The greater the risk, the more likely people are to include larger networks of people (Minnis 1985). However, for the trade networks to be beneficial a high degree of environmental complexity is needed. If trading partners are facing the same issues because they are in the same environmental contexts, trade will be ineffective (Halstead and O’Shea 1989a). By understanding which risk-management techniques are used, it is possible to make inferences about the social and physical environments, and potentially better understand the nature of social relationships; both those creating and mitigating risks.

Defining Risk:

Risk, as used by archaeologists, often refers to the potential for loss (Marston 2010, 2011). For example, each year agricultural groups face the potential for an early frost, hail storm, or numerous other events that can kill the crops before they can be harvested. Economists and ecologists typically use the term risk to refer to the probability of particular return rates, or the variance of the yields (Fleisher 1990). For example, resource A has a mean return rate of X and a variance of Y. When a known diet and risk levels are compared to the required intake levels, it can be predicted how often the whole diet, or individual aspects of the diet will produce insufficient returns (e.g., Cashdan 1990a; Fleisher 1990; Fitzhugh 2001; Stephens and Charnov 1982). Studies in risk management often look at these predicted return rates and measure the effects of various diet modifications or other risk buffering mechanisms (e.g., Byers et al. 2016 –

storage; Goland 1993 – field scattering; Scarry 1993 – crop diversification; Kuznar 2002, Winterhalder 1986 – food sharing).

Also of importance is the concept of uncertainty. For anthropological research, the concepts of uncertainty and economic risk are often merged; however, economists and ecologists typically use the term uncertainty to refer to chance occurrences that cannot be predicted (Fleisher 1990; Marston 2011). For archaeologists working with past human populations, the terms bear little operational difference. The people under study can rarely assign precise probability values to many of the variables that are faced, so most factors, at best, can only be loosely predicted (Marston 2010, 2011).

Using the economic definition of risk, ecologists created a means to determine what plants should be included in a diet, and the associated risk of failure of such a diet. This method assumes that risk is based on stochastic variation, so the probability of the return rates can be expressed as an equation or graphically (Stephens and Charnov 1982). This model is referred to as the Z-score model. By graphing several procurement strategies together, it allows for easy interpretation of the utility and risks associated with each and determining which is the most appropriate. Stephens and Charnov's (1982) model has been described by many scholars (e.g., Bettinger 1991:118-123; Byers et al. 2016; Gremillion 1997; Marston 2010, 2011:191-192; Winterhalder 1986:374-375; Winterhalder, et al., 1999:307-310).

Figure 3.1 depicts two alternate subsistence strategies relative to the minimum required return rate (line R). So long as the return rate remains to the right of R, the group will fill their dietary requirements successfully. Strategy A (red line) has a lower mean rate, so it has a lower maximum potential than Strategy B. However, it has a low variance, so the amount returned is highly predictable. Conversely, Strategy B has a high variance, so it also has the potential to produce both the highest and the lowest return rates (i.e., it represents a high-risk and high reward scenario).

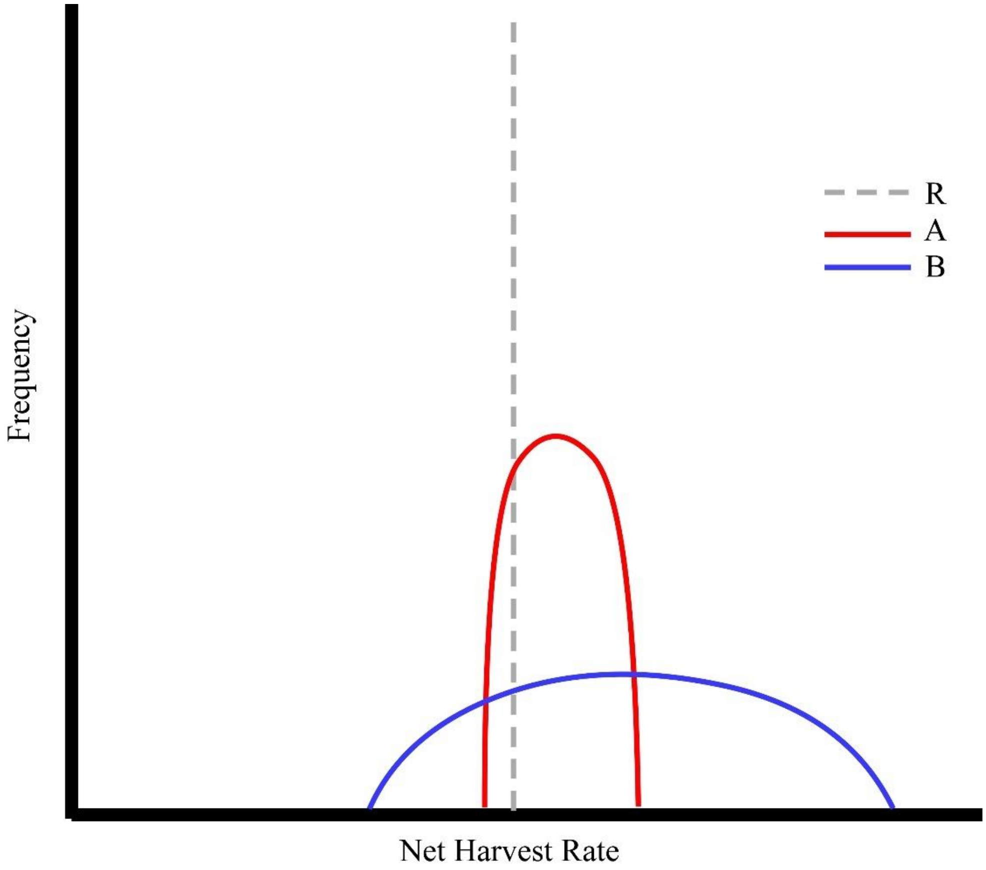


Figure 3.1: Hypothetical Z-Score Model where A and B represent two different subsistence strategies and R represents the minimum required harvesting rate to feed the population. The portions of the curves for A and B left of R represent risk. While the mean return rate of B may be higher than the mean return rate of A, it also has a higher variance. In this case, the high variance also means it has a higher proportion left of R and so it has the potential to be the most profitable, but also carries a higher risk of starvation.

Just because Strategy A has a lower risk, it does not necessarily mean that it will be the option chosen. If R were higher, relative to the two strategies, such as in Figure 3.2, both scenarios would offer a low chance of feeding the population. In these cases, experimental and ethnographic data indicate that people will likely choose the Strategy B, the high-risk option (see Cashdan 1990). Altogether, the evidence indicates that most people choose to minimize risk, unless they are caught within an already precarious situation (Henrich and McElreath 2002; Stephens 1990; Stephens and Charnov 1982).

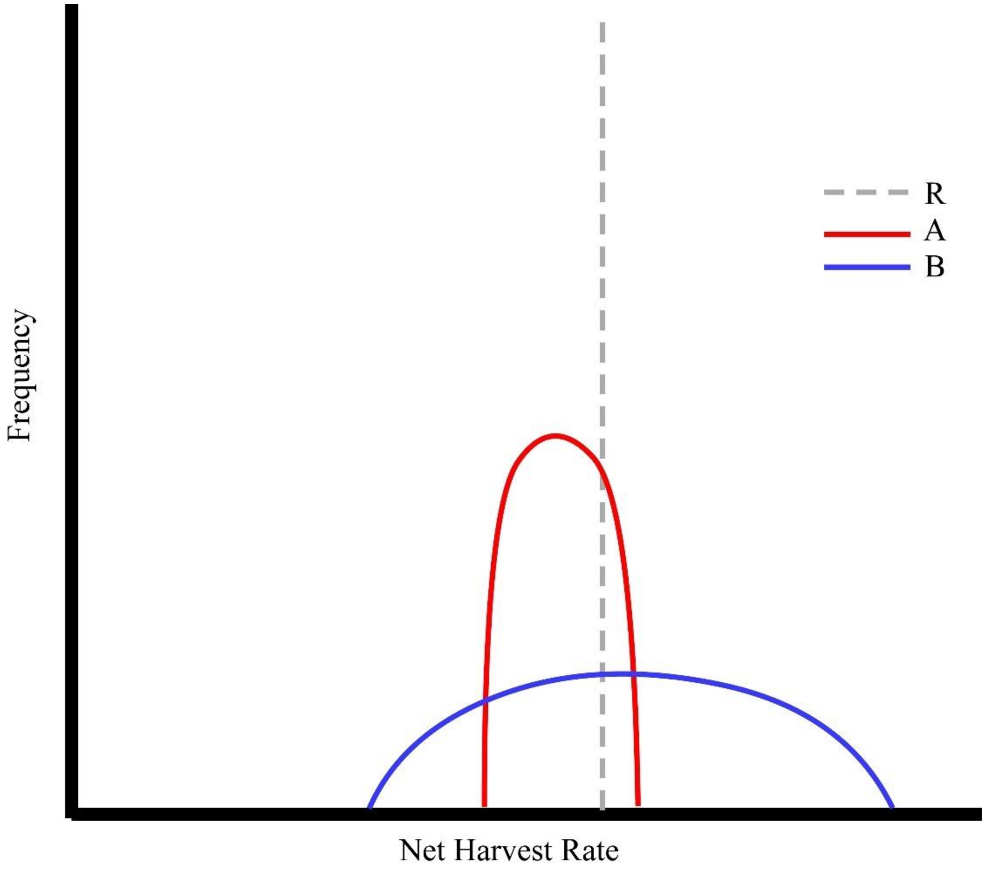


Figure 3.2: Z-Score Model with increased R

General Risk Management Techniques:

The z-score models demonstrate that every subsistence system has inherent potential, and corresponding limits, which are determined by a variety of factors (e.g., populations size, technology, annual precipitation, etc.). Under non-extreme situations (e.g., Figure 3.1), the strategy with the lowest risk has the greatest consistent chance of success. Generally, we should expect groups to implement the subsistence strategy with the lowest variance (i.e., least risky). While many techniques to reduce variance are not mutually exclusive, some are poorly compatible, thereby constraining human action. Therefore, information about the specific techniques used to minimize risk can allow for inferences about the contexts, both social and environmental, in which people chose to implement the strategies (Cashdan 1990a; Halstead and O'Shea 1989b; Marston 2010).

There is a wide array of social structures in which risk management strategies can manifest. The techniques chosen are dependent on the specific cultural, economic, and environmental contexts for a given society (e.g. Halstead and O'Shea 1989b; Hart 1993). Hallstead and O'Shea (1989b) divide strategies into four categories: mobility; diversity; storage; and exchange. Marston (2011) divides them into two broad categories: intensification and diversification. In this second system, storage is considered a means of temporal diversification and mobility is related to the degree of intensification.

Mobility: Mobility refers to the ability of groups to move away from areas where natural resources are not in sufficient abundance (see Wendrich and Barnard 2008). If resources become depressed in a region, in many circumstances, human groups may choose to move to a new area – where resource depression is either not present or present to a lower degree. The source of resource depression and the extent of the move will determine its efficacy. Localized issues may not require a long-distance relocation to completely mitigate the issue; whereas if large-scale problems arise, like region-wide droughts, it may not be possible to move out of the affected area. In these cases, it is necessary to either move to the location that is least affected, or to move on a regular basis as resources become depleted. Mobility can be significantly constrained by a variety of social, economic, and environmental factors. Generally, mobility works best for groups with small populations, non-stored resources, and in regions with low population densities; easily traversed terrains; and sufficiently dispersed resources (Binford 1980). Cultivated fields are not portable, so mobility generally works best for foraging societies.

Diversity: In some situations, it makes more sense to widen the resource base – to expand the diet breadth, rather than to increase mobility (e.g., Colson 1979; Kaiser and Voytek 1983; Morrison et al. 1996' Scarry 1993). If the resources typically exploited by a group are less available, it may make more sense to exploit a wider array of resources in a given region than to move to a new area. The nature of the shortage and of the available resources will affect the utility and character of diversification. For example, if drought is the root cause of the shortfall, it is likely that all plants and animal will be affected to varying degrees. Depending on the suite of resources available, groups may choose to focus on a narrow range of drought resistant resources (relatively narrow diet breadth), on a wide array of resources over a large geographic area (relatively wide diet breadth), or some combination of the two.

Diversity and mobility can work together well (Halstead and O’Shea 1989a). In some cases, diversification may require increased mobility (or the reverse may be true). For example, relatively sedentary groups may need to set up camps in new locations to acquire new resources. Also, if a group moves to a new territory, or a different portion of their territory, high-ranked resources may be in lower abundance or densities, requiring the use of other resources to offset the loss.

Storage: In situations where resources are abundant, but only for a limited amount of time, it may make sense preserve them for future use, essentially increasing the available food diversity to a future point in time (e.g., Kaplan et al. 1990, Kuijt 2009; Low 1990; O’Shea 1989). The portion of the food gathered but not needed immediately can be curated. However, storage is not without costs. Food usually requires labor to prepare it for storage (e.g., drying of wild rice or smoking of meat). Storage facilities must be constructed, requiring additional labor and material inputs. The food must then be guarded from any number of factors that could destroy the stored food. For example, pests (e.g., rodents or insects), moisture, raiders (both human and non-human animals such as raccoons) that may wish to steal some or all the stored food, and fire (natural, intentional, and accidental) can all destroy stored food resources. Relying on stored food is both a means to mitigate risk, and it is a source of risk itself. Ideally, however, it is easier to predict and prevent loss during storage than many other forms of risk.

Storage and high mobility are not usually complementary, though there are strategies that can incorporate both (e.g., partial group or seasonal mobility). Storage facilities are rarely transportable. Therefore, relocation of habitation sites becomes a greater labor investment if new storage pits, corncribs or other structures need to be rebuilt at the new village location. The contents of the pits also need to be relocated, so extensive storage facilities must either be moved at great expense and increased potential for loss, or the stored food must be left at the old location. Such a loss would mark wasted energy and resource expenditures for the initial acquisition of the food, and it would temporarily increase subsistence risk until the lost food can be replaced. In situations where food is readily and regularly available, this may not mark a significant risk, but for agricultural groups in temperate climates, the long duration between harvests means that supplemental resources may be taxed until the next harvest if stored surplus is lost or reduced during relocation.

Sedentism is usually more compatible with storage, and can allow for part of the group to remain mobile, while other segments of the group can remain with the stored resources. Extractive camps (e.g., for hunting, fishing, wild ricing) can be established away from the main village. The food resources can then be brought to the main village for final processing and consumption/storage. Resources that are not immediately available around sites can be added to the diet (potentially allowing for the incorporation of diversification), and surpluses can be saved and used during lean times. Since the resources need to be transported anyway, the cost of using strategies together are minimized, while at least some degree of risk reduction is gained from each activity (see also Byers et al. 2016; Winterhalder et al. 1999).

Exchange: The final category under consideration is exchange. Exchange includes any type of interaction where one group obtains needed items from another. This can potentially incorporate elements of mobility and diversification if the exchange requires travel beyond the normal range, and/or if it includes the procurement of items not typically found within the diet. When Halstead and O'Shea (1989b) discuss exchange, they describe it in reciprocal terms, which includes trade among allies (positive reciprocity), but also include raiding/stealing as a form of negative reciprocity.

Positive Reciprocity: When groups have insufficient food, they may turn to neighbors with whom they have a positive relationship as a potential solution (Halstead and O'Shea 1989b). If the neighbors are not also facing shortages, they may be able to provide some level of subsistence support. As is the nature of any reciprocal relationship, there is some expectation that the debt will be repaid at some date in the future. In some cases, the relationship is relatively informal and occurs on an as-needed basis. However, because the timing of resource depletion is not usually predictable, nor is it necessarily equitable, these exchange networks often include some form of regular exchange or a ceremonial aspect that encourages each group to invest in the relationship with the other. That way, each group has some regular expected contributions, the debts are continually cycling, and both groups are invested in maintaining the relationship even during a long string of good years (see also Hames 1990; Kaplan, et a., 1990; E. Smith and Boyd 1990; Winterhalder 1986).

Food Sharing: In addition to intergroup exchange, individuals or subgroups within any group may also engage in reciprocal exchanges for food. This can include many of the advantages of both diversification and mobility without actually changing the resources or territories targeted. Though its utility depends greatly on the structure of the group and the nature of resource/land ownership. If members of a given society do not usually use the same portion of the overall territory for resource acquisition, then the various members will have access to different suites of resources and these resources (diversification) may be differentially affected by various sources of variability (mobility). Historically and ethnographically, foraging groups are far more likely to engage in this type of behavior than food producers (Gurvan 2004, 2006; Kaplan and Hill 1985; Kaplan et al. 1990; Winterhalder 1990; Winterhalder and Goland 1997).

Negative Reciprocity: Rather than asking for food from a neighbor, there are situations where it may prove advantageous to simply take it. In this situation, wherein one group obtains something for relatively no cost from another, it is, by definition, a form of negative reciprocity. A successful attack on an enemy village may be able to provide considerable quantities of food; however, there are several caveats that must be considered. For example, if the opposing group does not utilize storage facilities then the amount of food that may be obtained from this method is limited to what is collected for immediate use. Also, since food is usually stored in the habitation sections of sites, it is normally defended relatively heavily. The more defended the stores, the more the cost of procurement increases. If the storage facilities are hidden (e.g., underground pits) or otherwise difficult to access, the cost increase is magnified. It may also be possible to attack work parties and take what food they have on hand, either from collection or brought from the habitation for meals. This introduces the challenge of finding and successfully attacking a mobile target while remaining undetected themselves. Finally, it may be possible to raid the sources of the food itself (e.g., fields, hunting grounds, etc.) however, this will require some familiarity with enemy territory and runs the risk of accidental discovery (see Garnsey and Morris 1989; O'Shea 1989 for examples of negative reciprocity).

One additional consideration is that once the attack has been made (or the attacking force is otherwise discovered) the enemy is then alerted to your presence. To be successful, it requires you to evade the enemy and retreat to friendly territory while carrying the stolen food. Regardless of success, a raid on an enemy may also spur retaliatory attacks. Even if no attack ever comes, your group must allocate resources to defensive activities, leading to yet further costs. Under most circumstances, raiding strictly to minimize risk does not make sense. However, because risk management is rarely the sole purpose of raiding, nor does raiding exist in a social vacuum, it was employed in many past circumstances (e.g., Chagnon 1992; Milner 2007).

Agricultural Risk Management Strategies:

Agricultural risk management strategies fall under the same categories described above, but the specific strategies employed are often distinct from hunter-gatherer techniques (Marston 2010:120). Because archaeologists only see disarticulated fragments of the risk management systems the "challenge … lies in identifying the material products of risk-management systems, recovering those material remains and then quantifying them in such a way as to relate them directly to a particular risk management strategy" (Marston 2010:120). To surmount this challenge, it is necessary to have a firm understanding of the social and physical environment, the resources necessary to sustain the group under study, and a variety of factors that can affect subsistence choices. While understanding the effects of these multiple physical and social constraints on human behavior is difficult, doing so has the potential to inform us about subsistence choices and it may elucidate aspects of other social structures that may explain changes through time.

While the basic goals remain the same, there are several strategies and concerns related specifically to agriculturists that do not apply to foragers. The differences tend to revolve around two factors. First, agricultural societies are highly reliant on one or more plant taxa that provides food relatively few times per year (in northern latitudes usually once); whereas, foraging societies often rely on a wide array of resources that provide food on a regular basis (Marston 2010). Typically, the foraging interval is shorter than the harvest interval for crops so failure or loss can be replaced or mitigated more quickly. Furthermore, agriculturalists usually rely on a fewer plant taxa, and those taxa are more spatially aggregated. This makes them more vulnerable to predation, damage, or disease. (Winterhalder and Goland 1997).

Agriculture Specific Techniques: Marston (2011) divides agricultural diversification into three categories: spatial; temporal; crop diversity. Temporal diversification is storage – it works essentially the same way for agricultural and foraging groups. However, large surpluses associated with agriculture may magnify the number and/or size of storage facilities. Spatial diversification in agricultural settings is usually achieved though field scattering. By varying field locations, and placing fields in different microecological contexts, it may be possible to avoid total crop failure from small-scale threats such as a localized storm (O'Shea 1989). Field scattering can also mitigate the effects of larger ones. For example, in dry years, fields in low areas or wetter soils may out preform those in better drained or higher fields. The reverse is true in wet years. Because farmers do not know what the upcoming year will bring, planting in multiple locations can act as a good insurance policy, but it comes with a cost – primarily in terms of increased labor and time while moving people, equipment, and food between and among fields (Gallagher et al. 1987; Goland 1993; McClusky 1972, 1991; Winterhalder 1990; Winterhalder and Goland 1997). Today, many farmers continue to plant in a both high and low areas so that they can be prepared for wider array of weather events – in the summer of 2017, heavy rains in the study area killed many of the crops in low areas (Figure 3.3), but the crops on

Figure 3.3: Modern flooded agricultural fields west of Crescent Bay on STH 106, east of STH 73

high ground survived. By planting in both areas, the farmers ensured that at least a portion of their harvest would survive despite not knowing how much rainfall would come.

The final form of agricultural diversification includes increasing the number or varieties of agricultural crops. Multi or intercropping maize with other plants, particularly squash and beans has been proven beneficial (Gallagher 1992; Hart 2008; Monaghan et al. 2014; Mt. Pleasant 2010; Mt. Pleasant and Burt 2010; Scarry 1993). Distinct varieties of a single taxon will perform differently under varying circumstances, “The cultigen has a bewildering array of varieties, each with different growth characteristics and requirements” (Doolittle 2002:138). The different types represent different levels of risk and different potential uses, “Huron primarily raised flint corn, which matured in one hundred days, and flour corn, which ripened within 130 days” (Hurt 1987:33). By varying the types planted, it may be possible to decrease the risk of crop failure (Hart 1999). While cob row numbers do not directly correlate with maize varieties, they can act as a proxy (Bird 1970; Cutler and Blake 1969; Fritz 1992; Goette et al. 1990; King 1994). Analysis of the number of domesticated taxa, and the number of maize varieties can act as a measure of agricultural diversity (Marston et al. 2014).

Increasing the consumption of wild resources can also diversify the diet. For a resource to be a sufficient supplement or buffer for a high-yield domesticate like maize, it must meet several criteria (O’Shea 1989:59). First, it must be storable; second, occur in sufficiently dense patches to be exploited with the necessary efficiency; third, its harvesting (or hunting, etc.) should not conflict with the agricultural labor; fourth, its abundance should be based on factors independent of the agricultural output. That is, any environmental factors that may depress maize output should not significantly affect the availability of the buffer resource. O’Shea (1989) identifies fish, and to a lesser-degree, wild rice, as ethnohistoric examples of buffer resources. If a buffering option is chosen to replace significant quantities of crops in lean years, then increased storage capacity must also be available, or it must be continuously available for harvest/collection.

Marston (2011:196) argues that overproduction is the primary outcome of agricultural intensification. However, it is difficult to identify overproduction in archaeological contexts because it consists of producing more of the same. He suggests that it can most easily be seen through increased storage facilities and vessels. However, clear chronologies for features, known use lengths, and population densities are necessary to determine a storage baseline.

Risk and Uncertainty

Winterhalder and Goland (1997) use a combination of systems theory, evolutionary ecology, and risk management to explain the adoption of domesticated plants. In so doing, they use the Eastern Woodlands as an example and describe the pathways to adoption that various domesticates could take. Agricultural origins, and even the rise of maize as a primary crop, are beyond the scope of this dissertation. In this case, EAC plants had been used for generations in Wisconsin prior to the occupation of the Koshkonong Oneota sites (see Stevenson et al. 1997 for general Woodland subsistence patterns in Wisconsin). Regionally, maize was a staple crop for at least 100 years prior to the occupation of Koshkonong sites, as supported by the presence of maize macroremains, corresponding with isotopes ($\delta^{13}C$), indicating that maize consumption became an increasingly important in people’s diets (Buikstra, et al., 1994; Lopinot 1992; Schoeninger 2009; Simon 2014). For example, maize is found in the pre-Mississippian Late Woodland contexts at Aztalan (Cutler and Blake 1969; Picard 2013) and $\delta^{13}C$ values show an increasing consumption of maize, though the dates of these samples are less secure (Bender et al.

1981). Other Late Woodland sites also show increasing amounts of maize macroremains in flotation samples (Gartner 1999; Meinholz; Salkin 2000).

Winterhalder and Goland's (1997) theoretical framework for plant domestication sets up a series of testable hypotheses about how people will react under certain circumstances, and the potential ramifications of these actions. Thus, establishing plausible explanation for a series of social changes witnessed in the Late Prehistoric Great Lakes, and how the continued use of maize could impact inter and intragroup dynamics. Therefore, a complete description of their model is warranted. The social implications of Winterhalder and Goland's (1997) model can provide the basis for a testable framework for this dissertation, which will be discussed in the following section.

The Power of Selection Based Arguments: At the core of their argument, Winterhalder and Goland (1997) reject prime movers as explanations of major social or economic shifts (e.g., population pressure or climate change leading to the adoption of a particular resource). They argue that such explanations fail to account for the fact that the actors involved in the societies under study are constantly making decisions. These individuals are faced with imperfect information, changing conditions, and the decisions they make reflect this. Explanations using prime movers are typically based on assumptions of continuous and gradual changes occurring homogenously over a large region and temporal span, and that this rarely reflects the human condition. Hart (1993:83) also favors this approach and argues, "Agricultural subsistence-settlement change is best explained as a result of a number of causal factors…". Furthermore, by focusing on a single normative variable, other important factors are missed. Finally, they argue that using a benefit of a resource to explain its origin is problematic. It is difficult to demonstrate a causal relationship between the initial use of a plant and its eventual benefits. Therefore, they argue that an evolutionary ecological approach using selection theory is needed because it can account for local decisions being made on a regular basis in an ever-changing environment (Winterhalder and Goland 1997).

The selection-based explanation offers the most productive avenue of inquiry because it relies on three principles. First, it is focused on the consequences of actions in a particular environment. For example, in Oneota contexts, the farmers would be concerned with ensuring sufficiently large harvests of maize. If a new variety of the plant was introduced, they would look at the areas available to plant, and combine their knowledge of the about how plants normally perform in these areas with information gained from whomever introduced the plant. Together, decisions on when, where, and how to plant could be effectively made based on the local conditions, and the desire to optimize the output. Changes, such as a variety morphing to become better adapted to local conditions (e.g., Hart 1999) are assumed to be part of a dynamic process, where one choice or alteration affects others. In this framework, the potential morphological changes are not assumed to have been a goal when the plant was initially adopted. Those making the selections are assumed to be making their decisions based on the conditions at hand, rather than what the unknown end product will be.

Winterhalder and Goland's (1997) second principle states that use of non-normative environmental variables are more effective than use of normative variables. Essentially, their argument is that most functionalist arguments are focused on mean conditions and try to interpret change based on general environmental trends. In other words, instead of using the Z-Score model described above, functionalist arguments rely solely on the means and ignore the variance. This does not usually explain human or any animal behavior very well (Stephens and Charnov 1982).

The third principle states that a focus on immediate variables will have greater explanatory value. Essentially, large-scale changes and broad patterns affect human behavior less than small-scale and local ones. The knowledge that there are broad changes in environmental patterns, or that the population is somewhat larger and has been slowly and steadily growing is less likely to affect someone's behavior than would the knowledge that the food that they forage is no longer present in the same densities or that they have additional mouths to feed. For example, people were probably quite aware that temperatures were decreasing as the Little Ice Age began, and were no doubt aware that this led to decreasing food supplies. However, these large-scale climactic shifts likely had less of an impact on day-to-day decision making than their ability to feed themselves and their family. It is through these day-to-day decisions that will ultimately help people determine the appropriate course of action to mediate the large-scale issues.

Diet Breadth and Optimal Foraging Theory: Like most mathematical applications of risk-management-based research, Winterhalder and Goland (1997) rely on Optimal Foraging Theory to provide a framework for their interpretation and baseline comparisons for their different models. In this case, they rely on the diet breadth model. This approach is useful because it ranks resources based on their economic value and efficiency. Those that can be both easily exploited and provide a significant dietary contribution will be ranked more highly than those that cannot. The model can then determine which suite of plants a group is expected to exploit (i.e., the diet breadth) based on the needs of the group and the rankings of the available resources (Bettinger 2009; Charnov 1976; Hawkes et al. 1982; Winterhalder 1986).

Efficiency is determined by comparing the value (often calories) to the average pursuit and handling times (i.e., how long it takes to locate a resource and make it edible) and how densely it can be found in the study area. The highest ranked resource is always expected to be in the diet, with each lower-ranked resource considered in turn. Taxa will be included if their addition will increase overall efficiency. That is, if a hunter/forager is seeking a higher-ranked resource, and a lower-ranked is encountered, the lower-ranked resource will only be included if it is more efficient to acquire and process it than it would be to continue searching for the higher-ranked resource (for a concise description, see Bettinger 2009). For example, if elk is the highest ranked resource it is expected to be in the diet. The question becomes, is it more efficient to ignore another resource when encountered (e.g., a deer or a mouse) than it is to hunt and kill that resource. If new prey is encountered, it would necessitate that the hunter stops searching for elk, however it would ensure that some food is returned if no elk could be quickly located. In the case of deer, the amount of food provided would likely be sufficiently high to warrant stopping the hunt for elk. The deer has already been located so its pursuit time is relatively low, and it will provide many calories. In the case of a mouse, given its size, once located, it may not be easy to kill, with the few calories provided, it is not likely going to prove efficient, even if when already located.

Therefore, it makes most sense to ignore mice while including deer. While such an example is extreme, and may seem obvious, this model provides a method for differentiating between resources that are more similar. For example, if raspberries are in the diet, should you ignore or acquire squirrels? Including mathematical functions to account for diminishing returns can enhance these models. For example, the pursuit time of deer will increase as population density declines. Winterhalder and Goland chose this model, in part, because it is easily incorporated into a selection-based framework.

Diet Breadth and the Introduction of Domesticates: When the diet breadth model is applied to the questions of incorporating domesticates, and identifying their impacts, Winterhalder and Goland posit three generalized scenarios that vary based on the attributes of the resource (Figure 3.4). Box Three is representative of most Eastern Agricultural Complex plants in the Midwest. They represent relatively low-density plants that co-evolve with the human population. This co-evolution results in increased efficiency, which increases the rank of the plant through time. Despite the higher rank, the increasing incorporation of the plant into the diet has little effect on other resources, and does not greatly alter the population dynamics.

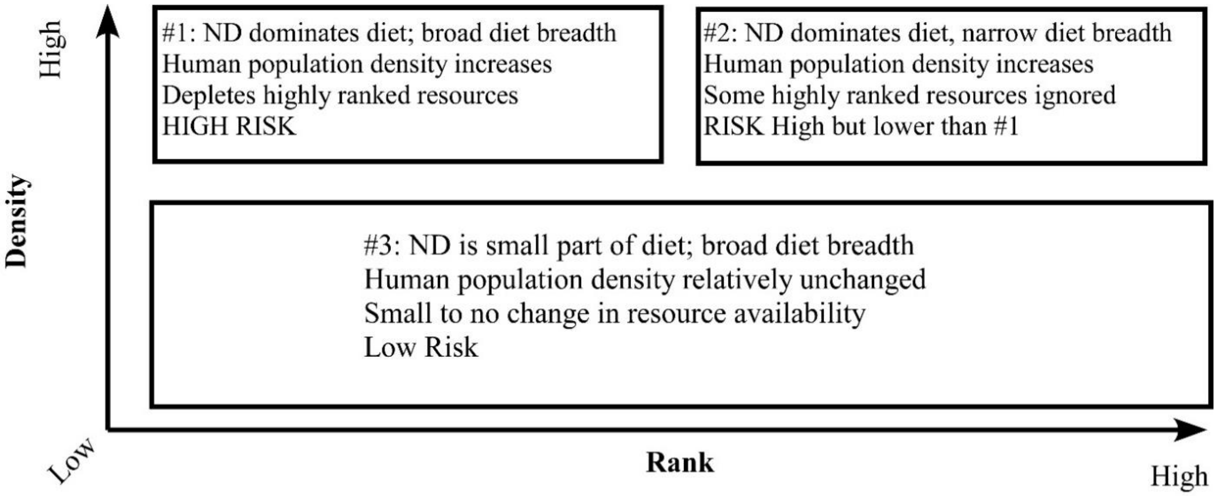


Figure.3.4: Model of Plant Domestication: ND = new domesticate (after Winterhalder and Goland 1997:133 Figure 7.2)

Box One represents plants that are not typically part of the optimal diet despite being present in high numbers. However, if there is a shift that leads to their incorporation (e.g., something increases its relative ranking either through depression of higher ranked resources, a change that leads to increased efficiency of the plant, or some social factor that alters planting patterns), the high overall abundance of the plant will lead to increased population growth though time. As population increases, high ranked resources will be over-exploited and subsequently depleted. As high ranked resources become rarer, they will account for a smaller portion of the diet, thereby shrinking diet-breadth. In-turn, this increases risk as this abundant but marginal plant must make up larger portions of the diet or new subsistence strategies must be employed.

Box Two also represents a situation where the new domesticate has high density; however, in this situation it is also highly ranked. Because its efficiency will increase as morphological changes occur in the plant, its rank will also increase. This will reduce the diet-breadth as other resources are ignored in favor of the new domesticate. This narrower diet breadth becomes riskier as groups rely on fewer resources. The newly ignored resources become a buffer resource in the event of a poor harvest of the domesticate; however, if population levels increase, there may not be sufficient levels of buffer resources to mitigate a substantial harvesting decrease of the domesticate. Box Two represents a risky situation, one that increases in risk as the population grows; however, the presence of the buffer resources means that it is consistently a lower risk situation than presented in Box 1. Despite the marginally lower risk, both situations likely represent an irreversible reliance on the new domesticate because the larger populations cannot subsist exclusively on the wild resources.

Because situations like those in Box Three have little impact on population density, dynamics, or subsistence systems the incorporation of low density/low ranked plants are unlikely to have a large social impact. The situations in Boxes One and Two represent population growth, economic shifts, and increases in risk exposure. These changes will require numerous cultural shifts to accommodate them, including modification to political and kinship systems to include larger groups sizes, altering of labor distribution to acquire the new suite of resources, and new or enhanced risk-buffering mechanisms. Each of these changes can lead to yet further social and economic shifts as people interact with one another, their resources, and the environment in different ways. Some of these changes may stabilize and become part of cultural traditions, while others may lead to yet further adaptations of cultural norms.

For example, Winterhalder and Goland (1997) suggest that, as groups shift from foraging to farming, they begin to increase the degree of anthropogenic modifications to the landscape to plant their crops. Similarly, resource abundance becomes much more dependent on human action (e.g., greater investment of labor should equate to some degree of greater returns through increased planting, management, or protection). The differences in resource location and availability will necessitate a negotiation among group members concerning how to allocate access to field areas and how the harvested crops should be distributed. They argue that this typically results in a constriction of reciprocal food sharing among non-family members within the group, and the development of land access systems that allow for distributed fields.

Furthermore, because of the long production interval associated with temperate-climate farming (i.e., one harvest, per field, per year), survival of the group depends on sufficient and significant labor investment at key points during the plants' growing seasons (e.g., field preparation, planting, harvesting). This may lead to further constriction of the diet breadth if resources are only available for harvest during times where agricultural labor demands are high. For societies with a strong reliance on a high valued domesticate (i.e., Boxes One and Two) the long production interval also necessitates storage as a risk buffering mechanism.

EAC, Maize, and Late Prehistoric Subsistence Shifts: Winterhalder and Goland (1997) argue that the introduction and coevolution of EAC domesticates during the Woodland in the North American Midcontinent offered only modest food resources to the diet. Farming was only one aspect of a diversified diet that was heavily reliant on wild resources, and in many ways resembled pre-farming diets more than the agricultural subsistence systems of the Late-Prehistoric.

Conversely, they argue that once maize was fully introduced (circa AD 800-900), subsistence systems quickly shifted from Box 3 to Boxes One or Two (this depends on how highly ranked maize was in the diet which is likely locally variable). If maize enters the diet as a low ranked system, they posit that wild non-maize resources should remain in the diet, but their contribution should shrink as they are over exploited. If maize enters or becomes a high-ranked resource, then we should see the disappearance of some high-ranked resources. As either of these options occur, risk levels increase necessitating new buffering mechanisms.

Critiques of OFT

As used by Winterhalder and Goland, Optimal Foraging Theories are not without their pitfalls. One of the most prevalent issues with many optimal foraging models, particularly diet breadth, is that they use overly simplified assumptions about the behavior of humans and animals (e.g., Gremillion 2002; Zeder 2012). For example, the assumption that prey animals are encountered randomly simplifies the math involved in determining shifting rate of capture (e.g., Bettinger 2009; Winterhalder and Goland 1997), but it does not necessarily reflect human hunting patterns or technologies employed (e.g., traps, lures, tree stands on game paths) (e.g., Hewitt 1983). Technology varies among groups, which will affect the efficiency of various resources (e.g., Torrence 1983).

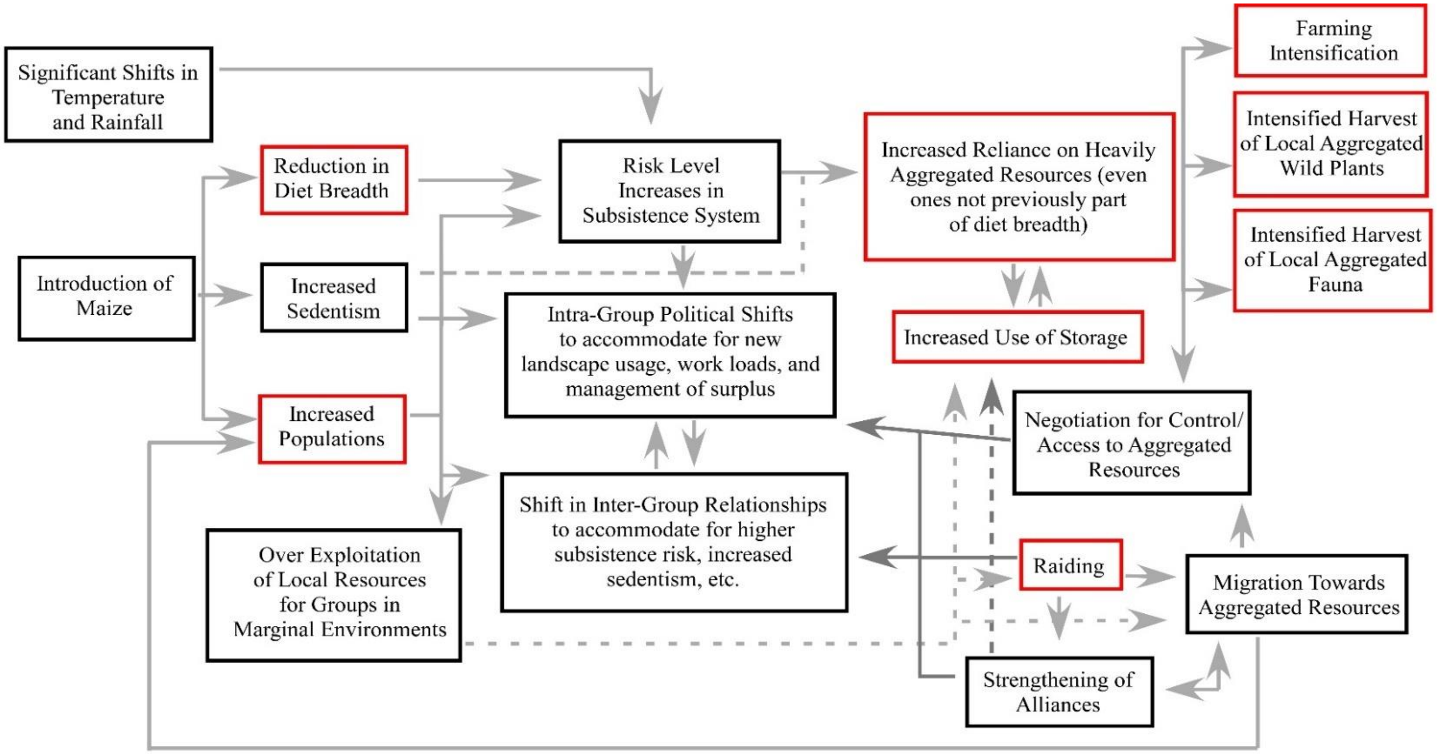
Over simplification can causes many issues, including the invalidation of the model. In the case of simple or classic applications of OFT (such as used by Winterhalder and Goland 1997), it is not unexpected. The models were developed so that they used few assumptions, and to be broadly applicable (Lupo 2007). It should be noted that more advanced models have been generated that can account for many of its limitations, but they are difficult to apply broadly (e.g., Bird and O'Connell 2006). When a specific model works well in a region, it has typically been tailored to account for the taxa in the region, the local technology, and social organization. If any one of these factors change, it becomes difficult to apply the model

In the case of the Winterhalder and Goland's (1997) application, many of the specific critiques are bypassed. Their general model (Figure 3.4) is at a sufficiently broad level that specific assumptions about particular prey are not actually applied. Rather, they use the logic concerning efficiency to predict outcomes of multiple potential decisions. Their initial conclusions are likewise large scale. Their specific application of the model to the introduction of maize may be hampered by their application of OFT, but it is the broad level model that is modified to create a framework for this research. The issues addressed above were kept in mind as the model was adapted for the Late Prehistoric of the western Great Lakes, and no direct application of OFT is actually used.

A Theoretical Framework for Oneota Subsistence:

This generalized model provides a reasonable framework from which we can build a model tailored to the Western Great Lakes region (Figure 3.5). By the time the earliest Oneota sites were occupied, maize had been used as an important crop for somewhere between 100-200 years. In that relatively short time span, large population movement/aggregations had begun, landscape usage patterns shifted, and a distinct set of lifeways were adopted by large segments of the population (Richards and Jeske 2002). Within another few hundred years, this transition appears to have encompassed essentially everyone within what is now Wisconsin.

By looking at the social, physical, and environmental factors present in the region from AD 800 to AD 1400, we can begin to build a more localized model that is based on assumptions of evolutionary ecology, selection-based decision making, and risk-minimization. Given the high



Potential Aggregated Wild Resources in Koshkonong Locality
Fish
Water Fowl
Wild Rice
Nuts

Potential Intra-Group Shifts
- Household/Kinship Interaction Altered (e.g., reciprocal ties)
- Alteration to Work Force Distributions
- Corporate (e.g., clan level) Control of Surpluses and Farm Land
- Larger Populations require shifts in group leadership systems

Key
- Black cells: Assumptions based on model
- Red cells: Testable Assumptions (directly or indirectly)

Figure 3.5: Selection Based Interpretive Framework

violence in the late prehistoric, it is also prudent to build in the effects of institutional violence (e.g., Milner 2007).

By the beginning of the Oneota occupation of the Koshkonong Locality, or any Oneota sites in eastern Wisconsin/northern Illinois (Hart 1990; Jeske 1989), all groups, except effigy mound building Late Woodland groups (Salkin 2000; Stevenson et al. 1997) had moved out of Box 3, and into either Box 1 or 2. That is, maize had become a primary food resource for collared-ware Late Woodland, Upper Mississippian, and Middle Mississippian groups (e.g., Fritz1992; Hart 1990; Overstreet 1997; Picard 2013; Salkin 2000; Stevenson et al. 1997). They had begun the process of aggregating on the landscape into larger and more substantial settlements than previously. Those living in these settlements are usually interpreted as being more sedentary, though with different levels of mobility. Without some kind of intervention, this situation left most groups at the risk of catastrophic subsistence failure (e.g., Halstead and O'Shea 1989b). Figure 3.5 depicts the integrated model developed for this dissertation based on these risk factors.

Expectations: This new type of settlement-subsistence system would have set in motion several shifts to intragroup organization. Some would have happened immediately. Others would have a slower onset. As small changes accumulate, they create further changes down the line. The move to these larger villages, filled with more sedentary populations, requires different organizations systems. There are more mouths to feed, more houses, more garbage, and more voices with opinions how thing should be done, or with requests for those who have influence. If a person decides things are not going satisfactorily, it becomes harder to leave if they have invested significant amounts of time, energy, and resources in to planting. New mechanisms to manage disputes may be necessary. The shift to an agricultural economy has different labor demands than a foraging economy. Shifts in the size, distribution, and timing of work parties are required. Maize agriculture of the terminal Late Woodland and Mississippian periods would need intensive labor investments, particularly women's labor. Some scholars have argued that this may have led to an alteration in the ways that gendered labor was valued (e.g., Benn 1995; Hollinger and Benn 1995). Unfortunately, many of these shifts are difficult to identify archaeologically. It is possible to identify shifts in subsistence strategies, food processing, etc. From there, it is possible to make inferences about some correlated human actions. Using Winterhalder and Goland's model, further informed though a broader lens of risk management, we can test hypotheses to determine which behaviors, relationships, or strategies were in use by the Koshkonong Oneota population.

First, it is necessary to test the primary ideas on which the model is built. Maize has long been inferred to have been a major component of the diet, but we need to know several major pieces of information.

1) **What was the nature of the diet in the Koshkonong locality?**
    a. How important was maize to the diet?
    b. How diversified was the diet, and what taxa did it include?
2) **How does the subsistence system in Koshkonong differ from other groups (Upper & Middle Mississippian, Late Woodland)?**

Understanding the nature of the Koshkonong system allows for comparisons to other contemporaneous groups (Late Woodland, Middle Mississippian, Oneota). The nature of any similarities or differences, and any potential exchange can also help determine what sorts of stresses groups were under. Regional stresses (e.g., wide-spread drought) should have different outcomes than local ones (e.g., localized hail storm). Also, such relative data are essential for determining how broad or focused the Koshkonong subsistence system was. Once we have answers for the first questions, we can begin to apply the data to the model by asking

3) **What risk management strategies were used in the Koshkonong Locality?**
    a. **Can we see risk management strategies that work with the natural environment?**
    b. **Can we see risk management strategies that work with the social environment?**

According to Pearsall (2009:611), to understand the role and implications of agriculture, it is essential to look not just at sites, but at the physical and social landscape. Furthermore, Halstead and O'Shea argue that risk management strategies were

> …interrelated, such that changes in any one component altered the role and other strategies in the mediating episodes of stress. The aggregate result of such compounded alterations was directional or evolutionary change, which transformed the social matrix in which decisions were made and through which further responses were affected (1989a:38).

Because these changes were made through and mitigated by social actions and decisions of people, it is though this lens that it is possible to better understand the social fabric underlying the economic activities that are archaeologically visible. Finally, with an informed understanding of the social mechanisms responsible for agricultural production and the degree of agricultural reliance we can begin to revisit a very old question:

4) **What are the relationships between the development of agriculture and complex social structures, social hierarchies, and institutions?**

There is a frequently cited relationship between intense (or intense and specialized) agriculture and social stratification and complexity that has both historical (Buckland 1878; Morgan 1877; Tylor 1881), global (Bar-Yosef 2000; Bender 1978; Childe 2003; Drennan and

Quattrin 1995; Price 1995) and local roots (Benn 1989; Gallagher and Arzigian 1994; Griffin 1967; Jeske 1992; Kelly 1992; Lopinot 1992, 1994; Mueller and Stephens 1991). In recent decades, the ubiquity and thereby necessity of this relationship has been called into question (e.g., Price 1995, 2003; Price and Bar-Yosef 2011; Smith 2001). This dataset provides an ideal means of testing the assumption and bringing the Eastern Woodlands into the larger anthropological debate.

To begin to test the model, assumptions and inferences (Figure 3.5) must be made explicit and expectations must be tested (Figure 3.6). First, reliance on maize can be best established using multiple lines of evidence, including macrobotanical data and isotopic data. Once reliance on maize has been confirmed, it is necessary to measure how it was integrated into the subsistence system. Each of the groups that relied on maize had increased subsistence risk. Regardless of probability, a harvest will eventually fail, caused either by environmental or outside social factors. It is difficult to replace a substantial portion of any system, so a failure of maize puts the whole system at risk. If groups live in the less than optimal locations, the loss is will be even harder to replace. If an area does not have access to substantial supplementary aggregated resources, self-reliance in famine years may be impossible. If poor harvests last for multiple years, the problem becomes exacerbated.

Therefore, it is necessary for maize agricultural groups to have or develop mechanisms to reduce risk of catastrophic failure. Using the heuristic framework provided by Halstead and O’Shea (1989b), we can expect groups to intensify, diversify, increase mobility, use of storage facilities, and engage in exchange (positive and negative). Each of these strategies should have archaeologically visible signatures. The model also allows for extrapolating potential secondary outcomes based on the employment (or lack of) various strategies. The following sections

Maize/Sedentism Maize dependent groups should exhibit greater sedentism

- If true - Subsistence-Settleement systems should reflect longer-term occupations
  - longer/more seasons of occupation
  - larger/more durable structures
  - ↑ use of storage
  - ↑ reliance on lgoistical mobility, lower residential mobility
- If false, then settlement-subsistence should look same among groups on the three metrics above

Diet Breadth ↓ Groups that use maize will have a reduced diet breadth

- If assumption is accurate then maize dependent groups should have less diverse diets than non-collared ware Late Woodland groups
- If assumption is false then maize dependent groups should have equally or more diverse diets than non-collared ware Late Woodland groups

Climate Based Risks Shifting climate increases instability

- If only source of risk then groups should turn to non-agricultural resources and increase mobility (↑ dietary diversity)
- If false, and only social risks exist, then simple agricultural systems should be relied on heavily (homogenous system)
- If a combination of environmental and socal risk factors, should see increased reliance on agriculture with attempts to diversify agricultural system to mitigate environmental losses

Resource Depletion Increased population levels, increased social stress, or a combination will lead to a focus on local resources and the depletion of some high-ranked wild resources

- If false, no dietary shifts through time notable
- If true, high-ranked wild resources will
  - ↓ importance
  - fall out of diet breadth
- Those most likley to decrease or drop are
  - those with slower regeneration times - such resources would be over exploited and not be present in sufficient quantites to maintain significant use
  - and/or have greater variance - reliance on such plants would increase risk factors - removing it from diet breadth or demoting its ranking would increase stability - except in years when more stable measures are/have failed

Aggregated Resources Increased risk in system leads to further decrease in diet breadth and focus on aggregated resources

- If true then expect one or more of the following
  - ↓ diversity indices in later contexts
  - ↑ reliance on agricultural remains
  - ↑ reliance on wild rice, goose foot, or other local cultigens
  - ↓ in high variance resources
- If false, then no shift in subsistence strategies through time

Intergroup interaction Alliance networks are strengthened - Relationships with foes deteriorate

- If true - one or more of the following should be evident
  - evidence of intergroup violence
  - construction of defensive structures
  - increased trade or interaction among groups
  - aggregation of allied groups together on landscape

Figure 3.6: Assumptions, inferences, and expectations for theoretical model

provide a description of how we might test the various expectations of the model and their potential ramifications using floral data. When floral data are unavailable, a discussion of other data are provided.

Intensification is one option for managing risk in the Koshkonong Locality (Gallagher and Arzigian 1994; Keegan and Butler 1987; Marston 2011). The easiest means to identify the intensification of any single resource is to see its density or ubiquity increase through time. Minor shifts may be difficult to see, but any large-scale efforts at intensification should be visible in this manner. Agricultural intensification does not only have to be growing more of something; greater investments of labor to ensure the same number of plants survive is another form of intensification, such as the construction of ridged fields (Gallagher and Arzigian 1994). Two agricultural sites have been identified in the Koshkonong Locality, Loge Bay (47JE087) and Messemer (47JE092). Both agricultural sites were described as garden beds (Stout and Skavlem 1908); however, it is unclear if either site is associated with the Oneota occupation (Stout and Skavlem 1908). To date, it is unknown if there are other forms of agricultural intensification in the locality (e.g., technological).

Diversification: Intensification can help groups to overproduce food, which allows surpluses to last longer. However, if an entire harvest in a given year is lost, so too is any intended surplus. Therefore, intensification is still risky if it is not coupled with diversification or some other risk management strategy (e.g., storing surplus sufficient for multiple years). If the risks are sufficiently great, multiple forms of agricultural diversification may be needed.

Field scattering: Because most agricultural fields have not survived, it is impossible to directly test the expectation that Koshkonong groups would have diversified field location. Indeed, Doolittle (2002:162) describes the act of looking for non-ridged agricultural fields as akin to looking for the proverbial needle in the haystack. While corn hills and ridged fields have been identified archaeologically in a few cases, such as the now buried but still extant corn hills at Carroll University in Waukesha, Wisconsin (R. Sasso, personal communication), at Sand Lake (Gallagher et al. 1987), and at the Garden Bed and Kletzsch Park sites (Benchley et al. 1979; McKern 1930) they are few and far between (Doolittle 2002:162-164) However, indirect indicators may be present. Examination of the locations of sites relative to soil types, topography, etc. can be used to infer possible locations of fields and their potential for variation (Doolittle 2002:165).

Diet Breadth: Per Winterhalder and Goland (1997) and O'Shea (1989), aggregated wild resources can act as an ideal resource to buffer against agricultural loss. Prehistorically, there were numerous aggregated resources available throughout Wisconsin that could potentially serve this function (Table 3.2). However, their utility may be locally and temporally dependent; therefore, their ability to buffer a poor maize harvest depends on their local conditions, their nutritional value, and the amount of maize being replaced. Ideally, the food will have a fast renewal rate, that is, its population rebounds quickly after heavy exploitation. For example, wild rice has very specific habitat requirements (Vennum Jr 1988) and it was only abundant in select locations. If conditions are consistently right, it will provide significant quantities of food, year after year. Historically, wild rice harvests failed roughly every four years. So, it may have been an option for groups with access to significant stands. However, it was not necessarily a widely available resource. Elk, which form small sex-based herds most of the year, and large herds of 100 plus animals in the winter, would have been a large aggregated resource. However, the slow reproduction of large mammals could lead to significant resource depletion in a relatively short amount of time. Therefore, elk may have been a short-term buffer, but is risky to rely on as a primary supplement (Keene 1981). Furthermore, under heavy predation, elk reproduction rates decrease making them unreliable long-term primary resources (Winnie 2007).

Table 3.1: Potential Aggregated Resources in Wisconsin and northern Illinois

Resource Type	Example	Habitat	Availability	Source
Nuts	Acorn Walnut	Forests (Dense) Savannah (Less)	Aug-Oct (species dependent)	Keene (1981)
Wild Rice	n/a	Shallow water	Late Aug to Early Sept	Jenks (1901) Vennum Jr (1988)
Spawning Fish	Walleye Sturgeon	Lake, Rivers, Streams	Variable	Becker (1983) Theler (1989)
Bush Fruits	Raspberry Grape	Forest/Savannah (especially edges)	Mid-Summer to Fall	Keene (1981)
Tubers	Wild Leek Cattail	Wet Environments	Early Spring Late Fall	Curtis (1959) Keene (1981)
Weedy seeds/greens Weedy seeds	Goosefoot Amaranth	Disturbed Habitats	Spring / Late Fall Late Fall	Keene (1981)
Herd Mammals	Elk Deer Bison	Forest Edge Forest Edge Prairies	Most aggregated in Winter Most aggregated in Winter Most aggregated in Winter	Keene (1981)
Migrating Birds/ Waterfowl	Passenger Pidgeon Duck	Forest (pigeon) Lakes/Wetlands (waterfowl)	Late Spring/ Early Fall	Keene (1981)

Lake Koshkonong was known historically as an productive source of wild rice. In the mid-1800s, it was said to look like more like a meadow than a lake because this aquatic grass was so prevalent (Lapham 1855). Previous research on Koshkonong Oneota subsistence has identified wild rice as a highly ubiquitous and dense food resource (Edwards IV and Pater 2011; Egan-Bruhy 2001). While wild rice is prone to periodic failures, it will produce large quantities of food in good years, and the factors that reduce productivity typically occur in the spring, giving groups sufficient time to focus on other resources (Vennum Jr 1988). This food source is also particularly attractive because of its availability. It is generally available before the main harvest of maize, and it is available for several weeks which means that harvest timing has some measure of flexibility (Jenks 1901; Vennum Jr 1988). Given these characteristics, it is expected that wild rice should increase in importance through time.

Southeastern Wisconsin was home to large tracts of oak/hickory forests and savannahs (Brink 1835; Miller 1833). Acorn, hickory and walnuts a widely available source of food in this environment. Nuts are typically good sources of both calories and nutrients; however, they are subject to significant variation in annual productivity that is difficult to predict (Gardner 1997; Keene 1981). Furthermore, nuts are typically available for shorter amounts of time than wild rice. They also are more likely to be eaten by other animals before humans can acquire them, if significant steps to curb the rodent population are not enacted. Finally, many species of acorn and walnut are available around the same time that large amounts of labor would be needed for harvesting and processing maize and other agricultural outputs, or wild rice. Past research at Oneota sites in the Koshkonong Locality support nuts as an important resource, particularly acorn (Egan-Bruhy 2001, 2014). Nuts are expected to be important buffer resource; however, as time goes on, they will most consistently be used as a backup rather than a primary aspect of the diet.

Weedy Seeds: Weedy seeds may have been a highly aggregated resource, but they were also already an important aspect of the Late Woodland diet (Stevenson et al. 1997). According to the Winterhalder and Goland (1997) model, these plants are likely to reduce in dietary rank, and some may even be dropped from the diet all together. Of the starchy and oily seeds previously identified at the Crescent Bay Hunt Club, only goosefoot has been identified as a significant aspect of the diet (Edwards IV and Pater 2011; Egan-Bruhy 2001; Olsen 2003). Olsen (2003) identified wild and domesticated variants, though both could have been grown together in managed garden plots. Based on the model, *Chenopodium* should be less important at Oneota sites than at Late Woodland sites, and its importance should decrease slightly over time as groups intensify use of other resources (e.g., density may remain constant, but maize, wild rice, or other aggregated resources will become more important as these aggregated resources become a greater focus of the diet).

Fruits: Bush fruits (*sensu* Keene 1981) offer a relatively productive source of food. They are relatively dense, and are found most prolifically at the edges of forest, which were common in the savannah dominated environment around Lake Koshkonong (Edwards IV 2010). However, it is unlikely that berries could have been acquired in sufficient quantities to act as a primary resource for large, aggregated, and sedentary populations. Historic accounts indicate that berries were combined with animal fat and bone grease to make pemmican, an important traveling food and stored resource (Hodge 1910; Stefansson 1960). Pemmican is not likely to show up in the archaeological record of Wisconsin. I predict that berries will be a minor aspect of the Koshkonong Oneota diets.

Tubers: Keene (1981) identified tubers as one of the most abundant and productive resources in Michigan's Lower Peninsula. However, tubers rarely preserve archaeologically; therefore, regardless of their dietary importance, it is unlikely that they will account for a significant amount of the Koshkonong Oneota floral assemblage.

Faunal Resources: The variation in faunal resources is beyond the scope of this analysis. However, previous studies (Agnew et al. 2016; Edwards IV 2013; Edwards IV and McTavish 2012; Hunter 2002; McTavish 2013; Van de Pas et al. 2015) have shown both large mammals and fish to be significant resources. Deer, bison, and elk have both been identified from CBHC and KCV. While deer may not be an aggregated resource for most of the year, yard up in the winter, becoming aggregated. They will also be attracted to the agricultural fields, so garden-side hunting both protects crops and artificially aggregates deer. Fish are also a highly ranked resource. Keene (1981) notes that fish is often most productive per area on smaller bodies of water, and many species aggregate while spawning (e.g., walleye, various panfish). Lake Koshkonong, the Rock River, and its tributaries provide a great deal of surface area that should be highly productive. The concentration of Oneota sites along Koshkonong Lake and Koshkonong Creek (Edwards IV 2010) fit well with the inference that groups would move to areas with significant access to such aggregated resources.

Crop Diversification: A final expected means of diversification is an increase in crop diversification. Diversification may manifest in several different ways. Distinct varieties of maize have different growth characteristics and can survive in different situations (Hart 1999; Hurt 1987). Maize varieties are most easily archaeologically visible through cob row numbers (Cutler and Blake 1969; Scarry 1993). In addition to maize, multiple species of agricultural resources are expected. Past research has identified squash (Egan-Bruhy 2001a), as well as cultigens like goosefoot (Olsen 2003).

Exchange, Warfare, and Mobility: Depending on the proportional importance of maize, access to aggregated resources as buffers may have been as important to the settlement subsistence system as access to arable land. The more these resources were available, the more stability inherent in the system. So long as stability is maintained, there would not be subsistence pressures to relocate. If resources are not available locally, a group can either move to where they are or send work parties to obtain them. However, the threat of attack can force people to remain close to home where defenses are available (Milner 2007; VanDerwarker and Wilson 2016).

In theory, mobility should be relatively easy to identify archaeologically. Sites with short occupation spans were likely occupied by people that employed the a highly mobile strategy. However, it is often difficult to determine if a site was continuously occupied or returned to on a regular basis and the error range on radiocarbon dates is too wide to differentiate. Furthermore, the radiocarbon issue makes it difficult to use the number of sites in a region. A region may have many sites because of greater mobility, or there may have been a larger contemporaneous population occupying multiple sites simultaneously. Hart (1993) argues that mobility is unlikely for groups under physical threat. Given the proximity of Aztalan and Late Woodland sites to Koshkonong, this does not seem to be a likely option in Koshkonong if there were hostilities among the various archaeological groups.

Within the Eastern Woodlands, the resource base makes combining aggregation and mobility difficult. In regions like the Plains, where there are large aggregated migratory resources (e.g., bison), the relationship between sedentism and defense may be different. For example, bison can provide a resource base for a large population, be acquired by large cooperative hunting groups, thus allowing them to maintain safety in numbers. Furthermore, bison hunting does not require the group to remain in the same location for large portions of the year. In southeastern Wisconsin, no analogous resources exist. Most wild plants must either be obtained in small groups to be efficient, or their locations are so aggregated that guaranteed access to the resource would encourage increased sedentism. Without a consistent presence in the area, it would be difficult to prevent other groups from laying claim to the resource. Animal resources in the Eastern Woodlands are also unlikely to allow for effective group aggregation and mobility. For example, many fish aggregate for spawning, but this occurs at predictable times and locations. While this may feed a large aggregated population for that time, once the fish disperse, it is difficult to maintain large population densities without other aggregated resources. Historically, to the north of the study area, the Chippewa would aggregate during spawning season and disperse into smaller groups afterwards (Densmore 1979; Nesper 2002).

If there is evidence of considerable mobility, then the threat of warfare was likely either minimal, or less significant than the risk of remaining sedentary. If there is evidence of restricted mobility then the threat, or perceived threat, of attack must have been significant. The greater mobility is restricted, the greater the threat. There is no way to quantitatively measure mobility, but qualitative assessment of the number and types of sites in a settlement system, the defensibility of sites, and the general character of a settlement system can be used to determine the relative threats.

The interaction among neighboring groups is subject to change once one group's buffering mechanisms fail. Increased mobility increases the chance of groups competing for territory, particularly if more than one group is on the move. In southeastern Wisconsin, the non-collared ware using Late Woodland groups are often thought to have been particularly mobile, while Late Woodland collared ware and Oneota groups are thought to have primarily used other strategies, though it is unclear to what extent (e.g., Overstreet 1997; Stevenson et al. 1997). It is also unclear how much competition for land existed among or within archaeological cultures. Smith (2011) has argued that during earlier Archaic and Woodland times, populations were not sufficiently dense to push groups to domesticate plants, suggesting that pressures other than population led to domestication. Populations sizes in Late Woodland and Mississippian times are also unknown, making it difficult to assess competition for land.

Trade is another option to mitigate resource failure that would not require population movement. However, trade can be difficult to identify. Exchange of food items would be difficult, if not impossible, to see archaeologically (Minnis 1985). The food itself, and any associated bags or baskets are unlikely to survive. If any did survive, it would be nearly impossible to differentiate the imported from local foods. Ceramic containers are more likely to survive. However, it can be difficult to distinguish undecorated Oneota vessels, so interlocality exchange can be difficult to identify without petrographic analysis. Trade between archaeological cultures (e.g., Late Woodland and Oneota) should be easier to identify stylistically, particularly if ceramics were included in the exchange. In such cases, the reasons and type of exchange is still unknown. Other items may also be exchanged during trade expeditions, some of which may be more easily identified as non-local (e.g., copper, galena, food, etc.).

While testing is beyond the scope of this dissertation, there is another important aspect to exchange that must be considered. Historically, before groups could trade with one another, members of the two trading parties were often expected to engage in some type of ceremonial activity to formalize the relationship, often becoming fictive kin, e.g., the Calumet Ceremony (Hall 1997). It is not known how far back in time these ceremonies extend. While they are not easily seen archaeologically, these ceremonies would require a shared set of symbols that allow both groups to identify and acknowledge that the opposing party accepted the shared rights and responsibilities.

While a single exchange or ceremonial occasion may be beyond our ability to identify, reoccurring use of the ceremony should show a patterned use of the shared, or at least overlapping sets of symbols on one or more media. If these relationships were, or became important then we can expect that they may have been incorporated into more mundane items as well. Schneider's (2015) ceramic analysis of the Waupaca, Grand River, and Koshkonong assemblages shows that there was some degree of communication and shared symbology among the localities. There are also shared symbols between Koshkonong and northern Illinois groups, albeit fewer. Pozza (2016) has shown that many of the same ceramic symbols were also used in copper. And Overstreet (1997) has argued that there is a shift in ceramic decorations; from mostly undecorated to mostly decorated, after AD 1300. For now, an argument can be made that people within the multiple Oneota localities were connected through ceremony—religious and/or cosmologically, and the importance of the ceremonies may have increased through time. The symbolic similarities may have been a means of signaling membership in a larger shared network (sensu Hart et al. 2016; Hall 1960; Schneider 2015).

We must also consider exchange among or between different archaeological cultures. Edwards and Jeske (2015) have examined the evidence for interaction between Aztalan and Koshkonong sites, and found it lacking. Overstreet (1997) has suggested any such interaction was likely confrontational, and not cooperative. Additionally, there are several Late Woodland sites around modern-day Madison that contain small numbers of Oneota sherds (Haas et al. 2017). While it is unclear why there is a minority of Oneota vessels at otherwise Late Woodland sites, exchange cannot be ruled out at this time (Figure 3.7).

Intergroup violence has also been previously noted within the study area. The best data from the Midwest indicate that warfare took the form of cyclical violence: One group raids another, followed by retaliation (Keeley 2003; Milner 2005, 2007; Milner et al. 1991; Strezewski 2006; VanDerwarker and Wilson 2016). In this process, neighbors become blood enemies as cyclical raiding turns minor disputes into large, long-standing feuds. In the process, crops are destroyed, farmers, hunters, and foragers are killed, and it becomes more difficult to leave settlements to obtain food (Milner 2007; VanDerwarker and Wilson 2016). Violence does not necessarily have to occur regularly for it affect people’s behavior. Sasso (1989) notes that only

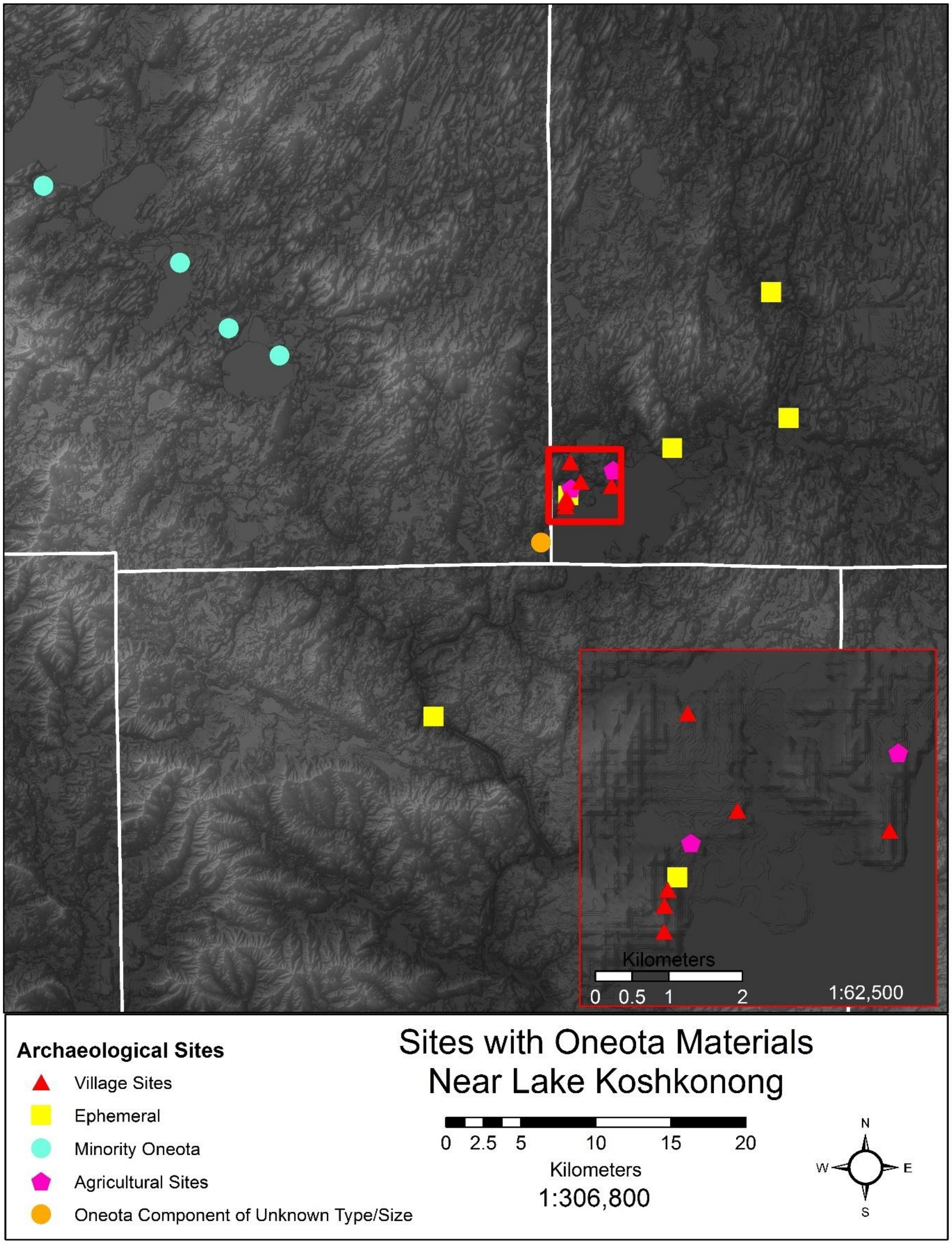


Figure 3.7: Distribution of sites with Oneota ceramics in region around Lake Koshkonong

the perception of a threat is necessary for people to take extensive actions, like building stockades or palisades for defense. Ethnographers have recorded the investment of substantial amounts of time, energy, and raw materials towards defense when a threat is perceived. For example, among the Dani of Highland New Guinea, men spent a large portion of their time building and repairing defensive structures (e.g., watch towers) and weaponry (bows and spears). Even more time was spent manning defenses. On a typical day, men generally stood guard while women worked the agricultural fields, cared for the pigs, and tended to children. This does not account for the time men spent on the ritual/religious aspects of war that would not necessarily leave a clear material trace (Gardner and Heider 1969; Heider 1996). As Winterhalder and Goland (1997) argue, non-normative risks are often better predictors of human behavior. As Hart (1990; 1993) notes, these social stresses tend to push people into reducing mobility while intensifying agricultural production to supplement the resources lost while reducing active catchments.

Summary:

In this chapter I described the background and theoretical underpinnings behind the concept of risk-management as a facet of subsistence strategies, and a source of social and cultural change. I also described Winterhalder and Goland's (1997) and O'Shea's (1989) models of risk-minimization in the North American Midcontinent. I then integrated these approaches to create a framework in which to interpret Oneota subsistence in Koshkonong Locality.

Diet Breadth: According to the model, Oneota groups should exhibit a smaller diet breadth than their Late Woodland predecessors (and potentially contemporaries). This inference can be tested using diversity indices (see Chapter 4). Depending on the degree of change, we may also see differences in diversity indices between the early and late components of the Koshkonong Oneota sites.

Aggregated Resources: We should also see an increase in the use of aggregated resources over time. The aggregated resources (Table 3.2) should make up a larger portion of the diet, and they should become either more ubiquitous or denser through time. Additionally, we should see an increased reliance in more reliable dense resources. Given what is already known of Koshkonong Oneota subsistence, the environment, and the resources themselves, we can focus our attention to particular resources, such as nuts, wild rice, and maize (Egan-Bruhy 2003a; Olsen 2003).

Storage and Population Increase: It is trickier to test increased reliance on storage or larger populations. The sites in the study area are subject to issues of palimpsest (Edwards IV 2014; Edwards IV and Spott 2012; Moss 2010), making interpretations of population size and feature use difficult. The number of radiocarbon dates from the two sites is also not large enough to convincingly discuss such issues; however, most dates from the region post-date AD 1200. From this, one can tentatively argue that either a) the sites' occupants were utilizing more features later in time, therefore we have uncovered more features from later occupations; b) there was a large population living in the area later in time, which required more features, produced more refuse, and created more material to date. It is also possible that the prevalence of post-AD 1200 features reflects sampling bias.

Raiding: While few human remains have been recovered from Koshkonong sites, a remarkably large proportion have shown evidence of trauma and violence, which is highly suggestive of significant intergroup violence during the Oneota occupation (Jeske 2014; Jeske et al. 2017). Taken in conjunction with high incidence of violence at the neighboring and contemporaneous site of Aztalan (Birmingham and Goldstein 2005; Goldstein 2010; Rudolph 2009), at Lake Winnebago to the north (Karsten 2015), and the Illinois River Valley to the south

(Fowler 1949; Jeske 2003; Milner 1992, 2007), there is a well-established pattern of intergroup violence within the region, which supports the interpretation of significant violence and raiding in during the occupation of the Koshkonong Locality.

4. Methods & Methodology

What people deem fit to eat, how they choose to prepare and eat it, and with whom they share it are all part of a cultural code. What is required in order to answer the perplexing questions is a research strategy that considers these codes… (Wetterstrom 1978:82)

Introduction:

This chapter provides a description of the methods used for data collection and analysis. It is divided into two major sections. The first section provides a description of the methods used to identify and analyze the macrobotanical remains from the study sites and the quantitative techniques used to compare the sites to each other and other sites in the study area. The second section provides a description of the canine surrogacy approach (CSA) and the methods for isotopically analysis of the domesticated dog remains used in this dissertation. The chapter concludes by connecting the analytic methods to the theoretical approach and research questions.

Paleoethnobotanical Methods

Introduction and Background.

Paleoethnobotany includes several different broad techniques and specializations (Marquardt 1988). Generally, the three primary areas include macrobotanical analysis (identification of remains large enough to be seen without magnification – e.g., seeds), pollen analysis (identification of pollen grains), and phytolith analysis (identification of the microscopic remains of plants) (Ford 1979; Pearsall 2010). Residue and DNA analyses are also rising in importance (Marston et al. 2014; Wright 2010). The following discussion will focus on the formation, recovery, and interpretation of macrobotanical remains as that is the only paleoethnobotanical approach used in this dissertation.

Formation of the Paleoethnobotanical Record

The nature of the paleoethnobotanical record makes direct comparisons among taxa or contexts difficult (Pearsall 1988, 2010). Prior to the beginning of any analysis, an understanding of the various ways plant materials are: 1) brought to a site prehistorically; 2) treated prior to deposition; and 3) by which they enter the paleoethnobotanical record are necessary (Ford 1979; Fuller et al. 2014; Gallagher 2014; Pearsall 1988). Broadly, it is important to understand the ways in which botanical remains can preserve from prehistoric contexts; it is also necessary to understand both anthropogenic and non-anthropogenic ways plant remains enter the archaeological record.

Sources of Preservation: Relative to ceramics, lithics, or even faunal remains, plant materials are particularly susceptible to decomposition (Gallagher 2014). Without the proper conditions, botanical remains are unlikely to survive in the archaeological record (Ford 1988; Gallagher 2014; Pearsall 2010). However, in wet-anaerobic, dry, or cold environments, as much as 90% of the floral materials may be preserved (Ford 1988). When these conditions do not exist at any of the study sites, so the only prehistoric plant remains likely to survive are those that are carbonized (Pearsall 2010). Carbonization occurs most readily when the floral remains are exposed to heat in an oxidizing environment that is hot enough to burn the organic components but cool enough for the inorganic components to survive. However, in most cases only a minor subset of the plants from a given site are exposed to such conditions and only a subset of those will survive (Fritz and Nesbitt 2014; Gallagher 2014; Pearsall 2010). Once carbonized, floral remains are much more resilient and are less likely to decay. While resistant floral remains are not immune, alkaline environments have the potential to break down carbonized remains, and they are still susceptible to mechanical damage and some bacteria (Bryant 1989; Gallagher 2014;

Toll 1988; Wright 1998). Because there are no extremely dry or waterlogged contexts at KCV or CBHC – the bulk of the floral remains used at the village sites likely decayed several centuries ago. The only materials that survived are the subset that were carbonized; of those, taphonomic processes and loss during recovery further reduced the recovered sample (Figure 4.1). However, not all plants, nor all plant parts, are equally likely to be exposed to fire; therefore, factors that can account for these biases are also important to understand.

Anthropogenic and Non-Anthropogenic Patterning of the Paleoethnobotanical Record: Gallagher (2014) divides the routes that botanical remains take entering a site into three categories: direct anthropogenic, indirect anthropogenic, and non-anthropogenic. Direct anthropogenic routes, include intentional collection of materials for use by the site's residents (Box 1 in Figure 4.2); such as collection of fruits or other edible parts of a plant, or wood materials for fuel. Indirect anthropogenic methods include those that were carried to a site by humans, but done so unintentionally. For example, unneeded portions of crops or weeds accidentally mixed with the crops while harvesting. Non-anthropogenic sources include seed rain (seeds naturally blown in by wind, flowing water, etc.) as well as those brought in by animals such as rodents. This may occur before, during, or after the occupation of the site. Gallagher (2014) notes that most seeds deposited in this manner are unlikely to be carbonized, particularly those that are deposited after the occupation of the site.

The choices of which plants to use, and how to collect and process them, reflect a series of culturally habituated behaviors, and the aggregate byproducts should reflect the behaviors that

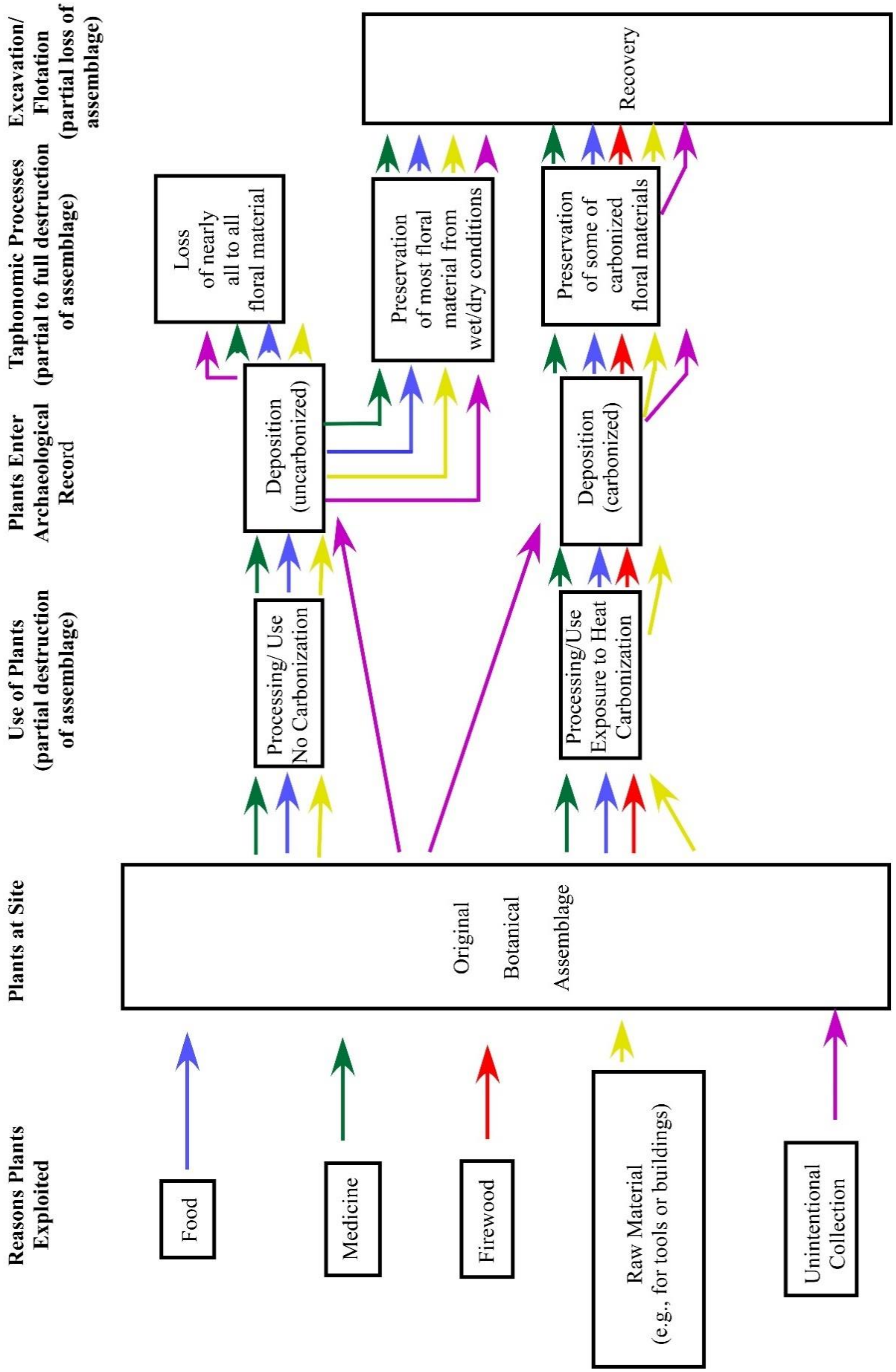


Figure 4.1: Botanical Pathways to Archaeological Recovery after Bush (2001:30)

Collection/Harvest Usable portions of plants removed and brought to site

- Seeds (e.g., maize kernels, or chenopodium)
- Fruits (e.g., strawberries, raspberries)
- Nuts (e.g., acorn, hazelnut)
- Leaves (e.g., chenopodium)
- Roots (e.g., cattail)
- Wood (e.g., firewood for cooking, heating, pottery production or wood for construction)

Initial Processing Removal of unneeded portions of plants to make them usable

- Winnowing (e.g, wild rice)
- Dehusking (e.g., maize)
- Shelling (nuts)
- Parching (e.g., acorn)
- Drying

Storage Placement of usable parts into storage pit or other container

Final Processing Preparation for use

- Grinding (e.g., maize or acorn into flour)
- Boiling (e.g., maize in hominy)
- Baking
- Consumption (of both cooked and uncooked portions of plants)
- Burning of fuel (both wood as well as waste materials such as corn cobs)

Deposition intentional or unintentional disposal of floral remains

- Primary: materials accidentaly Burned & incorporated with fire refuse - left *in situ*
- Secondary or Tertiary: materials accidentally Burned & incorporated with fire refuse - moved into trash pit or other refuse context
- Primary: intentionally Burned materials left *in situ (e.g., firewood left in hearth)*
- Secondary or Tertiary intentionally Burned materials (e.g., firewood) moved to a trash pit or other refuse context

Figure 4.2: Use-life of floral remains: Red text indicates potential for exposure to high heat / fire

created them (Fuller et al. 2014; Guedes and Spengler 2014; Wetterstrom 1978). However, these cultural behaviors will bias the samples in non-random and non-correctable ways; therefore, it is essential to take these factors into account during interpretation of the data (Pearsall 2010). For example, Pearsall (2010:502) points out that foods eaten raw, relative to cooked foods, are likely to be rare in the paleoethnobotanical record. Among cooked plants, not all are equally likely to preserve – she points out that tubers tend to be fragile and often break down in conditions where others will preserve. While it is not possible to circumvent these issues, it is possible to mitigate them by understanding various use lives of the plants at archaeological sites (Fuller et al. 2014; Gallagher 2014).

The question of which plants to collect (or how people in a society decide which plants to collect) is a long and complicated one. If a group regularly collects a particular taxon of plants, then it must be one seen as capable of fulfilling a needed role or function (Ford 1979; Wetterstrom 1978). Food, fuel, and raw material are three primary functional reasons for the collection of flora. How much, and which parts of that plant are brought to the site is usually restricted to those that are useful (e.g., fruits) and portions that cannot be easily removed, such as the chaff (Fritz and Nesbitt 2014).

For example, ethnohistoric accounts of wild rice harvests describe Native Americans using boats to collect the seeds, leaving the stems and roots in the water (Jenks 1901). Before consumption, the seeds needed to be dried, the chaff removed, and potentially stored (Boxes 2 and 3 of Figure 4.2). These activities provide opportunities for seeds to be lost, destroyed, or carbonized, prior to the cooking, consumption, or deposition of the food (Box 4 of Figure 4.2). They also further change the floral remains from their initial state when they were first harvested. Most the seeds harvested will be consumed and rendered unidentifiable. While the chaff may make it back to the site, it stands little chance of surviving, being recovered, or identified.

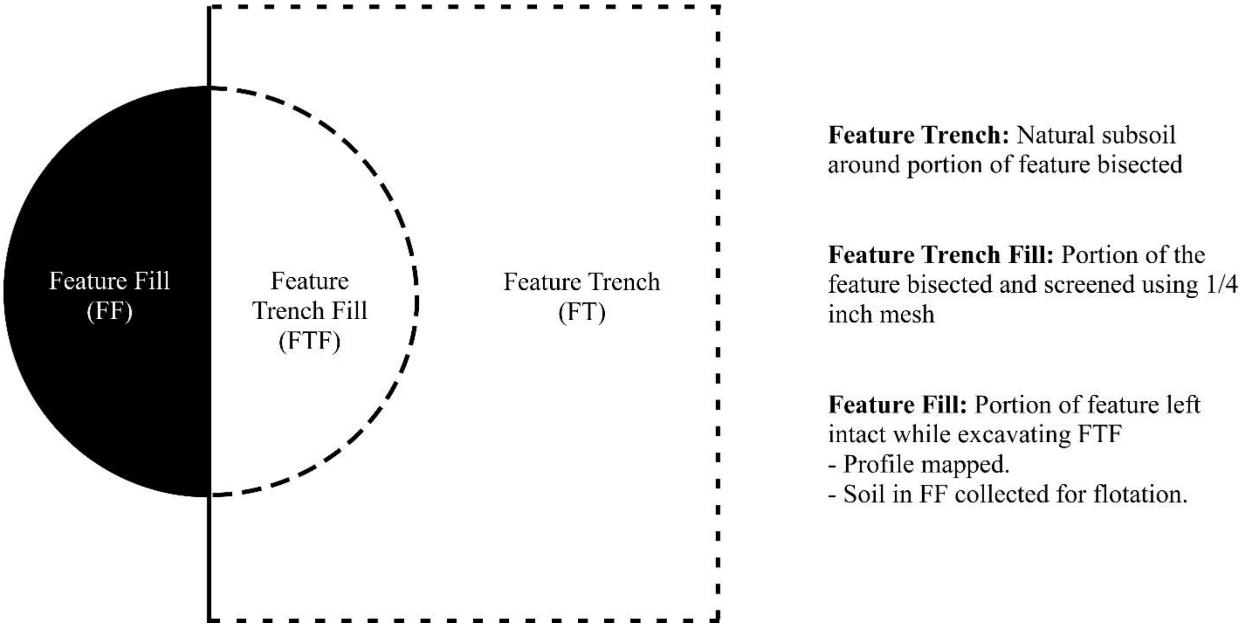
In contrast, maize is typically brought back to the site by the ear before being processed (Smith and Cowan 2003). So long as processing takes place at the village, cornhusks, cobs, cupules, and glumes may be found in deposits in the site. Furthermore, their potential use as fuel further adds to the likelihood that they will enter the paleoethnobotanical record. Therefore, maize is biased towards greater representation at the village relative to wild rice, regardless of relative dietary importance. Therefore, the biology of the plants, harvesting techniques, and processing methods, makes recovery of each plant independent from the other. This means that the amount of various taxa recovered are not directly comparable.

The final, and possibly most important factor to consider, is the deposition of remains (Box 5 of Figure 4.2). Fuller et al. (2014) summarize a large body of research concerning the ways botanical remains are used and eventually end up in refuse contexts. They argue that paleoethnobotanists need to be "clear about the form of preservation (charred) and their assumptions or inferences about how the remains came to be charred and then deposited archaeologically" (Fuller et al. 2014:177). The bulk of contexts with charred botanical remains are rarely connected to the contexts in which they were burned. That is, they are rarely primary depositions (i.e., the location of deposition is the same as the location they were burned) nor secondary depositions (material moved directly from where they were burned to a refuse area), but tertiary deposits (materials from a variety of contexts mixed together in a deposition context). Because of the tertiary nature of paleoethnobotanical deposits, Fuller et al. (2014:179) argue that the context in which the plants are found is "usually only tenuously, if at all, connected to the activities that produced it." Therefore, the contents must be examined with an eye towards understanding the habitual activities that make up the assemblage. Through this understanding, and an examination of the specific parts of the plants that have preserved (e.g., only seeds vs. semi-cleaned spikelets vs. partially threshed ears), it is possible to understand the activities that occur regularly at the site (e.g., plant processing, cooking, etc.), and thereby reconstruct the basic economy, workload distributions, and other factors involved in those activities.

In sum, it fair to say that macrobotanical remains are perhaps the among most biased class of materials we can use to describe prehistoric diets. Due to all of the above taphonomic problems, it works reasonably well to identify if a species is present, if many taxa were regularly used (e.g., but is not very useful when discussing the total importance of any plant to the diet

Recovery Methods

Excavators at KCV and CBHC used the same recovery techniques. Flotation samples were collected exclusively from features. Once identified, features were bisected. The first half excavated (Feature Trench Fill, or FTF) was always screened using ¼ inch mesh (Figure 4.3). Once the profile was exposed, any zones present were mapped. The remaining half of the feature (Feature Fill or FF) was collected for flotation based on zones identified in profile. Overall, 50% of features were collected for flotation.



Feature Trench: Natural subsoil around portion of feature bisected

Feature Trench Fill: Portion of the feature bisected and screened using 1/4 inch mesh

Feature Fill: Portion of feature left intact while excavating FTF
- Profile mapped.
- Soil in FF collected for flotation.

Figure 4.3: Feature Excavation Diagram

Once returned to the laboratory, ten poppy seeds were added to each zone (or entire features if no zones were present) for control purposes. Samples were also measured to determine the total volume of flotation. The samples were then run through a FloTech flotation machine and the light and heavy fractions were separated. While botanical remains were recovered in the FTF while screening, these materials were not included because a) it would not be possible to accurately calculate the density without flotation; b) significant differences in recovery bias would make the results incomparable (Wagner 1988). Flotation is capable of much higher recovery levels, as much as 50 times greater than quarter-inch screens (Munson et al. 1971). However, the difference is bigger than quantity alone. Most of the seeds, and large proportions of non-charcoal botanicals are only recoverable with screen sizes smaller than a one-quarter inch. Flotation is one of the most reliable ways to obtain these small remains.

Macrobotanical Identification Methods

The methods used to identify carbonized botanical remains generally parallel those described by Pearsall (2010). The following methods were chosen match those used at Commonwealth Heritage Group where previous analyses at CBHC were conducted (Egan-Bruhy 2001; Olsen 2003) as have been the bulk of eastern Wisconsin Oneota paleoethnobotanical analyses (e.g., Egan-Bruhy 2010b). After samples were fully floated, procedures for sorting the light and heavy fractions to identify charred macrobotanical remains were implemented. Because such large flotation samples were collected, it was not realistic to examine 100% of each of the samples. Therefore, larger samples were generally subsampled using a riffle sorter until the total amount remaining was between 10 and 25 liters. Counts and weights for the entire feature were estimated based on the proportion of the feature examined; that is, if ¼ of the floated material was subsampled, the values were multiplied by four to estimate the value for the entire context.

Light Fraction samples were then sorted by size. All carbonized botanical remains larger than 2 mm were identified. Wood and bark charcoal, aquatic tubers, and other non-dietary floral remains (e.g., buds, monocot stems) were not identified without any additional specificity. Seeds and other dietary floral remains were identified as precisely as possible without sacrificing accuracy, and identifications were made conservatively to reduce misinterpretation from false precision. Nutshell was identified to genus whenever possible, family when it was not. Seeds, maize (kernels, cupules, glumes, and cob fragments), and squash rind were identified as precisely as possible. Ideally, all identifications were made to either genus or species (rarely), but when this was not feasible they were backed off to family. If the family of a seed could not be accurately determined, but its morphological characteristics were intact – it was classified as an unidentified seed and given a type designation. If seeds were too damaged to be identified they were classified as unidentifiable. Unidentified non-seed floral remains were classified as unidentified organic. Charcoal, nutshell, nutmeats, organic material (e.g., buds or fungus) and domesticates (except for tobacco) were counted and weighted to the nearest 0.001 grams. All other seeds (tobacco, cultigens, fruits, and other seeds) were counted but not weighted.

The portion of samples between 0.5 and 2.0 mm were sorted and charred seeds were removed for identification. Nutshell and maize remains were not removed – but if they were absent in the larger size grade, their presence was noted for ubiquity calculations. Seeds removed were identified and counted using the same procedure for non-domesticated seeds in the larger than 2.0 mm size grade. Samples smaller than 0.5 mm were not examined, as they rarely contain identifiable seeds or other identifiable macrobotanical remains (Toll 1988).

Heavy Fraction samples were subsampled using the same methods as the light fraction. Once the subsample was prepared, materials larger than 2.0 mm were scanned for botanical remains. Any prehistoric botanicals from this size grade were removed and identified using the same procedures as the light fraction samples of the same size grade. No heavy fraction materials smaller than 2.0 mm were examined for this analysis. Counts and weights for light and heavy fractions were then combined to determine the botanical assemblage for each archaeological context analyzed (i.e., feature or feature zone).

Several sources were used to aid in identification. Modern specimens were collected by the author. Additionally, materials from a CBHC feature analyzed by Dr. Katie Egan-Bruhy were used as comparatives. Additionally, several identification manuals and paleoethnobotany websites were used to aid identification (Deloit 1970; Fritz n.d.; A. Martin and Barkley 1961; Montgomery 1977).

Comparative and Quantitative Analysis Methods:

Raw botanical counts have little analytical value to archaeological interpretation because "cultural and non-cultural factors bias the types and number of remains we recover at archaeological sites," (Popper 1988:53). The size of the feature, the cooking techniques used to prepare the food, taphonomic conditions, and many other factors affect the number and types of botanical remains recovered. To account for these biases and be able to identify culturally relevant patterns, raw counts require transformation, standardization, or modification in one or more ways (Minnis 1985; Popper 1988).

Ratios: Ratios are a simple way of standardizing data so that variation among contexts, sites, or region become visible (see Table 4.1 for broad categories of use). Ratios are simply the count (or weight) of one taxa divided by another value from that context (Marston 2014; Miller 1988; Pearsall 2010; VanDerwarker 2010b). Densities are technically ratios – with the numerator the count or weight and the denominator is the amount of soil. Densities are discussed in more detail below (Miller 1988). The numerator and denominator of ratios can technically be the value of any data collected from a given context; however, careful consideration must be given when choosing variables. Miller (1988:83) gives three criteria to consider for each ratio employed a) what is your ratio measuring; b) are the measurements relevant to research questions; c) are reasons to accept "assumptions of equivalence," or in other words, are you dealing with contexts that have similar preservation levels and other contextual concerns? Regardless of the availability of answers for each of these questions, they should be discussed whenever using any ratios (Miller 1988; Wright 2010).

Non-density ratios, where the numerator and denominator are different taxa, are sometimes called "relative measures" (Marston 2014:168) or "comparisons" (Miller 1988:75). These "are powerful tools for identifying patterns in the paleoethnobotanical data, visualizing those patterns, and testing hypotheses" and can answer questions concerning a wide array of questions (Marston 2014:169). For example, Bohrer (1970) uses charcoal as a denominator and uses various food seeds as the numerator. By comparing the ratios across contexts or sites, he highlights where particular seeds increased in use. In Anatolia, ratios of two crops with different resistances to drought conditions have been used to model agricultural risk (Marston 2011); the ratio of seeds in dung fuel has been used as a proxy for steppe health and population packing (Marston 2015). In North America, Asch et al. (1972) use the ratio of nutshell to seeds to show the increase in the importance of seed plants through time. A common ratio used in Late Prehistoric North American sites is the kernel: cupule ratio to indicate the degree of maize processing that takes place on site or storage techniques (Arzigian 1989; Egan-Bruhy and Nelson 2013; Parker 1996; Scarry and Steponaitis 1997; Schirmer 2002; Simon and Parker 2006).

Table 4.1: Comparative functions of ratios (after Miller 1988)

Ratio Comparisons	
1	Samples with uneven sizes
2	Samples with differential preservation OR divergent depositional histories
3	Samples with different but related botanical specimens

Density: The density metric is a common means of standardizing values, which allows for inter-context and potentially intersite comparison of individual taxa (Miller 1988). Density values are calculated by determining the abundance of a taxon relative to the amount of soil floated from that context (Wright 2010). The abundance metric is usually either count or weight, standardized by the number of liters floated. In the Midwest, density numbers are usually measured as the abundance per 10 liters floated; or

$$d = \left(\frac{a}{s}\right) * 10\ ,$$

where d=density, a= abundance (count or weight) of a particular taxon in a given context, and s=total number of liters floated from that context. Density measurements have been used for a wide array of analyses. The reason that they are so useful, is because their standardization allows for comparison across contexts (Marston 2011; Miller 1988). This accounts for discrepancies in raw abundance numbers caused by differences in sample size. Therefore, variation in density values are the result of taphonomic processes, environmental differences among contexts (e.g., seasonality, exploitation of different microenvironments), or different cultural behaviors (e.g., contexts have different functions, were produced by different groups, or produced at a different time) (Miller 1988). Because different species enter the archaeological record at different rates (see above), and densities are based on measures of abundance, it is still inappropriate to compare density values between or among taxa (Marston 2014; Miller 1988).

Ubiquity: One of the simplest ways to look for patterns in the paleoethnobotanical data are to calculate the number of contexts in which each taxon occurs relative to the number of context sampled (Popper 1988). This value is preferred to raw counts because it likely is more reflective of the overall importance of the plant (Minnis 1985). Ubiquity values are determined by counting the number of contexts a particular taxon is present and dividing it by the total number of contexts analyzed; or

$$u = \frac{c}{t},$$

where u=ubiquity, c=the number of contexts where a given taxon was recovered, and t=the total number of contexts examined. Ubiquity is typically expressed as a percentage. One of the advantages of using this method is that the value of one taxon does not affect the values of other taxa, i.e., the values are independent (Marston 2014; Popper 1988; Wright 2010). Also, this method allows for the direct comparison of sites where different recovery or analytic techniques were used, or where differential preservation obscures other comparative methods.

The use of ubiquity measures is hampered by several key factors. First, because it ignores differences in the total number of taxa recovered, it can potentially obscure patterns in the data (Popper 1988). For example, if one seed of Taxon A found in seven features, it would have the same ubiquity score as Taxon B with 70 seeds found in seven features. Both would have a higher score than Taxon C that occurs in one feature with a total count of 7,000 specimens. In this case, Taxon A will appear to have made an equal dietary contribution of Taxon B and a much higher contribution than Taxon C, though this may not be the case. However, the differences among the values of the counts of taxa may also reflect differences in processing, storage, or preparation techniques (e.g., Minnis 1985) so incorporating both ubiquity and other measures can be beneficial. Therefore, ubiquity scores are generally best used in conjunction with other analytic methods (Marston 2014; Miller 1988; Popper 1988; Wright 2010). Second, it is also important that contexts are assigned accurately and systematically. If two different contexts are merged into one, (or the reverse) then the ubiquity score will be altered (e.g., zones merged to feature level). The fewer contexts analyzed, the more such errors affect the ubiquity scores (Popper 1988).

Diversity / Heterogeneity: Assemblages can be compared using a variety of methods, and indices are particularly helpful for comparing the structure of entire floral and/or faunal assemblages (Lyman 2008; Popper 1988). Lyman (2008:178) states that there are three main variables that inform on the diversity of an assemblage; richness – the number of taxa in an assemblage (NTAXA) (Lyman 2008; VanDerwarker 2010b); evenness – or the degree to which species abundance varies (Peres 2010); and heterogeneity, a measure of diversity that combines how rich and evenly species are distributed in an assemblage (Lyman 2008). According to Lyman ecologists use these values to understand changes in plant or animal communities across space or time. In archaeological contexts, it can help to highlight changes in subsistence systems through time or variation in foodways among societies (Marston 2014; VanDerwarker 2010b).

Taxonomic richness is measured by the number of different taxa present in an assemblage, and has been used by archaeologists as a measure of focus/specialization in a subsistence system, particularly in the 1960s and 1970s (Lyman 2008). In other words, sites with few species are thought to be focused or specialized whereas sites with many species are thought to be diversified. For this study, it will be used as an initial step towards testing the argument that Oneota subsistence should be characterized as diversified (e.g., Gibbon 1982).

However, because taxonomic richness only looks at the number of species present, and not their dietary contribution, labor investment, or proportion of the assemblage, its values can be skewed by heterogeneous datasets (Lyman 2008). Furthermore, taxonomic richness measures can be easily skewed by differences in sample size, with larger samples more likely to contain greater numbers of species (Lyman 2008; VanDerwarker 2010b).

The Shannon-Wiener Index of Heterogeneity, also known as the Shannon-Weaver Index or Shannon Index (VanDerwarker 2010b), is a means of estimating the heterogeneity of a sample. It is combines measures of both evenness and richness into a single score to provide a proxy of overall diversity in an assemblage (Pearsall 1983; Popper 1988). The generated indices can be compared among sites or temporal periods to look for trends. To calculate the value, the proportion of the total taxonomic abundance of each taxon is multiplied by its natural log. All the products are summed and multiplied by -1. The equation is written as

$$H = -\sum P_i(\ln P_i) ,$$

where H= heterogeneity or, the value of the index, and P_i is the proportion of each taxonomic class per site (Lyman 2008:192; Peres 2010:29-30; Popper 1988:66-68). Values often vary between 1 and 3.5 (Lyman 2008), however the absolute minimum is 0 and the maximum is dependent on the number of species in the sample (Marston 2014). There is no way to determine if differences in values among sites or contexts are statistically significant, only that they are different (Popper 1988).

The main difficulty with this index, is that by combining richness and evenness into one score, assemblages may appear more similar than they really are. The Shannon Index will return similar results for samples with relatively few taxa that are evenly distributed as samples with many taxa that are unevenly distributed (Marston 2014; Pearsall 1983; Popper 1988). Samples with values smaller than 10 are problematic for this index (Pearsall 1983). Because small values are common in paleoethnobotanical analyses, it is not necessarily the most ideal measure of diversity available (Marston 2014).

The issues caused by combining evenness and richness can be ameliorated by measuring the evenness of similar samples. This can be accomplished by dividing the Shannon Index by the natural log of the taxonomic richness:

$$e = \frac{\mathrm{H}}{\mathrm{lnS}} \quad ,$$

where e= evenness, S=number of taxa in the assemblage and H = the Shannon Index score. Higher scores indicate higher levels of evenness within the assemblage (Lyman 2008:195). This relatively simple extra step can allow researchers to distinguish between scores caused by few taxa from those caused by low evenness. However, because this method relies on Shannon index, it may still not be appropriate for samples composed of taxa with counts less than 10 (Pearsall 1983).

An alternate approach can be to use the Simpson's Index; this measure can more accurately access assemblages with low-density taxa (Marston 2014). Because archaeological samples represent finite populations, the more complicated version of Simpson's Index is required.

$$D = \sum \frac{n_i(n_i-1)}{N(N-1)} ,$$

where D= Simpson's Index, n_i is the number of a given taxon, and N is the total number of all taxa (Lyman 2008:196-197). It ranges from 0 to 1 – where 1 indicates no diversity and 0 represents infinite diversity (Marston 2014). By taking the inverse of D, it is possible to determine the evenness of the assemblage as well. As the inverse decreases, "the more an assemblage is dominated by a single taxon" (Lyman 2008:197). Since D ranges between 0 and 1, the lowest possible value of 1/D is 1 (samples with a single taxon).

In this study, both Simpson's and Shannon's indices will be generated. Since the dataset for this dissertation includes many values smaller than 10, the Simpson's Index will be given greater attention. Additionally, since it is less sensitive to sample size effects, it will allow for a wider range of comparative sites from other regions. Because not all taxa are weighed, the diversity indices will be based solely on counts.

Correspondence Analysis and Principle Components Analysis: Historically, multivariate analyses in paleoethnobotany are rare (Pearsall 2010:216) but have become increasingly important over the last 10 years (Smith 2014). Common multivariate analyses in paleoethnobotany include clustering analysis, discriminate analysis, principle components analysis (PCA), correspondence analysis (CA), and factor analysis (Pearsall 2010; Smith 2014). CA and PCA are both multivariate means of highlighting patterns between and among contexts, without running each set of variables individually (Pearsall 2010; VanDerwarker 2010a). Both methods are ideally suited for exploratory data analysis (Smith 2014: VanDerwarker 2010a) as they can "reveal patterning within large sample/species datasets and identify similarities or dissimilarities between samples or groups of samples" (Smith 2014:187). The two methods differ in numerous ways. These differences include how they are calculated, but the two I want to highlight are data types (Greenacre 2007; Shennan 1997) and assumptions of the structure of the data (Gauch 1982; Greenacre 2007; ter Braak 1995); where CA assumes non-linear relationships, but can only handle nominal (e.g., presence/absence) and raw abundance values (i.e., count), whereas PCA assumes a linear relationship, but can handle ratio or interval data (e.g., density values). Many paleoethnobotanists prefer to use CA because it does not assume a linear relationship is present (see VanDerwarker 2010a; Smith 2014). However, as discussed above, there are significant issues with using raw counts. Because the samples that will be compared in this analysis include drastically different sample sizes, I will be using PCA so that count data can be normalized by volume (i.e., density per 10 liters of FLOT).

Furthermore, CA is particularly sensitive to small values – or taxa that are present in only a few samples, which can significantly distort the results (Smith 2014). Smith (2014:189-191) provides examples of species being eliminated or combined to address this problem. Given the large numbers of species with low values, and the number of such species that are present at a minority of sites, this would prove problematic for this analysis. Combined with CA's inability to handle density values, PCA seems to be the more appropriate measure for this analysis.

Paleoethnobotany Sampling Strategy:

A total of 16 features, totaling 41 contexts from the Koshkonong Creek Village and Crescent Bay Hunt Club sites were examined for this project. Both sites contain dated deep cultural deposits, near structures, with a similar suite of morphological shapes. Additionally, both sites were excavated using the same procedures; therefore, field sampling bias should not affect the results of the analysis. The AMS samples taken from burned food residues scraped from ceramic vessels, or from individual corn or nutshells associated with vessels, provide relatively tight control for context and confidence in the chronology.

The samples from CBHC include eight cylindrical pits and five basin features. From the features, 22 zones were selected for examination (Table 4.2). In total, they represent over 3,700 liters of floated soil. Features were chosen from across the site, and in association with several different house structures. Commonwealth Heritage Group already analyzed three full and two partial features. The remainder, I analyzed. Three features from KCV were chosen, representing 19 different zones. The samples totaled 1,100 liters of floated soil. Prior to this dissertation, no floral analysis had been conducted.

Table 4.2: Dissertation Floral Samples (blue cells: fully analyzed prior to dissertation; orange cells: partially analyzed previously)

Feature Number	Feature Shape	Liters of FLOT Sorted	Number of Zones Sorted	Chronology	Association	Known Seasonal Association
Crescent Bay Hunt Club						
F00-11	Cylinder	430.5	2	Late	Longhouse 1	Winter
F00-26	Cylinder	189.5	1	Late	Longhouse 1	Winter
F02-25	Basin	57	1	Unknown	Longhouse 1	Unknown
F04-03	Cylinder	27	1	Middle	No Structure	Unknown
F04-11	Basin	499	1	Unknown	House 3	Unknown
F04-14	Cylinder	201	6	Mixed	House 2	Unknown
F04-15	Cylinder	279	2	Early	House 2	Unknown
F04-22	Cylinder	950	1	Early	Longhouse 1	Winter
F06-63	Cylinder	210	3	Early	House 2	Unknown
F10-14	Cylinder	300	1	Unknown	No Structure	Unknown
F10-19	Basin	110	1	Unknown	House 3	Unknown
F10-29	Basin	375	1	Middle	House 3	Unknown
F10-98	Basin	88	1	Middle	House 3	Unknown
Koshkonong Creek Village						
F12-01	Cylinder	410	5	Early	House 1	Unknown
F12-06	Cylinder	615.5	13	Late	House 1	Unknown
F12-26	Basin	79	1	Unknown	House 1	Unknown

Samples were chosen to control for both inter and intrasite variation. Care was taken to find samples that represent both the early and late portions of the Oneota occupation at the sites; thus, allowing for comparison of changes through time. Samples from different associations were also chosen. At CBHC, samples near Longhouse One and wigwams Two and Three were chosen so that household variation can be examined. Two features (F04-03 and F10-14) are in the southeast corner of the site and may be part of a ritual area. F10-14 has a dog burial that appears to be a ritual deposition (Edwards 2014b). Adjacent to the feature is a shallow basin with a dog and bear skull and an articulated dear leg, which are an uncommon combination of features. The feature is also near one of the burials at the site. F04-03 is only three meters from the dog burial; while it may not be associated with any ritual activity, it is also not associated with any identified house structures at the site. All samples from KCV came from the 2012 field season because the 2014 and 2017 materials were not floated when the analysis began. Since all the 2012 units were in the same excavation block, all the features appear to be associated with the same longhouse structure (Edwards and Spott 2012).

In addition to chronological and household variation, feature morphology was also considered. Moss (2010) suggests that cylindrical pits and basins were used for different functions. Therefore, both feature types were selected for the assemblage. Furthermore, whenever possible, both basins and cylindrical pits were selected from early and late/wigwam and longhouse contexts.

Comparative Sites: To see how Koshkonong foodways compare to regional subsistence systems, several comparative sites with comparable datasets were chosen (Table 4-3). Sites were chosen to compare Upper Mississippian sites across space, and compare different archaeological cultures (e.g., Lake Koshkonong Oneota vs. Aztalan). Sites with comparable methods were selected for analysis; most were analyzed by Dr. Egan-Bruhy, or those she trained. Non-Collared ware sites with paleoethnobotanical data are few, so only one was chosen for comparison.

Table 4.3: Sites for Comparative Analysis

Site Name	**Site #**	**Archaeological Culture**	**Locality**	**Reference**
Centra 53/54	47WT189	Late Woodland: Non-Collared Ware	Central Wisconsin	Egan (1993b)
River Quarry	47DA768	Late Woodland: Collared Ware	Central Wisconsin	Egan-Bruhy (2009)
The Murphy Site	47DA736	Late Woodland: Collared Ware	Central Wisconsin	Egan-Bruhy (2009)
KCV	47JE379	Oneota	Koshkonong	This Dissertation
CBHC	47JE904	Oneota	Koshkonong	This Dissertation
Tremaine	47LC095	Oneota	La Crosse	O'Gorman (1995)
OT	47LC262	Oneota	La Crosse	O'Gorman (1993)
Filler	47LC149	Oneota	La Crosse	O'Gorman (1994)
Citgo	47BR460	Oneota	Green Bay	Egan-Bruhy personal communication
Pamperin Park	47BR245	Oneota	Green Bay	Egan-Bruhy (2012)
Schrage	47FD581	Oneota	Middle Fox	Egan-Bruhy (2010a)
Soggy Oats	47WN595	Oneota	Middle Fox	Egan-Bruhy personal communication
Dambrowski	47PT160	Oneota	Waupaca	Egan-Bruhy (2010b)
Blinded by the Light	47PT191	Oneota	Waupaca	Egan-Bruhy (2010b)
Burley Brew	47PT159	Oneota	Waupaca	Egan-Bruhy (2010b)
Washington Irving	11K052	Langford	Fox/Des Plaines	Jeske (2000)
Zimmerman	11LS013	Langford	Upper Illinois	Egan (1993a)
Hoxie Farm	11CK004	Fisher	Chicago Lake Plains	Egan-Bruhy and Nelson (2013)
Aztalan	47JE001	Middle Mississippian	Southeast Wisconsin	Picard (2013)
Lundy	11JD140	Middle Mississippian	Apple River	Emerson et al. (2007)

Canine Surrogacy Approach/Isotopic Analysis Methods:

Because it is so difficult to determine the relative importance of any particular plant in the subsistence system, or to determine the proportion of the diet provided by plants relative to meat, non-paleoethnobotanical methods were sought. Isotopic analyses of human remains have been used in the Midwest to gain insight into these topics (Ambrose 1987; Ambrose et al. 2003; M. M. Bender et al. 1981; Emerson et al. 2005; Emerson et al. 2010; Hedman et al. 2002; Lynott et al. 1986; Schurr 1998).

Of particular interest to this study are Carbon 13 ($\delta\,^{13}C$) and Nitrogen 15 ($\delta\,^{15}N$) analyses. The use of $\delta^{13}C$ analysis is helpful for determining the types of plants consumed by the specimen under study; specifically, C_3 versus C_4 pathway plants (Farquhar et al. 1989). C_3 pathway plants include cool-season grasses, trees, and most bushy plants and discriminate against ^{13}C relative to ^{12}C (Cerling et al. 1998). The bulk of plants native to the Great Lakes region are C_3 plants, and represent the entirety of wild plant that were available for human consumption prehistorically (M. Bender et al. 1981). C_4 pathway plants primarily include warm-season grasses (Ehleringer et al. 1997). Because they do not discriminate against ^{13}C to the degree of C_3 pathway plants, the two plant types can be distinguished isotopically. Modern C_3 plants return $\delta^{13}C$ values of -26.7 +/- 2.7 ‰, whereas C_4 pathway plants return values of -12.5 +/-1.1 ‰ (Cerling et al. 1998). For prehistoric contexts (and any prior to the Industrial Revolution and the intense burning of fossil fuels), the values are enriched 1-2 ‰ (Marino and McElroy 1991; Tieszen and Fagre 1993).

As plants are consumed, these values transfer through the food chain predictably. The values are enriched by 5‰ as the plant is consumed, and they can be passed to higher trophic levels with further enrichment of 1‰ (Burton and Koch 1999; Katzenberg 1993). Samples taken from adult bone collagen represent a weighted average of long-term diet since the carbon in human bone collagen turns over slowly, requiring approximately 30 years to replace existing carbon with an equivalent amount of carbon (Harkness and Walton 1972; Libby et al. 1964; Stenhouse and Baxter 1977, 1979). Since maize is the only C_4 plant to play a significant role in the prehistoric Great Lakes diets, $\delta^{13}C$ provides an ideal means of tracking the use and importance of maize among Late Prehistoric populations (M. Bender et al. 1981).

$\delta^{15}N$ analyses measure the ratio of ^{15}N:^{14}N, as the ratio increases approximately 2-4.5 ‰ per trophic level it can provide an estimate of the importance of meat in the diet (Ambrose and DeNiro 1986; Schoeller 1999). For archaeologists, $\delta^{15}N$ analyses are ideally suited for estimating the dietary contribution of hunting to the diet (Ambrose 1987; Ambrose and Norr 1993; Bochrens et al. 2006).

While these studies normally rely on the analysis of human remains, there are often ethical (e.g., Walker 2008) or legal issues (e.g., NAGPRA or Wisconsin burial law 157.70) that limit such testing. In cases where human remains are unavailable for testing, archaeologists have begun using dog remains as a proxy (Cannon et al. 1999; Guiry 2012, 2013). The use of dogs as proxies is known as the Canine Surrogacy Approach (CSA) and has been proven effective at forager and agricultural sites around the world (Guiry 2012). CSA applications have been used as a proxy for human diets (Burleigh and Brothwell 1978) and for tracking human movement on the landscape (Clutton-Brock and Noe-Nygaard 1990; Fischer et al. 2007; Noe-Nygaard 1988). They are based on the premise that dogs have a unique bond with humans (Morey 2006) that leads to human populations feeding dogs a suite of foods similar to their own, dogs having access to humans' scraps and food by-products (Guiry 2012, 2013; White et al. 2004; White et al. 2001), and dogs' regular consumption of human feces; the similar diet is reflected in the bone chemistry (Allitt et al. 2008; Cannon et al. 1999; Katzenberg 1989; White et al. 2004).

Tankersley and Koster (2009) have shown that CSA is applicable in Ohio, and Edwards et al. (2017) have done so for the western Great Lakes. The applicability of CSA is assessed by comparing dog isotopes to associated human samples. For dog $\delta^{13}C$, values are often within the range of the human values, and dog $\delta^{15}N$ values often trail human values slightly (circa 0.5‰). The discrepancy in $\delta^{15}N$ is often attributed to human consumption of dog meat (see Guiry 2012, 2013 for a full discussion).

To supplement the paleoethnobotanical values for this dissertation, a National Science Foundation Grant (#1640364) was awarded, and used to analyze as many Late Prehistoric dogs from Wisconsin and Northern Illinois as were available. In addition to the NSF, four previously analyzed dogs were included. This includes three samples from the Fisher site and the one from the Nitschke Effigy Mound (Edwards et al. 2017). All samples (Table 4.7) were sent to the University of Utah's Stable Isotope Ratio Facility for Environmental Research. Under the supervision of Dr. Joan Coltrain, the samples were processed and $\delta^{15}N$, $\delta^{13}C$, and AMS testing was conducted. While the sample is skewed towards Western Wisconsin, particularly the La Crosse locality, it represents all the definitive dog remains that could be located.

Table 4.4: Dog remains sent for isotopic analysis: MPM=Milwaukee Public Museum, WHS = Wisconsin Historical Society, MVAC = Mississippi Valley Archaeology Center

Site Name	Site Number	Archaeological Culture	Locality	Curating Institution	# of Samples
Crescent Bay Hunt Club	47JE904	Oneota	Koshkonong	UW-Milwaukee	2
Aztalan	47JE001	Late Woodland/ Middle Mississippian	Near Koshkonong	UW-Milwaukee	3
Diamond Bluff	47PI002	Oneota	Red-Wing	UW-Milwaukee	2
Fisher	11WI005	Langford/Fisher	Upper Illinois	UW-Milwaukee	3
Nitschke Mounds	47DO027	Effigy Mound	n/a – Horicon	MPM	1
OT	47LC262	Oneota	La Crosse	WHS	2
Valley View	47LC034	Oneota	La Crosse	MVAC	2
Pammel Creek	47LC061	Oneota	La Crosse	MVAC	1
Gunderson	47LC394	Oneota	La Crosse	MVAC	3

Evaluation of Research Questions:

1) What was the nature of the diet in the Koshkonong locality?

The first research question was divided up into smaller, more specific ones that could be more easily evaluated by data (Table 4.8). Below, I discuss the methods that will be applied to each question.

Table.4.5: Research sub-questions

#	**Sub-Questions**
1.1	Which plants were the largest contributors?
1.2	What were the role of agricultural plants?
1.3	Did the residents of CBHC and KCV rely on the same food?
1.4	Did they exploit the same environmental zones?
1.5	What do the species utilized tell us about the seasonal scheduling and labor organization?
2.1	Is the Koshkonong Oneota diet diversified?
2.1a	Relative to other Oneota localities?
2.1b	Relative to other contemporary cultures?
2.2	Is the Koshkonong Oneota diet locally adapted (Hart 1990)
2.2a	Does each locality equally rely on agricultural resources?
2.2b	Does each locality rely on the same suite of non-agricultural resources?
2.2c	In what ways do Oneota subsistence systems vary?
3.1	Does the Koshkonong diet display the expected reduction in diet breadth relative to Late Woodland groups?
3.2	What evidence do we have of storage at the sites?
3.3	What evidence is there of other risk management strategies in the Koshkonong Locality?
3.4	What details about life in the Koshkonong Locality can be inferred from the chosen risk management strategies?
4	Does the Oneota subsistence system support a relationship between agriculture and cultural complexity?

To address the first question, “what was the nature of the diet in the Koshkonong locality” six aspects were examined. **Question 1.1, 1.2 and 1.3** will be addressed with density and ubiquity measures at both KCV and CBHC. Species with the greatest densities and highest levels of ubiquity will be considered as high ranked. Issues of processing, preparation, and taphonomy will also be considered. The ranking of the plants, and the range of plants used at each site will be compared. **Question 1.4** will be addressed by looking at the habitats of the plants used at the site and compared to the environmental reconstruction model. **Question 1.5** will be addressed by examining the seasonal availability of resources, the tending, harvesting, and processing needs of the plants to interpret the labor requirements needed to harvest the resources found archaeologically.

2) How does the subsistence system in Koshkonong differ from other groups?

The second question was broken into two parts. First, I address the assumption of diversity in Oneota diets. **Question 2.1a, b, c** will be addressed using diversity indices for each of the comparative sites. Indices for other Oneota sites will be used to determine if the Koshkonong levels are typical of Oneota subsistence, or if such a baseline even exists. As a site in a similar region, Aztalan will act as a control for the cultural role in dietary diversity. Additionally, the Koshkonong diversity values will be compared to earlier components in southeast Wisconsin. Second, I examine Hart's (1990) assertion that Oneota agriculture should be locally variable (**2.2a**). I also assess the similarity of the non-agricultural aspects of the diets (**2.2b**) through Mann Whitney U and principle component's analysis. This will highlight which sites are most similar, and which aspects of the diet differentiate them.

3) What risk management strategies were used in the Koshkonong Locality?

The question is divided into four parts. For the first part **3.1**, I assess the dietary aspects, and for the latter three, I assess other artifact classes at the study sites. To assess aspects of dietary change, Mann Whitney U tests are used to compare early and late components. If the model is correct, agricultural and aggregated resources should be statistically distinct between early and late contexts. The degree of storage (**3.2**) will be assessed by examining feature size and morphology. Evidence of other risk management strategies (**3.3**) will be examined using human osteological data (evidence of intergroup violence), site distribution data (as evidence of group mobility), and will reference ceramic analyses (evidence for interaction – Carpiaux 2018; Schneider 2015).

4) What are the relationships between agriculture and cultural complexity.

This question is assessed through statistical comparison of Upper and Middle Mississippian $\delta^{13}C$ values. Human and dog samples from Illinois, Wisconsin, and Minnesota are combined. Upper and Middle Mississippian values are compared using Mann Whitney U tests. Traditional approaches suggest that Middle Mississippian values should be higher than and statistically distinct from the Upper Mississippian values.

5. Results of Macrobotanical Data Collection

Introduction:

In this chapter I discuss the results of the macrobotanical analysis. The chapter begins with a description of the Crescent Bay and Koshkonong Creek assemblages. Site datasets are followed by univariate and multivariate comparisons of the assemblages. Next, a diachronic intralocality analysis is conducted to see if there are changes from the early (pre-AD 1250) and late (post-AD 1250) occupations of the sites. The chapter concludes with a comparison of the Koshkonong assemblage with assemblages from other localities.

Paleoethnobotanical Analysis: Crescent Bay Hunt Club:

A total of 21 samples from 12 features, totaling 3,217 liters were examined from the Crescent Bay Hunt Club. A variety of botanicals were identified in the samples, including Wood Charcoal, Domesticates (e.g., maize), nutshell, cultigens (e.g., chenopodium), fruits, other seeds, and organic material (e.g., fungus).

Wood and Bark Charcoal: Wood Charcoal (183,780 ct., 3,000 g) was found in 100% of samples (Table 5.1). The overall density was 570 ct./10 liters, with an average density of 1,040 ct./10 liters. The density ranges from 100 to 4,155 ct./10 liters. Only feature 04-14 zone 6N, the densest context, was significantly denser (95% confidence interval). Wood charcoal is by far the most abundant category in the floral assemblage, and it accounts for 89% of the total assemblage.

Bark charcoal (4,180 ct., 25 g) was recovered from 90% of contexts and in significantly lower densities relative to wood charcoal. This pattern is normal, and expected. The overall density was 13 ct./10 liters with an average density of 27 ct./10 liters and ranging from 0 to 14, with a total density of 8.75 ct./10 liters. Three contexts had higher than normal densities (95%

confidence interval), features 00-11 zone B, 04-14 zone 6N, and 06-63 zone B. Bark is typically thought to be an incidental inclusion from the burning of firewood with bark still adhered.

Table 5.1: Identified CBHC Charcoal Summary Data

Taxa	Count	Ubiquity	Density	Avg. Density
Wood Charcoal	183,783	100%	571.29	1,037.19
Bark Charcoal	4,184	90%	13.01	27.34
Total	**187,917**	**100%**	**584.29**	**1,064.53**
	Weight (g)		**Density**	**Avg. Density**
Wood Charcoal	3,006.23		9.34	15.45
Bark Charcoal	25.42		0.08	0.19
Total	**3,031.65**		**9.42**	**15.63**

Nutshell: This category represents (3,675 ct., 22 g) one of the most ubiquitous food resources at the site (Table 5.2). Some form of nut is present in 100% of contexts, though there is a large range of variation in count and density (from 0.5 ct./10 liters to 297 ct./10 liters), likely representing a resource of variable dietary importance. A total of three families of nutshell were identified from the site: *Juglandaceae, Fagaceae,* and *Betulaceae*.

Of these three families, four genera were identified including two from *Juglandaceae* (*Carya* or hickory, and *Juglans* or walnut), and one from both *Fagaceae* (*Quercus* or oak/acorn) and *Betulaceae* (*Corylus* or hazelnut). Specimens were rarely preserved sufficiently well for species identifications so this analysis is limited to the genus level. Acorn was the most abundant (2,613 ct., 10.5 g), found in 81% of contexts at relatively high densities (8 ct./10 liters, 0.3 g/10 liters). Hickory was the second most abundant (531 ct., 7.5 g), found in 67% of contexts, but at much lower densities (4 ct./10 liters, 0.05 g/10 liters). Walnut (120 ct., 1. 4 g) and Hazelnut (77 ct., 0.5 g) were both present in 48% of contexts, though Walnut was found in denser concentrations (0.4 ct./10 liters versus 0.2 ct./10 liters).

Feature 04-03 stands out for acorn, hazelnut, and hickory, with significantly denser counts of nutshell (95% confidence interval). Feature 06-63 zone B has significantly raised levels of hickory and acorn (95% confidence interval). Feature 04-14 zones 2 and 6N both have denser concentrations of walnut (95% confidence interval). Feature 04-03 also has elevated levels of walnut; however, it is within the normal range, albeit the high end. This feature's contents are possibly associated with nut processing. Features 04-03 and 06-63 zone B are both relatively small contexts (27 and 32 liters respectively), and are potentially associated with mast processing or mast waste.

Table. 5.2: Identified CBHC Nutshell Summary Data

Taxa	Count	Ubiquity	Density	Avg. Density
Hickory	531	67%	1.65	4.37
Hazelnut	77	48%	0.24	1.17
Walnut	119	48%	0.37	1.10
Acorn	2,613	81%	8.12	22.20
Total	**3,340**	**100%**	**11.43**	**0.18**
	Weight (g)		**Density**	**Avg. Density**
Hickory	7.55		0.02	0.05
Hazelnut	0.49		<0.00	0.01
Walnut	1.37		<0.00	0.01
Acorn	10.46		0.03	0.09
Total	**19.87**		**0.07**	**31.97**

Domesticates: This category includes maize (*Zea mays*), beans (*Phaseolus vulgaris*), squash rinds and seeds (*Cucurbita pepo*), and tobacco (*Nicotiana sp.*). All but tobacco is considered food plants. No Bottle Gourd (*Langeneria*) were identified in the samples (Table 5.3).

Of the domesticates, maize is the most abundant, ubiquitous, and dense (9,440 ct., 87 g). Maize kernels, cupules, and cob fragments have been identified from all contexts at CBHC (100% ubiquity) in relatively high densities (29 ct./10 liters, 0.3 g/10 liters, with average density of 45 ct./10 liters, 0.4 g/10 liters). Maize kernels (4,221 ct., 38 g) have been identified in 100% of features and contexts in relatively high densities (13 ct./10 liters, 0.1g/10 liters). Feature 04-14 zone 4 has significantly denser concentrations of maize kernels by weight and count (95% confidence interval).

Table 5.3: Identified CBHC Domesticates Summary Data

Taxa	Count (including cf.)	Ubiquity (including cf.)	Density (including cf.)	Avg. Density (including cf.)
Z. mays kernels	4,221 (4,390)	100%	13.12 (13.24)	24.06 (24.29)
Z. mays cupules	4,884 (4,899)	100%	15.18(15.31)	18.90 (19.08)
Z. mays cobs	151	38%	0.47	0.48
Z. mays Total	9,256 (9,440)	100%	28.77(29.34)	43.45(45.08)
C. pepo rinds	22	14%	0.07	0.02
C. pepo seeds	40	19%	0.04	<0.01
C. pepo total	62	19%	0.07	0.02
P. Vulgaris Seed	0 (1)	5%	0.00 (<0.00)	0.00 (0.02)
Total	**9,380 (9,565)**	**100%**	**28.97 (29.54)**	**43.58 (45.21)**
	Weight (g)		**Density (including cf.)**	**Avg. Density (including cf.)**
Z. mays kernels	37.82 (38.78)		0.12 (0.12)	0.22 (0.23)
Z. mays cupules	42.18 (42.25)		0.13 (0.13)	0.19 (0.19)
Z. mays cobs	5.69		0.02	0.02
Z. mays Total	85.69 (86.72)		**0.27 (0.27)**	**0.43 (0.43)**
C. pepo rinds	1.14		**<0.00**	**<0.00**
C. pepo seeds	0.13		**<0.00**	**<0.00**
C. pepo total	1.27		**0.01**	**<0.00**
P. Vulgaris Seed	**0 (0.02)**		**<0.00**	**<0.00**
Total	**86.98 (88.01)**		**0.27 (0.27)**	**0.43 (0.44)**

Despite being much smaller and physically less dense than acorn shells, maize kernels are found in concentrations 1.6 times the density by count, and 3.7 times the density by weight. The differences in density suggest that maize was a more important food resource.

Maize cupules (4,884 ct., 42 grams) were also found with 100% ubiquity by context. The overall ratio of kernels to cupules was 0.9 by count and 0.8 by weight, suggesting that a great deal of maize processing occurred on site. Maize cupules are found in relatively dense concentrations (15 ct./10 liters, 0.1 g/10 liters, average density 18 ct./10 liters, 0.2 g/10 liters). Several features (n=8, 38% ubiquity) also contained identifiable cob fragments (150 ct., 5.7 g). Features 10-14 and 10-19 both stood out with high densities of maize cupules (95% confidence interval). F10-14 stood out by count only, and F10-19 stood out by count and weight. This feature also had significantly denser quantities of cob fragments (count and weight), as did feature 10-98. Features 10-19 and 10-98 may represent general refuse from the processing of the autumn harvest. Feature 10-14 deserves more careful consideration because it contained a dog burial and its contents may represent atypical refuse deposition patterns.

Squash (62 ct., 1.3g) is found in much lower abundance, density (0.2 ct./10 liters, <0.00g/10 liters) and ubiquity (19%) than maize. The numbers likely underrepresent the importance of this plant as a crop as squash is less likely to enter the archaeological record due to preparation techniques (often eaten raw or cooked a low temperatures) and the fact that it does not survive well in the archaeological record (Toll 1988).

One possible bean (cf., *Phasaeolus vulgaris*) seed was recovered from F02-25; however, it was too fragmented for a definitive identification. Definitive beans have been identified from KCV (see below) and based on recent reexaminations (Monaghan et al. 2014) of the introduction of the bean to the Great Lakes region, the presence of bean in the Koshkonong Locality is not unexpected. The low density and ubiquity of the plant suggests that it was not a major part of the diet, though like squash, beans are often underrepresented in the archaeological record (Toll 1988).

Two contexts, features 00-26 and 02-25 both have potential tobacco seeds (cf., *Nicotiana sp*.). Eight potential seeds were identified in F00-26 and 12 in 02-25. Tobacco would not have been used as a food crop, but smoked during important religious ceremonies. This has been recorded ethnographically, and ethnohistorically among many Great Lakes groups. The plant is often mentioned in creation stories and its use was described as a means to communicate with deities of the Upper World (e.g., Radin 1923; Skinner 1921).

Cultigens & Grains: This category, hereafter referred to as cultigens, includes a wide array of plants with either starchy or oily seeds: goosefoot (*Chenopodium sp.*); barnyard grass (*Echinochloa*); little barley (*Hordeum pusillum*); knotweed (*Polygonum sp.*); and wild rice

(*Zizania sp.*). These plants are included in this category because they either represent semi-domesticated to domesticated varieties (e.g., *Chenopodium berlandieri*) or at least managed populations (e.g., wild rice) (Vennum Jr 1988). In short, even if these plants are not morphologically distinct from their wild relatives, they represent plants whose populations were enhanced by human intervention.

A total of 2,948 cultigen seeds were identified with 100% ubiquity and a density of 9 seeds/10 liters. Wild rice (1,563 ct., 1,670 ct. including cf.) is the most abundant and ubiquitous (76% ubiquity, 86% ubiquity including cf.), accounting for over half of the cultigen seeds identified. Goosefoot is the second most abundant (1,210 ct., 1,290 ct. including cf.), ubiquitous (71%, 76% including cf.,), and dense (3.77 ct./10 liters, 3.9 ct./10 liters). The remaining seeds account for less than 1.5% of the identified cultigens (Table 5.4).

Feature 04-14 zone 2 is an outlier with significantly more wild rice than the others (95% confidence interval). Feature 04-15 zone A has significantly more goosefoot than the other features (95% confidence interval). Overall, feature 04-14 zones 2 and 4 have more cultigens than other features. The remaining features were within the normal range of variation.

Table 5.4: Identified CBHC Cultigens Summary Table

Taxa	Count (including cf.)	Ubiquity (including cf.)	Density (including cf.)	Avg. Density (including cf.)
Wild Rice	1,563 (1,666)	76% (86%)	4.85 (5.17)	9.07 (10.37)
Chenopodium	1,212 (1,239)	71% (76%)	3.77 (3.85)	2.68 (2.78)
Hordeum/ Zizania	18	14%	0.06	0.19
Little Barley	10	5%	0.03	0.05
Knotweed	13	15%	0.04	0.05
Barnyard Grass	2	5%	0.01	0.14
Total	**2,948**	**100%**	**9.16**	**13.57**

Fruits: A total of six species of fruits were identified from Crescent Bay (Table5.5), totaling 213 seeds (0.7 ct./10 liters, average 0.9 ct./10 liters) in just under half of the contexts (43% ubiquity). Nightshade accounts for nearly half of the fruit seeds identified (100 ct.) with

19% ubiquity, and the highest density at 0.3 ct./10 liters (average 0.4 ct./10 liters). Raspberry (*Rubus sp.*) accounts for the next largest taxa (66 ct.), also with 19% ubiquity, though lower density (0.2 ct./10 liters, average 0.3 ct./10 liters). Hawthorne (*Crataegus sp.*) is the third of the of the three significant fruit species (44 ct.) with 14% ubiquity and 0.1 ct./10 liters (average density, <0.1 ct./10 liters). Black Huckleberry (cf., *Gaylussacia baccata*), Choke Cherry (*Prunus pensylvanica*), and Canada Plum (*Prunus nigra*) are each present in 5% of contexts with a single seed.

Features 10-98 and 04-14 zone 2 are high outliers, with more fruit seeds than other contexts (95% confidence interval). Feature 04-14 zone 2 has significantly more nightshade. Features 04-14 zone1 and F10-98 have significantly more raspberry. Feature 04-14 zone 5 has significantly more Hawthorne.

Table 5.5: Identified CBHC Fruit Seeds Summary Data

Taxa	Count	Ubiquity	Density	Avg. Density
Nightshade (*Solanum*)	100	19%	0.31	0.43
Raspberry (*Rubus*)	66	19%	0.21	0.34
Hawthorne (*Crataegus*)	44	14%	0.14	0.07
Black Huckleberry (cf., *Gaylussacia baccata*)	1	5%	<0.00	0.01
Choke Cherry (*Prunus pensylvanica*)	1	5%	<0.00	<0.00
Canada Plum (*Prunus nigra*)	1	5%	<0.00	<0.00
Total	**213**	**43%**	**0.66**	**0.86**

Other Seeds: A total of 1,013 additional seeds were recovered. The bulk are either unidentifiable (464 ct.) or unidentified (102 ct.). Most of the remainder could only be identified to family e.g., 97 grass seeds (*Poaceae*) and 62 rose family seeds (*Rosaceae*).

***Other Botanicals*:** A variety of other botanical remains have been identified from CBHC. Of note, buds were identified in features 00-11, 00-26, and 04-22 indicating a late winter/early spring occupation of the site. Fungus (1,034 ct.; 3.5 g) was also identified from 86% of features. Feature 04-14 zone 4 has statistically more fungus than other contexts (95% confidence interval).

The only item of dietary note is the 53 (3.8 g) fragments of aquatic tuber identified from 24% of contexts.

CBCH Floral Summary and Seasonality: The macrobotanical assemblage (Figure 5.1) indicates that the residents of Crescent Bay were heavily reliant on maize agriculture. The remains of the plant were found in greater densities and ubiquities than any other taxa. Maize agriculture was supplemented with a wide array of seeds, nuts, and tubers though acorn, hickory, wild rice and chenopodium were found in greater densities and ubiquities than any other. Small amounts of squash seeds and rind indicate that other domesticated flora were also used to supplement the maize harvests; however, the nature of squash preservation makes it difficult to determine how significant it was. The floral data support a year-around occupation of the site. Maize and squash would have been planted in spring and harvested in the autumn. Many of the seeds (e.g., *Panicum*) and fruits (e.g., *Rubus*) would have been available in the late summer and into the early autumn. Maize, wild rice, and nuts would have been available for harvest through most of the autumn months. Buds indicate that firewood was collected during the late winter and into the early spring. When the botanical data are combined with the number of large storage pits present at the site, a year around occupation is well supported.

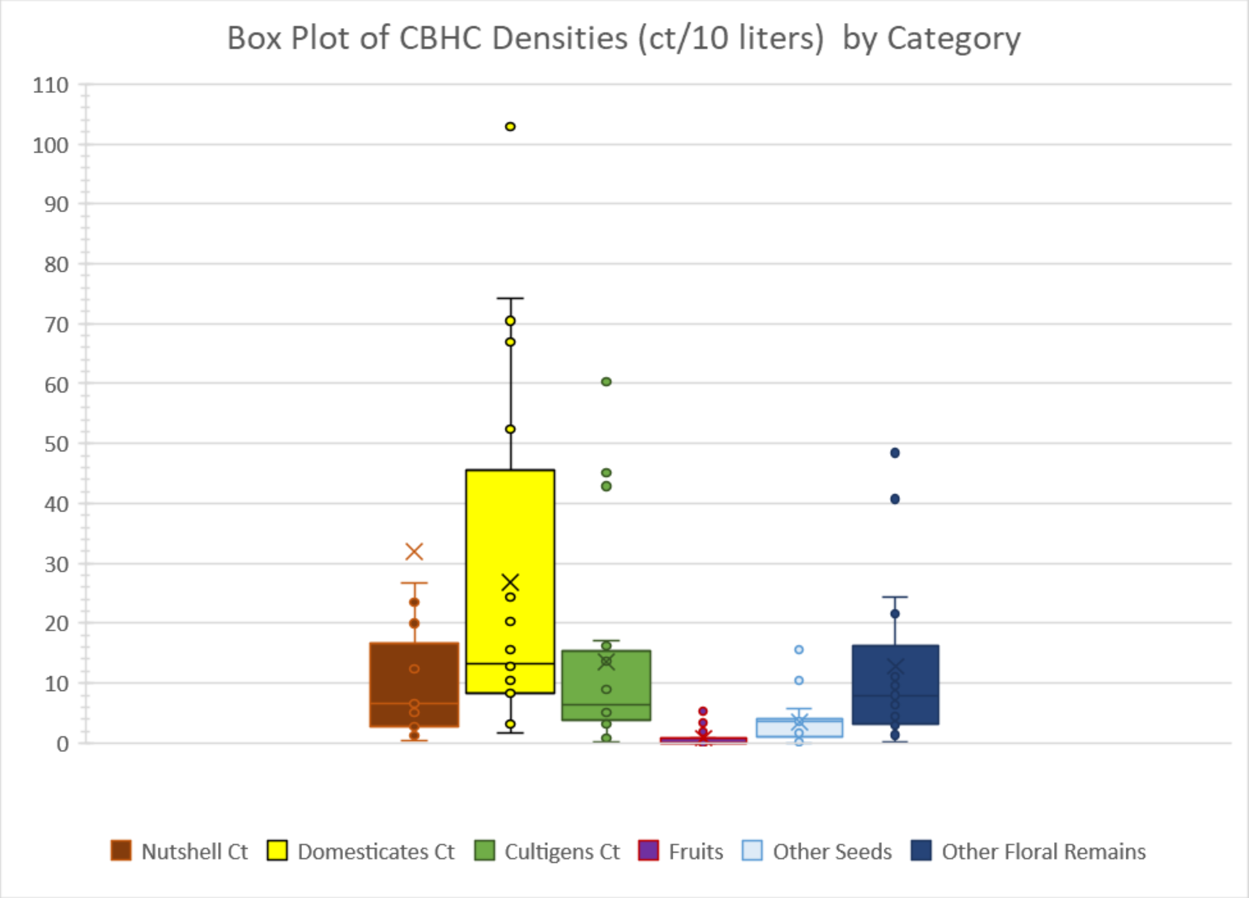


*Figure.5.1: Density Box Plot for CBHC by Floral Category *Two nutshell outliers are not shown (F04.03: 210 ct./10 liters; F06.63b: 297 ct./10 liters)*

Paleoethnobotanical Analysis: Koshkonong Creek Village:

A total of 19 contexts from three features were examined from the Koshkonong Creek Village. These samples totaled 1,100 liters of soil. A variety of botanicals were identified in the samples, including wood charcoal, domesticates (e.g., maize), nutshell, cultigens (e.g., chenopodium), fruits, other seeds, and organic material (e.g., fungus).

Charcoal: Wood charcoal (176,853 ct., 2,170 g) was found with 100% ubiquity. The overall density was 1,601 ct. 10/liters and an average of 1,910 ct./10 liters. Density ranges from 180.00 to 3,935 ct./10 liters. No outliers were identified (95% confidence interval). Wood charcoal is the most abundant category in the assemblage, accounting for 88% of the total site assemblage (Table 5.6).

Bark charcoal (1,830 ct., 143 g) was recovered from 95% of contexts and in significantly lower densities relative to wood charcoal. The overall density was 17 ct./10 liters with an average density of 28 ct./10 liters and ranging from 0 to 65. Two contexts had higher than normal densities (95% confidence interval), Feature 12-06 zone R had significantly more bark charcoal by count, and F12-06 zone O had significantly more bark charcoal by weight.

Table 5.6: Summary data for KCV Charcoal

Taxa	**Count**	**Ubiquity**	**Density**	**Avg. Density**
Wood Charcoal	176,853	100%	1,601.20	1,909.47
Bark Charcoal	1,831	95%	16.58	27.69
Total	**187,917**	**100%**	**1617.78**	**1937.16**
	Weight (g)		**Density**	**Avg. Density**
Wood Charcoal	2,169.06		19.64	20.93
Bark Charcoal	142.52		1.29	2.18
Total	**2,211.58**		**20.93**	**23.11**

Nutshell: The assemblage from KCV has nutshell (5,890 ct., 33 g) in 84% of contexts (Table 5.7). Initial examination of the data suggests much higher densities (53 ct./10 liters, 0.3 g/10 liters; average 35 ct./10 liters, 0.2 g/10 liters) than CBHC; however, the sample from feature 12-26 includes 74% of all nutshell by count and 58% by weight. The feature is a 79-liter basin, and if removed from the sample, density of nutshell drops precipitously (14.11 ct./10 liters 0.13 g/10 liters; average 7 ct./10 liters, <0.1 g/liters) to levels more in-line with the CBHC sample. In total, nutshell accounts for 3% of the floral assemblage and approximately 45% of the edible plant remains. If feature 12-26 is discounted, nutshell drops to less than 1% and 18% respectively.

Acorn (5,270 ct., 23 g) is the most ubiquitous (79%) and dense (48 ct./10 liters, 0.20 g/10 liters; average 33 ct./10 liters, 0.1 g/10 liters) genus of nut recovered from KCV. It represents approximately 90% of all nutshell identified from the site, and more than 80% of the acorn were found in feature 12-26. Hickory accounts for the bulk (10%) of the remaining nutshell (610 ct., 10 g) and was found in moderate densities (6 ct./10 liters, <0.1 g/10 liters; average 2 ct./10 liters, <0.1 g/10 liters). Feature 12-06 zone B has significantly more hickory than other features at a 95% confidence interval. A single walnut and hazelnut shell were identified in the sample.

Table 5.7: Summary Data for KCV Nutshell

Taxa	Count	Ubiquity	Density	Avg. Density
Hickory	1	5%	0.01	0.01
Hazelnut	1	5%	0.01	<0.01
Walnut	610	37%	5.52	2.34
Acorn	5,272	79%	47.73	32.79
Total	**5,892**	**84%**	**53.35**	**35.43**
	Weight (g)		**Density**	**Avg. Density**
Hickory	7.55		0.02	0.05
Hazelnut	0.49		<0.00	0.01
Walnut	1.37		<0.00	0.01
Acorn	10.46		0.03	0.09
Total	**19.87**		**11.43**	**31.97**

Domesticates: The KCV sample includes four different domesticates: maize; beans; squash; and tobacco (Table 5.8). Like CBHC, no bottle gourds were identified. Of the domesticates, maize is the most abundant (8,460 ct., 72 g), ubiquitous (100% of features, 95% of contexts) and dense (77 ct./10 liters, 0.7 g/10 liters, average densities 86 ct./10 liters, 0.7 g/10 liters). F12-06 zone E had a significantly more by both count and weight (95% confidence interval).

Maize kernels (5,350 ct., 45 g) have been identified in all three features and 95% of contexts in high densities (49 ct./10 liters, 0.4 g/10 liters, average 41 ct./10 liters, 0.3 g/10 liters). Feature 12-01 zone E had significantly higher densities by count, and Feature 12-06, zone G had significantly higher densities by weight. Maize kernels account for 3% of the total assemblage and 41% of the edible plant assemblage.

Table 5.8: Summary data for KCV Domesticates

Taxa	Count (including cf.)	Ubiquity (including cf.)	Density (including cf.)	Avg. Density (including cf.)
Z. mays kernels	5,353 (5,359)	95%	48.47 (48.52)	41.47 (41.60)
Z. mays cupules	3,045	95%	27.57	42.90
Z. mays cobs	52	37%	0.47	1.23
Z. mays Total	***8,450 (8,456)***	***95%***	***76.51(76.56)***	***85.61 (85.75)***
C. pepo rinds	5	5%	0.05	0.14
C. pepo seeds	7	11%	0.06	0.09
C. pepo total	12	16%	0.11	0.24
P. Vulgaris Seed	2 (4)	5% (16%)	<0.00(0.04)	0.02(0.08)
Total	**8,464 (8,472)**	**95%**	**76.65 (76.71)**	**86.01 (86.07)**

	Weight (g)	Density	Avg. Density
Z. mays kernels	45.29 (45.32)	0.41 (0.41)	0.34 (0.34)
Z. mays cupules	24.16	0.22	0.30
Z. mays cobs	2.15	0.02	0.05
Z. mays Total	***71.63 (71.66)***	***0.60 (0.65)***	***0.55 (0.69)***
C. pepo rinds	0.01	<0.01	<0.01
C. pepo seeds	0.12	<0.01	<0.01
C. pepo total	0.13	<0.01	<0.01
P. Vulgaris Seed	0.08 (0.70)	<0.01(0.01)	<0.01(0.02)
Total	**71.84 (72.49)**	**0.60 (0.66)**	**0.69 (0.71)**

Cupule and glume fragments (3,045 ct., 24 g) were also found in all three feature, and in 95% of contexts. Cupules and glumes were also found in relatively high densities (28 ct./10 liters, 0.2 g/10 liters, average 43 ct./10 liters, 0.3 g/10 liters). Feature 12-06 zone E has significantly higher densities of cupule/glume fragments by both count and weight. Cupule/Glume fragments account for 2% of the total assemblage. Cob fragments (52 ct., 2 g) were found in 37% of features, but at much lower densities (0.5 ct./10 liters, <0.1 g/10 liters, average 1 ct./10 liters, <0.1 g/10 liters). Feature 12-06 zone L is significantly denser than other features by weight. Maize cobs account for <1% of the total assemblage.

Squash has been identified at KCV in low abundance (12 ct., 0.1 g), ubiquity (16%) and densities (0.1 ct./10 liters, <0.01 g/10 liters; average 0.2 ct./10 liters, <0.01 g/10 liters). Both squash seeds and rind are present in the sample, though seeds are more common. Squash seeds account for 58% of the squash remains by count and 95% by weight. Squash seeds are also found in both features 12-01 and 12-06 whereas rind has only been identified in 12-06; however, the sample size is too small to try to draw any conclusions from this disparity. Together, squash represents approximately 0.1% of the edible portion of the floral assemblage and less than 0.01% of the total floral assemblage.

Common beans (4 ct., 0.70 g) have been identified in one definitive zone and possibly in two other zones within feature 12-06. Beans are found in relatively low ubiquities (16%) and densities (<0.1 ct./10 liters, <0.1 g/10 liters; average <0.1 ct./10 liters, <0.1 g/10 liters). The feature dates to the 13th century AD, which aligns well with the projected timeline for the spread of beans from the Great Plains across the Great Lakes (Monaghan et al. 2014). Beans account for less than 0.01% of the total floral assemblage and approximately 0.03% of the edible portion of the assemblage. This suggests that it may have taken time after the introduction of the bean for it to rise to a prominent position within the diet. However, like squash, beans rarely preserve well (Toll 1988). Their presence, which has not been noted on any other contemporaneous sties in eastern Wisconsin, may indicate a greater reliance than their low abundance suggests. Furthermore, the use of an additional domesticate may be indicative of a greater reliance on agricultural output than other Wisconsin localities.

The final potential domesticate identified at KCV is tobacco. No definitive tobacco has been identified to date; however, two contexts in F12-06 contain possible tobacco seeds. A total of 14 cf., tobacco seeds are present in zones A2 and V.

Cultigens: The KCV floral assemblage includes cultigens (980 ct., 9 ct./10 liters; average density 14.16 ct./10 liters) in every context (100% ubiquity). Wild rice (794 ct., 837 ct. with cf.) accounts for roughly 85% of the cultigens and is found in relatively high ubiquity (89%) and densities (8 ct./10 liters, average density 9 ct./10 liters). It accounts for roughly 0.4% of the overall assemblage, and 9% of the edible floral assemblage. Feature 12-06 zone L has significantly more Wild Rice than other contexts (95% confidence interval). Given the high ubiquity and density, wild rice likely represents a major food resource for the occupants of KCV (Table 5.9).

Table 5.9: Summary data for KCV cultigens

Taxa	**Count (including cf.)**	**Ubiquity (including cf.)**	**Density (including cf.)**	**Avg. Density (including cf.)**
Wild Rice	794 (837)	84.2% (89.5%)	7.19 (7.58)	7.88 (9.02)
Chenopodium	77 (82)	57.9% (63.2%)	0.70 (0.74)	1.48 (1.53)
Hordeum/ Zizania	48	21.1%	0.43	3.40
Little Barley	10	21.1%	0.09	0.14
Maygrass	2	5.3%	0.02	0.07
Total	979	100.0%	8.86	14.16

Chenopodium (77 ct., 82 ct., including cf.) is the next most abundant (77 ct., including cf., 82). With roughly 60% ubiquity, chenopodium is present in much lower densities (0.7 ct./10 liters, average density 2 ct./10 liters) than wild rice. Most of the identifiable prehistoric chenopodium were chenopod embryos. Goosefoot accounts for 8% of the identified cultigens, 0.62% of the edible seeds, and 0.04% of the total floral assemblage. Feature 12-06 zone L also had a significantly higher amount of goosefoot at a 95% confidence interval. Based on ubiquity, chenopodium appears to have been a consistently used resource, though the low density suggests that it likely a mid-to-low ranked resource. Because this resource can also be eaten as a green, it is likely that its density underrepresents its importance. When consumed as a green, its presence is not readily visible in the archaeological record.

A total of 48 seeds were identified as either little barley or wild rice (21% ubiquity, 0.4 ct./10 liters, average density 3 ct./10 liters). An additional 10 seeds were definitively identified as barnyard grass (21% ubiquity, 0.1 ct./10 liters, average density 0.1 ct./10 liters). Maygrass (*Phalaris caroliniana*) is the only other domesticate identified at the site. Maygrass (2 ct., 5%

ubiquity, <0.1 ct./10 liters; average density <0.1 ct./10 liters) was found in a single context. It does not appear that either little barley or maygrass were major dietary contributors.

Fruits: The KCV floral assemblage includes five genera of fruits: Hawthorne; Strawberry (*Frageria sp*.); Sumac (*Rhus sp.*); Raspberry (*Rubus sp.*); and nightshade (*Solanum sp.*). Nightshade is the most common (24 ct., 36.8% ubiquity; 0.2 ct./10 liters; average density 0.5 ct./10 liters), followed by sumac (19 ct., 16% ubiquity; 0.2 ct./10 liters; average density 0.1 ct./10 liters), raspberry (10 ct.; 16% ubiquity; 0.1 ct./10 liters; average density <0.1 ct./10 liters), strawberry (3 ct.; 11% ubiquity; <0.1 ct./10 liters; average density 0.2 ct./10 liters), and Hawthorne (2 ct.; 5.3% ubiquity; <0.1 ct./10 liters; average density; 0.01% ubiquity). Given the low values, fruits may not have been a significant aspect of the diet. However, they were likely a seasonally important resource (Table 5.10). If eaten raw, this would reduce the likelihood that they would encounter fire and enter the archaeological record. If they preserved regularly and in large numbers for use year around, they would likely be found in greater numbers and ubiquity.

Table 5.10: Summary data for Fruits at KCV

Taxa	Count (including cf.)	Ubiquity (including cf.)	Density (including cf.)	Avg. Density (including cf.)
Hawthorne	2	5.3%	0.02	0.01
Strawberry	3	10.5%	0.03	0.18
Sumac	19 (21)	15.8% (15.8%)	0.17 (0.19)	0.14 (0.20)
Raspberry	10	15.8%	0.09	0.06
Nightshade	24	36.8%	0.22	0.50
Total	**60**	**58.9%**	**0.5**	**0.97**

Other Seeds: A variety of other seeds have also been identified at KCV (992 ct.; 95% ubiquity; 9 ct./10 liters; average density 9 ct./10 liters). The bulk (70%) of these seeds are from the genus *Najas* (Water Nymph), and were recovered exclusively in cylindrical pits (F12-01, F12-06, and most commonly in the lowest zones of the features (F12-01 zone E: 35.2 ct./10 liters, F12-06 zone V: 28 ct./10 liters). This plant may have been used to line storage pits and the density of the seeds at the base of the pit corroborate this interpretation (Egan-Bruhy, personal communication). Therefore, *Najas* is not interpreted as a dietary plant. Though if it were, its density (6 ct./10 liters) would make it the second densest seed after wild rice, and the fourth densest plant after maize, acorn, and wild rice. The next most abundant are unidentifiable seeds (94 ct.). Other seeds include wild bean (*Strophstyles helveola*), bulrush (*Scirpus sp.*) and a variety of seeds identifiable only to the family such as *Rosaceae* and *Poaceae.*

***Other Floral Remains*:** A variety of non-seed/wood remains have also been identified. Of note, three buds were identified from feature 12-06 zones D, L, and W. Buds are significant in that they are reasonably good indicators of seasonality. Buds form in late winter and early spring, so their presence is indicative of a winter occupation at KCV, and winter use of feature 12-06. Zone D is relatively high in the feature, while zones L and W are towards the base. This suggests that either the one-meter wide, one-meter deep feature was filled relatively quickly (i.e., within one season), or it took at least one year to fill with refuse.

A considerable amount of fungus was also recovered from the site (3,602 ct. 11.29 g) in 89% of contexts. It is the fourth most common item in the assemblage (after wood charcoal, maize, and acorn), accounting for nearly 2% of the assemblage. Feature 12-06 zone Q is the only outlier context with a higher density (95% confidence interval) of fungus. A variety of stems and other plant remains were found. The only one of dietary importance is aquatic tuber fragments (18 ct.; 0.48 g; 21% ubiquity).

KCV Summary and Seasonality: The general patterns noted in the CBHC assemblage hold true for KCV (Figure 5.2). Maize is the densest and most ubiquitous taxon, from which we can infer that maize agriculture was a major component of the residents' diet. Squash has also been recovered from KCV, as has domesticated beans. Acorns and wild rice appear to be the most significant non-agricultural resources. Relative to CBHC, chenopodium and hickory appear in more modest densities and do not appear to be as significant to the overall diet. KCV has the same suite of seasonally available plants (domesticates, nuts, fruits, buds, tubers) to support a year-around occupation.

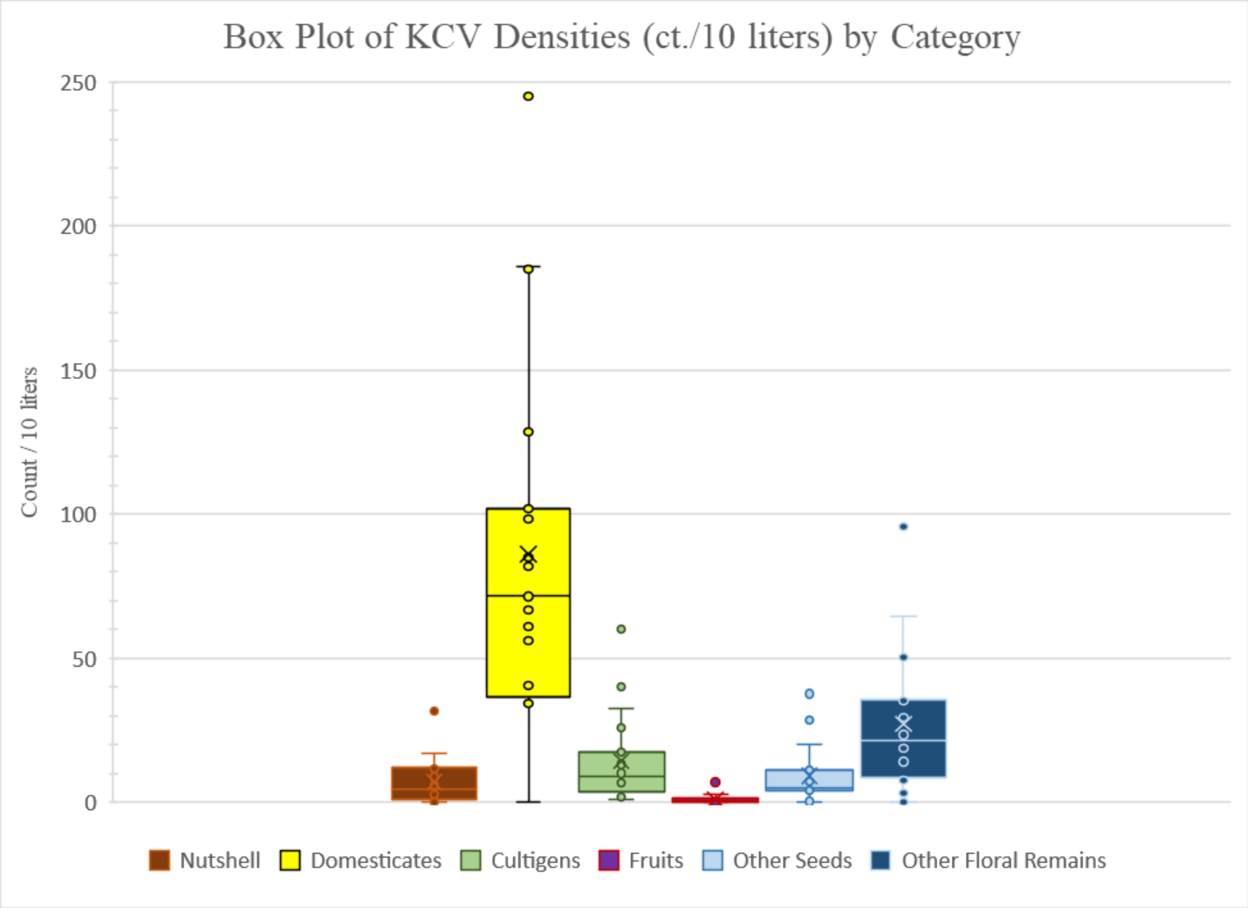


*Figure 5.2: Density Box Plots for KCV by Floral Category *One nutshell outlier not shown (F12-26: 549 ct./10 liters)*

Comparison of KCV and CBHC

The assemblages at KCV and CBHC were compared using several techniques to determine if differences were present, and if so how were they different. Several initial comparisons were made based either on research questions (e.g., did access to arable land affect the amounts of maize), or observations of differences in the descriptive statistics of the datasets (e.g., diversity indices, amounts of nutshell appeared different between the sites). To determine if amounts of various taxa were significantly different between the sites, they were subjected to independent sample t-tests. Principle component's analysis (PCA) was then applied as an exploratory data technique. Because it can find patterns not readily available on a multivariate level, it was used to both look for differences between the sites and to better understand the assemblages.

Expected Environmental Differences: Based on environmental reconstructions (Edwards 2010), the residents of the two sites likely had different access to certain resources. With its location along Lake Koshkonong, CBHC residents would have had greater access to wetland resources, such as wild rice. Conversely, KCV had greater access to savannahs and arable land. In this location, residents would have had greater access to many types of fruits and nuts. They would also have had a greater potential for maize output. A series of comparisons, using statistical measures ranging from diversity indices to t-tests, were administered to the datasets to determine if there was a significant difference between the sites assemblages.

For the t-tests, to avoid differences in sample size, densities were compared whenever possible, rather than absolute counts or weights. For maize and nutshell, the density of both counts and weights were used. For wild rice, chenopodium, and fruits, weight data were not collected so only count data were used. Because each taxa fruit was present in low ubiquities and densities, the total density of fruit was used.

Diversity Indices: Based on all the available measures (Table 5.11), the Crescent Bay assemblage is more diverse than KCV's. The total number of taxa at CBHC (NTAXA=36) is slightly higher than at KCV (NTAXA=33). The Simpson's diversity index shows that CBHC is more even, and the Shannon index shows that it is more heterogeneous. In other words, the

*Table 5.11: Diversity indices comparing Crescent Bay and Koshkonong Creek Village - *contexts with extreme outlier values removed*

		Shannon			Simpson	
Site Name	NTAXA	diversity index	max index	homogeneity	diversity index	1/D
KCV	33	1.42	4.19	0.34	0.33	3.01
CBHC	36	1.89	4.28	0.44	0.22	4.47
KCV*	30	1.41	4.09	0.35	0.40	2.53
CBHC*	35	1.83	4.25	0.43	0.25	4.00

residents at CBHC relied on a broader suite of plants for subsistence than those at KCV. An examination of the proportions of each taxon can highlight which are causing the score discrepancies. The KCV assemblage is dominated by two taxa (maize and acorn), which account for more than 80% of the assemblage. Maize and acorn also account for the bulk of the Crescent Bay assemblage at 59%, but wild rice and chenopodium also account for a large proportion (25%). The proportional importance of each taxa indicates that KCV residents were most reliant on two species where CBHC residents were heavily reliant on at least four.

However, the high reliance on acorn at KCV is largely due to one outlier feature, 12-26. It accounts for more than 80% of the acorn shells recovered. If this feature is removed, the diversity indices drop, indicating that the KCV assemblage is even more dominated by a single taxon. The proportion of maize correspondingly rises to over 60% of the assemblage and wild rice climbs to 9% of the assemblage. Acorn drops to near parity with wild rice, from 40% to 11%. When the two acorn outliers (Feature 04.03 and 06.63b) from CBHC are dropped, there is a shift in the diversity indices (Table 5.11); however, the Simpson index shifted slightly less for CBHC than KCV. Also, the proportions of the taxa at CBHC did not shift significantly. The most notable difference is a roughly 5% drop in the proportion in acorn and a corresponding 5% increase in the proportion of maize. From these data, we can infer that maize is a consistently important crop at both sites, acorn levels fluctuate but are generally moderate. Wild rice is important at both sites, and this pattern is more visible when contexts with atypical amounts of nutshell are not included. Maize appears to be a larger component at KCV than CBHC. Conversely, wild rice appears to be more important at CBHC, than KCV and chenopodium appears to be important only at CBHC. However, since these proportions are based on raw counts and not densities these inferences need further examination.

Maize Consumption: The results of the Mann Whitney tests comparing total maize densities (kernels, cupules/glumes, and cob fragments), indicates that the null hypothesis (H_0: CBHC-dist. = KCV-dist.), is supported. KCV and CBHC samples are not different (Count U=114 p=0.06; Weight Count U=95 p=0.14) (Figure 5.3 and 5.4). By count, KCV is moderately larger, but by weight, there is no difference. The difference between the two tests may signify that the maize from KCV is likely more fragmented. However, maize kernels do demonstrate a difference between the sites. By count and weight, the kernels are more numerous at KCV than CBHC (Count & Weight U=90, p=0.01).

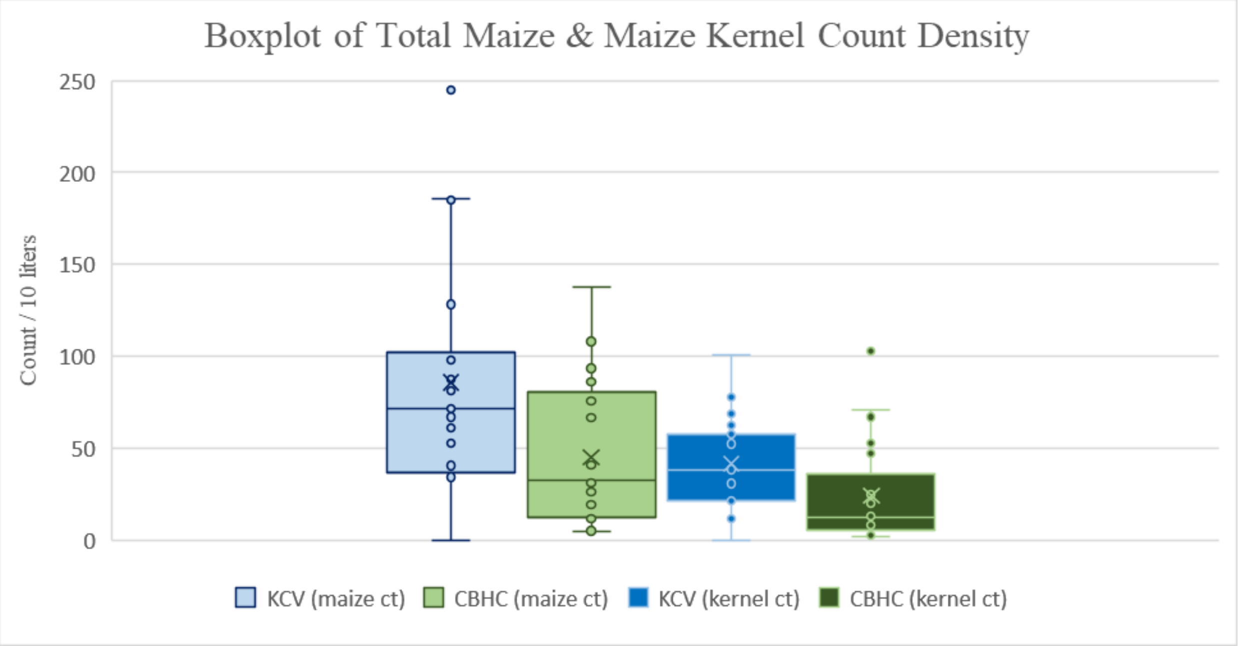


Figure 5.3: Distribution of maize density (count) for total maize and maize kernels at KCV (blue) and CBHC (green)

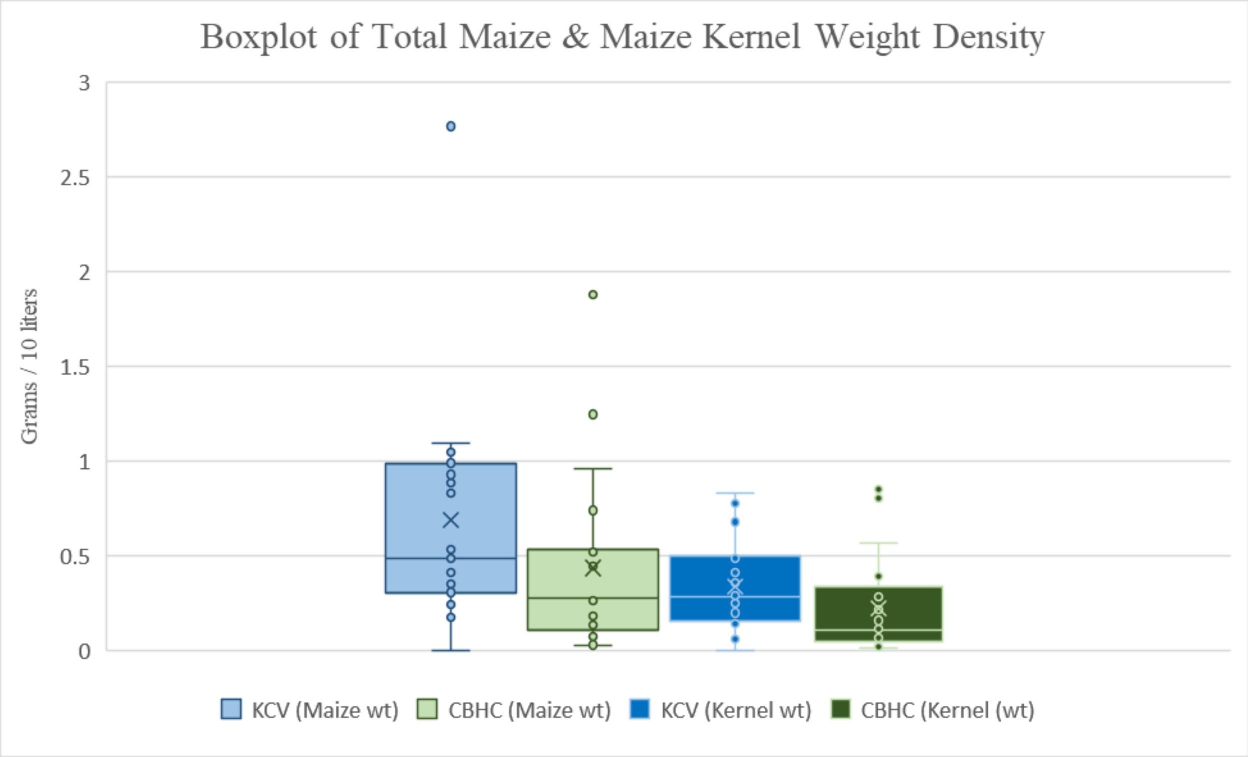


Figure 5.4: Distribution of maize density (weight) for total maize and maize kernels at KCV (blue) and CBHC (green)

While both the overall and mean density of maize kernels is also higher at KCV than CBHC, there was a smaller difference between the sites' average kernel densities than the average total maize densities (average total maize is 1.92 times greater at KCV than CBHC; average kernel density is 1.72 times greater at KCV than CBHC). This variation may indicate a difference in maize processing techniques between the sites, or a difference in maize cob disposal techniques.

A closer look at the ratio of kernels to cupules suggests that maize was processed onsite to a greater degree at CBHC than a KCV. Based on count, the kernel to cupule ratio at KCV was approximately 1.73, and 0.87 at CBHC. By weight the ratio was 1.72 at KCV and 0.81 at CBHC. Two Chi-Square tests of cupules and kernels (count and weight separately) from the two sites indicate that the ratio of kernels and cupules is different at the two sites (P<.05 for count and weight; Table 5.12). We can infer that either the processing or disposal patterns of maize was different between the two sites. However, Cramer's V values indicate that the difference was small, which may indicate that 1) residents at CBHC were more likely to process maize on the site than the residents at KCV, 2) they used a different technique to remove the kernels from the cobs, or, 3) that they disposed of the cob remains in a fashion that was more likely to preserve. A final possibility is that the larger number of features at CBHC provides a more complete picture of the local processing/refuse patterns and the high ratio at KCV reflects sampling bias. At this point, it is not possible to distinguish among these various scenarios.

Table 5.12: Chi-Square results - maize kernel to cupule ratio

	df	*chi-sq*	*p-value*	*x-crit*	*sig*	*Cramer V*
Pearson's (count)	1	532.68	<0.00001	3.84	yes	0.17
Pearson's (weight)	1	4.88	0.027	3.84	yes	0.18

Wild Rice and Chenopodium Consumption: It does not appear that CBHC residents used a greater amount of wild rice, *Chenopodium*, or cultigens overall (Figure 5.5). While CBHC Wild Rice density does trend higher, the two samples cannot be statistically differentiated (U=152, p=0.42). It appears either that wild rice was sufficiently ingrained into the local subsistence regimen that people at KCV were willing to travel a little further to harvest or trade for the plant, or that Koshkonong Creek and its associated wetlands provided an adequate habitat for it to grow in sufficient numbers to fulfill the needs of the site residents.

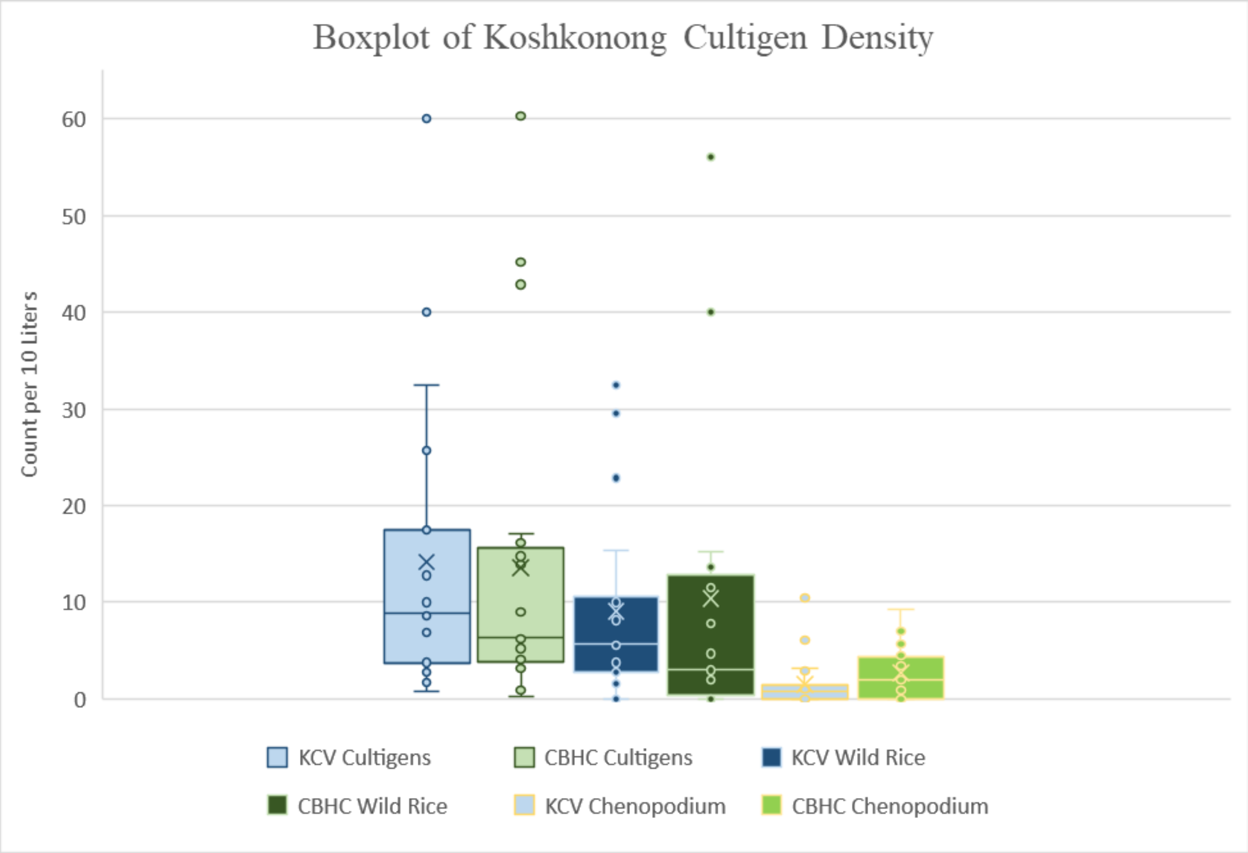


Figure 5.5 Boxplot results of Total Cultigens, Wild Rice, & Chenopodium from KCV (blue) and CBHC (green)

Chenopodium: The efficiency models do not necessarily predict which site should have greater amounts of chenopodium. As a wild plant, it grows in disturbed areas so it would likely have been found in and around both habitation sites. Forest edges, near wetlands, and along agricultural fields are also prime locations for the plant to grow (Fant and Gordon 1998; Fritz 1988; Robinson 2012, Smith 1987). Both sites are located near many areas such as these, and availability would likely fluctuate to favor one site or the other. However, a domesticated variant of chenopodium (*Chenopodium berlandieri*) was also grown in the Koshkonong Locality, which indicates that the plant was actively managed and planted (Olsen 2003). If one site's assemblage produced greater amounts of the plant, it may reflect cultural differences in taste, food choice, or land-use patterns among the residents. Variation in land-use patterns can be tied back to any number of economic (e.g., soil conditions) and non-economic (e.g., personal preference) root causes.

Chenopodium has previously been identified as one of the most ubiquitous and dense plants found at CBHC (Edwards and Pater 2011; Edwards 2016; Jeske et al. 2016). However, the KCV assemblage contains only small amounts of the seed, based on raw count and density values. The total density at CBHC is roughly five times greater than at KCV and the average density is more than 1.5 times greater at CBHC. The Mann Whitney U test generally supports this contention (U=118, p=0.07).

Nut Consumption: Based on the environmental contexts of the two sites, if nuts were exploited opportunistically or proportional to their availability, it would not be unexpected for the residents at KCV to have used nuts to a greater degree than those at CBHC. The higher proportion of savannah and forests around KCV and the corresponding lower amounts of prairie and lake means that there were likely more trees near KCV than CBHC. Furthermore, the General Land Office survey notes (Brink 1835; Miller 1833) indicate that oak and hickory were the dominant tree types in the region, so acorn and hickory could have been readily available, depending on the level of deforestation for firewood, clearance for agricultural lands, and burning to maintain a savannah environment (Wagner 2003).

The raw data initially provide an ambiguous picture. The overall densities suggest that KCV residents utilized more nut than CBHC residents. F12-26 at KCV is an extreme outlier, and most of the KCV densities parallel the CBCH values. Even with the high values of F12-26, the average density at CBHC is only moderately lower than at KCV. All outliers were removed from statistical analysis. The Mann Whitney tests could not differentiate the two samples (Count: U=133, p=0.25; Weight: U=137, p=0.31). The null hypothesis (H_0: KCV-dist. = CBHC-dist.) is supported. The one-tailed test indicated that KCV did not have more nutshell than CBHC, and the two-tailed test indicated that the two samples were not independent. In short, there is no statistical difference in the amount of nutshell (count or weight) between the two sites, which aligns well with the results of the PCA (see below). The PCA highlights features from both sites with atypical amounts of nutshell, but does not appear to distinguish between the sites. If there are differences in nut usage, it may be based on which kind of nut, rather than overall nut reliance.

Wood Charcoal: A final univariate comparison of wood charcoal densities showed significant differences between the CBHC and KCV assemblages based on count and weight (Figure 5.6). Based on count, the KCV samples include significantly more pieces of burned wood (U=88, p=0.003). KCV samples weigh more than the CBHC by an average of 5.5 grams per 10 liters (U-96, p=0.009). It is safe to say that KCV samples have marginally more charcoal, but are also more fragmented. This variation is consistent with the maize samples, but it is not clear if the difference is taphonomic or cultural.

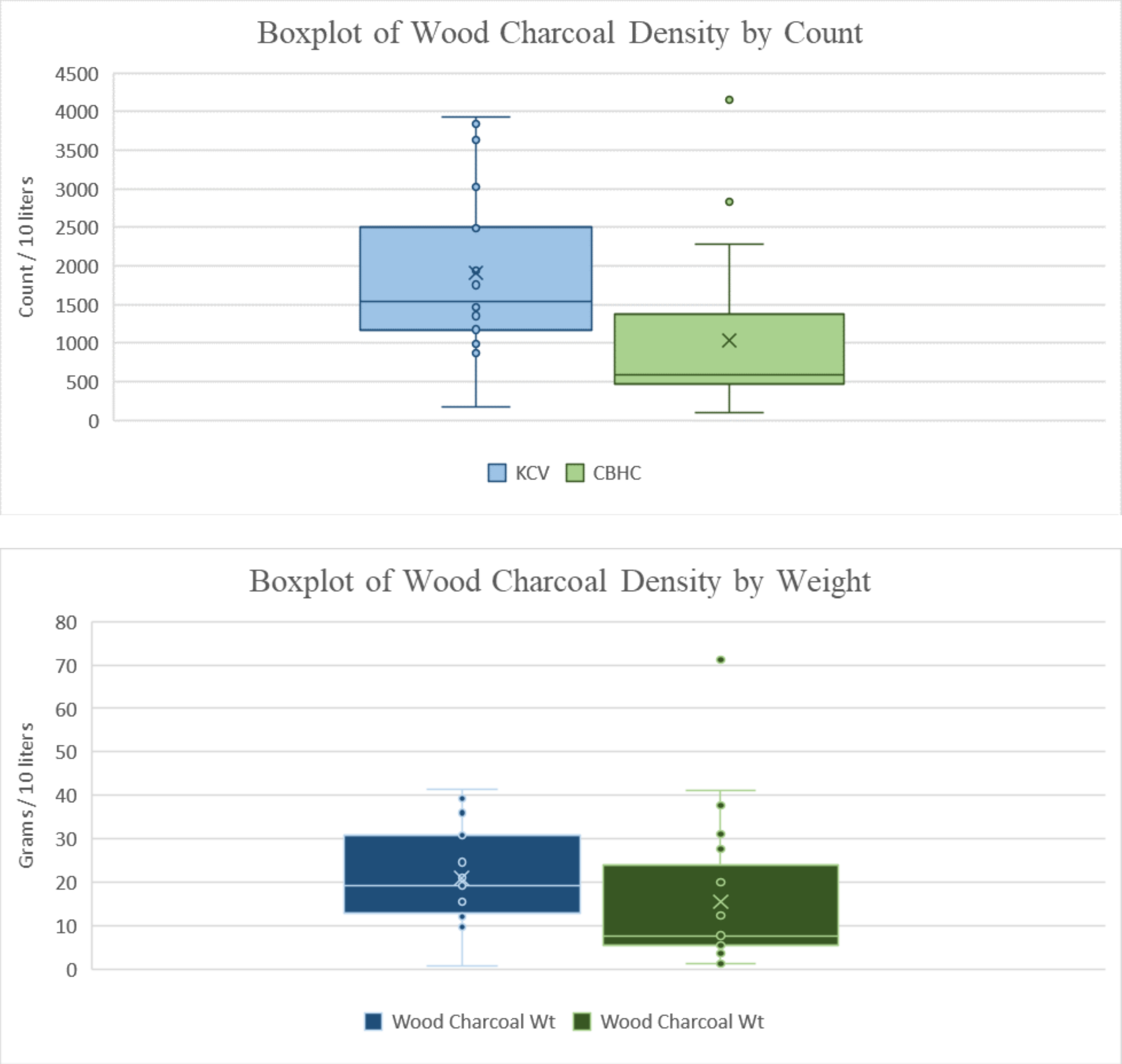


Figure 5.6: Boxplot of Wood Charcoal - Top by density by count - Bottom density by weight for KCV (blue) and CBHC (green)

Multivariate Analysis:

Principle component analysis was conducted between the two sites, using a correlation matrix. The Excel add-in program CAPCA, which was used to run the PCA, provides a normality check of each variable prior to running the primary analysis. Many taxa were initially skewed, but the program also offers two means of normalizing the data (Log and Arcsine), and the calculated skew if they were used. Most taxa in the Fruits and Other Seeds categories were present in such low ubiquities that the data remained severely skewed (beyond +/- 3) and could not be used in the PCA. Therefore, the data were run through the PCA in aggregate form; that is, aggregate totals for Nutshell, Domesticates, Cultigens, Fruits, and Other Seeds were run through the PCA as a single category. The aggregated nature of the new dataset was either normal, or near normal. After applying a Log transform for the data, skewness was no longer a factor. After patterns, using the whole, albeit aggregated dataset, were ascertained, subsequent PCA tests could be administered to some or all the less-skewed taxa within the categories.

In the initial run of the PCA, the skew of Nutshell was greater than 4, and both Fruits and Other Seeds had a skew greater than 2. Therefore, the entire dataset was Log transformed which reduced the skew to within +/-1.0. Once this was completed, the PCA test generated five eigen vectors using the high precision setting, which increases the number of iterations the test is run. The resulting five principle components explained essentially all the variation within the data (Table 5.13). The first two principle components explained most the variation within the data (33% and 22% respectively).

An examination of the variable loadings (Table 5.13) shows that the first principle component distinguishes between contexts that have disproportionately high densities of nutshell relative to everything else. The second principle component primarily highlights differences between the relative proportions of nutshell and cultigens. When the first two dimensions are graphed (Figure 5.7), two things become apparent. First, there is considerable overlap between CBHC and KCV across the whole figure, which suggests that in most contexts, subsistence patterns at CBHC and KCV were very similar. Second, despite the overall similarities, CBHC appears to have a more significant presence at the right side of the figure, suggesting a greater reliance on nuts for these features, and potentially at CBHC overall.

Table 5.13: CBHC, KCV PCA Eigen values and Variable Loadings

Eigenvalues	1. Principal component	2. Principal component	3. Principal component	4. Principal component	5. Principal component
Eigen values	1.65	1.11	0.85	0.73	0.67
Explanation %	32.92	22.20	16.98	14.53	13.36
Cumulative explanation %	32.92	55.12	72.10	86.64	100.00
Variable Loadings					
Nutshell Ct (log)	0.21	0.80	0.09	-0.37	-0.42
Domesticates Ct (log)	-0.51	0.36	-0.32	-0.31	0.64
Cultigens Ct (log)	-0.50	-0.39	-0.10	-0.58	-0.50
Fruits (log)	-0.51	0.27	-0.30	0.65	-0.39
Other Seeds (log)	-0.44	0.09	0.89	0.08	0.09

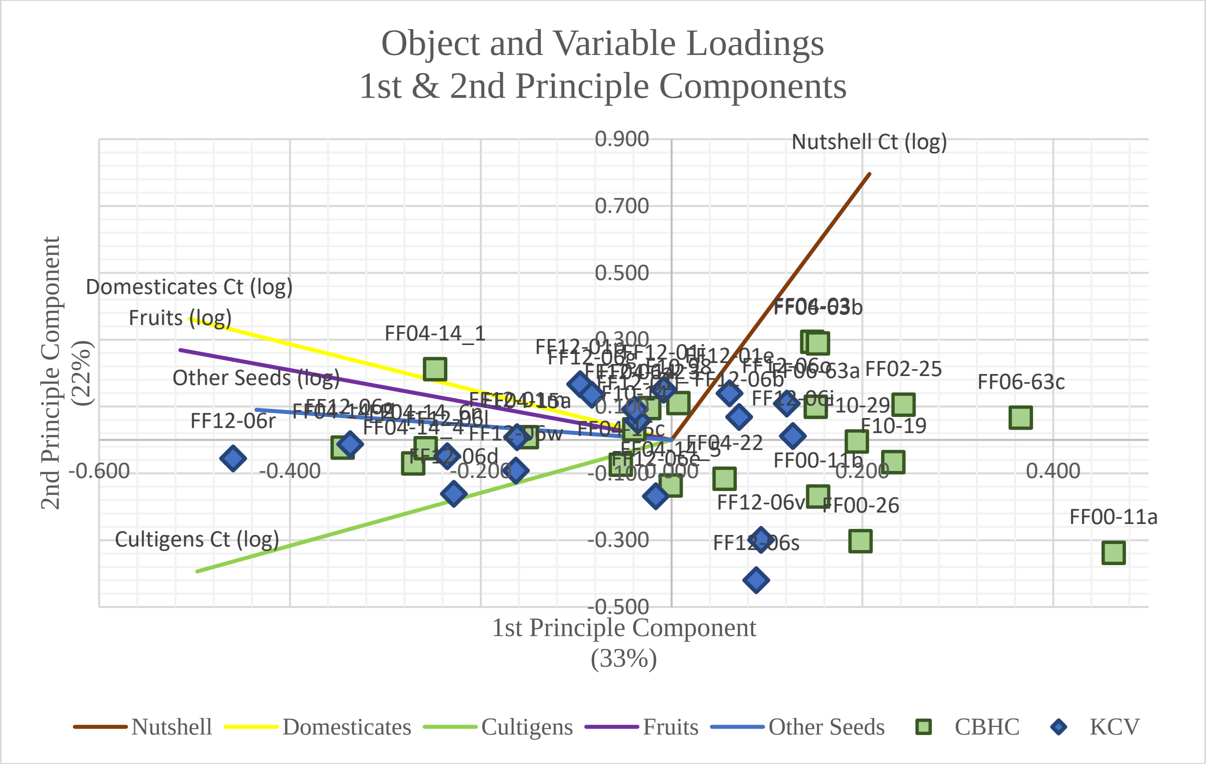


Figure 5.7: PCA Loadings of 1st and 2nd Principle Components grouped by site

To look for trends in the data, a K-Means Cluster Analysis was conducted. A total of five clusters produced the best fit (smallest sum of square error or SSE of 0.60). The graph of the two components was redrawn with cluster assignments built into the symbology (Figure 5.8). These clusters help to highlight the structure of the overall data and discern patterns from within it. Cluster 1 (left side of the graph) generally represents the high end of the agricultural output. These contexts all have moderate to very high densities of domesticates. When domesticate production is high, cultigens (primarily chenopodium and wild rice), as well as fruit and other seed densities also tend to be high. This cluster represents the second largest with 11 of the 40 contexts.

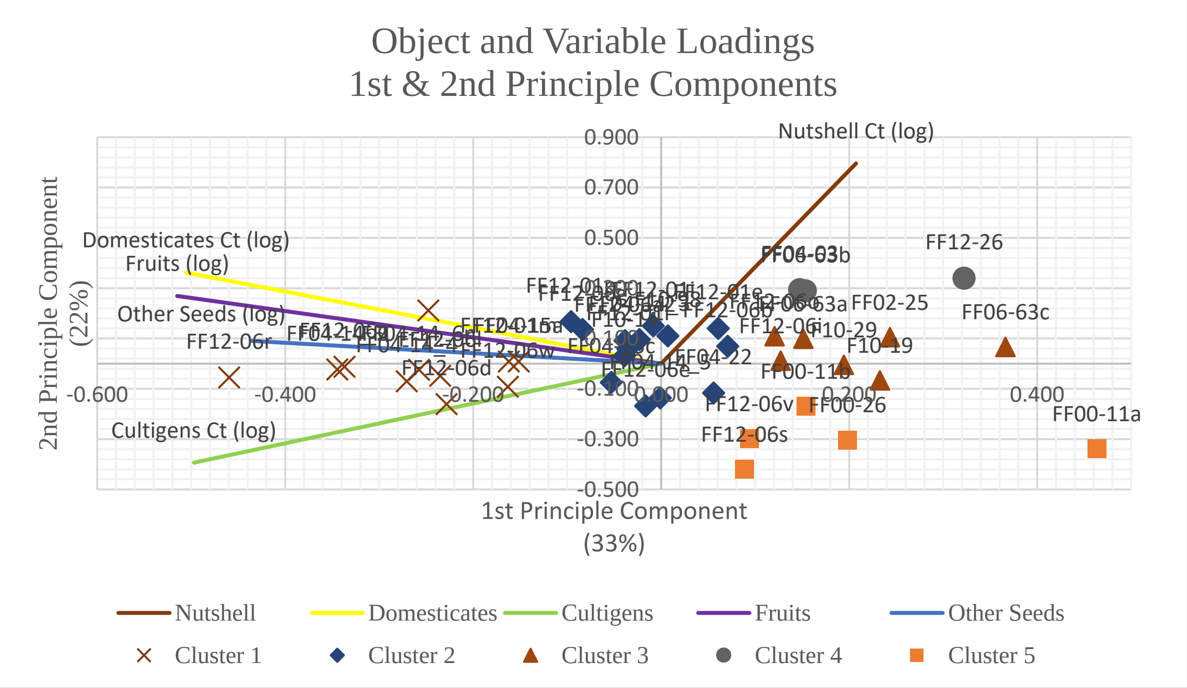


Figure 5.8: CBHC and KCV Floral Densities PCA by Cluster: First and Second Principle Components

Cluster 2 (near the origin) represents the largest cluster (14 of 40) whose floral distributions are more balanced. Domesticate densities are medium to low, as are densities of most other plants. More importantly (in terms of the PCA), the ratio of nuts to other class of taxa are closer to even. Note that the relatively equal proportion of their densities does not necessarily mean they contributed evenly to the overall diet. Due to differences in preservation, preparation, and use, the densities across taxa are not directly comparable (see Chapter 4). However, we can look at the relative densities across multiple contexts and infer a shift in the proportional dietary contribution of the various plant types.

Cluster 3, represented by seven contexts on the right side of the figure and along the x-axis, seems to reflect features with low densities of everything. Their presence on the right side of the figure (and the raw data) is indicative of low amounts of all material other than nuts, and its low absolute y-axis value indicates that nuts are roughly proportional to cultigens. Since cultigens densities are low, so too are nuts. Put simply, these are contexts with very few remains of edible foods. Clusters four and five, represented by three and five contexts respectively, are both along the right side of the figure but opposite ends of the y-axis. Cluster four contains contexts with significantly more nutshell than other features. Unlike Cluster 3, the high levels of nutshell does not necessarily mean that there are low levels of maize (or other domesticates), but that the density of nutshell is so high that all other taxa proportionally account for very little. In each case, acorn accounts for most nutshell. Cluster 5 contains the most loosely clustered contexts that exist on a continuum. The connecting factor is their proportionally high levels of cultigens. Generally, the lower the y-value, the less nutshell; and the higher the x-value the less material overall.

Before attempting to interpret the clusters or overall distribution of the data, it was essential to ensure that the patterns did not reflect context type or inter-site differences. Chi-Square tests were used to determine if clusters were independent of sites (Table 5.14) and context type separately (Table 5.15). The test showed sites to be independent of clusters (p=0.72) overall, indicating that differences among sites were not a factor. To ensure that there was not a relationship between a site and an individual cluster, a series of 2x2 Chi-Square analyses were also used. In each case, the results were far from significant (range of p=0.27 to 0.77).

Table 5.14: Chi-square results for PCA Clusters and Sites

CHI-SQUARE

	df	*chi-sq*	*p-value*	*x-crit*	*sig*
Overall	4	2.10	0.72	9.49	no
C1/Sites	1	0.30	0.58	3.84	no
C2/Sites	1	0.80	0.37	3.84	no
C3/Sites	1	1.22	0.27	3.84	no
C4/Sites	1	0.26	0.61	3.84	no
C5/Sites	1	0.09	0.77	3.84	no

Because KCV features 12-01 and 12-06 had numerous zones with clearly defined descriptions, whereas many of the CBHC features were more homogenous or had less detailed descriptions, only KCV contexts were used in the Chi-Square test, which indicated that there is no relationship between context type and clusters (p=0.13). Additional Chi-Squares (Table 5.15) were conducted between individual clusters and context type in as a series of 2x2 Chi-Squares. All but one of the Chi-Square tests returned a non-significant result (range p=0.11 to 0.81). The Chi-Square test for Cluster 5 and Burned contexts did reach significance (p=0.05), however Cluster 5 contained only two contexts and there were only two burned contexts in the sample. The statistical result is likely an effect of sample bias.

To further explore the variation in nut use, which was identified, but poorly described by the traditional statistical measures, a second PCA was conducted. This time only nutshell counts and densities were included. During the normality check, the Juglandaceae category was too skewed to use, even with normalization, so it was dropped. The remaining categories were normalized with a log transform. The resulting four principle components explain all the variation in the data. The first component, which accounted for roughly 45% of the inertia simply identified which contexts contained the greatest densities of nutshell. Since this information was already highlighted through the first PCA, the second and third principle components became the focus for the comparisons (Table 5.16).

Table 5.15: Chi-square results for PCA Clusters and Context Types

CHI-SQUARE					
	df	*chi-sq*	*p-value*	*x-crit*	*Sig*
Cluster/Contexts	12	17.58	0.13	21.03	No
C1/Contexts	3	4.92	0.18	7.81	No
C2/Contexts	3	5.15	0.16	7.81	No
C3/Contexts	3	6.61	0.09	7.81	No
C4/Contexts	3	1.45	0.69	7.81	No
C5/Contexts	3	4.40	0.22	7.81	No
C1/Midden	1	2.33	0.13	3.84	No
C1/Ash	1	1.38	0.24	3.84	No
C1/Burned	1	1.03	0.31	3.84	No
C1/Fish	1	2.03	0.15	3.84	No
C2/Midden	1	2.36	0.12	3.84	No
C2/Ash	1	0.12	0.73	3.84	No
C2/Burned	1	1.63	0.20	3.84	No
C2/Fish	1	2.59	0.11	3.84	No
C3/Midden	1	1.63	0.20	3.84	No
C3/Ash	1	1.03	0.31	3.84	No
C3/Burned	1	3.70	0.05	3.84	No
C3/Fish	1	1.97	0.16	3.84	No
C4/Midden	1	1.45	0.23	3.84	No
C4/Ash	1	0.49	0.49	3.84	No
C4/Burned	1	0.12	0.72	3.84	No
C4/Fish	1	0.20	0.66	3.84	No
C5/Midden	1	0.06	0.81	3.84	No
C5/Ash	1	1.03	0.31	3.84	No
C5/Burned	1	3.70	0.05	3.84	Yes
C5/Fish	1	0.42	0.52	3.84	No

Table 5.16: Eigen values and Variable loadings of KCV/CBHC Nutshell count density

Eigenvalues

	1. Principal component	2. Principal component	3. Principal component	4. Principal component
Eigen values	1.79	1.19	0.67	0.36
Explanation %	44.65	29.72	16.76	8.89
Cumulative %	44.65	74.37	91.13	100.00

Variable loadings

	1. Principal component	2. Principal component	3. Principal component	4. Principal component
Carya Ct (log)	0.600	-0.345	0.315	-0.650
Corylus Ct (log)	0.430	0.518	-0.706	-0.221
Juglans Ct (log)	0.252	0.717	0.630	0.158
Acorn Ct (log)	0.626	-0.313	-0.072	0.710

The second principle component contrasts contexts with proportionally high densities of acorn and hickory against features with high densities of walnut and hazelnut. In other words, densities of acorn are positively correlated with hickory and negatively correlated with walnut and hazelnut. The third principle component primarily contrasts contexts with greater densities of hazelnut from walnut and/or hickory. Contexts with large x and y-values (Figure 5.9) are dominated by walnut. Those with relatively large x-values and low (near zero) y-values (e.g., FF04-03) represent features with low densities of all nuts. Because hazelnut is so poorly represented in the assemblage, there are no contexts with large x-values and very low (negative) y-value. Those with very low (highly negative) x-values and high y-values are disproportionately represented by hickory. Because acorn is so well represented in most contexts, it presence does not necessarily explain much of the variation; therefore, its third component (y-axis) score is near zero. Therefore, there are not any contexts with particularly low (highly negative) x and y-axis scores, however those with y-values near zero to the left of the origin are dominated by acorn.

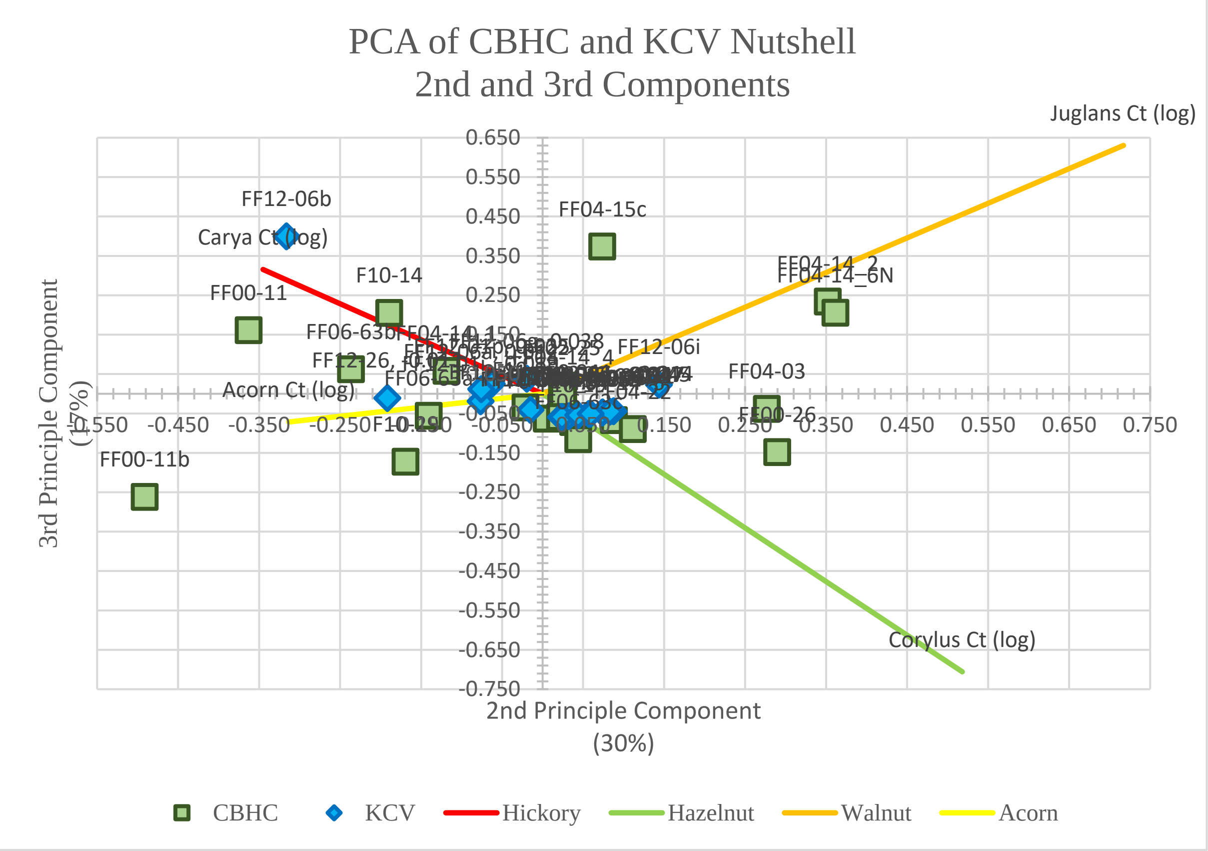


Figure 5.9: CBHC and KCV Nutshell Density PCA by site: Second and Third Principle Components

The distribution of each sites' contexts does show that KCV contexts tend to cluster near the origin. There are two that could be considered outliers: FF12-26, which has already been noted for the disproportionate amount of acorn it holds (80% of acorn shell from the site); and FF12-06b which has considerably more hickory than any other context at the site. Conversely, CBHC is spread across the chart. From this, we can infer that KCV is more consistent with its nutshell use, and acorn almost always makes up a major component of the nutshell at the site. While the total amount of nutshell the two sites and the total amount of any given genera of nutshell is not significantly different, the density of nutshell from any given taxa at CBHC is more variable among contexts.

Summary: Based on the results of the diversity indices, PCA, and t-tests, it appears that the two sites' assemblages do not differ significantly in most aspects. Both sites seem to have relied on nuts, cultigens, and fruits to a similar degree. Wild rice use was not significantly different, and the sample size of other identified seeds is so low that differences can be easily attributed to sampling bias. One of the two factors that does appear to distinguish the two sites is the use of maize. The KCV sample has a higher average density of maize kernels than CBHC; however, the densest features at CBHC are equally dense as the top features at KCV. Therefore, if sampling bias is not an issue, KCV residents seem to have relied on maize to a higher degree more consistently; whereas the CBHC residents consumed high levels of maize, but less consistently. It also appears that there may have been some differences in the way that maize was processed or maize refuse was disposed of between the two sites. The second distinguishing factor is the manner in which nuts were used. At KCV, nuts were recovered in similar proportions, with few exceptions. At CBHC, there was a high degree of variability in the taxa recovered.

The results of the PCA show that people at CBHC and KCV, generally shared patterns of plant use. However, there are questions that need investigation before we can see the patterns completely. One of these questions concerns change through time.

Diachronic Trends

To assess if changes in the diet occurred through time, similar procedures as the site comparisons were undertaken. Since many contexts do not have associated AMS dates, fewer contexts were used in the analyses. Features were divided into clearly early (radiocarbon range totally pre-AD 1250), clearly late (radiocarbon range wholly post-AD 1250, intermediate (error range crosses AD 1250), and unknown (no associated radiocarbon dates). While Feature 06-63 does cross the AD 1250 mark, it was placed into the early dataset because the bulk of the probability curve for the date is pre-AD 1250. A total of 29 contexts were included in the analysis.

The AD 1250 boundary was chosen because it is roughly the midpoint in the regional occupation and is a point where most non-intermediate samples can be differentiated. However, this date also marks a significant shift in the regional political dynamics. Pre-AD 1200, the region is occupied by four contemporaneous groups – Oneota, Middle Mississippian (at Aztalan), Collared ware producing Late Woodland groups, and non-collared producing ware Late Woodland groups (see Richards and Jeske 2002). Between AD 1200-1250, however Aztalan and the Late Woodland occupations around Lake Koshkonong seem to be abandoned. By AD 1250 at the latest, the residents of the Oneota sites appear to be the only people living near Lake Koshkonong (Richards and Jeske 2002).

Diversity: Early vs Late: As with the diversity indices comparing CBHC and KCV, some data were discarded prior to the calculation of the diversity indices. For example, wood and bark charcoal were not used at all because they do not represent edible resources. Maize cob fragments and unidentified seeds were also removed. Finally, tentatively identified seeds were merged with the definitively identified seeds.

Overall, the diversities confirm our expectations; there is a narrowing of the diet-breadth through time. The Simpson index (Table 5.17) indicates that the early assemblage is more even (1/D = 3.6 relative to 3.0). This means that the proportion of each taxon was more equal, or in other words, more plants contributed larger portions of the floral diet. The biggest shift appears be centered around three taxa, maize, acorn, and wild rice. Acorn changes most dramatically, dropping from 21% to 5% of the overall assemblage. Maize (46% to 54%) and wild rice (6% to 17%) both increase through time. In addition to these three taxa, two other genera had noticeable, albeit less dramatic, changes. The proportion of hickory doubles from early to late contexts (4% to 8%), and chenopodium drops from 9% to 6% of the overall assemblage.

Table 5.17: Diversity Indices for Early vs. Late Contexts

Diversity Indices

		Shannon			*Simpson*	
Context	NTAXA	diversity index	max index	homogeneity	D index	1/D
Early	25	1.75	3.91	0.45	0.28	3.60
Late	35	1.65	4.28	0.39	0.33	3.00

It does not appear that the overall density changes significantly through time. In early contexts, the density is approximately 49ct/10 liters and is roughly 46ct/10 liters in late contexts. Therefore, the shifts are not the result of particularly plentiful harvests skewing the data; these shifts indicate a reduction in the energy and time expended on collecting acorns, and potentially, a corresponding increase in maize and wild rice tending/harvesting activities. The results of the Shannon index (also Table 5.22) correspond with the results of the Simpson's index. This index is sensitive to both taxonomic richness and evenness. Despite the greater taxonomic richness in the later contexts (35 taxa compared to 25), they are less even. This unevenness provides additional support to the observation that maize and wild rice become more important aspects of the diet as the importance of acorn declines. Unfortunately, it is not possible to determine if the diversity scores are significantly different from one another. T-tests can determine if the changes in the frequency of specific taxa are significant.

Maize Consumption: Early vs. Late: An examination of maize kernels through time suggests that there was no significant increase in maize use (Table 5.18). The average number of kernels in late contexts is actually slightly lower than the average in early contexts, but the two are statistically indistinguishable by count (U=70, p=0.10) and weight (U=78, p=0.18). It appears that while maize may have increased in rank, this was not necessarily due to an increase in maize harvesting. This pattern does not change when maize cupules, glumes, and cob fragments are included in the sample. When the total maize (cupules/glumes, cobs, and kernels) are considered the data likewise indicates no increase in total maize through time (Count U=96, p=0.46; Weight U=84, p=0.26). However, late contexts are 156% more dense by count, and 180% by weight so further analyses were conducted.

A Chi-Square test was used to compare the ratio of kernels to cupules in early and late contexts. This test was run once using both sites combined, and then each site individually. The results (Table 5.18) were highly significant in all three cases (p <0.001); later contexts are associated with greater proportions of cupules relative to kernels. It appears that there are several inferences possible: 1) a larger proportion of maize was processed on-site, 2) more maize refuse was used as fuel, or 3) maize was de-husked or cooked in a different manner which led to more cupules and glumes being burned and added to the botanical assemblage of the sites. The cultural significance of this trend will be discussed in Chapter 8.

Table:5.18: Chi-Square results of Kernel: Cupule ratio through time

	df	*chi-sq*	*p-value*	*x-crit*	*Sig*	*Cramer V*
KCV kernel: cupule	1	97.34	<0.0001	3.84	Yes	0.11
CBHC kernel: cupule	1	59.94	<0.001	3.84	Yes	0.15
Koshkonong kernel: cupule	1	232.19	<0.0001	3.84	Yes	0.15

Maize summary: Despite predictions, and the trend noted in the diversity section, the expectation that maize use would increase through time was not verified by the data. Average maize kernel densities were statistically indistinguishable. Comparisons of the kernel to cupule ratios did suggest that techniques to prepare or dispose of maize did change through time, leading to an increase in the proportion of cupules to kernels at both sites.

Wild Rice Consumption: Early vs. Late: As a highly aggregated resource, the increase in the rank of wild rice through time fits well with the theoretical model. The noted increase is supported by an initial examination of the data. Average density increases over 230% in later contexts. Statistically, the null hypothesis is rejected (U=59, p=0.04). Based on the analyzed samples, wild rice use increased through time.

Chenopodium Consumption: Early vs Late: As a plant that can be aggregated both naturally and through human intervention, the theoretical model indicates that chenopodium, like wild rice, should have been a candidate for increased exploitation through time. However, given the increased rank of wild rice along with the demonstrated reduction in diet breadth, it is easy to surmise that chenopodium use may have been reduced in favor of wild rice. Therefore, we have two competing expectations; based on the expectation of intensified reliance on aggregated resources, chenopodium use should increase through time; however, based on our expectation of a narrowing diet breadth, in conjunction with the documented increase in wild rice, we should expect chenopodium use to remain the same or decrease. It is possible that, if chenopodium use decreased, then it was in favor of other aggregated resources such as squash, beans, or wild rice.

An initial examination of the data support the latter expectation. As noted above, chenopodium accounts for a smaller proportion of the over diet in later contexts. However, the smaller proportion does not necessarily mean that absolute chenopodium use declines; it may be the result of the dramatic increases in wild rice use. The average density of chenopodium drops approximately 7%, which is insignificant (U=52, p=0.02).

Nutshell Consumption: Early vs Late: Like wild rice and chenopodium, nuts are also a highly aggregated resource. As with chenopodium, because of the increase in wild rice, the theoretical model generates two competing expectations. First, the expectation of a narrowing diet-breadth suggests that nut usage should remain even or decrease through time. As an aggregated resource, the expectations are that nut use increases through time. Given the drop in the proportion of acorn, an increase in nut use is the less likely of the two scenarios.

Average counts of nutshell drop from over 38 ct./10 liters to less than 5 ct./10 liters and average weight drops from 0.23 g/10 liters to 0.04 g/ 10 liters. The Mann Whitney tests indicate a significant (Count, U=3, p=0.003, Weight U=48, p=0.01) difference in nutshell presence. Interestingly, the early dataset contains a high variance (7,443) that is not seen in the later dataset (22.59). Based on the sampled features, nut was used inconsistently during the early occupation of the Koshkonong Locality. Some years it was heavily used while in others less so. By AD 1250, nut use had stabilized and this new baseline is consistent with low-use contexts from the early occupation at the sites.

A Chi-Square test (Table 5.19) comparing the use of all identified nut types from early to late contexts showed that early and late contexts were significantly different (p<0.00001), indicating that nut type and time-period are not independent. Subsequent 2x2 Chi-Square tests for each nut type also indicate that no single nut type is independent of time-period (p<0.00001).

Table 5.19: Nut Type: Time-Period Chi-Square statistics

CHI-SQUARE	*df*	*chi-sq*	*p-value*	*x-crit*	*sig*	*Cramer V*	*Odds Ratio*
Time/All	4	655.34	< 0.00	9.49	yes	0.43	-
Time/Carya	1	580.02	< 0.00	3.84	yes	0.41	0.14
Time/Corylus	1	20.87	< 0.00	3.84	yes	0.08	0.04
Time/Juglans	1	22.20	< 0.00	3.84	yes	0.08	0.36
Time/Juglandaceae	1	32.95	< 0.00	3.84	yes	0.10	2.67
Time/Quercus	1	389.65	< 0.00	3.84	yes	0.33	4.89

Based on the results of the Chi-Square tests, there is a relationship between amount of each nut type and the time-period. To determine if there is a significant increase or decrease in densities through time a series of t-test were used. Based on the proportion of the seed assemblages determined during the calculation of the diversity indices, an increase through time in hickory, hazelnut, and walnut is expected. A decrease in the amount of acorn is also expected. The earlier component also had larger counts of undifferentiated Juglandaceae. Based on proportions, its density is also expected to decrease. However, since this category represents either hickory or walnut, an additional comparison of total Juglandaceae was also administered. This test included the overall density of hickory, walnut, and hickory/walnut.

Nutshell Summary: The reduction in nut density is significant, the biggest shift appears to be in the use of acorn. With the decline in acorn, there is a downward trend for nut levels overall. While this trend appears large, it is not highly significant, in part because most features in both early and late components contain a moderate amount of nutshell. The early values are skewed because of a small number of contexts with strikingly dense deposits (e.g., Cluster 4 from the PCA). Crescent Bay feature 06-63 was classified as an early feature, KCV feature 12-26 does not have a radiocarbon date, and Crescent Bay feature 04-03's date straddled AD 1250

Fruit Consumption: Early vs Late: Initial examination of fruit data suggest an increase through time. The average density of fruit in late contexts is roughly 2.5 times greater than the average density of early contexts. However, the statistical results suggest, while later contexts have more fruit, the difference is not significant (U=89, p=0.43). This may be, in part, due to the increase in variance (jump from 0.23 to 2.89). Opposite of nut use, fruit use seems to become less consistent during later years, with some years showing greater reliance than during the early occupation of the sites.

Charcoal Early vs. Late:

A Mann Whitney test indicates that there are no significant differences of wood charcoal densities between early and late contexts (Count U=67, p=0.08; Weight U=82, p=0.23), suggesting that firewood was being used at a similar rate. Given that the charcoal comes from tertiary deposits, there are many potential implications that will be addressed in the Chapter 8.

PCA and Temporal Change

When the PCA analysis is reexamined to look for temporal changes (Figure 5.10), two things are apparent. First, the later contexts have a wider distribution on the first component (x-axis). The second is the relatively high y-values of the early contexts. Both factors correspond well with expectations based on the t-tests. The poor representation of early contexts on the left side of the graph is largely due to the ubiquity and relatively high proportional representation of mast in the pre-AD 1250 samples. The tendency for early contexts to trend towards the positive end of the y-axis indicates a greater proportion of nutshell relative to cultigens. The later contexts trend towards the negative side of the y-axis the greater proportion of cultigens relative to nutshell. Given the highly significant increase in wild rice densities in the later contexts, and their general decrease in nutshell densities, this pattern fits our expectations well.

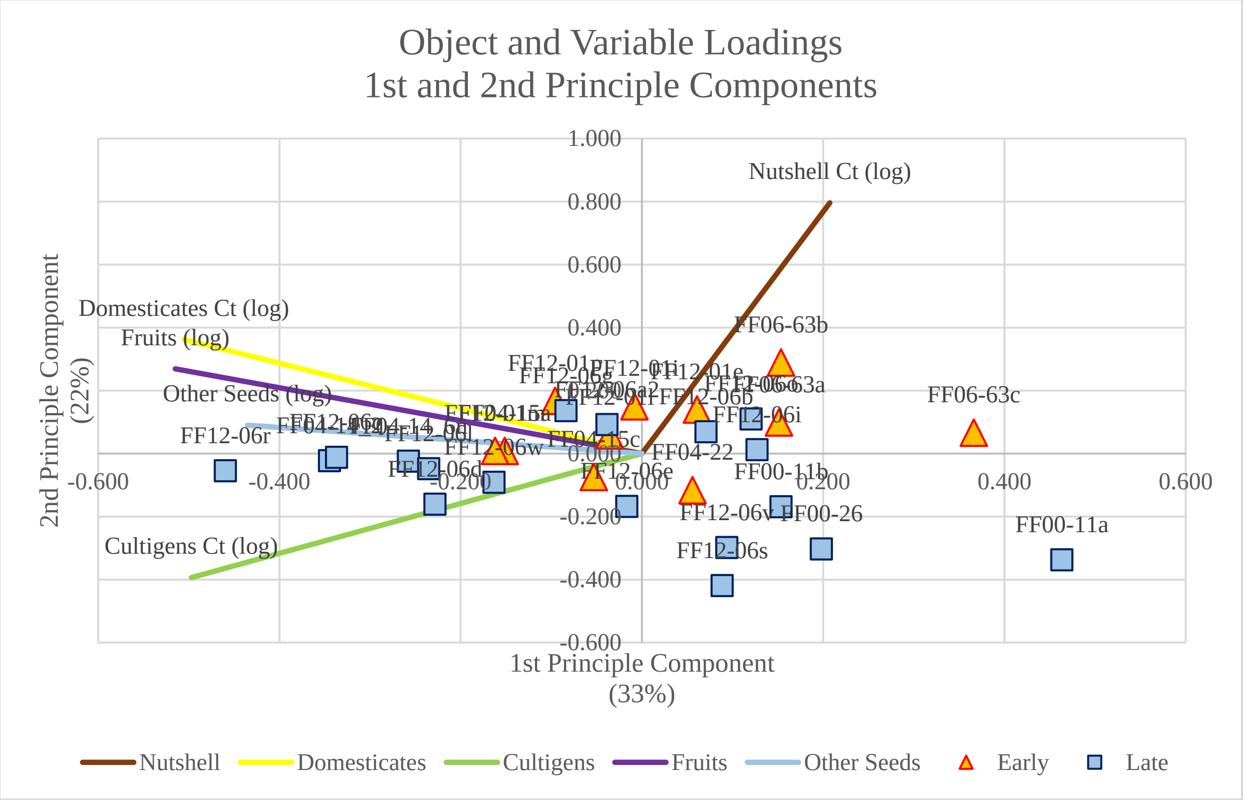


Figure 5.10: PCA Object and Variable Loadings for 1^{st} and 2^{nd} Components – Temporal Context Emphasized

The multivariate analysis consistently identifies nutshell changes as significant. It highlights the decline in nutshell and the corresponding rise in cultigens as the largest structural shift in the composition of the datasets. This change does not reflect the abandonment of subsistence practices and the adoption of a new one, but rather adaptions to the older system. The PCA shows moderate overlap between the early and late contexts near the origin. Features in this area tend to have proportionally high densities of maize relative to cultigens and nutshell. The importance of maize does not appear to shift in either the univariate or multi-variate analyses. The big shift is in the species used to supplement maize. In both contexts, a wide suite of plants was used to augment agricultural production; however, during the early occupations of the Koshkonong Locality, the sites' residents tended to turn more towards nuts as a supplement. Nuts were included into the diet to the exclusion of most other resources (e.g., other cultigens and fruits). This pattern is visible in the raw dataset and PCA. Nutshell is rarely seen in high densities in contexts with other dense taxa, and the PCA's first component indicates that the largest component of the dataset is this negative correlation between mast densities and all other categories.

After AD 1250, a base level of nutshell is typically maintained; however, there are many contexts (see the left side of the graph in Figure 5.10) where the data indicate a decline in the importance of mast resources. Wild rice becomes an increasingly important supplement for maize during the later occupations of the Koshkonong Locality. Unlike acorn, wild rice is not negatively correlated with other types of floral remains. Contexts on the extreme-left side of the graph include high amounts of cultigens, fruits, and other seeds (e.g., F04-14 zone 2). Wild rice also appears to become the primary buffer resource. In the later contexts with low maize densities (see the right side of the graph in Figure 5.10), there are correspondingly low levels of nutshell and elevated levels of wild rice.

Structure Comparisons:

Two different structure types have been identified at Crescent Bay (see Chapter 2 for a fuller description). To date, it is not clear what, if any functional distinction exists (Moss 2010). A series of comparisons between contexts associated with the two house-types were undertaken to a) determine if any distinction in use was apparent b) determine if the data from CBHC was potentially biased by any functional distinctions c) describe and interpret any such distinctions.

If two structure types were used in the same manner (i.e. both habitation structures used throughout the year), then their assemblages should be very similar. However, if there are seasonal or functional differences between longhouses and wigwams, then we should expect to have differences in the floral assemblages (Table 5.20). For example, the presence of buds is a good indicator of cold-season use, as they normally form during the late winter or early spring. However, their absence does not necessarily indicate a warm season occupation. Violets (*Viola sp.*) also bloom in the spring, so the presence of their seeds are good indicators of a cold-season occupation. While nuts, maize, wild rice, aquatic tubers and many other plants are harvested in the fall, they can be stored so it is difficult to use them as seasonal indicators. Cold temperatures in winter require heating of structures. This, in addition to the normal cooking and other domestic activities, will produce wood charcoal in greater densities than warm-season occupations. Therefore, if the structures have the same function, but difference seasons of occupation there should be a greater density of wood charcoal in the winter structures.

If the structures have different functional uses, then we can expect differences in floral assemblages that are distinct from seasonal indicators (Tables 5.20 and 5.21). The main distinction should be evident in food refuse. As the locus of domestic activities, habitation structures should have relatively high densities of a wide array of food remains. The presence of significant amounts of food remains does not guarantee that they were used as habitations, as some special purpose structures may have been associated with communal food consumption (e.g., clan lodges, ceremonial structures). However, food remains in low densities or absent from features is inconsistent with habitation structures.

Table 5.20: Seasonal and functional criteria.

Seasonal Criteria for habitation structures	**Warm Season**	**Cold Season**
Buds		X
Wood Charcoal (High Density)	X	X
Wood Charcoal (Low Density)	X	
Violet (*viola*)		X
Functional Criteria	**Habitation**	**Non-Habitation**
Food Refuse (High Density)	X	
Food Refuse (Low Density)		X

Table 5.21: Presence of seasonal and functional criteria in structure types

Seasonal Criteria for habitation structures	**Wigwam**	**Longhouse**
Buds		X
Wood Charcoal (High Density)	X	
Wood Charcoal (Low Density) (warm)		X
Violet (*viola*)		X
Functional Criteria	**Wigwam**	**Longhouse**
Food Refuse (High Density)	X	
Food Refuse (Low Density)		X

Ubiquity values and Mann Whitney U tests were used to compare each of the important taxa identified in the Crescent Bay assemblage (Table 5.22). A total of five contexts were sampled near the longhouses. Fourteen contexts from wigwam contexts representing six features were also sampled. The data indicate potential seasonal differences, but that would only logically follow if there are also functional differences. The floral assemblages are inconsistent with the activities associated with the indicated season(s) of occupation if the structures had the same functions. Buds have a 60% ubiquity in longhouse contexts and 20% ubiquity for *Viola*, consistent with a winter occupation for much of the time they were in use. No buds or *Viola* have been identified in association with the wigwam structures. Interestingly, the longhouses have significantly less wood charcoal than the wigwam structures (p=0.01 for count and p=0.02 for weight). The lower charcoal densities are inconsistent with a winter occupation of the longhouses. If anything, the larger size and wider spacing of posts should necessitate fuel to maintain the heat of the longhouses, which would produce more charcoal. While the buds indicate that the longhouses were likely used in the cold-seasons, they were probably not used as household habitations.

The density of food remains also supports a functional difference. Wigwam structures had more maize kernels ($p=0.05$ count), more total maize ($p<0.05$ for count and weight), and nutshell ($p<0.02$ for both count and weight). Moderately more wild rice was also present around the wigwam structures ($p=0.09$). The only food not present in much larger numbers around the wigwams was *Chenopodium* ($p=0.33$). The low density of food and wood charcoal is inconsistent with interpreting the longhouses as habitation structures.

Table 5.22: Mann Whitney U tests comparing the density of floral taxa associated with CBHC wigwam and longhouse structures

	Total Maize (ct.)	**Total Maize (wt.)**	**Maize Kernels (ct.)**	**Maize Kernels (wt.)**
U	11	13	13	18
p	0.029	0.047	0.047	0.126
	Wild Rice (ct.)	***Chenopodium* (ct.)**	**Nutshell (ct.)**	**Nutshell (wt.)**
U	16	24	7	8.5
p	0.087	0.332	0.011	0.016
	Wood Charcoal (ct.)	**Wood Charcoal (wt.)**		
U	7	9		
p	0.011	0.018		

The multi-variate analysis shows a similar pattern. The longhouse contexts trend towards both the right and bottom sides of the PCA when charted (Figure 5.11). In these contexts, most floral materials are generally absent, or present only in relatively low densities; represented primarily by wild rice and/or chenopodium. These contexts come from a variety of features, ranging from small to large and about 100 to 2,000 liters in size. Because winter is typically a time of scarcity, these features should show evidence of increased reliance on easily stored resources, such as maize, wild rice, or acorns. Apart from feature 02-25, maize kernels are found in low densities in each of the features. While proportionally important, wild rice is present in low-to-moderate densities. Nutshell is also found in low-to-moderate densities, which is inconsistent with a larger population of people aggregated under a single roof for long-periods. Under these circumstances, food refuse should be equal or more concentrated. So, if the longhouses were used as habitations, the low firewood density indicates that they were a summer structure. However, a warm season occupation is not supported by the presence of buds. Therefore, it is likely that longhouses were special purpose (i.e., non-habitation) structures. However, the paleoethnobotanical data do not indicate what that function may be.

The wigwams also have evidence for occupation throughout much of the year. Maize would have been grown in the summer months and harvested in the autumn, along with the nuts, wild rice, and many of the other identified taxa. The wigwam structures are also associated with a variety of fruits, such as hawthorn (*Crataegus*), raspberries (*Rubus*), and nightshade (*Solanum*) indicative of a late summer or early autumn occupation. There have yet to be any true cold season indicators, however, aquatic tubers have been identified in association with the wigwams. Some aquatic tubers can be seasonal indicators, but as a general category of plant, they are present from spring through fall and can be stored for winter use (Arzigian 1993:394-395; Gilmore 1919:58). Without greater identification specificity, they cannot be used as definitive seasonal indicators.

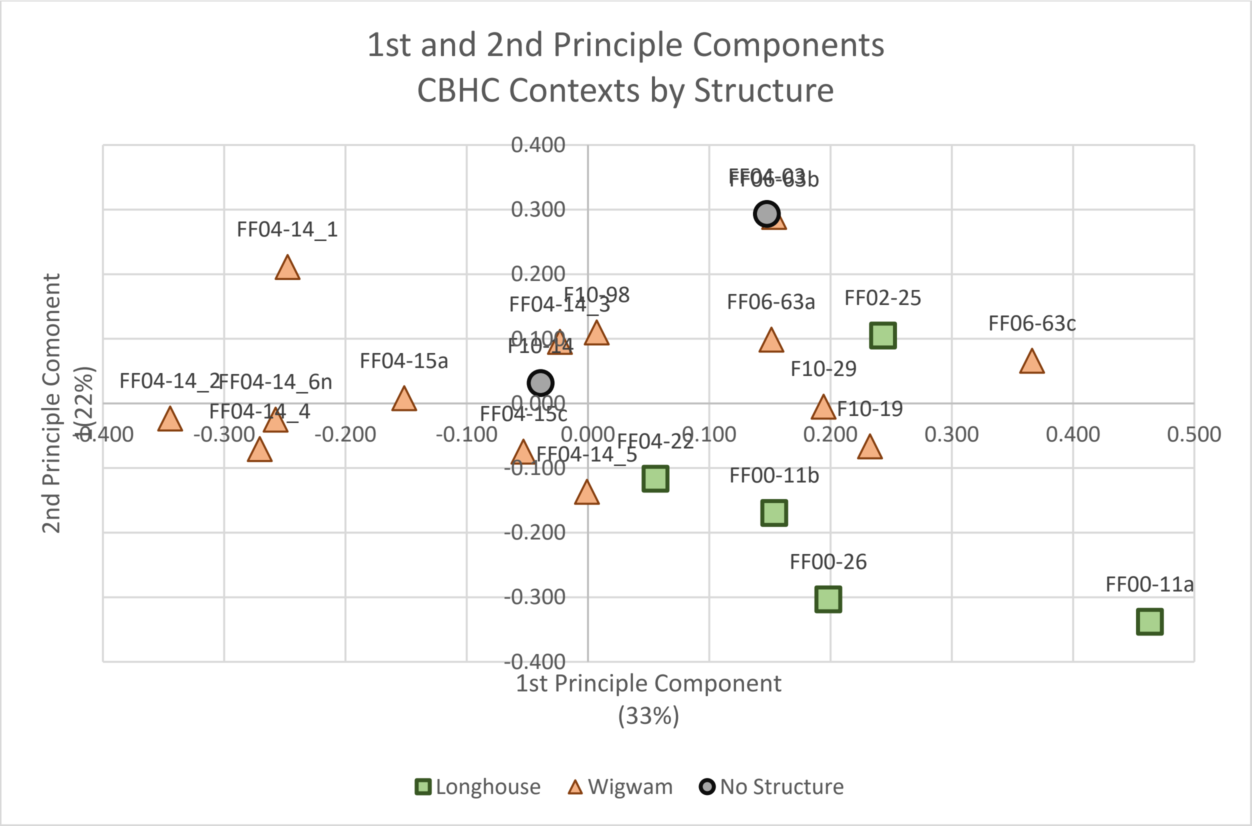


Figure 5.11: PCA results showing CBHC contexts by structure type

However low densities of both wood charcoal and food remains suggests that fewer or less intense domestic activities occurred within longhouses. We can infer that the two structures were likely used for different functions. If so, then the longhouses, with lower densities of domestic refuse, are unlikely residences. The longhouses may have been used as communal structures of some kind (e.g., public house or clan lodge) where larger groups could meet. Ethnographically, the political and religious activities that would have taken place in such structures would have included fires and meals that would have been prepared elsewhere (e.g., Radin 1923; Skinner 1921). This may account for the presence of low quantities of domestic refuse and the presence of burials within two of the three identified longhouses (Jeske 2014; Jeske et al. 2017).

Summary of Botanical Analysis:

The above macrobotanical analysis describes the general floral-based subsistence patterns used by the residents of the Koshkonong Locality. Initial examination of the CBHC and KCV data sets shows generally similar patterns. The sites were occupied year-around, and the residents relied upon maize-based agriculture, accompanied by squash, with beans added in later contexts. Agricultural output was supplemented with a variety of plants; however, wild rice and acorns were the most significant non-agricultural food resources. Chenopodium and hickory were also used to moderate degrees. Small amounts of fruits, tubers, and other wild resources were also used to lesser and varying degrees.

While the general pattern is similar, the two sites did exhibit some differences. Though maize was the focus of subsistence at both sites, it seemed to be of greater importance to the residents at KCV. Maize kernels were found in greater densities at KCV than CBHC. The assemblages also indicated a difference in the manner maize was processed. At KCV, there was a higher ratio of kernels to cupules than at CBHC, indicating a greater proportion was processed on site, or at least near the features analyzed at CBHC. Chenopodium was also a major component of the CBCH assemblage, accounting for a substantial portion of the overall seed assemblage. This pattern did not extend to KCV, where it was present only in low densities. Nut selection at KCV also appeared to be more predictable. The proportions of the four genera identified were relatively consistent; whereas at CBCH it was not. The final notable difference in two sites assemblages is wood charcoal. Both count and weight densities are significantly higher at CBCH than at KCV.

Several important temporal trends were also noted. The most significant shift was in reliance on nutshell relative to wild rice. Throughout the occupation of the Koshkonong Locality, the sites’ residents used nuts, particularly acorn, as an important aspect of the diet. However, during the earlier occupation, nuts was often collected at the cost of non-agricultural resources. It appears that acorn was likely a buffer resource during the first half of the Oneota occupation of the Koshkonong Locality, and may have been exploited more heavily when maize harvests were poor. Later, wild rice appears to take over the buffering role that was performed by nuts prior to AD 1200. In early contexts, wild rice densities were moderate and relatively consistent. In later contexts, the density of wild rice was significantly higher and more variable. It was also positively correlated with non-nutshell densities, indicating that it was not necessary for the foragers to reduce the collection of fruits and other seeds when wild rice harvests were plentiful. The later contexts also suggest that wild rice was used as a buffer during poor maize harvests instead of nutshell.

A third important trend noted in the analysis was the distinction between the assemblages associated with different house types at CBHC. The assemblages indicate that longhouses were likely used in the cold season, and wigwams were likely used throughout much of the year; however, they are significantly different. Overall densities of floral materials appear to be the biggest difference. Features associated with wigwams tend to be dense with food refuse and charcoal; those associated with longhouses are not. This distinction is likely related to a functional difference in the structures. If the densities associated with wigwams are typical of domestic refuse, then it does not seem likely that the longhouses were used as dwellings. If they were, their larger size should accommodate more people and correspondingly denser concentrations of materials. Since they do not, the structures may have served as a public or communal structures.

6. Results of Isotopic Data Collection

Introduction:

This chapter introduces the results from the isotopic analysis of dog remains recovered from secure contexts in northern Illinois and in Wisconsin. First, the comparative sites from contemporaneous and regional related sites with human isotope values are introduced and discussed. These data are useful for framing expectations from the dog isotopes. Second, the raw numbers from the $\delta^{13}C$ and $\delta^{15}N$ are provided. The ^{14}C AMS data follows to contextualize the data. Finally, the data will be set in a regional perspective by integrating them with the comparative data.

For many years there have been two competing expectations for the relative reliance on maize among Oneota and related groups. Traditional interpretations of Oneota suggests that their agriculture will be less intensive than Middle Mississippians (e.g., Overstreet 1976; Michalik 1982). However, data from Langford sites calls this into question (Edwards et al. 2017; Emerson et al. 2005, 2010). The average $\delta^{13}C$ values of Langford sites are on par with Middle Mississippians. Left unanswered is whether Langford values are representative of their Oneota neighbors as well, or if the differences noted between Langford and Oneota material culture and settlement (e.g., Jeske 1989; 2003) are related to significant differences in agricultural reliance.

We also have competing expectations for $\delta^{15}N$ values. As a complex, hierarchical, and relatively urbanized society without domesticated animals (except dog), it might be expected that Middle Mississippian individuals had less access to meat resources than their more rural Oneota neighbors (e.g., Hedman et al. 2002). However, if Theler and Boszhardt (2000, 2006) are correct, and Oneota groups were faced with depleted deer populations, it would follow that $\delta^{15}N$ values may be equally depressed as Middle Mississippians. Even if Theler and Boszhardt’s theory is only accurate in the La Crosse Locality, those samples should be lower than the Langford and Oneota values from other localities.

Comparative Site Data, Human bone $\delta^{13}C$ and $\delta^{15}N$ levels:

Data from published sources were used to compare and contextualize the results of the dog isotopic analyses. Values from several relatively contemporaneous or culturally related sites were chosen (Table 6.1). When some of the available cases could not be reliably tied to a specific context or time-period, they were excluded from the comparative dataset.

*Table 6.1: Aggregated Comparative Isotopic data * excluding anomalous value*

Archaeological Culture	**Region**	**# of Sites**	**n**	**Mean $\delta^{13}C$ (‰)**	**Mean $\delta^{15}N$ (‰)**
Middle Mississippian	American Bottom/Lower Illinois River Valley	7	79	-12.95	9.21
Late Woodland/ Middle Mississippian	Aztalan	1	8	-16.14	no data
Oneota	Red Wing	1	5	-13.86	13.1 (9.43*)
Oneota	Riceford Creek	2	15	-13.36	10.29
Langford	Northern Illinois River Valley	4	60	-12.24	9.73

The largest portion of the American Bottom samples came from the ESLSQ site (n=20; Hedman et al. 2002) The next largest sample is from Cahokia (n=15; Bender et al. 1981: n=6; Ambrose et al. 2003: n=9). The remaining samples come from Corbin MD (n=13), Florence St (n=9), Schild A (n=9), Range (n=6), and Hill Prairie (n=6) (Hedman et al. 2002). Technically, the Schild A site is from the Lower Illinois River Valley, approximately 50km north of the American Bottom, but it will be included with the American Bottom samples for this analysis. Excepting the Cahokia samples, the American Bottom skeletons tested were from the Moorehead Phase (circa AD 1200-1275).

Both Cahokia samples primarily come from Mound 72. The Bender et al. (1981) samples includes only $\delta^{13}C$, four are from Mound 72, and two are from the Fingerhut. At the time, the authors argued that the remains likely dated from AD 950-1050. Since then, Mound 72 has been reinterpreted several times. Most recently, Emerson et al. (2016) reanalyzed the human remains and obtained AMS dates from several of the burials. Burial 16, which was sampled by Bender et al. (1981), dated to two-sigma cal. AD 990-1115, with 97% of the curve falling between AD 990 and 1040, which essentially supports the 1981 interpretation. However, many of the other burials analyzed by Emerson et al. (2016) post-date Burial 16 by as much as a century, which they interpret as a series of subsequent intrusive burials. Therefore, any non-radiocarbon dated burials can reasonably be expected to range from AD 950 to 1150.

Regardless of where in this timeframe they land, the Cahokia sample generally represents the early Mississippian occupation of the American Bottom, and the non-Cahokia samples are later. There does appear to be a significant difference between the early and late samples. The early samples show significantly less maize in the diet but no difference in the amount of meat consumed. In the Cahokia sample, the collagen levels appear the same between both status groups, suggesting that the differences among sites can be fully explained by diachronic shifts. However, the picture is more complicated. The apatite levels indicate high-levels of maize in the diet, significantly higher than suggested by the collagen levels. Ambrose, et al. (2003) conclude that the discrepancy is a result of eating higher protein C3 plants and a small number of animals, which also primarily consumed C3 plants. The result is that the American Bottom diet varied based on several factors and the status of an individual impacts the isotopic results. Because of these factors, and the nature of the early diet, it is difficult to determine how the dietary significance of maize shifted through time. Despite these issues, the evidence seems clear: Elites consumed more meat and less maize than the average resident of the American Bottom

(Ambrose et al. 2003), and those living in the uplands consumed more wild plants and slightly less maize than those living in the flood plain hamlets, villages, and cities (Hedman et al. 2002).

Bender et al. (1981) also included eight individuals from the site of Aztalan. Three of the samples come from the Northwest Mound and are thought to be from high-status individuals, after the arrival and addition of Middle Mississippians to the Late Woodland population. The remaining samples were from isolated human remains found in refuse pits throughout the site. The timeline of interment, and if they represent members of the community or a neighboring community is unclear. The individuals interpreted as high-status generally show lower levels of maize consumption (mean $\delta^{13}C$ = -17.77‰) relative to the remainder of the population (mean $\delta^{13}C$ = -15.16‰). Given the small sample size, no statistical comparisons were made.

The Minnesota samples (Red Wing and Riceford Creek localities) were obtained by Pratt (1994) as part of a large regional study of maize consumption. This dataset did include several other sites in Iowa, Minnesota, and Wisconsin, but many of these sites were multi-component, excavated several decades ago, and in such a way that the burials cannot reliably be tied to a specific component. Three sites remained that could be reliably tied to an Oneota occupation. Five individuals from the Bryan site in the Red Wing locality were analyzed. The site is generally contemporaneous with the Koshkonong Locality sites (Fleming 2009; Schirmer 2002). The remaining samples come from two later sites much further to the west in Minnesota. The Hogback (n=9) and Wilsey (n=6) sites date to roughly AD 1600-1700. One $\delta^{15}N$ value from the Bryan site was an anomalous outlier (>27 which is greater than expected for marine predator values) and was not included in any of the statistical analyses below.

The final comparative sample comes from the Northern Illinois River Valley. Isotopes from 10 individuals at the Material Service Quarry (MSQ), a Langford site, have been reported.

The site is largely contemporaneous with the Koshkonong Oneota sites (Emerson et al. 2010). Relative to the other Oneota sites, the diet of MSQ residents appears to include more maize and less meat. Emerson et al. (2005; 2010) reports the summary data from three additional sites. Full statistical comparison of these sites is not possible because the full dataset is unavailable; however, the summary data suggests that MSQ is representative of other contemporaneous Langford sites (Fisher, Oakwood Mound, Gentleman Farm) in the region (Emerson et al. 2010).

According to Hart (1990), we should expect to see variation among Upper Mississippian agricultural systems. Since maize was an important aspect of all agricultural systems, that should include variation in maize reliance and therefore δ^{13}C values. A Kruskal Wallace test was conducted to determine if there were differences among groups of related sites (e.g., cultural, temporal, geographic). The sites were grouped into three categories: Langford (MSQ); early Oneota (Bryan pre-AD 1400 Oneota site); and protohistoric Oneota (the Riceford Creek locality sites post-dating AD1400) (Table 6.2). The results indicate that there are differences among these groups ($p<0.06$). The boxplot (Figure 6.1) suggest that the Langford groups consumed the most maize, and while the western groups had roughly the same maximum amount of maize, some Red Wing individuals consumed the least maize.

Table 6.2: Kruskal Wallis results comparing δ^{13}C values from Upper Mississippian sites

SUMMARY

Groups	*Count*	*Average*	*Variance*
Langford	10	-12.49	1.00
Early Oneota	5	-13.86	2.77
Protohistoric Oneota	15	-13.36	0.58
	df	*H*	*p value*
	2	5.515	0.063

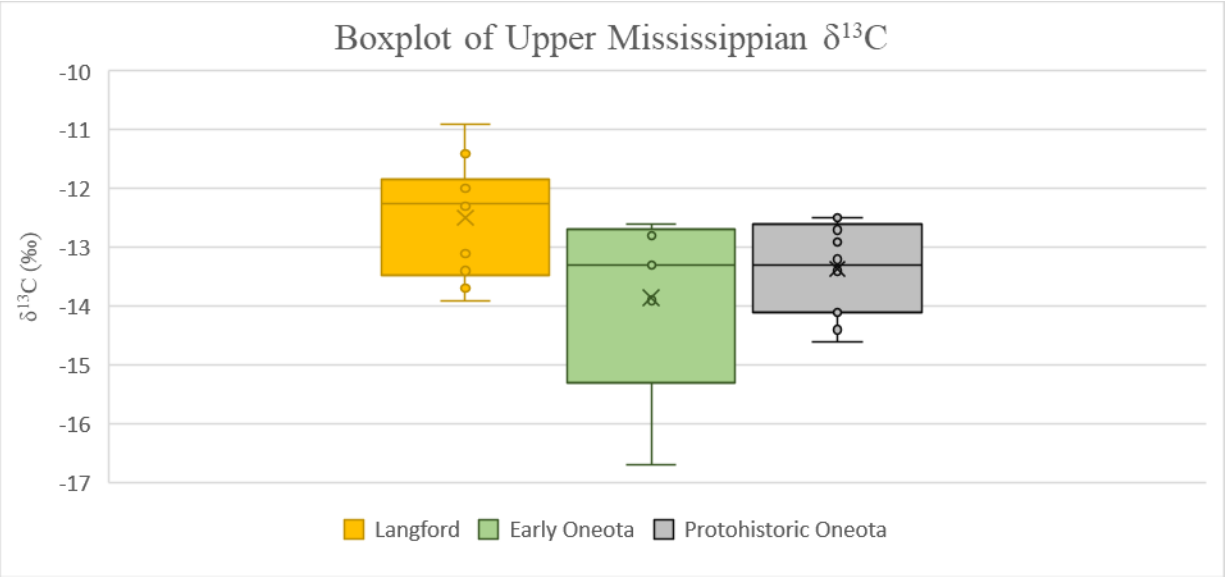


Figure 6.1: Boxplot of $\delta^{13}C$ *values for Upper Mississippians (Emerson et al. 2010; Pratt 1994)*

Most researchers that have suggested shifts in Oneota hunting patterns have suggested an increase in meat consumption through time. Gibbon (1972a; 1986) has argued that Oneota groups intensified hunting in the 14th century, and many authors (e.g., Boszhardt 1994) have suggested people in the La Crosse abandoned the locality to move west where bison was more plentiful. Even if they are not descendants of the La Crosse residents, the western location of the Hogback and Wilsey sites site would have provided greater direct access to bison herds. Regardless of the reason, we should expect that the late western sites should have higher $\delta^{15}N$ values. The statistical measures support our expectations, the Kruskal Wallace test shows significant differences ($p=0.002$) among the regions (Table 6.3) and the null hypothesis is rejected. An examination of the boxplot of the data (Figure 6.2) clearly shows that the individuals from the protohistoric site consumed have the highest $\delta^{15}N$ values indicating they consumed the most meat. Langford and Red Wing values have considerable overlap; however, there is more variance in the Bryan samples.

Table 6.3: Kruskal Wallace test results for δ¹⁵N for Upper Mississippian sites

SUMMARY

Groups	*Count*	*Average*	*Variance*
Langford	10	9.56	0.11
Early Oneota	4	9.43	0.50
Protohistoric Oneota	15	10.29	1.89
	df	*H*	*p value*
	2	12.721	0.002

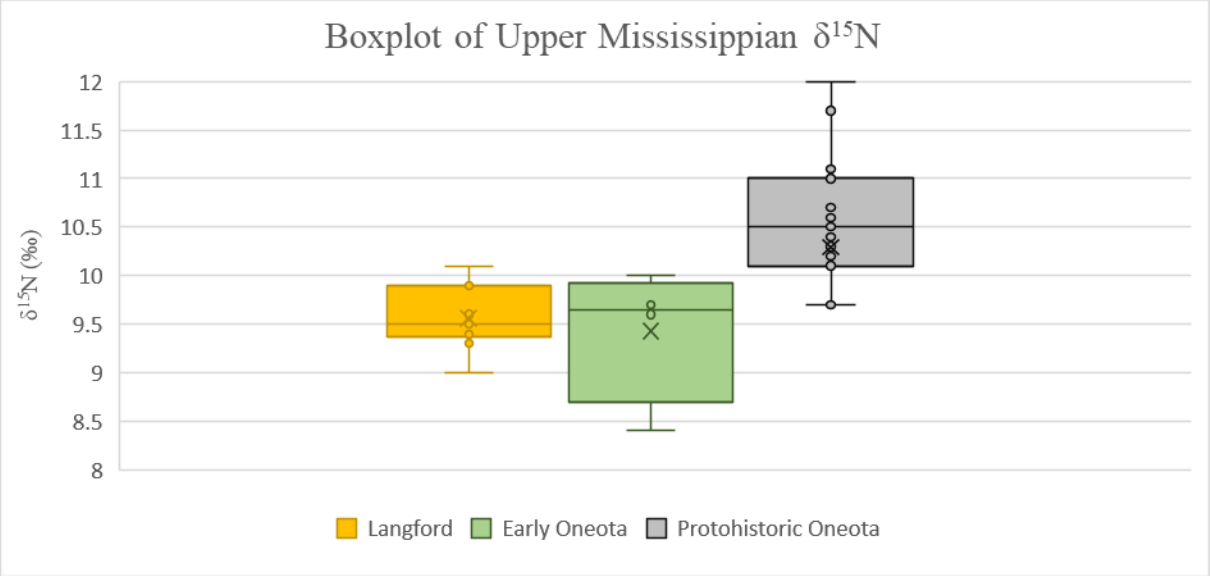


Figure 6.2: Boxplot comparing variation in Upper Mississippian δ¹⁵N values

Emerson et al. (2005) have already noted that Langford and Middle Mississippian groups consumed, on average the same amount of maize. With the expanded the samples discussed here, (both geographically and temporally), this pattern appears to hold true. The δ^{13}C values of American Bottom sites and Aztalan compared to the Langford and Minnesota sites show no discernable differences (p-value = 0.14). While Upper Mississippian δ^{13}C levels may average higher, they are subsumed within the wider Middle Mississippian range (Figure 6.3). However, there are highly significant differences ($p<0.001$) in δ^{15}N levels. While elite Middle Mississippians consumed significant amounts of meat, Upper Mississippian values are clearly higher (Figure 6.4). Part of this difference is likely due to the inclusion of the Riceford Creek values, which have already been noted as high. Even still, most Upper Mississippian values are quite high relative to the Middle Mississippian $\delta^{15}N$ values.

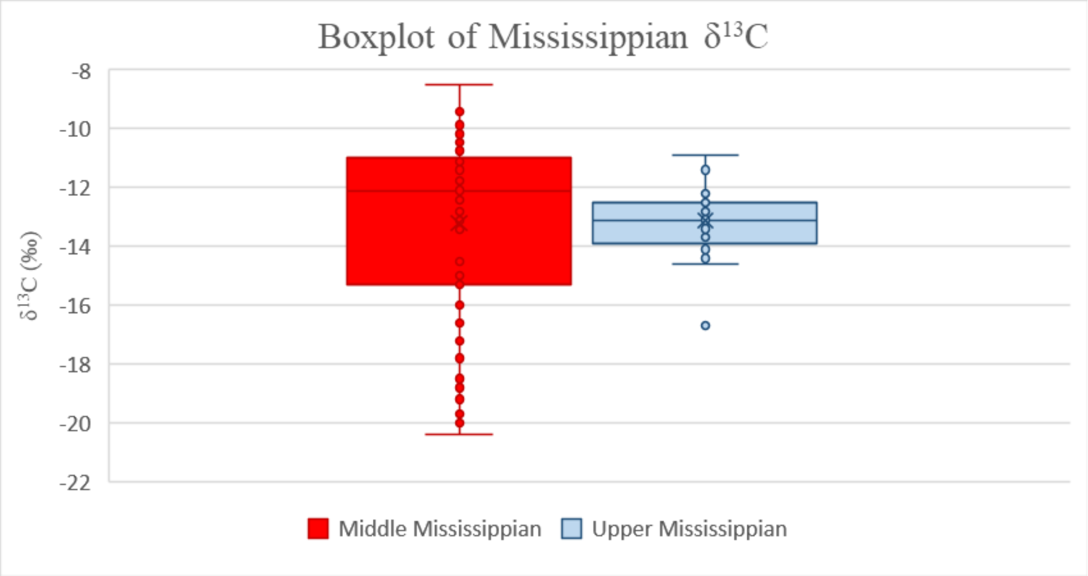


Figure 6.3: Boxplot comparisons of $\delta^{13}C$ levels between Upper and Middle Mississippians

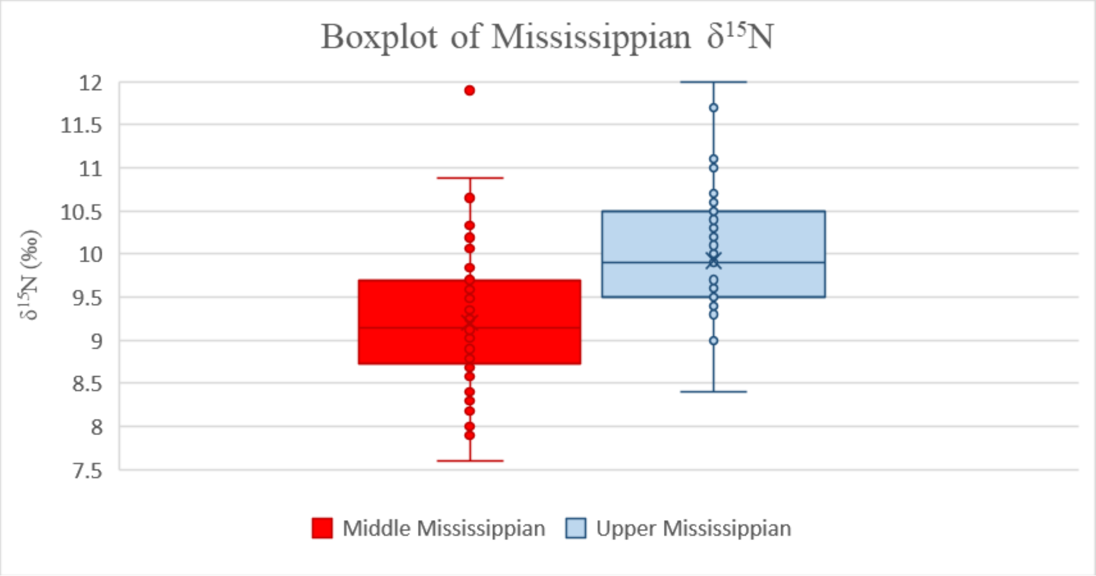


Figure 6.4: Boxplot comparison of $\delta^{15}N$ levels between Upper and Middle Mississippians

Canine Surrogacy Approach Isotope Results:

Expectations: Based on the results of the human isotopic analyses, we can generate a series of expectations for the dog values.

- Moderate variation of both δ^{13}C and δ^{15}N among samples from Oneota sites
    - Variation may be greater among localities than within
- δ^{15}N values should range between 7 and 12‰
    - Eastern Upper Mississippian values likely lower than western: ≈ 9.5‰
    - Western Upper Mississippian values: ≈ 10‰
    - La Crosse samples > Red Wing, Koshkonong, Langford samples
- Dog δ^{15}N may be lower than expected based on human values (Guiry), likely 0.5‰ given past research in the region (Edwards et al. 2017)
- Dog δ^{13}C values between -21 and -8‰: most ≈ -13‰
    - Upper Mississippian range more narrow than Middle Mississippian: ≈ -15 to -9‰
    - Eastern Upper Mississippi values ≈ -12.5‰
    - Western Upper Mississippian values ≈ -13.5‰

Dog Isotopic Values: The summary results of the isotopic analysis are presented below (Table 6.5, see also Appendix B for complete dataset, e.g., C:N ratio). Each of the dogs have an accompanying AMS assay (Table 6.6). The results from Fisher and Nitschke Mounds were previously reported in Edwards et al. (2017) and were obtained using funding from the University of Wisconsin-Milwaukee's Preliminary Dissertation Grant. The remaining isotopes were obtained using funding from National Science Foundation: Dissertation Improvement Grant (Award # 1640364).

*Table 6.4: Isotopic Data (for additional isotopic data, e.g., C: N ratio see Appendix B) - * Edwards et al. (2017)*

Locality	**Site Number**	**Site Name**	**Context**	**$\delta^{13}C$**	**$\delta^{15}N$**
				vPDB	**vAIR**
Koshkonong	47JE904	CBHC	F10-14	-11.7	9.0
			F10-11	-13.7	8.1
Red Wing	47PI001	Diamond Bluff	Sq G	-12.1	8.9
			Sq Z	-14.0	9.0
La Crosse	47LC19	Midway Village	F99; Mand. 12	-11.6	9.4
			F106; Mand. 8	-13.8	8.8
	47LC34	Valley View	F180; Mand. 2	-16.4	8.8
	47LC394	Sanford Complex	F59; Mand. 1	-13.6	9.0
			F516; Mand. 7	-14.9	8.7
			F37; Mand.4	-14.0	9.3
	47LC0262	OT	Feature 3 Lv. 10	-13.7	9.5
				-13.7	9.5
			Feature 3 Lv. 12	-15.4	8.6
				-14.9	8.6
				-15.6	8.6
Langford	11CK4	Fisher*	Dog 1	-14.1	8.4
			Dog 2	-11.9	8.4
			Canid 3	-18.6	11.6
Late Woodland	47DO027	Nitschke*	Mound 21	-19.5	9.9
Middle Mississippian/ Late Woodland	47JE0001	Aztalan	Mandible 1	-15.1	8.3
			Mandible 2	-14.4	9.2
			Mandible 3	-16.2	8.2

*Table 6.5: AMS results from dog bones subjected to Isotopic Analysis - *(Edwards et al. 2017)*

Locality	**Site #**	**Site Name**	**Context**	**Lab Code**	**Age BP**	**Error**	**1σ**	**%**	**2σ**	**%**
Koshkonong	47JE904	CBHC	F10-14	3572	854	21	1169-1177	20%	1156.1228	96%
							1181-1214	80%	1231-1247	4%
			F10-11	3573	866	24	1162-1210	100%	1050-1083	10%
									1125.1136	1%
									1150-1224	88%
									1235.1241	1%
Red Wing	47PI001	Diamond Bluff	Sq G	3574	870	19	1162-1194	80%	1054.1077	6%
							1196.1206	20%	1153.1219	94%
			Sq Z	3575	685	27	1278-1299	79%	1270-1311	71%
							1370-1379	21%	1359-1387	29%
La Crosse	47 L	M id w	F99 Mand. 12	3759	485	22	1422-1439	100%	1413.1445	100%

Locality	Site #	Site Name	Context	Lab Code	Age BP	Error	1σ	%	2σ	%
			F106 Mand. 8	3760	437	19	1438-1452	100%	1430-1467	100%
	47LC34	Valley Vie	F180 Mand. 2	3761	543	20	1333.1336	6%	1323.1346	22%
							1398-1422	94%	1393.1429	78%
	47LC394	Sanford Complex	F59 Mand. 1	3762	540	21	1398-1424	100%	1323.1346	19%
									1393.1431	81%
			F516 Mand. 7	3763	648	24	1290-1309	40%	1283.1321	44%
							1361-1386	60%	1348-1392	56%
			F37 Mand. 4	3764	466	21	1430-1444	100%	1419-1450	100%
	47LC0262	OT	Feature 3 Level 10	3765	415	19	1444-1465	100%	1438-1487	100%
									1605-1606	<1%
				3766	305	27	1521-1575	74%	1491-1602	75%
							1625-1644	26%	1614-1649	25%
			Feature 3 Level 12	3767	418	19	1443-1464	100%	1437-1486	100%
				3768	250	20	1644-1663	100	1533-1536	1%
									1636-1668	82%
									1782-1797	17%
									1948-1950	<1%
				3769	361	19	1470-1517	65%	1455-1524	56%
							1594-1618	35%	1559-1564	2%
									1568-1631	42%
Langford	11CK4	Fisher*	Mandible 1	3029	745	29	1258-1282	100%	1224-1239	9%
									1240-1288	91%
			Mandible 2	3030	760	25	1251-1279	100%	1224-1281	100%
			Mandible 3	3031	873	28	1059-1063	2%	1045-1097	20%
									1119-1142	5%
							1154-1216	98%	1146-1224	74%
									1235-1241	1%
Late Woodland	47DO027	Nitschke*	Mound 21	3033	1035	24	993-1019	100%	973-1028	100%
Middle Mississippian/ Late Woodland	47JE0001	Aztalan	Mandible 1	3791	942	24	1034-1050	20%	1029-1154	100%
							1082-1127	59%		
							1135-1151	21%		
			Mandible 2	3792	1049	26	985-1018	100%	901-921	6%
									955-956	<1%
									960-1026	94%
			Mandible 3	3793	976	31	1019-1047	48%	999-1001	<1%
							1089-1122	42%	1013-1154	100%
							1139-1148	10%		

Overall, the results conform to expectations. The radiocarbon assays align well with previously reported dates from each of the sites (see Chapter 2). Where applicable, the dog values were generally in line with the associated human values (see Edwards et al. 2017). Upper Mississippian dogs consumed more maize than Late Woodland dogs, and dogs from collared ware sites consumed more maize than those from non-collared ware sites (i.e., Nitschke). In fact, the Nitschke dog appears to have eaten a very different suite of foods than all of the other dogs.

The radiocarbon assays indicate that many of the dogs were relatively contemporaneous. One dog from Aztalan and the Nitschke dog clearly predate all the others. Two Aztalan dogs lived either just before, or right after the arrival of the Middle Mississippians. It is not known if they are associated with an exclusive Late Woodland or joint Late Woodland/Middle Mississippian occupation of the site. They are generally contemporaneous with the Crescent Bay dogs, and one Diamond bluff dog. While somewhat later the remaining Diamond Bluff dog and the Fisher dogs predate cal.1300. The La Crosse dogs are the latest in the sample.

- CBHC dogs and Fisher canid (Mandible 3) somewhat earlier than Fisher dogs -
    - Nitschke dog and Aztalan mandible 2: cal. AD 960-1030
    - Aztalan mandibles 1 and 3: cal. AD 1015-1155
    - CBHC dogs & Fisher canid: cal. AD 1150-1240
    - Fisher dogs: cal. AD 1225-1280
- Diamond Bluff earlier than La Crosse
    - Diamond Bluff overlaps CBHC and Fisher samples: cal. AD 1150-1300
    - La Crosse mostly post cal. 1400
        - One Sanford Complex sample may be as early as AD 1280

The $\delta^{13}C$ analyses indicate moderate variation among the Upper Mississippian samples, along the lines as predicted above. The Red Wing and Eastern Upper Mississippian values all indicate that Late Woodland groups consumed more maize in these Localities than in La Crosse.

The Aztalan dogs were only slightly lower than the La Crosse values. The general patterns are listed below.

- Eastern dog values in line with MSQ human values and other Langford human values (Emerson et al. 2005, 2010)
    - Eastern dogs' range: -11.7 to -14.1‰
    - Diamond Bluff dogs mirror Brian close to Eastern dogs -12.1 to -14‰:
    - La Crosse trends lower but with wide range: -11.6 to -16.4‰
    - Aztalan dogs: -14.4 to -16.2‰
    - Nitschke dog: -19.5‰

Likewise, the $\delta^{15}N$ assays returned values within the expected ranges. As predicted, the dog values were slightly lower than the human values by roughly 0.5‰ (see Chapter 3; Edwards et al. 2017; Guiry 2013). The variation among archaeological cultures was also roughly as expected. Early Upper Mississippian groups consumed the least meat on average, followed by later western groups. The Nitschke dog consumed the most meat. Somewhat surprising was the low $\delta^{15}N$ values at Aztalan, given their relatively early radiocarbon dates.

- CBHC and Aztalan dogs have lowest $\delta^{15}N$ values: 8.1-9.2‰
- Fisher (Mandibles 1 and 2) & Diamond Bluff dogs mirror associated human values (MSQ and Bryan respectively)
- La Crosse $\delta^{15}N$ has greatest variation: 8.6-9.4‰
- Nitschke $\delta^{15}N$ value highest: 9.9‰

Taken together, the data indicate that there were several different subsistence strategies in place during the Late Prehistoric of Wisconsin and northern Illinois. Statistical analysis is necessary to determine fine grained differences within archaeological cultures, but the raw data do identify broad differences among these larger groupings.

- Effigy Mound building people (and their dogs) ate a diet distinct from the Upper Mississippian pattern

    - The isotope values are concordant with a more mobile lifestyle, as argued by several authors (Salkin 2000; Stevenson et al. 1997)
    - Despite the low reliance on agricultural crops, dental carries were still prevalent among humans at levels associated with agriculturalists (Bradley 2002:78-79)
- The collared ware sample (i.e., Aztalan) indicates more maize and less meat consumed compared to the non-collared.
    - The values indicate the dogs had a lower reliance on agricultural products than their Upper Mississippian neighbors
- Variation among Upper Mississippian populations is evident, but relatively high maize reliance is indicated

One anomalous sample was noted in the preliminary dataset: Fisher Mandible 3. Edwards et al. (2017:522) argue that this may reflect one of four factors: 1) it is a wild canid, not a dog that feeds on C4 consuming animals; 2) it reflects earlier diets of the Fisher, not Langford, occupants of the site; 3) it reflects a change through time with earlier populations consuming less maize and more meat; 4) it reflects the overall range of diet at the site as it is still within the overall Mississippian dietary range. Because we cannot differentiate among these options, we must conservatively exclude it in the following discussion of isotopes.

Integrating the Datasets: A Regional Perspective

When dog isotopes are integrated into the human datasets, it is possible to make interregional and intercultural comparisons. To first determine if there are overall differences among Upper Mississippian populations, a series of Mann Whitney U tests were conducted on this non-normally distributed dataset. As was noted above, only Langford human samples from MSQ could be used in these tests because the Emerson et al. (2005) only provided summary data for the other sites. First, a regional comparison was made between eastern (Koshkonong and Fisher dogs with MSQ humans) and western (Diamond Bluff and La Crosse dogs with Bryan humans) samples. The test showed that the eastern sample was larger than the western (U=49.5;

p<0.01), indicating that the null hypothesis (H_0: east-distribution = west-distribution) that maize contributed a larger portion of the diet is rejected (Figure 6.5). Differences among localities and regions are not unexpected given Hart's (1990) expectation of variation among Upper Mississippian agricultural strategies.

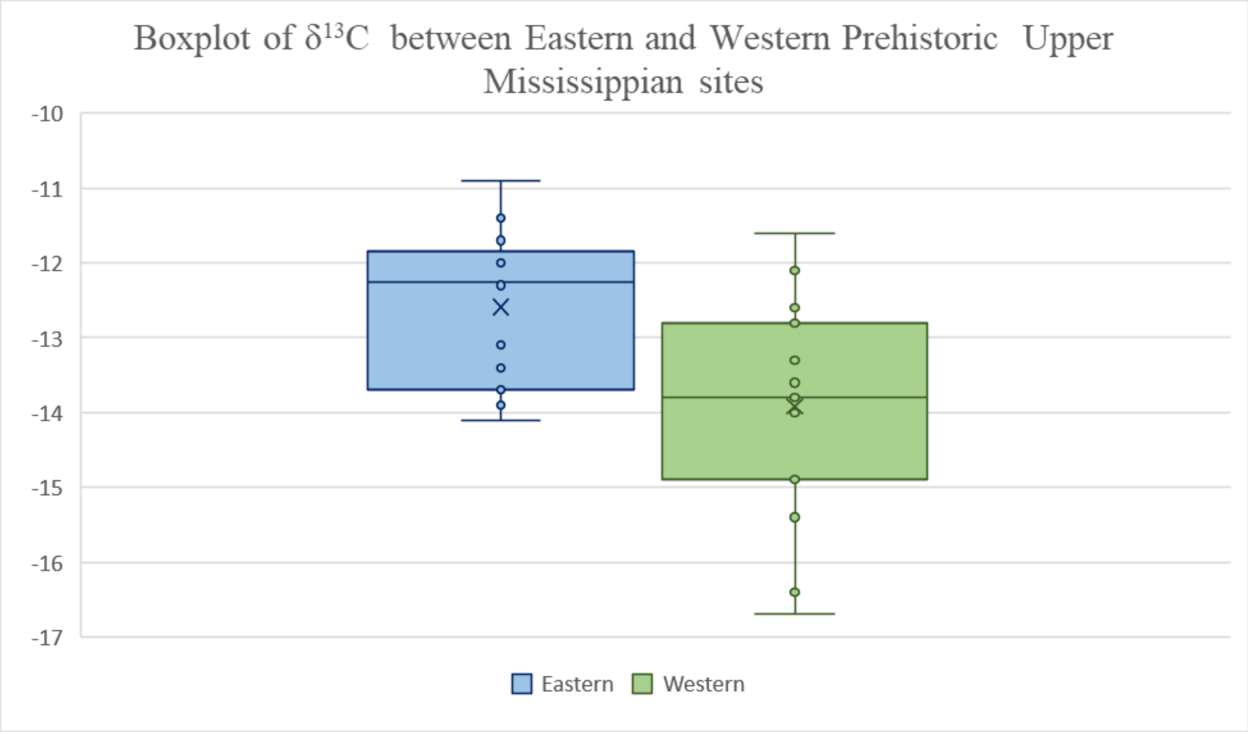


Figure 6.5 – Boxplot of aggregated eastern and western $\delta^{13}C$ values

In addition to geography and synchronic differences, potential chronological shifts must also be assessed. Gibbon's (1972b; 1986) grassland/fractionalized adaptation (see Chapter 2) based on his timeline argues for reduced reliance on maize through time, so we should expect to see larger $\delta^{13}C$ values in earlier samples. However, Overstreet's (1997) chronology suggests that during the Classic Horizon, the later samples should have greater $\delta^{13}C$ levels. To assess any potential differences, two additional Mann Whitney tests were used. First, chronological differences were tested among the Oneota localities (i.e., Red Wing and Koshkonong vs La Crosse), and then chronological differences for all Upper Mississippians (Langford, Koshkonong and Redwing vs La Crosse). One Red Wing value was statistically an outlier (Figures 6.6 and 6.7), and therefore removed from the analysis. Because there are two competing theories about which time-period should have greater levels of maize reliance, two-tailed Mann Whitney U tests were conducted to see if the distributions are different.

While the earlier values were generally higher, the values between Red Wing/Koshkonong and La Crosse were not significantly different (U=16; p=0.10), indicating no chronological shifts in agricultural production. The second test (Langford, Koshkonong and Redwing vs. La Crosse) suggested that there were chronological differences (U=34.5; p=0.02). The first test appears to refute both Gibbon's and Overstreet's theories, as they both suggest no shift. The second test appears to support Gibbon's theory; early groups consumed greater amounts of maize than later groups. However, with the additional 10 eastern samples, the increase in maize use values may just represent the geographic differences identified above. The data clearly indicate that the eastern samples have larger $\delta^{13}C$ values than western. Overall, $\delta^{13}C$ values tend to decrease through time, but this trend is weak and is likely associated with multiple factors in addition to time.

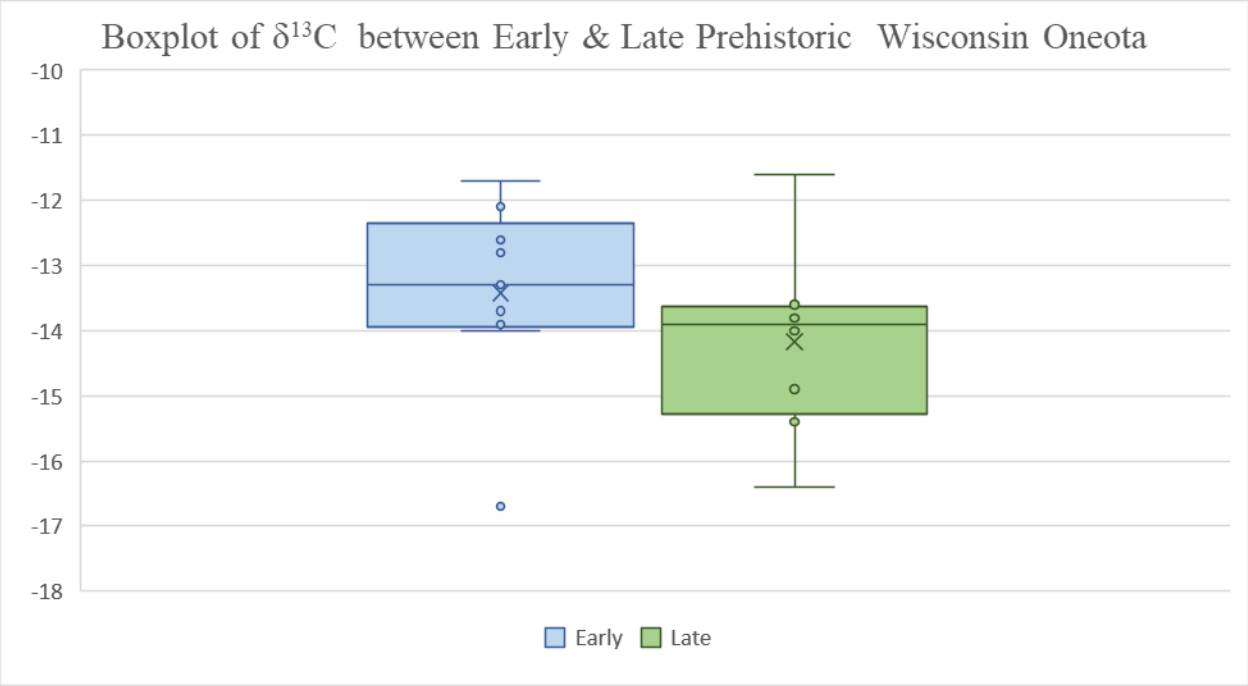


Figure 6.6: Boxplot of aggregated early (Red Wing and Koshkonong) and late (La Crosse) Oneota $\delta^{13}C$ values

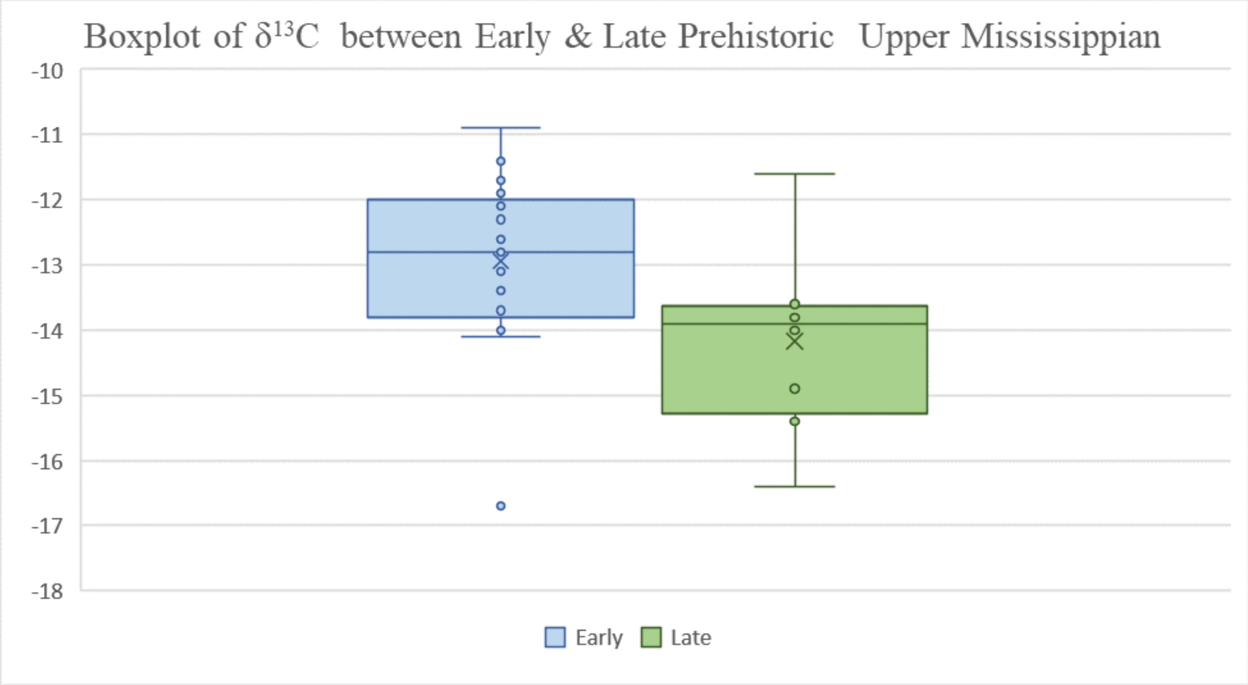


Figure 6.7: Boxplot of aggregated early (Langford, Red Wing, and Koshkonong) and late (La Crosse) $\delta^{13}C$ Upper Mississippian values

In order to assess the idea that agriculture is associated with cultural complexity, comparison between Middle and Upper Mississippian values were run. This included two additional Mann Whitney U tests; however, because we are testing if Middle Mississippians consumed greater amounts of maize, one-tailed tests were used. Because previous tests showed significant differences between eastern and western Upper Mississippian samples, each were independently tested against the Middle Mississippian values. A comparison of Middle Mississippian (American Bottom, Lower Illinois River Valley, and Aztalan) human isotopes with eastern Upper Mississippian (Koshkonong dog, Langford human and dog) showed no significant differences in δ^{13}C levels (U=579.5, p=0.39). However, when the western sites were compared to the Middle Mississippian samples, a different result was returned (U=456, p=0.03 indicating that western Oneota δ^{13}C values are lower than Middle Mississippian values. LaCrosse inhabitants consumed less maize than American Bottom inhabitants (Figure 6.7).

The Late Woodland values were not used in the statistical comparison. Four samples are insufficient for statistical analysis. The fact that one of the specimens is from a non-collared ware site (Nitschke) further complicated the issue, it would be inappropriate to aggregate the Nitschke dog with the dog samples from Aztalan, a collared ware site. However, it does appear that as a whole the Late Woodland samples indicate lower maize consumption. The bulk of the distribution is beyond the Eastern Upper Mississippian range. However, the Aztalan samples are on par with many of the La Crosse samples, and the Nitschke dog appears to have eaten as little maize as the Middle Mississippian elites.

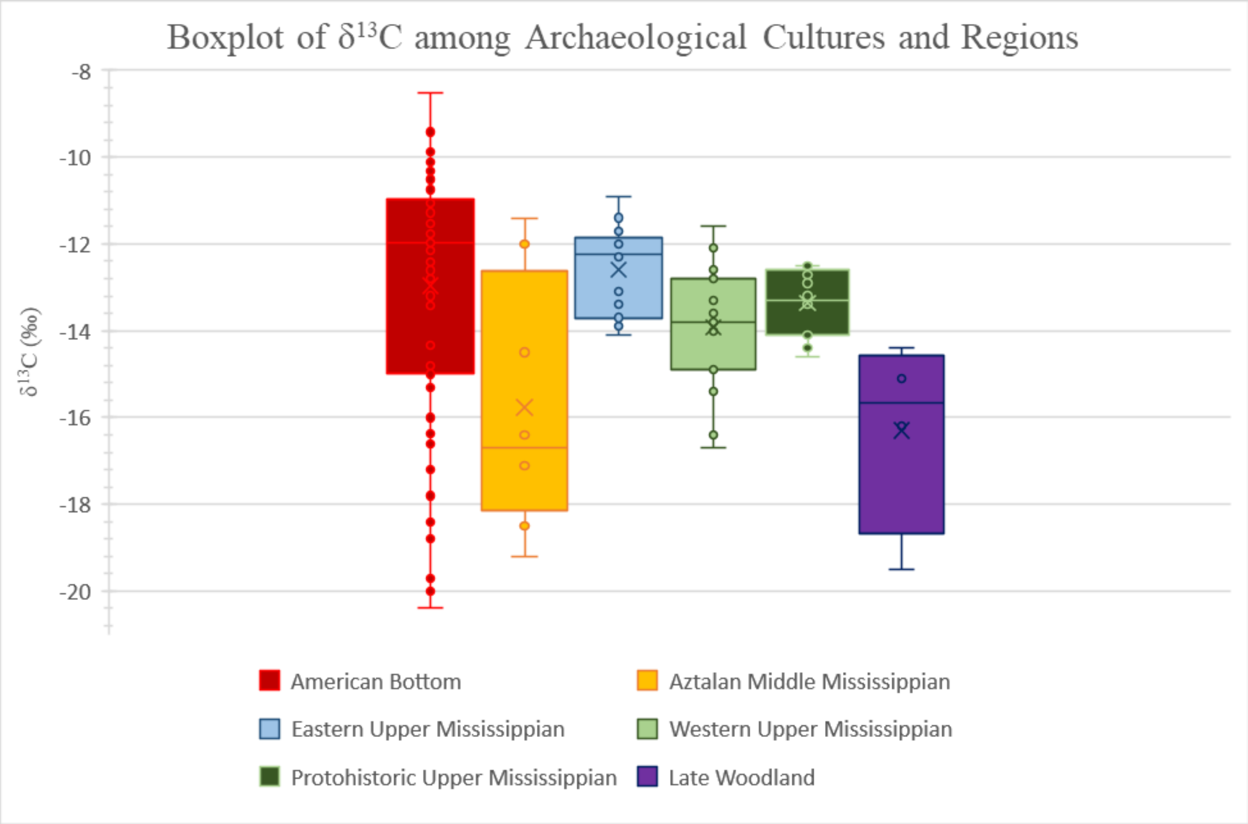


Figure 6.8: Boxplot of $\delta^{13}C$ values for each archaeological culture by region

For $\delta^{13}C$, it is also helpful to contextualize the isotopic values in terms of total dietary contribution. Since collagen reflects protein consumption in well understood ways, it is possible to estimate C4 pathway plants' proportional contribution to the protein portion of the diet with the following equation.

$$\%C4\ of\ protein\ component = \frac{-25 - (\delta^{13}\text{C collagen} - 5.1‰)}{15} * 100$$

The middle Mississippians populations $\delta^{13}C$ exhibit the widest range, from -20.4‰ to -8.5‰, or 0% to 75% of total protein intake. The Upper Mississippian values, which also include values from other Langford sites where only summary data was available, have a narrower range, corresponding to 35% to 67% of protein intake. The Late Woodland values are the lowest, ranging between 3% to 35% of protein intake (Table 6.6).

The Middle Mississippian values reemphasize the extreme diversity present in the hierarchically organized populations. The 95% confidence interval for all Middle Mississippians' maize consumption ranges from 2-82% of the protein intake. However, not all sites exhibit such a wide range. Sites like Schild A, Aztalan, and Cahokia all exhibit extremely low δ^{13}C levels for a portion of their samples, indicating low maize consumption for at least one segment of the sites' populations (minimum values < 15%). On the other hand, ESLSQ and Florence St both have minimum values greater than 40% protein from maize. Hedman et al. (2002) note that these inter and intrasite differences come from multiple sources including geography, sex, and status. Generally, individuals from upland sites consumed more wild plants (e.g., acorn) and less maize. Males at some sites consumed more meat and less maize, and individuals of high status generally consumed significantly less maize and more meat (Ambrose et al. 2003; Hedman et al. 2002).

Table 6.6: Descriptive Statistics for Middle Mississippian δ13C values and Maize values as a percent of protein consumed

Region	**Site Name**	**n**	**δ13C**				**95% Confidence Interval**		**% Maize of Protein in Diet**			**95% Confidence Interval**	
			μ	**σ**	**Min**	**Max**			**μ**	**Min**	**Max**		
American Bottom	Cahokia	15	-16.8	1.9	-20.0	-13.3	-20.6	-13.0	20.6	-0.67	44.0	-4.6	45.8
	Corbin	13	-12.1	1.6	-15.0	-9.9	-15.3	-8.9	52.1	32.73	66.9	31.0	73.2
	ESLSQ	21	-11.0	1.1	-13.3	-8.5	-13.2	-8.8	59.6	44.20	75.9	44.9	74.3
	Florence	9	-11.2	1.0	-13.1	-10.1	-13.2	-9.3	57.7	45.27	65.2	45.0	70.5
	Hill Prairie	6	-14.6	3.9	-19.7	-10.2	-22.3	-6.8	35.5	1.33	64.7	-16.2	87.3
	Range	6	-11.4	1.5	-14.3	-10.3	-14.4	-8.4	56.9	37.07	64.0	36.8	76.9
	Schild A	9	-14.1	2.8	-20.4	-10.4	-19.	-8.5	38.4	-3.33	63.3	0.6	76.3
	Overall	79	-13.3	2.9	-20.4	-8.5	-19.1	-7.5	**44.1**	**-3.33**	**75.9**	**5.7**	**82.6**
Lake Mills	Aztalan	8	-15.8	2.9	-19.2	-11.4	-21.5	-10.0	**27.6**	**4.67**	**56.7**	**-10.7**	**65.9**
Overall Middle Mississippian		**87**	**-13.5**	**3.0**	**-20.4**	**-8.5**	**-19.5**	**-7.6**	42.6	**-3.33**	75.9	**2.9**	**82.3**
Koshkonong	CBHC	2	-12.7	1.4	-13.7	-11.7	-15.5	-9.9	**48.0**	**41.33**	**54.7**	**29.1**	**66.9**
La Crosse	Sanford	3	-14.2	0.7	-14.9	-13.6	-15.5	-12.8	38.2	33.33	42.0	29.3	47.1

Region	Site Name	n	δ13C				95% Confidence Interval		% Maize of Protein in Diet			95% Confidence Interval	
			μ	**σ**	**Min**	**Max**			**μ**	**Min**	**Max**		
	Valley View	1	-16.4	-	-16.4	-16.4	-	-	23.3	23.33	23.3	-	-
	Midway	2	-12.7	1.6	-13.8	-11.6	-15.8	-9.6	48.0	40.67	55.3	27.3	68.7
	OT	2	-14.6	1.2	-15.4	-13.7	-17.0	-12.2	35.7	30.00	41.3	19.6	51.7
	Overall	8	-14.2	1.4	-16.4	-11.6	-17.0	-11.3	**38.2**	**23.33**	**55.3**	**19.1**	**57.3**
Red Wing	Bryan	5	-13.9	1.7	-16.7	-12.6	-17.2	-10.5	40.3	21.33	48.7	18.1	62.5
	Diamond Bluff	2	-13.1	1.3	-14.0	-12.1	-15.7	-10.4	45.7	39.33	52.0	27.8	63.6
	Overall	7	-13.6	1.5	-16.7	-12.1	-16.7	-10.6	**41.8**	**21.33**	**52.0**	**21.6**	**62.1**
Upper Illinois	Gentleman Farm	10	-11.7	1.0	-14.4	-10.3	-13.7	-9.7	54.7	36.67	64.0	41.3	68.0
	Oakwood Mound	11	-12.6	1.2	-14.4	-10.2	-15.0	-10.2	48.7	36.67	64.7	32.7	64.7
	Fisher Overall	31	-12.3	1.2	-14.7	-9.8	-14.7	-9.8	51.0	34.67	67.3	34.7	67.3
	Fisher (humans)	29	-12.2	1.3	-14.7	-9.8	-14.8	-9.6	51.0	34.67	67.3	34.0	68.7
	Fisher (dogs)	2	-13.0	1.8	-14.1	-11.9	-16.5	-9.5	46.0	38.67	53.3	22.4	69.6
	MSQ	10	-12.5	1.0	-13.7	-10.9	-14.5	-10.5	49.4	41.33	60.0	36.2	62.6
	Overall Langford	62	-12.3	0.7	-14.7	-9.8	-13.6	-10.9	**50.9**	**34.67**	**67.3**	**41.7**	**60.1**
Overall Prehistoric Upper Mississippian		**79**	**-12.6**	**0.6**	**-16.7**	**-9.8**	**-13.7**	**-11.4**	**48.7**	**21.33**	**67.3**	**41.0**	**56.4**
Riceford Creek	Hogback	9	-13.2	0.7	-14.4	-12.5	-14.6	-11.9	44.6	36.67	49.3	35.5	53.7
	Wilsey	6	-13.6	0.9	-14.6	-12.5	-15.4	-11.8	42.1	35.33	49.3	30.3	53.9
	Overall	15	-13.4	0.8	-14.6	-12.5	-14.9	-11.8	**43.6**	**35.33**	**49.3**	**33.4**	**53.8**
Total Upper Mississippian		**94**	**-12.7**	**0.5**	**-16.7**	**-9.8**	**-13.7**	**-11.7**	**47.9**	**21.33**	**67.3**	**41.3**	**54.6**
Late Woodland	Nitschke	1	-	-	-19.5	-19.5	-	-	-	2.7	2.7	-	-
	Aztalan	3	-15.2	0.9	-16.2	-14.4	-17.1	-13.4	31.0	24.5	36.8	18.7	43.3
Overall Late Woodland		**4**	**-16.3**	**2.3**	**-19.5**	**-14.4**	**-20.8**	**-11.8**	**23.9**	**2.7**	**36.8**	**-6.2**	**54.0**

The complex interplay of population movement, social hierarchies, and tiered settlement systems within the Mississippian populations leads to a wide range in maize consumption among individuals and sites. This stands in stark contrast to the Upper Mississippian samples. As a whole, the variation, both among and within sites, is significantly less for the northern groups. The lowest recorded Upper Mississippian value is -16.70‰, which still represents a diet where maize contributed more than 20% of the protein. The highest level is -9.80‰, representing a diet with nearly 70% of protein from maize. While this represents a wide range (≈50% of protein), it is smaller than the range of Middle Mississippians (≈75%). Furthermore, most Upper Mississippian values fall within a relatively narrow range (41 to 57% at a 95% confidence interval). Variation among regions accounts for much of Upper Mississippian variation. The Langford samples are the most consistent and the highest $\delta^{13}C$ ($\mu > 50\%$ of protein from maize). While the sample size is small, the Koshkonong dogs were generally high, and on par with the Langford values ($\mu = 48\%$ of protein). Western localities trend lower in averages (Red Wing $\mu < 45\%$; La Crosse $\mu < 40\%$; Riceford Creek $\mu < 45\%$) at 95% confidence intervals.

The overall Late Woodland values appear to have a high degree of variation (95% confidence range = 0-54%). However, most of the range appears to be due to intersite differences. Aztalan, a collared-ware site, has minimal variation (19 to 43% protein at 95% confidence interval). The Late Woodland dog values from Aztalan trend lower than their Oneota neighbors at Koshkonong, and elsewhere. While sample size is an issue, it is important to note that the 95% confidence intervals for Late Prehistoric Upper Mississippian and Late Woodland only have a minimal overall (2% of protein). Looking at the sample values, the three Aztalan dogs ate more maize than some Upper Mississippians, particularly in the west (La Crosse and Red Wing), but even the high-end Aztalan samples are at the low-end of the Upper Mississippian range. Nitschke, an effigy mound site, exhibits values on par with Middle Mississippian elites, as well as Middle Woodland people and a dog from the Richter site in Door County (Edwards et al. 2017; Wellner 2006) and Late Archaic elites at the Jaco site in Jefferson County (Jeske et al.2011; Romond et al. 2011). The single dog sampled appears to have consumed very little maize (<3% of protein). While the sample size is small, it conforms with previous expectations for Effigy Mound groups (see Edwards et al. 2017 for a full discussion).

An analysis of the $\delta^{15}N$ values also shows differences among archaeological cultures. However, there is less variation in $\delta^{15}N$ than $\delta^{13}C$. The data indicate that Middle Mississippian meat consumption was the most variable (7.6-11.9‰). The range for Upper Mississippians is smaller, 8.1-10.7‰, but the Late Woodland dogs had the smallest $\delta^{15}N$ range, 8.2-9.9‰ (Table 6.6).

Table 6.7: Descriptive Statistics for $\delta^{15}N$ values of Middle and Upper Mississippian sites

Region	**Site Name**	**n**	**μ**	**σ**	**Min**	**Max**	**95% Confidence Interval**	
American Bottom	Cahokia	9	9.04	1.34	7.90	11.90	6.37	11.72
	Corbin	13	9.12	0.35	8.70	9.59	8.41	9.83
	ESLSQ	21	9.05	0.64	7.91	10.23	7.77	10.33
	Florence St	9	9.87	0.44	9.02	10.33	8.99	10.75
	Hill Prairie	6	9.65	0.57	9.14	10.65	8.50	10.79
	Range	6	9.43	0.83	8.32	10.88	7.77	11.08
	Schild A	9	8.74	0.74	7.60	9.90	7.27	10.22
	Overall	**73**	**9.21**	**0.77**	**7.60**	**11.90**	**7.66**	**10.75**
Koshkonong	CBHC	2	**8.55**	**0.64**	**8.10**	**9.00**	**7.28**	**9.82**
La Crosse	Sanford	3	9.00	0.30	8.70	9.30	8.40	9.60
	Valley View	1	8.80	-	8.80	8.80	-	-
	Midway	2	8.90	0.71	8.40	9.40	7.49	10.31
	OT	2	9.05	0.64	8.60	9.50	7.78	10.32
	Overall	**8**	**8.96**	**0.40**	**8.40**	**9.50**	**8.16**	**9.77**
Red Wing	Bryan	4	9.43	0.70	8.40	10.00	8.02	10.83
	Diamond Bluff	2	8.95	0.07	8.90	9.00	8.81	9.09
	Overall	**6**	**9.27**	**0.60**	**8.40**	**10.00**	**8.07**	**10.46**
Upper Illinois	Gentleman Farm	10	9.50	1.00	8.70	10.20	7.50	11.50
	Oakwood Mound	11	9.90	1.20	9.50	10.50	7.50	12.30
	Fisher Overall	**31**	**9.71**	**1.22**	**8.40**	**10.70**	**7.28**	**12.14**
	Fisher (humans)	29	9.80	1.30	8.90	10.70	7.20	12.40
	Fisher (dogs)	2	8.40	0.00	8.40	8.40	8.40	8.40
	MSQ	10	9.56	0.33	9.00	10.10	8.91	10.21

Region	**Site Name**	**n**	**μ**	**σ**	**Min**	**Max**	**95% Confidence Interval**	
	Overall Langford	**62**	**9.69**	**0.67**	**8.40**	**10.70**	**8.36**	**11.02**
Overall Prehistoric Upper Mississippian		**79**	**9.43**	**0.53**	**8.10**	**10.70**	**8.37**	**10.49**
Riceford Creek	Hogback	9	9.83	1.54	5.90	11.10	6.75	12.92
	Wilsey	6	10.98	0.73	10.20	12.00	9.53	12.44
	Overall	**15**	**10.29**	**1.37**	**5.90**	**12.00**	**7.54**	**13.04**
Total Upper Mississippian		**94**	**9.57**	**0.49**	**5.90**	**12.00**	**8.58**	**10.56**
Late Woodland	Nitschke	1	-	-	9.9	9.9	-	-
	Aztalan	3	8.5	0.55	8.2	9.2	7.44	9.66
Overall Late Woodland		**4**	**8.89**	**0.81**	**8.2**	**9.9**	**7.26**	**10.51**

The Middle Mississippians with the highest δ^{15}N values consumed more meat than the prehistoric Upper Mississippians at the high end of their range (11.9‰ compared to 10.7‰). Likewise, the Middle Mississippians at the low end of the spectrum consumed less meat than their Upper Mississippian counterparts (7.6‰ compared to 8.8‰). Because dog values trend 0.5‰ lower than humans, it may be necessary to calibrate the dog values to make them comparable (Edwards et al. 2017; Guiry 2013). When dog δ^{15}N values are increased 0.5‰, the Upper Mississippian range increases marginally. This indicates that those Upper Mississippian humans that consumed the most meat may have eaten as much as Middle Mississippian elites. Raising the dog δ^{15}N simultaneously increases the low end of the Upper Mississippian range. This increase indicates that almost all humans at Upper Mississippian sites ate more meat than the non-elites on Middle Mississippian sites. However, the isotopic samples cannot be differentiated statistically from Eastern Upper Mississippian (U=467.5, p=0.62) or Western Oneota (U=462, p=0.58).

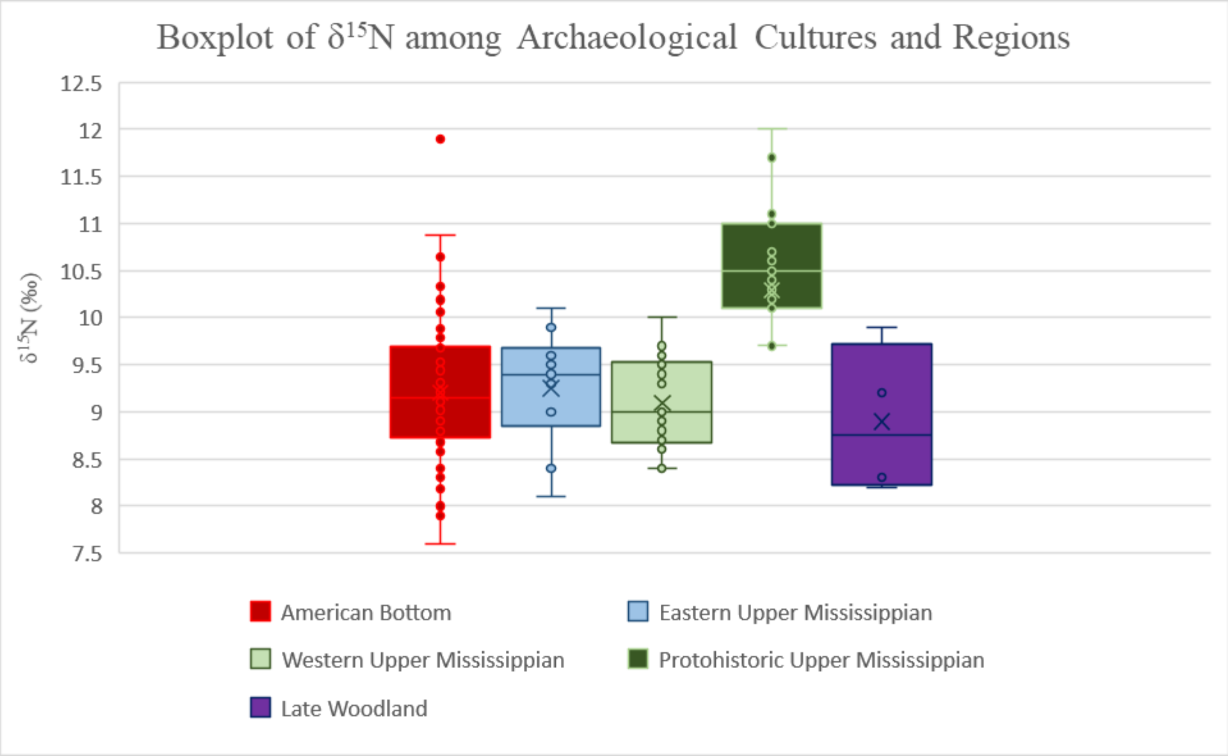


Figure 6.9: Boxplot comparing δ^{15}N values among archaeological cultures and regions

The chronological and geographic variation within the Upper Mississippian values must also be explored. Values from early and eastern sites (i.e., Langford sites and Crescent Bay) range from 8.1-10.7‰. Early western samples (i.e., Red Wing) range from 8.4-9.5‰, with Langford groups consuming the most meat. The Langford sample is also the largest (n=2 dogs, 60 humans), and so the high end of meat consumption may be missing from the small samples at Crescent Bay (n=2 dogs) and Red Wing (n=2 dogs, 4 humans). Compared to the later La Crosse samples (n=8 dogs) meat consumption appears to decrease (8.4-9.5‰). These samples are lower than either Red Wing or La Crosse samples (La Crosse μ=9.0‰; Red Wing μ=9.3‰; Langford μ=9.7‰). The Crescent Bay sample remains the lowest (μ=8.6‰). However, when the dog values are calibrated up 0.5‰, much of the variation disappears between localities. The Langford mean is relatively unchanged because of the relatively small number of dogs (μ=9.7‰), with a larger proportion of dogs in the sample, the Red Wing shifts upwards slightly (μ=9.4‰).

Without any human values, the La Crosse (μ=9.5) and Koshkonong (μ=9.1) means increase a full 0.5‰. After adjusting the dog δ^{15}N values, the western samples become indistinguishable. Langford values are only slightly higher than the western samples, and Koshkonong continues to stand out with its relatively low values.

Statistically, early sites (Red Wing, Koshkonong, MSQ) cannot be differentiated from the La Crosse sites (U=51.5, p=0.16) (Figure 6.10). Furthermore, the eastern sites (MSQ and CBHC) cannot be differentiated from the western (Red Wing and La Crosse) sites (U=80, p=0.42) (Figure 6.11). While maize may vary among localities and regions, the role of hunting seems to be fairly consistent within the Late Prehistoric Oneota world. However, groups further to the west, later in time, or both (i.e., Riceford Creek) do appear to have relied on hunting significantly more.

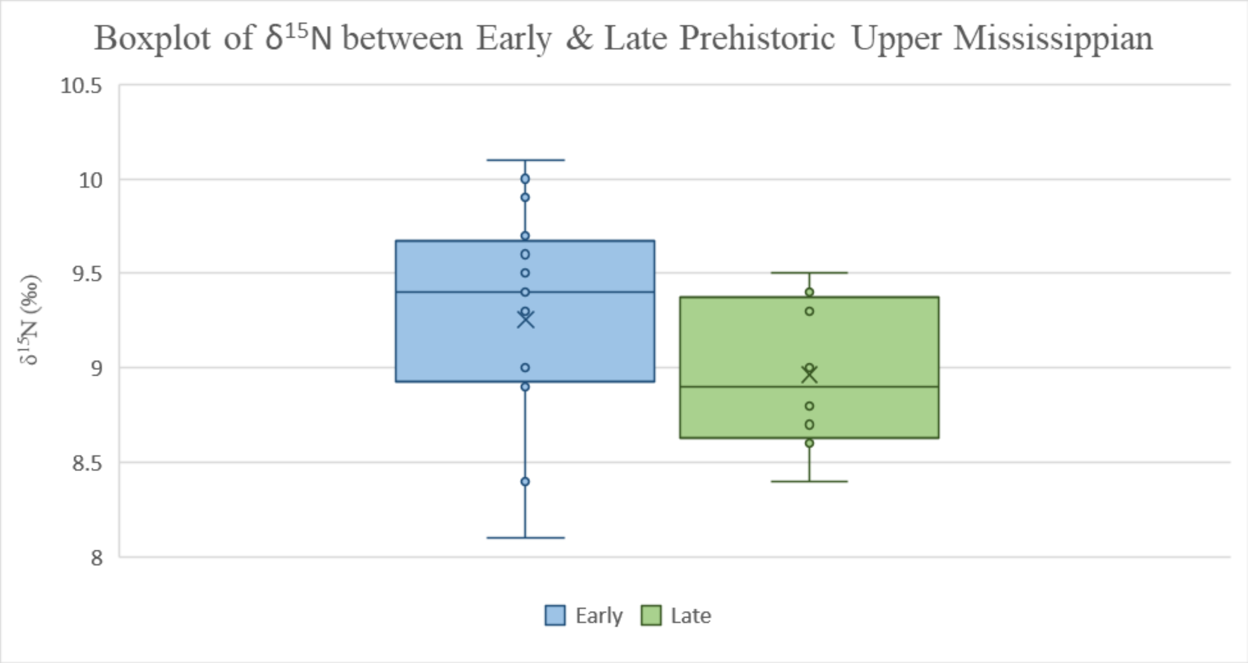


Figure 6.10: Boxplot of δ^{15}N between Early and Late Prehistoric Upper Mississippian

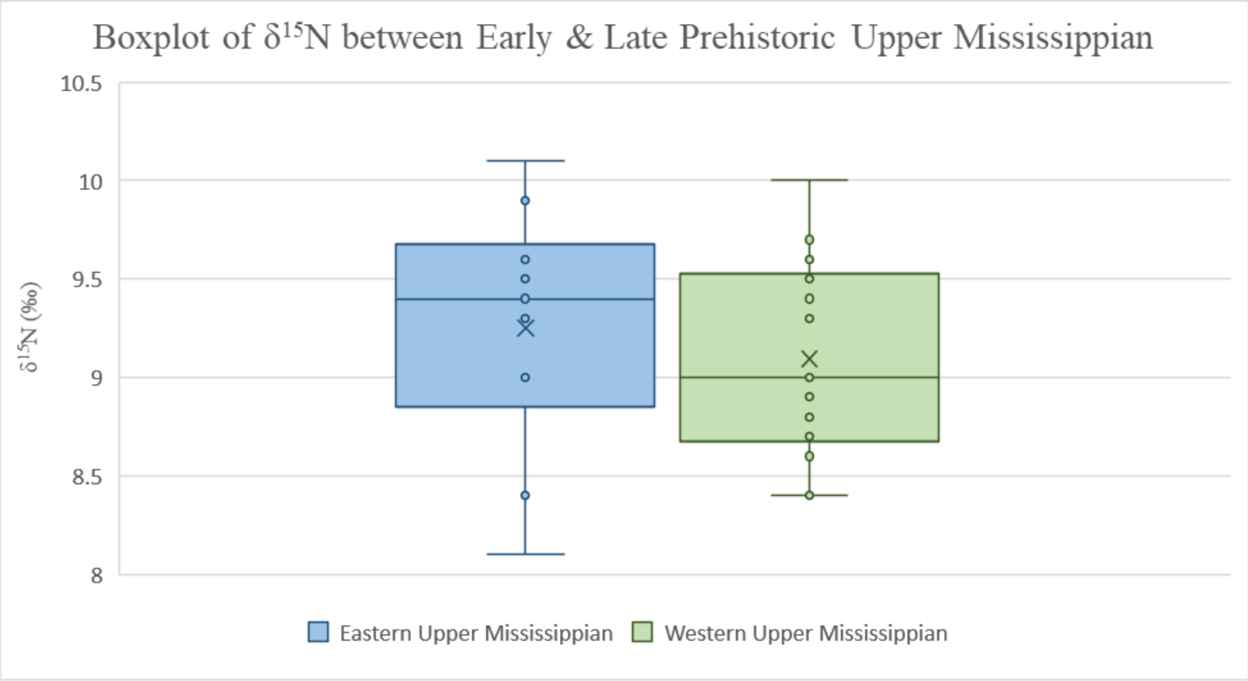


Figure 6.11: Boxplot of δ^{15}N between Eastern & Western Upper Mississippian

The Late Woodland δ^{15}N values also vary between sites. The Nitschke dog consumed considerably more meat than its southern neighbors (beyond the 95% confidence interval). Crescent Bay is the only site to have lower δ^{15}N than the Aztalan dogs. In fact, the CBHC dog δ^{15}N range closely mirrors the Aztalan range (0.1 lower at both ends of the range). Given the proximity of the sites, it is tempting to argue that deemphasized meat consumption is a part of a longstanding local tradition, but a sample of five dogs from two sites in a relatively narrow time range makes this a tenuous assertion at best. It may also be related to population packing, or the arrival of intrusive groups into the region, forcing a contraction of hunting territories. If there is competition over territory, hunters may remain closer to the villages to avoid ambushes by opposing groups, thereby reducing access to meat (see Chapter 3). In such cases, some or all of the reduced meat may be replaced by plants, which would lower the δ^{15}N values.

Chapter Summary:

The results of the isotopic analysis suggest that, while there are some differences between Upper and Middle Mississippian populations, there is also a great deal of overlap. For Upper Mississippians, most of this overlap seems to be associated with regional variation (east vs. west). For Middle Mississippians, status and site type differences are the major sources of variation. Some general trends do become apparent. Western Upper Mississippian groups tend to consume more meat than those in the east. Meat consumption is likely at the expense of maize, which trends lower than their eastern counterparts (roughly 10% of total protein intake). Upper Mississippians consume, on average, slightly more maize than their Middle Mississippian counterparts. However, this result is misleading, and is largely due to the wide range of variation within Middle Mississippian populations. High status individuals at Middle Mississippian sites show values indicating the least maize consumption (Ambrose et al. 2003) of all samples. In addition, the residents of upland American Bottom sites show values associated with less maize than their low-status lowland counterparts. These lowland dwelling, low status Middle Mississippian individuals appear to have consumed more maize than all other sampled. This large maize consumption is largely at the expense of meat and wild plants, which accounts for a very small portion of the diet (<15% of protein for some individuals). The upland residents are not necessarily consuming more meat that the low-status lowland residents; rather, they are likely consuming more wild plants (Hedman et al. 2002).

7. Analysis and Discussion

Introduction:

In this chapter I answer, in full, the four primary research questions and sub questions. This chapter will tie in comparative paleoethnobotanical data with the isotopic data. Finally, this chapter will provide interpretations of the cultural meaning of the patterns identified in the data collected for this dissertation.

Question 1: What is the nature of the floral portion of the Oneota diet?

The simplest way to answer this question is to say that it is agriculturally focused. The isotopic data indicate that Oneota dogs consumed large amounts of maize. The values suggest that for the humans, roughly one-third to two-thirds of their protein came from maize. Considering that it is not a good source of protein, maize likely accounted for an even greater portion of the overall diet. The density and ubiquity of both kernels and cupules/cobs supports the isotopic results. With maize found in nearly every context and in every feature, it is the most dense and ubiquitous plant in the macrobotanical assemblage in Koshkonong. In addition to maize, the data show squash, beans, and chenopodium were also actively grown. The placement of the sites adjacent to and directly upon highly arable land highlights the importance of the agriculture.

1.1 Which plants were the largest contributors to the diet?

In addition to maize, wild rice and acorn were both highly ranked resources. The isotopic data confirm that maize was the top ranked resource, above the C3 plants. Because the recovered nutshell represents waste from food preparation and the wild rice represents accidentally burned grains, it is not possible to determine which plant was second and which the third ranked resource. The diachronic analysis shows that acorn was intermittently a very important resource during the first two centuries that the sites were occupied. Wild rice was used in consistently high densities, but never in the extreme densities of acorn. Sometime after AD 1250, acorn use declined significantly, but remained an important resource. As acorn declined, wild rice became more important and likely was the second ranked resource.

1.2 What role did agricultural plants play?

In addition to maize, there are several other sown plants. Below, I discuss all the plants that were actively grown in the Koshkonong Locality. Our modern divisions between cultivated and fully domesticated probably meant little to the farmers who had to tend to both types. While the domesticated crops may have been grown over larger areas, or been more reliant on human propagation, and therefore required greater labor investment, both suites of plants would have required sowing, tending, and harvesting (Smith and Cowan 2003). This need for land and labor makes the separation of domesticated and cultivated plants, in this context, unnecessary and arbitrary. Because they were both grown at the same sites (or in the vicinity), they were part of the same subsistence system and more interconnected than they are with wild resources.

Goosefoot appears to have been an important plant at CBHC, and a consistent but lower-ranked resource at KCV. The botanical record may also fail to capture the full importance of the plant, as its greens may have been eaten while leaving few traces that would have been archaeologically visible. Olsen (2003) has shown that *Chenopodium berlandieri*, a southern variety of the plant was grown at CBCH, the plant would not have survived without human intervention so it would have been planted and tended as an agricultural plant.

There are several other plants that also follow this pattern. Maygrass, amaranth knotweed, and little barley have all been found at KCV and/or CBHC (Olsen 2003). They are also plants that are either not native to Wisconsin, or only some species are native to Wisconsin

(Asch and Hart 2004; Smith 1985, 1992). People in the Eastern Woodlands had been cultivating these crops for over 1,000 years (Smith 1992:103). While the non-native variants are clearly cultivated (Asch and Asch 1982; Ford 1979), it is not clear where on the wild-to-weed-to-domesticated continuum (Smith 1992:104.107) the wild varieties (on non-differentiated seeds) lie. They may have been sown along with their cultivated counterparts. Or, it is possible that they were uncultivated, but exploited in wild or disturbed habitats. Furthermore, in other analyses from CBCH, a small number of sunflower seeds were also recovered (Egan-Bruhy 2014).

Historically, bulrush (*Scirpus validus*), a wetland plant, was also cultivated for use as a medicine by the Cherokee (Asch 1994). Although medicinal use of bulrush is not reported ethnohistorically, seeds of the *Scirpus* genus have been recovered from one context at each site. It is therefore possible that the residents were managing a population of bulrush, though such an argument is tentative at best. Asch (1994) notes that, where grown, it was not intensively cultivated. So even if Koshkonong residents did grow bulrush, it was not likely a major labor investment, nor would it have used much space that could have been dedicated to another crop.

Wild rice is the final, and likely most important cultigen grown in the Koshkonong Locality. In the first half of the sites' occupations, it was clearly an important crop based on density and ubiquity. During the second half, it appears that it became more important as its densities and ubiquities also increased. It also accounts for a larger percentage of the overall assemblage as acorn decreased in abundance. As its name implies, wild rice is not domesticated and it is native to Wisconsin (Vennum Jr 1988). Despite its indigeneity and lack of morphological changes, the plant is considered by many to have been cultivated prehistorically (e.g., Arzigian 2000). Using the Plausibility Argument developed by Asch and Asch, a strong argument for its cultivated status can be made (Asch and Asch Sidell 1982 cited in ; Smith 1992:108). This argument has seven parts, five of which wild rice meets.

Wild rice is an extremely important economic plant prehistorically (1), at least in the Koshkonong and La Crosse localities (Arzigian 2000). This reliance is in stark contrast to preceding time periods (2), at least in the La Crosse Locality (Arzigian 2000). Based on the other comparative sites in southeastern Wisconsin, this pattern holds true for Koshkonong as well (Egan-Bruhy 2009; Egan 1993b). There were few-to-no barriers preventing it from being artificially propagated (3) and there are extensive ethnographic and ethnohistoric accounts of this happening (4) across the Upper Great Lakes, including Wisconsin (Jenks 1901; Vennum Jr 1988). Finally, as just noted, wild rice is found in conjunction with other cultivars (5).

It cannot be said that there are other known similar plants to have been cultivated (6). The final criterion is that it is associated with increased population levels and sociopolitical complexity (7). Population levels are notoriously difficult to estimate, but a case could be made for increased centralization on the landscape (e.g., Jeske and Richards 2002). The second half of the criterion, relating to sociopolitical complexity is based on a now contentious argument that agriculture and sociopolitical complexity must go together (Price and Bar-Yosef 2011; Smith 2001). Given that it fits five of the six applicable criteria, wild rice should be treated as a cultivated plant.

Beyond the cultigens, at least three domesticated species were grown for food. The presence of squash and beans in low ubiquities likely underrepresents their importance. It is likely that most of the evidence of their use did not preserve (Toll 1988). Furthermore, these agricultural products could also help fix nitrogen back into the soils (Gallagher 1992; Hart 2008; Monaghan et al. 2014; Mt. Pleasant 2010; Thorne 1979). This would have been extremely important given maize’s reliance on nitrogen (Gallagher and Sasso 1987; Janick et al. 1974; Monaghan et al. 2014). Furthermore, if maize was intercropped with the other two, additional benefits could be wrought. Maize stalks can act as scaffolds for the beans and as squash leaves spread across the ground, it would have helped to keep down weeds, reducing labor requirements in the mid-summer (Gallagher 1992; Harwood 1979; Mt. Pleasant 2010; Mt. Pleasant and Burt 2010).

Of the cultivated and agricultural plants, there can be little doubt that all were secondary to maize. The plant was found in every feature and almost every context. It was the most dense and ubiquitous food-plant recovered (second only to wood-charcoal overall). This general pattern was repeated in most contexts. The two dogs from CBHC had relatively high levels of $\delta^{13}C$ levels (-13.7 to -11.7‰). These levels equate to a diet where 41-55% of the protein came from maize. While it is not possible to determine exactly how much maize was eaten, relative to all other resources, the $\delta^{15}N$ ranged from 8.1-9.0‰, which is indicative of a relatively low-meat diet. Even if the values are adjusted + 0.5‰ to account for the canine effect, the CBHC values are still lower than most other Oneota samples.

While the exact proportions are of the various resources may be beyond our knowing, it is possible to use the isotopic values and modern nutrition information to generate bounds. According to the USDA, uncooked maize contains 86 kilocalories and 3.27 grams of protein for every 100g serving (U.S. Department of Agriculture 2017). We know that the diet included many species, including deer, wild rice, numerous species of fish, and goosefoot. The USDA provides nutritional information (Table 7.1) for each of these taxa. While it is not clear how representative modern varieties are of the varieties used by the residents of Koshkonong, the USDA values can provide a proxy for model generation.

Table 7.1: Modern nutritional data on four known elements of the Koshkonong diet – all values for 100 grams of raw food (U.S. Department of Agriculture 2017).

	Maize	**Wild Rice**	**Deer**	**Pike/Walleye**	**Goosefoot**
Energy (Kcal)	86	357	120	93	43
Protein (g)	3.27	14.73	22.96	19.14	4.20

This model assumes a simplified diet of two types of food; maize and one other. It also assumes a daily diet of roughly 2,000 kilocalories. It starts with a single serving of maize and assumes the remainder of the calories comes from the other source of food. Total and proportional protein, based on the serving size, is then calculated. The proportional protein levels can then be calculated and compared to the CBHC isotope levels. The process is then repeated for each of the other foods.

Figure 7.1 and Table 7.2 depicts the results of the models. Because the high calorie to protein ratio of acorn, the maize + acorn diet includes the lowest amount of maize and the least amount of total food (by weight) while in the isotopic range (5-7 servings of maize). In these scenarios, maize would account for 17-30% of total calories. Wild rice is the next, lowest with 10-13 servings which accounts for 43-56% of the caloric intake. Goosefoot has a lower ratio of calories to protein, and fewer calories per serving. Thus, it takes a minimum of 15 servings of maize to make up at least 41% of the protein. The result is maize accounts for 65-77% of the caloric intake. If pike/walleye are used as a proxy for fish, then both fish and deer have similar results. A total of 18-20 servings of maize daily would account for a δ^{13}C value range between -13.7 to -11.7‰. In these scenarios, maize would account for 77-86% of caloric intake.

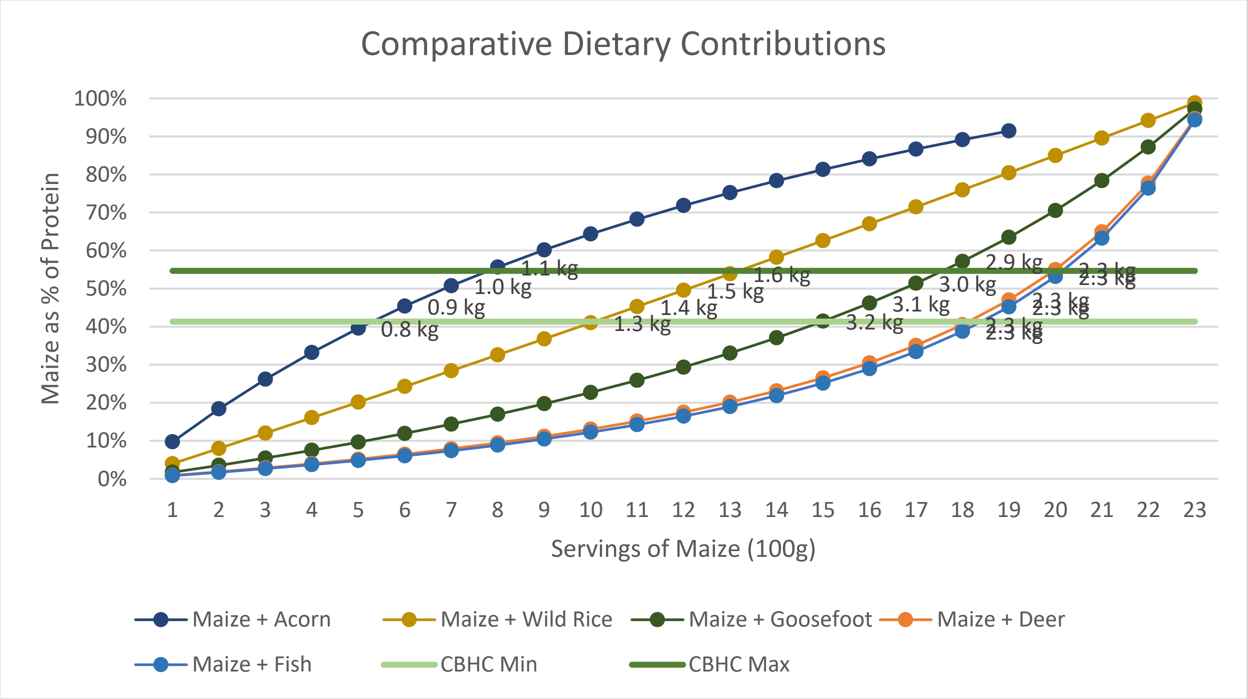


Figure 7.1: Comparisons of Modeled Dietary Contributions – x-axis displays number of servings of maize – labels indicate total weight of food consumed daily.

Table 7.2: Servings of maize and maize as % of total calories that match canine isotopes

Maize + Acorn		**Maize + Wild Rice**		**Maize + Deer**		**Maize + Fish**		**Maize + Goosefoot**	
Servings	**% kcal**	**Servings**	**% kcal**	**Servings**	**% kcal**	**Servings**	**% kcal**	**Servings**	**% kcal**
4	17%	10	45%	18	77%	18	72%	15	65%
5	22%	11	47%	19	82%	19	82%	16	69%
6	26%	12	52%	20	86%	20	86%	17	73%
7	30%	13	56%						

While none of the models above are sufficiently nuanced to represent the diet eaten by the residents of the Koshkonong Locality definitively, nor do they account for the ways in which food was cooked, they do provide some bounds for the importance of maize. The diet of only acorn and maize sets the minimum. This diet would lead maize to account for 20% of the calories in the diet. At the other end of the spectrum, with a diet of solely maize and venison, maize would account for as much as 86% of the caloric intake. Since we know that the diet included maize, multiple cultigens, nuts, and sources of meat we can assume that the importance of maize was between these two extremes. With the ubiquity of faunal remains, and the low density of acorn (except in a few outlier features) it is unlikely that the real importance of maize is anywhere near the minimum. Furthermore, most contexts contain an array of cultigens, nuts, or other non-faunal remains, which suggests that the high levels are also unlikely.

Conservatively, the model suggests that maize accounted for 45-75% of the caloric intake; a substantial investment in maize agriculture. This interpretation is supported by more diversified models (Figure 7.2, Table 7.3). For example, if we modify the maize and wild rice diet (probably the second most important food plant in the locality) and add just half a serving (50g) of the other foods, the minimum maize level accounts for 49% of the kilocalories. In this model, the levels of venison, fish, goosefoot, and acorn are held steady at 50 grams. The amount of maize is adjusted so that it accounts for 41% of the protein (minimum at CBHC), and the amount of wild rice is adjusted to maintain a 2,000-kcal diet.

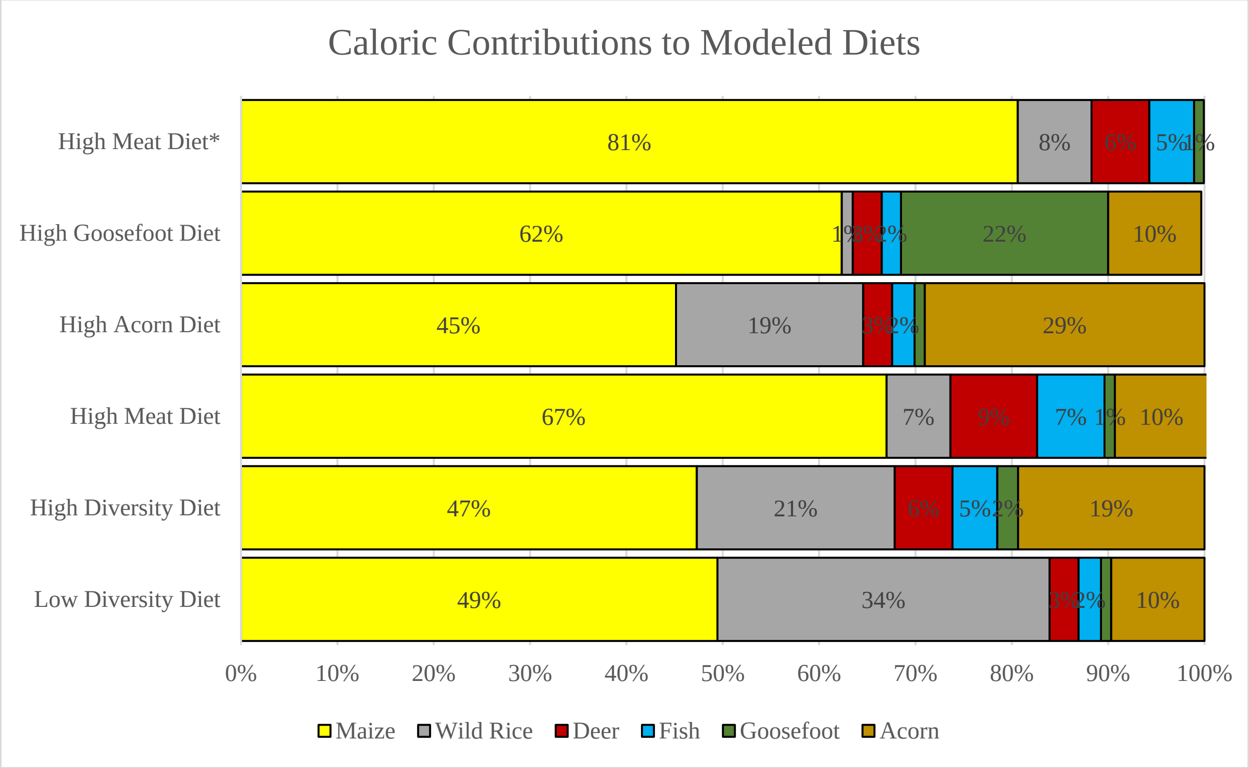


*Figure 7.2: Percent of total calories by taxon in modeled diets. *indicates maize accounts for 55% of protein, all others maize accounts for 41% of protein*

Table 7.3: Data from Figure 7.2 depicting the total calorie and protein contributions of each food source in the model. Each serving is 100 grams. The columns labeled P is protein (g).

		Maize		**Wild Rice**		**Deer**		**Fish**		**Goosefoot**		**Acorn**	
		kcal	P	kcal	P	kcal	P	kcal	P	kcal	P	kcal	P
Amount per serving		86	3.27	357	14.73	120	22.96	93	19.14	43	4.2	387	6.15
low diversity diet	servings	11.5		1.9		0.5		0.5		0.5		0.5	
	value	989	37.61	689.5	28.45	60	11.48	46.5	9.57	21.5	2.10	193.5	3.08
	% diet	49%	41%	34%	31%	3%	12%	2%	10%	1%	2%	10%	3%
high diversity diet	servings	11		1.2		1		1		1		1	
	value	946	35.97	411	16.96	120	22.96	93	19.14	43	4.20	387	6.15
	% diet	47%	34%	21%	16%	6%	22%	5%	18%	2%	4%	19%	6%
high meat diet	servings	15.5		0.4		1.5		1.5		0.5		0.5	
	value	1333	50.69	132.5	5.47	180	34.44	139.5	28.71	21.5	2.10	193.5	3.08
	% diet	67%	41%	7%	4%	9%	28%	7%	23%	1%	2%	10%	3%
high acorn diet	servings	10.5		1.1		0.5		0.5		0.5		1.5	
	value	903	34.34	388.5	16.03	60	11.48	46.5	9.57	21.5	2.10	580.5	9.23
	% diet	45%	41%	19%	19%	3%	14%	2%	12%	1%	3%	29%	11%
high goosefoot diet	servings	14.5		0.1		0.5		0.05		10		0.5	
	value	1247	57.42	23	15.18	60	11.48	46.5	9.57	430	42.00	193.5	3.08
	% diet	62%	41%	1%	14%	3%	14%	2%	12%	22%	37%	10%	3%
high meat (maize 55% protein)	servings	18.75		0.4		1		1		0.5		0	
	value	1612.5	61.31	153.0	6.31	120.0	22.96	93.0	19.14	21.5	2.10	0.0	0.00
	% diet	81%	55%	8%	6%	6%	21%	5%	17%	1%	2%	0%	0%

The model was adjusted to examine several different scenarios, including increasing the amount of all other food types, increasing just meat, and increasing just acorns. The model with the lowest caloric reliance of maize was the increased acorn model. The model that showed the greatest caloric reliance on maize was the high meat diet. In this scenario, maize accounted for 67% of the calories. The high meat model was adjusted to estimate the highest possible caloric reliance on maize at the 55% of protein level (max of CBHC isotopes). In order maintain some wild rice in the diet and not go over the 2,000-kcal limit, acorn was eliminated and meat was reduced to one serving each (deer and fish). For this scenario, maize accounted for 81% of the diet’s calories.

The composition of the diet undoubtedly varied among individuals based on age, gender, status, kin-group, and membership in other social organizations. Also, the dietary compositions would have varied throughout the year. Regardless, in the two dog samples maize accounted for 41-55% of the overall protein. So, if we estimate the caloric contribution of maize using the high acorn and the high meat diets, then 45-75% is a good approximation (Table 8.3). Bringing this back to the question at hand, ‘to what degree did the Koshkonong residents rely on agriculture?’ even a diet with the low-end estimate would be reliant primarily on agriculture (65% calories from agriculture in the high-acorn model and 75-93% in the high meat models).

Summary: The agricultural output of the Koshkonong Locality was a significant component of the diet and shaped the physical landscape around the sites. Maize alone accounted for one to two-thirds of the protein, and likely half to three-quarters of the calories. When squash, beans, and the various cultigens are included, it is likely that the bulk of the Koshkonong diet was derived from cultivated plants. This in turn would have major impact on the scheduling of labor, and potentially gender roles/hierarchies and other intragroup dynamics (Hart 2001; Hollinger and Benn 1995).

1.3 Did the residents of CBHC and KCV rely on the same foods?

The residents of CBHC and KCV largely relied on the same plant taxa. Maize, wild rice, and acorn are the three most dense and ubiquitous plants at both sites. However, there are some minor differences. Most lie in plants of minor importance, with Chenopodium being the one major exception. While present at KCV, Chenopodium does not appear to be nearly as important as at CBHC. There are minor differences in the proportions of nut genera used. There are other minor differences in which fruits or other seeds were used; however, the samples from these taxa are so small then either a) differences can be attributed to sample size; b) if they are real, it is likely related to what foods were immediately available around the sites rather than systematic attempts to exploit different resources (CBHC has a more diverse assemblage and is in a more diverse environment); or c) these refer to plants that accounted for a minor portion of the diet. While the assemblages might not be the same, the differences do not seem to add up to a *reliance* on different plants.

There may be a difference in the degree to which individual plants were relied upon. KCV has significantly denser concentrations of maize kernels by count. By weight, the difference is near significance. Alone, the count may only indicate that the KCV sample is more fragmented (as also suggested by the wood charcoal data). However, with the near significance of the maize weight, it is possible to claim that there was modestly more maize that was burned and preserved at KCV relative to CBHC. However, without isotopic data from both sites to confirm this, it is difficult to evaluate. Reliance on any given plant also likely varied on an individual basis. The 95% confidence interval of the $\delta^{13}C$ from the CBHC dogs indicated a relatively wide range of variation should be expected within the population.

1.4 Did the residents of CBHC and KCV use the same environmental zones?

The residents of both sites had access to the same environmental zones (Edwards 2010), but in different proportions. Given the importance of agricultural crops and wild rice at both sites, the residents would have spent a great deal of time in similar environmental settings. However, evidence suggests that there was some difference. The greater diversity of plants at CBHC and increased environmental diversity (Edwards 2010) around the site suggests that the residents used resources that were immediately available to them. Greater environmental variation would have allowed a wider range of plant resources at CBHC, and we see a wider array of plants its assemblage. The differences are not large enough or clear enough to determine which habitats were used to differently. However, if the practice is to exploit whatever resources were available in the immediate vicinity of the site, it appears that the residents were following the same general food procurement strategies and the different results are from differences in site setting.

1.5 What do the species utilized tell us about the seasonal scheduling and labor organization?

All subsistence systems require the investment of time, energy, and organization of human beings to be successful. It is through this understanding that it is possible to connect the material of the archaeological record to past systems of labor investment and social organization (P. Fowler 1983; Hastorf 1993). Because we know that agricultural crops were fundamental components of the diet, we can infer that the needs and the labor requirements to ensure successful harvests were likely a major consideration when deciding how to schedule tasks and organize labor parties. To better estimate the timing of labor requirements, a firm understanding of the nature and type of agricultural system is required.

Agricultural Labors and Timing: Gallagher and Arzigian (1994) argue that the labor investments (or agricultural inputs in their phrasing) can be broken down into seven pieces: construction of agricultural technology (e.g., digging sticks), field clearance, field construction, cultivation, soil improvement, harvest, storage. The nature of the work and the labor requirements would depend heavily on the type of field system used. Referring to prehistoric British agricultural practices, P. Fowler (1983:107) defined an agricultural system as delineated areas used regularly in a patterned way. Individual farmed plots were then referred to as fields. If we use this as a working definition, the term agricultural system will refer to all fields within the

Koshkonong area and the ways in which the land there was regularly modified and used. Historically, Native American agricultural systems were typically described as using corn hills placed in and around villages, typically no more than a few miles distant (see Gallagher 1992; Sasso 2003b for a summary). A second type of raised field has been reported in archaeological contexts, particularly in Wisconsin and Michigan. The raised garden bed, or ridged field, as they are also known, have been thoroughly described (e.g., Gallagher 1992; Gallagher and Sasso 1987; Sasso 2003a, Sasso 2003b, Peske 1966). It is unclear which type or types of agricultural fields were used in the Koshkonong Locality

Raised fields: There are several agricultural sites reported within the Koshkonong Locality (Table 7.4). Most are corn hills thought to be associated with the historic Ho Chunk village at Crab Apple Point. Two are raised garden beds, and are of unknown association. They are often thought to be associated with the Oneota occupation of the region, though there is little data that can be used to address the issue. Both raised beds and corn hills may have been used in the Koshkonong Locality. It is possible that each of the villages had a series of raised garden beds; however, this may not have been necessary given the higher proportions of good-rated arable land and higher elevations near KCV and CBHC. Therefore, we must look to other, less direct indicators to infer the field types used at study sites.

Table 7.4: Agricultural sites in Koshkonong Locality

Site Name	**Site Number**	**Site Type**	**Association**	**Reference**
Crab Apple Point	47JE0093	Corn Hills	Historic Ho-Chunk	Stout and Skavlem (1908)
Bingham Corn Hills	47JE1158	Corn Hills	Historic Ho-Chunk	Stout and Skavlem (1908)
Saunders Corn Hills	47DA1201	Corn Hills	Historic Ho-Chunk	Stout and Skavlem (1908)
Messemer Garden Beds	47JE0092	Raised Beds	Unknown	Brown (1909) Stout and Skavlem (1908)
Loge Bay Cornfields	47JE0087	Raised Beds	Unknown	Stout and Skavlem (1908)

Tilling Technology: Oneota agriculture is often associated with scapula-hoe technology, particularly those made of bison scapulae (Gibbon 1972a; Michalik 1982; Overstreet 1981, 1997; Peske 1966; Sasso 2014; Tiffany 1979). Peske (1966) goes as far as to argue that the furrows between garden beds at the Eulrich site near Lake Winnebago was made with a scapula. He is not the only person to associate hoes with raised garden bed agriculture. Jeske (1989) contrasted Oneota (Fisher and Huber) with Langford sites in northern Illinois. He notes that Oneota sites were generally found in lower elevations, where adjacent arable land would be wetter, and where hoe technology would be most useful. Notably, hoes were common on Oneota sites. In contrast, Langford sites, are found in upland settings, with drier soils, and are associated with digging sticks instead of hoes.

Excavations at CBCH and KCV have not recovered a single artifact identifiable as a shell, stone or scapula hoe. Instead, numerous digging sticks have been recovered from both sites, made from antler and bison horn (Edwards 2016). Jeske (1989) associated the digging stick technology with corn hills. Given KCV and CBHC are in an analogous upland setting, and have digging sticks, the fields immediately near the sites likely included corn hills rather than garden beds. While the residents of the Koshkonong Locality may have constructed garden beds, an upland agriculture using corn hills seems to be the most likely field type in the immediate vicinity of the study sites.

Field Clearance: Ethnographic accounts provide the best means of approximating the agricultural labor investments. For example, the accounts of *Maxi'diwiac* (Buffalo Bird Woman), a Hidatsa woman, provide some of the most detailed descriptions Native American agricultural practices (Wilson 1917). For the Hidatsa, the process began with burning the area. *Maxi'diwiac* says it helped to make soils easy to till. Burning also offered many other benefits; namely, increasing the nutrient content (Fritz 2000; Gallagher and Arzigian 1994; Wagner 2003). Burning was widely practiced in the ethnohistoric record, sometimes in a large radius around an entire village. It has been argued that this practice goes back as far as the Archaic, as it can also help to manage plant communities and consequently animal populations (Wagner 2003).

Despite a lack of direct evidence, we can safely infer that burning took place in the Koshkonong Locality. Dorney and Dorney (1989) argue that the presence of oak savannas like those reported in the Koshkonong Locality by the General Land Office surveyors (Brink 1835; Miller 1833), are a result of regular burning by Native American populations (see also, Bowles et al. 2003, Gleason 1913; McLain and Elzinga 1994). This alone suggests that burning on a large scale was practiced, though it is not clear how far back in time the practice would have extended far into the past, likely to 5,000 BP (Griffin 1994; Nuzzo 1994). The fact that the Koshkonong groups were practicing agriculture would necessitate managing the forests so that they could plant their gardens. Without iron axes, fire would be the only efficient way to do this. This would have also created a more attractive habitat for deer. Finally, without any evidence that arable land around the Koshkonong villages was not modified into raised garden beds (Edwards 2010), fallowing and burning would be an ideal means of replenishing the soils' nutrients (Fritz 2000; Gallagher and Arzigian 1994).

Field Construction, Cultivation, and Maintenance: Once fields were cleared, either corn hills or garden beds would need to be constructed. Among the Hidatsa, the initial construction was separate from sowing, but in subsequent years hill maintenance occurred concurrently with sowing or weeding (Wilson 1917). While *Maxi'diwiac* and others of her generation used iron hoes, her grandmother built corn hills with a digging stick. *Maxi'diwiac* said that this was the traditional practice. While we cannot claim that these accounts are a direct analogy, given the similarity in technology and the available arable land near the sties, the general patterns are likely similar to those practiced by the Koshkonong residents. This may be particularly true for corn hills, as Gallagher (1992) argues that their construction and use was quite consistent throughout much of the eastern United States.

Ethnographic evidence indicates that planting occurred between April and June in northern latitudes (e.g., Doolittle 2002; Wilson 1917). *Maxi'diwiac* accounts suggest that a single field could take roughly 250-350 person-hours to plant the maize. Other crops would likely take less, as they were not planted in the same abundance. The number and size of fields varied among families. For Oneota groups without lack of iron implements for earth breaking, the process would be slower than reported. This number may be further underestimated if the Koshkonong groups attempted to grow larger surpluses. While the Hidatsa grew maize sufficient to feed the population for one year, and to seed for two (Wilson 1917), the other historic groups, such as the Huron, grew enough food for two-to-four years (Hurt 1987:34). Larger surpluses would necessitate larger fields and more labor. Without a combination of population estimates, estimates of total area cultivated at a time, and experimental data concerning the efficiency of digging sticks, it is not prudent to estimate precisely the amount of time spent planting. However, we can infer that women likely spent the bulk of their day time, from April through June, planting the various crops. Men may have helped to clear the fields in March or April, though they had likely turned their attentions to non-agricultural pursuits during cultivation (Doolittle 2002; Hurt 1987; Wilson 1917).

Garden Maintenance: Once planting was done, maintenance of the fields would be necessary. In their description of input number 5: Soil Improvement, Gallagher and Arzigian (1994:178) argue that additional steps to improve the fertility of the soil were often taken. They cite the addition of charcoal and other cultural material (presumably some of which was nutrient rich) to the soils to increase fertility at Sand Lake. Peske (1966) notes a similar pattern in raised ridges near Lake Winnebago. At what point in the year this material would be added is unclear, but adding the nutrients to the soils could help to decrease the frequency of field rotation.

Gallagher and Arzigian (1994) also cite the need to protect crops form competition and predators. Ethnographically and ethnohistorically, protection from competing weeds was largely accomplished by weeding with hoes or digging sticks. Often, this resulted in the mounding of dirt around the plants – so even if corn hills were not constructed prior to planting, they would exist by the end of the growing season. Mounding also helped to support the weight of the growing maize, which had short roots and could easily be blown or knocked over (Doolittle 2000; Hurt 1987; Wilson 1917). Birds were apparently one of the most significant animal threats. To protect the crops from animals, groups across the Eastern Woodlands and into the Plains built platforms where women and girls would sit and look after the fields (Doolittle 2000).

Harvesting and Processing: For the Hidatsa, in early August, preparation for harvest would need to begin. By the mid-month, squash would start to ripen, and continue ripening for some time. Shortly thereafter, an early harvest of green corn could commence. Later in the autumn, ripe corn would be harvested. Beans ripened shortly after, and finally sunflowers would be harvested (Wilson 1917). The exact techniques used to dry, thresh, and winnow the crops varied among groups but these processes were invariably labor intensive (Wilson 1917). An important benefit of tropical domesticates (e.g., maize or beans), they were more easily harvested than EAC plants (Smith and Cowan 2003). By emphasizing domesticates, a significant amount of time is freed for other activities, such as foraging berries, nuts, or harvesting wild rice. However, little is known about the means of growing most EAC cultigens (Mueller et al. 2017).

Storage: The amount of food surplus varied, both by group and circumstance but ethnographic and ethnohistoric accounts place it between one and four years of surplus (Hurt

1978:34; Wilson 1917). The process of filling the pits would not have been particularly time consuming, though the process of digging the pits would have been labor intensive. At KCV, roughly one-third of pits are regularly more than a meter deep and a meter, or more, wide (Edwards 2014a; Edwards and Spott 2012). Pits at CBHC are often of equal diameter, and many extend to similar depths particularly when erosional patterns and modern agricultural practices are taken into consideration (Moss 2010). Houses at both sites are surrounded by pit features, in some cases they appear to be within structures, in other cases just outside. A palimpsest effect complicates the identification of relationships between pits and houses. The sites were occupied for four centuries, so pits and houses were often built and rebuilt in the same area, and even overlap. In some cases, features (e.g., KCV F12-01 and 12-06) that are physically within a few meters of one another are on the opposite end of the occupation span. Regardless, the number and size of features makes it clear that there was a considerable amount of food stored.

Summary: Given the importance of agricultural resources, agricultural work would have accounted for a large amount of labor. Based on ethnographic and ethnohistoric accounts, this labor would have been largely conducted by women of the Koshkonong Locality and would have consumed much of their time from spring into the autumn. Particularly during planting and harvest, this would have left little time to do other activities, though it was hardly the only responsibility held by the women of the village.

Winter/Early Spring: Indicators of cold season occupation are few, but are present at both KCV and CBHC. The presence of buds indicates that firewood was gathered and burned during the late winter or the early spring. While lumber may have been stockpiled in the warmer months, at least some wood was collected year around. Firewood collection was the most labor intensive cold season activity indicated by the paleoethnobotanical assemblages. The gathering of firewood, from an unknown distance, across what was likely a snow covered would have required greater time and energy expenditures than in warmer months. Archaeologically, it is impossible to determine who would have been responsible for gathering the firewood, but at least some ethnographic accounts describe the task falling to women, sometimes with the help of dogs (Morey 2010:92; Schwartz 1997:51).

Until spring, there would be few-to-no wild plants available for harvest, and most fallen berries or nuts that may have been missed by wild life would have been covered by snow (Arzigian 1993; Jochim 1976; Keene 1981). Therefore, during the winter months, any plants consumed would have been stored foods. Therefore, most labor requirements during the winter would be related to meal preparation. During this time, it is possible that some of the agricultural implements were constructed or repaired. Because stored food would likely compose much of the diet, time that would otherwise be spent procuring the foods could be spent on other activities (Jochim 1983; Keene 1981). If so, ensuring that equipment needed in the spring would appear to be an efficient use of time. Given that deer antlers are at their largest between autumn and late winter, and deer are some of the few available large fauna in the winter, fall and winter-hunted deer would produce antlers for use as digging sticks (Indiana Department of Natural Resources 2017). Deer and elk also shed their antlers naturally in late winter and these can be found on the ground in February and March. Antler tools have been found in abundance at KCV and CBHC (Edwards 2014a; Edwards and Spott 2012; Van de Pas et al. 2015). However, it is not possible to determine when such maintenance occurred with the available archaeological data (Figure 7.3).

As the snow and ice melted, and spring began, most wild plant foods would still be unavailable. Some of the few edible, and archaeologically visible, plants available would include aquatic tubers. Whether these would have been collected to replenish diminishing food stocks, to provide variety to the meal, or some combination thereof, both KCV and CBHC assemblages have several features with these plants. Foraging parties would have been organized from these villages, to search for, at least in part, these early spring foods.

Figure 7.3: Antler (top) and Horn (bottom) worked into digging sticks

Late Spring/ Summer: While some plants do bear fruits in the spring, most of the plants identified in the assemblages are not available until the late summer or autumn. However, chenopodium and purslane produce copious edible leaves, and aquatic tubers are available as soon as ice leaves water. Though in less quantities than winter, firewood would have undoubtedly been needed. Even if it was not necessary for warmth, firewood would have been required for cooking.

The late summer is a time when many different plants would start to ripen. This includes many tree and bush based berries, including raspberries, cherries, hawthorn fall, and strawberries late spring through fall. The assemblage from both sites shows that these plants were consumed with some regularity (5-35% ubiquity per taxa but 40-60% ubiquity overall) but in relatively small quantities (<1 fruit seed per 10 liters of soil). The regularity of the seeds suggests that they may have been systematically harvested. If so, then the most logical time to do so would be late summer, between the green corn harvest and the primary harvest of the other crops. The low densities are likely due to the mode of consumption and preparation. Wild fruits and berries can be eaten raw, which would limit the number entering the archaeological record. By harvesting the berries early, not only is labor conflict reduced, but it also limits the time for birds or other competitors to raid the patches. It is not possible to precisely determine the time of harvest; however, not only is this a logical explanation, it better fits the archeological data. If the fruits and berries were only harvested opportunistically, the ubiquities would likely be much lower. That is not to say that additional berries were not opportunistically harvested while collecting firewood or other resources throughout the time they were available. In fact, the wide availability of the fruits in the disturbed areas around the settlements would have made them ideal snacks while coming or going from the villages.

Late Summer/Autumn: Harvesting and processing the crops would have consumed a significant amount of time during the autumn; however, we can see in the paleoethnobotanical assemblages that other activities occurred as well. Wild rice was collected in mass quantities and would have needed significant amounts of labor to process for use and storage, including parching, threshing, and winnowing (Jenks 1901; Vennum Jr 1988).

Numerous wild plants that ripen in the autumn have also been identified. Like fruits and berries, nuts begin to ripen towards the end of summer and well into fall. Of the four genera in the assemblage, hazelnut ripens first in August and goes into September. Acorn is the next most available in September to October. Hickory and Walnuts are the latest in October. The high ubiquity of nuts (100% at CBHC and 84% at KCV) indicates that nuts were an important resource; however, their importance varied by genera and site. At CBHC, density and ubiquity indicate acorn and hickory were the most important resource. At KCV walnut and acorn were important, whereas hickory and hazelnut were quite unimportant.

While most of the contexts had at least some nuts, the distribution is decidedly clustered in a few contexts. The mean density of nuts was greater than 30 fragments per 10 liters, the median density is roughly one-fifth. Interpreting these dense concentrations as processing or fuel burning are simple interpretations. However, nutmeats are rare. If the nuts were collected for use as fuel, then the nutmeats should have been burned with the shells. The lack of nutmeats indicates that the nuts were processed and the edible portions removed prior to burning. The contexts do not appear to be processing deposits. The densest contexts (KCV F12-26, CBHC F06-63B) do not look particularly different, in profile (morphology, soil color, texture, etc.) or otherwise, from similar contexts. During excavation, F12-26 did not stand out from other features and there is no indication that the materials within are from a primary context. Both F12-26 and F06-63B look to be tertiary contexts like most of the others. The florae within then should be an aggregation of the waste from all the activities near the features, and should reflect numerous activities. The high density of nutshell in these contexts may be the result of processing, but should be mixed in with the general food waste from that time. However, these contexts have low densities of most other florae. These contexts have among the lowest densities of maize, cultigens, and fruits. Essentially, the only flora of significance in these contexts is acorn. So, if these contexts do not represent the use of nuts solely as fuel, and they do not represent simply processing contexts, then what do they represent? I suggest that these contexts are the result of acorns as a buffer or starvation resource. In contexts when where other resources are scarce, nut use rises. The PCA highlights this, the first principle component shows that nutshell is negatively correlated with all other values. When other food resources are scarce, the use of nutshell increases. This pattern is particularly strong in the early contexts where nutshell use is most dense.

Potential Implications to Future Research: A better understanding of the timing and distribution of labor resources and the importance of the fruits of such labors represents an early first step. These data can provide the ground work when trying to understand the gendered social dynamics both within and among Oneota societies and non-Oneota societies. Benn (1995:115) argues that "women almost certainly dominated the horticultural production process with their labor and knowledge, we need to know about the relative importance of the total contribution by women to the subsistence base to develop assumptions about their social influence." Perhaps when connected with an updated analysis of households (e.g., Hollinger 1995) and households (e.g., O'Gorman 2010), and sufficiently robust mortuary data this line of inquiry may bear fruit. Gibbon (1995:188, 189) rightly suggests that we still have little understanding of the basic social dynamics within any given Oneota group. He also suggests that "there may be gender-related symbolic and ritual aspects…" to systems of exchange because a) ethnohistoric accounts suggest that different types of items were exchanged by the different genders; b) exchange often worked through affinal or fictive kin networks; c) the goods exchanged were the result of someone's labor, often women. While it is beyond the scope of this dissertation to follow out these issues, the data presented above can mark a preliminary step toward some of these issues, if incorporated with many other lines of evidence.

Question 2: How does the Koshkonong Oneota subsistence system compare to other Oneota localities, and does it fit the expectations of the Oneota diet?

In short, the answer is that Koshkonong assemblage fits general regional trends while maintaining a distinct local character. All Oneota localities show a significant reliance on agricultural outputs, particularly maize. Most show some reliance on cultivars. However, the degree to which maize was relied upon varied, the important cultivars were different among localities, as were the local resources.

What is expected? There is a continuum of ideas concerning the nature of Oneota subsistence, with two extremes. The first, maize was a minor resource and composed a small component of a diverse diet (e.g., Michalik 1982; Overstreet 1976, 1981). This idea was perhaps expressed most clearly by Overstreet (1981).

> I submit that the adaptive pattern is one of intensive exploitation of the diverse resources found throughout the Eastern Ridges and Lowlands of Wisconsin. A heterogeneity of habitat occurs from site to site which in turn reflects a general pattern of adaptation. Based on the faunal and floral materials analyzed for Oneota sites, one can reconstruct a wide variety of resource zones which were utilized to varying degrees … Oneota adaptation is characterized by a highly diffuse economy. The emergence of Oneota culture is directly linked to the elaboration and intensification of resources in zone 6, the horticultural zone. Through time, horticulture apparently becomes more and more intensive. However, focalization, in terms of Cleland's (1966) economic definition, never takes place. Thus, the model of adaptation for Eastern Wisconsin Oneota populations is unique in the sense that aside from horticulture, which does intensify during later stages of development, a very broad range of wild flora and fauna continue as part of the exploitative pattern through the terminal stages of the Lake Winnebago Phase, which I would date to circa AD 1500 or later. The model employed here indicates that specificity of procurement such as that manifest in Middle Mississippian cultures or the Classic Plains Oneota cultures with a corn-bison tandem does not develop. The pattern is one of diverse resource utilization throughout the Oneota continuum in Eastern Wisconsin *with the general intensification of corn horticulture added to a mosaic or diffuse economic pattern*. – Overstreet 1981: 494 [italics added]

Overstreet later argued for a middle position, where maize was an economic cornerstone (1997:290) that acted as a stabilizing force of an overall mixed horticultural, hunting, foraging economy (1997:251). Some have wondered (e.g., Michalik 1982), suggested or argued that the productivity of maize in the northern climate of Wisconsin, Minnesota, and northern Illinois may have been too marginal for staple level crops to have been grown (see Brown 1982; Hart 1990 for discussion of various models). Brown (1982:111-112), accounting for the concerns of population density and maize productivity, argued "this economy owed as much to native food resources as it did corn agriculture." At the other extreme, authors like Gibbon (1986:332) argued "that corn dominated their diet and that the requirements of planting and growing corn were important factors in determining where they built their villages, [though] it is difficult to prove that this was so." Many other authors lie between the continuum between agriculture and horticulturally supplemented foraging.

One thing most authors seem to agree upon is that the economies are locally adapted. Both Overstreet (1981, 1997) and Gibbon (1972a; 1986) argue that the economies in each locality are dependent on an adaptation to localized resources. Hart (1990:575), using a micro-economic approach, argues that the general subsistence strategy, and particularly the agricultural system, should vary among and within regions. So, the questions are: is Oneota diet diverse or focused, and is it locally adapted?

2.1 Is the Koshkonong diet diversified?

This question is deceivingly complicated, and the answer depends on what part of the diet is examined, and where does one delineate diverse from focused. Dealing with these issues in reverse order, a diverse diet, to some is one that includes many different foods. The more taxa, the more diverse the diet is. However, as Lyman (2008) points out, the total number of taxa (NTAXA) can be misleading. A diet may be dominated by a single source of food, which accounts for much of calories, while still including many different taxa with minuscule dietary contributions. Is such a diet diverse, no. What if you have 10 taxa that are evenly represented, or 20?

Diversity indices can help determine, in a relative sense, how diverse a diet is. They have long been used in both zooarchaeological (Lyman 2008) and paleoethnobotanical studies (Popper 1988). Sadly, the data are rarely available in a sufficiently comparable manner to include both datasets, which in turn, leads to the other issue. What part of the diet is being examined – flora, fauna, or both. Past zooarchaeological analyses from Koshkonong relied on class level data and NISP values so they are not particularly helpful for this scale of analysis (e.g., Hunter 2002). More detailed analyses are currently underway on the Koshkonong samples. Preliminary results indicate that faunal NTAXA is large, and the assemblage is relatively heterogeneous, though diversity indices have not been calculated to date (R. McTavish, personal communication). Therefore, this discussion must focus on the floral portion of the diet. However, the nitrogen isotopes can allow some additional inferences.

The NTAXA suggests that the diet at the sites is relatively diverse (CBHC =36; KCV =33). However, many of the taxa are represented by a single specimen, or very few. Also, the isotopes suggest that maize, a single taxon, constituted over half of the diet. So, the question becomes, relatively how diverse is the Koshkonong diet? Relative to KCV, CBHC is more diverse on most every metric. The Shannon Index (Table 7.5) measures both how rich (NTAXA) the assemblage is, and how evenly distributed the taxa are. However, diversity can be a result of many taxa, or a very even distribution of several taxa both would indicate that no one taxa dominates the assemblage. CBHC is 1.89 compared to 1.42 for KCV. CBHC shows greater diversity, though the difference does not appear to be large. However, both are towards the low end of the possible spectrum. In the case of these assemblages, the maximum values were 4.28 and 4.19

respectively, or roughly one-third as diverse as possible. The low diversity is likely caused by the heavy presence of maize, which dominates the assemblage. Their evenness scores are 0.53 and 0.41 respectively; this supports the maize effect, as CBHC is proportionally less dominated by maize and is also more even. The importance of goosefoot at CBHC explains much of this shift. At KCV three plants (maize, acorn, and wild rice) dominate the assemblage. By adding a fourth important plant into the mix, the evenness is increased thereby reducing the level of focus in the diet. Overall, the Shannon Index suggests that the Koshkonong floral assemblage is relatively focused.

Table 7.5: Koshkonong Locality diversity scores

Site	NTAXA	H	E	Simpson’s D	1/D
CBHC	36	1.89	0.53	0.22	3.01
KCV	33	1.42	0.41	0.33	4.47
KCV (excluding F12-26)	31	1.20	0.34	0.40	2.53
Hypothetical focused	2	0.66	0.95	0.53	1.88
Hypothetical diverse	36	0.08	0.02	0.01	71.00

The Simpson’s Index supports this assertion. CBHC has an index of 0.22 with an evenness of 4.47. KCV has an index of 0.33 and an evenness of 3.01. These values become magnified if F12-26 (the acorn outlier) is removed (D=0.39, 1/D=2.52) from the KCV sample. The diversity index indicates that KCV is less diverse and more dominated by maize and acorn. Simpson’s index is not necessarily linear, so the fact that the values are closer to 0 (the most diverse possible value) does not necessarily indicate that the diets are not focused. For reference, two hypothetical assemblages were created, based on the CBHC assemblage. A hypothetical focused assemblage is the CBHC with all but the two most abundant taxa at CBHC (acorn and maize) removed. This barely raises the Simpson’s index to 0.5. A hypothetical diverse sample, with the same NTAXA as CBHC, but evenly distributed (equal to the value of maize) would have a Simpson’s Index score <0.03. The values from both sites more closely match the focused example. Because it is not possible to statistically compare the values, all that can be said is that the Koshkonong diet appears to be relatively focused, but includes several minor resources.

Unfortunately, these indices only include the floral portion of the subsistence assemblages. However, both the $\delta^{13}C$ and $\delta^{15}N$ can be used to make inferences about the whole diet. The $\delta^{15}N$ values indicate that meat did not provide a large portion of the diet's protein. The $\delta^{13}C$ values indicate that the bulk of the protein came from maize. While the faunal assemblage includes many species, the total contribution was likely less calorically important, than maize.

2.1a, b: Is the Koshkonong diet diverse relative to other Oneota localities, to other cultures:

Oneota Comparison: Using the same strategy as above, we can contextualize the Koshkonong sites diversities with the sites from other localities, and non-Oneota sites (Table 7.6). Among Oneota sites, diversity indices have a moderate range (H= 0.43, D=0.86 to H=2.10, D=0.15). Differences in seasonality, sampling, and other issues likely affect these values. Seasonal differences do not have a consistent effect, nor is that expected. One would expect that the sites occupied for the longest duration would have the highest diversity and those occupied for the shortest amount of time would have the least. One would also expect that sites occupied in warm seasons, when the widest array of plants is available, would be more diverse than those occupied in the winter when only stored plants were available.

The La Crosse Tremaine Complex sites are all thought to be warm season villages. OT and Filler faunal assemblages fit well with the pattern established by Pammel Creek as a warm season (early-spring through autumn) (O'Gorman 1995:198). Tremaine lacks definitive seasonal indicators but is generally consistent with the Pammel Creek Pattern (O'Gorman 1995:222). However, the diversity indices are more variable than the year-around Koshkonong villages. Other than Tremaine, most of the warm weather sites tend toward the high-diversity end of the

Oneota spectrum. Cold season sites, such as Citgo (and potentially Pamperin Park), surprisingly also have a relatively high degree of variation.

However, simply looking at the scores can be deceiving. While the heterogeneity and evenness scores make the opposite-season sites look similar, the NTAXA does not. As one would expect, the warm season sites have far more taxa in their assemblages. Cold season sites have fewer than a dozen species and warm season sites have roughly twice the taxa. The level of heterogeneity (Shannon's Index) of the sites range from 1.23-2.09. These relatively high values are likely caused from different sources. The values of the warm season sites are raised due to

Table 7.6: Regional Diversity Indices – ordered by Simpson's Index (largest to smallest) – color coded by archaeological culture (Late Woodland: red; Oneota: blue; Middle Mississippian: orange) and seasonality (Winter/Cold Season: light blue; Summer/Warm season: yellow; Autumn: brown; Year around: green)

Site Name	**Region**	**Site Type**	**NTAXA**	**Shannon**		**Simpson**	
				H	**e**	**D**	**1/D**
Centra 53/54	Late Woodland	Warm Season Camp	10	2.01	0.87	0.14	7.31
Burley Brew	Waupaca	Village	18	2.09	0.72	0.15	6.46
Filler	La Crosse	Warm Season Village	21	2.09	0.69	0.17	5.84
Washington Irving	Langford	Village	24	1.96	0.61	0.20	5.09
CBHC	Koshkonong	Village	36	1.89	0.53	0.22	4.47
Citgo	Door	Cold Season Camp	9	1.60	0.72	0.24	4.15
Schrage	Middle Fox	Village	17	1.82	0.64	0.24	4.25
OT	La Crosse	Warm Season Village	17	1.70	0.60	0.31	3.25
Aztalan	Middle Mississippian	Village	17	1.29	0.45	0.31	3.22
KCV	Koshkonong	Village	33	1.42	0.41	0.33	3.01
Zimmerman	Langford	Village	19	1.37	0.46	0.37	2.72
Hoxie Farm	Fisher	Village	41	1.37	0.37	0.41	2.41
Pamperin Park	Door	Cold Season Camp?	11	1.30	0.54	0.42	2.35
Blinded by the Light	Waupaca	Village	25	1.39	0.43	0.43	2.30
Aztalan	Late Woodland	Village	16	1.12	0.40	0.45	2.21
River Quarry	Late Woodland	Winter Camp	6	0.90	0.50	0.48	2.04
Bryan	Redwing	Village	33	0.97	0.28	0.62	1.62
Tremaine	La Crosse	Warm Season Village	19	1.23	0.41	0.67	1.47
Lundy	Middle Mississippian	Village	26	0.70	0.22	0.71	1.40
Dambrowski	Waupaca	Village	14	0.62	0.24	0.77	1.30
Soggy Oats	Middle Fox	Autumn Camp	14	0.43	0.16	0.86	1.17
Murphy	Late Woodland	Winter Camp	11	0.23	0.10	0.91	1.10

the large number of taxa. The evenness scores (e=0.41-0.69) are in line with the year-around villages that have similar heterogeneity indices. Like the Koshkonong samples, these sites have many species, but only a small number provide any meaningful dietary contributions.

The cold weather sites have fewer taxa, but they are more evenly represented in the assemblages, which causes their evenness scores to jump slightly (e=0.54-0.72). For the sites occupied only in the winter, the only food options available are those that are stored. Therefore, the diet breadth is narrowed. However, there does not appear to be the same focus on a single crop that we see in the other villages (typically maize, though the sample La Crosse sites are an exception, which have a greater maize-EAC balance). This may be related to shelf life of certain resources, rationing (maize stores need to last until the following harvest), or regional differences. The importance of maize for Wolf River tradition groups has not been quantified, and may not be as significant as it is for southern groups.

Not only does the season of the site affect its score, but so does its function. Village sites are expected to reflect a wide array of activities, and should show a cross-section of the full diet. Conversely, single-function camps should be less diverse as their assemblages should only contain short-term curated food, essentially “bag lunches,” potentially any local plants that could be opportunistically picked, and the remains of the activity. If the activity was not related to gathering plants (e.g., lithic procurement), then not even that. The NTAXA is expected to be low unless many types of plants are being processed simultaneously. The evenness should also be low, as the processing remains dominate the assemblage. The comparative site that fits this description is Soggy Oats. This nut processing site (mostly acorn) has a very narrow range of species, the lowest Shannon’s diversity index and one of the lowest of Simpson’s (H=0.43, D=0.86) of any Oneota site, and the lowest evenness of any Oneota site (e=0.16, 1/D=1.17). This indicates that the assemblage was more dominated by a single species than any other Oneota site. Unlike the village sites, acorn significantly outnumbered maize – which fits with the interpretation that it was a nut processing site.

Sampling may also slightly skew some assemblages. For example, F4 at Washington Irving contains over 90% of the site's acorn shell. If that feature had not been sampled, the value of H would drop to 1.78. However, this would only move the site two slots and not significantly impact the overall trends in the data. Perhaps the most dramatic example is Tremaine; Context 316 contains almost 1,900 of the nearly 2,000 little barley seeds (over 90%). Including such an outlier would reduce the NTAXA to 19, and decrease D to 0.21, which would move the index 11 positions. In short, it would no longer rate as one of the most focused, and would become one of the most diverse. With feature 316, little barley composes 71% of the assemblage. Without it, little barley drops to 16% of the assemblage and maize climbs to the most numerous, from 7% to 20% of the assemblage. Tremaine is the only Oneota site that is so skewed; therefore, the results will be interpreted with caution. As for the other sites, the exact place in the ranking may be subject to change based on sampling, but the general trends should hold true.

Interlocality comparisons do not show any clear trends. Waupaca locality sites show the most extreme variability. Among Oneota village sites, Dambrowski exhibits the most focused scores while Burley Brew the least. Langford samples have only a slightly smaller range, though this may be due, in part, to the small number of features in the Zimmerman sample (Rhode 1988). Koshkonong sites trend toward the diverse end of the index spectrum. They are generally more focused than La Crosse samples if Tremaine is excluded (or T316 is excluded from the sample); though CBHC is less focused than OT. In short, geography and locality are not good ways of explaining the variation of diversity index scores. Re-ranking the table based on

Shannon's index does not make the pattern any clearer. In the larger scope of the question, are the sites diverse or focused, the village sites are a far more focused than the hypothetical diverse numbers from the last section; supporting the interpretation that Oneota sites range from moderately to highly focused.

Cross-Cultural Diversity Comparison: In addition to the Oneota sites, four Late Woodland and two Middle Mississippian sites were chosen for comparison. As Late Woodland groups are generally thought to be less reliant on agriculture, all things being equal, Late Woodland sites would be expected to have the greatest diversity. Three of the sites (pre-Middle Mississippian Aztalan, River Quarry and Murphy) are collared ware sites and Centra is a non-collared ware site. Given that non-collared ware producing populations are thought to have been more mobile and even less reliant on agriculture, if at all (Salkin 1986, 2000; Stevenson et al. 1997; Stoltman 2000), a foraging population should have even higher diversity indices (e.g., Winterhalder and Goland 1997). However, all things are not equal. Excepting Aztalan, the two collared ware sites are interpreted as winter encampments, the non-collared ware site a summer camp. Our expectation is that the diversity indices between the two sets of sites should be even greater. Aztalan, a year around village, has an index slightly less diverse than the winter camps. However, the scores are low for different reasons. The winter camps have low diversity because they have few taxa. Aztalan, has many taxa as we would expect from a site occupied in all seasons. It has low diversity because it is highly focused, (i.e., uneven) with hickory making up more than 60% of the assemblage. NB: even though the Aztalan indices are derived from Picard (2013:143), my values vary slightly. To make the results consistent with my other diversity indices, I discounted fungus (a non-food taxa), taxa not identified to at least family (i.e., UNID nutshell), and merged the cf. taxa with the securely identified taxa so that NTAXA was not artificially inflated.

Middle Mississippian diets are regularly thought of as primarily focused on maize, both within the American Bottom (e.g., Griffin 1967), and beyond (Goldstein and Freeman 1997). Isotopic studies have shown this to be true for many Middle Mississippian site residents, whose diets were composed of more than 50% maize (Emerson et al. 2005; Hedman et al. 2002). The combined Middle Mississippian and Late Woodland component at Aztalan generally fits this trend. The diversity index is in the middle of the Oneota range, where we know from isotopes that maize was a significant part of the diet. Somewhat unexpectedly, the diversity score is higher than Late Woodland component. The evenness score and an examination of the data indicate that the relative high diversity is from a reduced focus on hickory. Hickory's proportional importance drops in half, from first to third. The proportional importance of maize increases roughly 25%, though it remains in second. Finally, goosefoot jumps from obscurity to first, accounting for nearly 40% of the assemblage. The end result is that the Middle Mississippian assemblage is dominated by three relatively equal taxa (maize, chenopodium, hickory), whereas the Late Woodland assemblage is strongly dominated only by two taxa (maize and goosefoot). Furthermore, while the Middle Mississippian NTAXA may be larger by one, most species present are agricultural domesticates or cultivars. The greater diversity score indicates greater agricultural diversity, and a diet more focused on agriculture.

Unsurprisingly, the Lundy Site is one of the least diverse assemblages. The only sites with lower diversity indices are seasonal or special purpose camps (Murphy and Soggy Oats), and the Oneota village site of Dambrowski. Both Dambrowski and Lundy have modest NTAXA (14 and 26 respectively) but are dominated by a single taxon, maize. Maize is more than 85% of the assemblage at both sites. The similarities do not stop there. At both sites, nut shell accounts for roughly 10% of the assemblage and cultigens for much of the rest. Excluding nuts, wild resources are only minor components of the assemblages.

Summary & Discussion of Diversity Scores: Diversity indices alone are not particularly effective at differentiating different archaeological cultures. This difficulty is in-part due to the range of variation both within localities and among archaeological cultures. Some localities such as Waupaca exhibit an extremely wide range of diversity indices while others, such as Koshkonong are relatively narrow. They are much more useful for distinguishing seasonality and functionality. As one would expect in most regions and time periods, village sites have greater diversity than single-function sites; winter camps have lower NTAXA and therefore relatively low diversity indices; though, the final score depends on how evenly stored resources are relied upon.

There are several reasons that the indices may not be particularly good at differentiating archaeological culture or localities. First, they likely over emphasize the importance of mast resources. Nutshell represents food processing waste. For every nut that is prepared, multiple shell fragments are produced and apparently burned and survive with great regularity. The indices I calculated only include maize kernels (not cupules). Each kernel represents one of many kernels from a cob; and not necessarily every cob will lose a kernel. While the amount of nutmeat consumed may be less than the number of recovered shell fragments (if preservation is good), each maize kernel likely represents many times more maize than what is in the archaeological record. This pattern holds true for seeds; however, most seed taxa are still at such low frequencies that the impact is likely negligible next to maize (VanDerwarker and Wilson 2016:93). Therefore, the processes that reduce the likelihood of maize entering the archaeobotanical record can obscure temporal, and possibly geographic shifts, to a more maize focused diet.

The Aztalan assemblage is a good indicator of this taphonomic issue. The amount of maize increased nearly 45%, and the proportional value increased nearly 25%. The increase indicates the diet is much more reliant on maize than it previously was. Furthermore, the taxa present indicate a much greater reliance on cultivated seeds relative to wild seeds, which is indicative of a diet highly focused on agricultural crops. However, the large number of hickory shell fragments obscures this shift.

Similar issues can be seen in inter-locality comparisons of Oneota sites. Crescent Bay and OT have similar diversity indices, and only moderately divergent evenness indices. Shannon's H and Simpson's D both indicate that Crescent Bay is more diverse and heterogeneous than OT. Such scores are often associated with a less focused diet. Without any other data, one might understandably infer that the more diverse/less focused diet was less reliant on agriculture since increased reliance on agriculture is so often associated with a narrowing of the diet breadth (e.g., Winterhalder and Goland 1997). Even adding the NTAXA to the discussion, this inference would appear to be supported. Crescent Bay has a wider array of species that were utilized. It is only with a close examination of the individual data that we see CBHC may be equally or more focused than OT. The assemblage at OT, like the Late Woodland Aztalan assemblage, is dominated by hickory. This proportional focus obscures the importance of other resources. If you compare the density of domesticates, cultigens, nutshell, fruits, and other seeds among the sites between the two sites (see Question 2.2a), CBHC appears to have a greater reliance on maize, a roughly equal reliance on domesticates, and twice the density of cultigens–but half the density of nutshell. The greater diversity score at CBHC is more related to the fact that there are several proportionally important agricultural crops, whereas wild taxa, such as hickory, do not dominate the assemblage.

In general, we can see that Mississippian groups tend to have a greater diversity of, and reliance on, agricultural products. Late Woodland groups tend to have a greater reliance on wild resources. Middle Mississippian sites tend to be less diverse than their Oneota counterparts, though there is considerable overlap in the scores. Different types of sites have different diversity indices, as one should expect. And there are nuanced differences among localities but in many cases intralocality variation exceeds interlocality differences.

2.2 Is the Koshkonong Oneota diet locally adapted?

Brown (1982:110-112) argues that while Oneota material culture is similar across a wide array of environments, groups in different areas used a generalized subsistence system modified to local conditions. This general system was tripartite: maize centered agriculture; wetland resources (flora and fauna); upland hunting. Brown (1982:110) concluded that “the Oneota economy was very flexible within a set of environmental parameters.” Hart (1990:575), looking specifically at the agricultural systems, argued that the Oneota economy should be expected to vary. However, he added an additional element: where Brown (1982) was focused his discussion on the physical environment, Hart (1990) discussed how an array of both cultural and physical factors could create different local environments. Variation in population density, social organization, technology, and climatic conditions should lead researchers to expect “regional and even local variation in agricultural production” (Hart 1990:575). This idea is not new (e.g., Gibbon 1972a); however, others have questioned the amount of difference among localities (Overstreet 1987). While variation is noted (Overstreet 1981), it is often at a broader scale (e.g., east vs west) than suggested by Hart, or chronological in nature (e.g., Overstreet 1997).

Unfortunately, until recently, data has been lacking for a comprehensive dietary comparison among sites. Many scholars have made this last point for decades.

What work that has been conducted, suggests that we should expect at least broad regional differences between eastern and western Oneota groups (e.g., Egan-Bruhy 2014; Overstreet 1981). The questions then become: is there significant variation within these larger regions, how much variation is there, and in what ways do they vary? Also, what is the source of variation (cultural or environmental) and what do these variations tell us about the groups under study? To begin tackling these questions, it is easiest to look for: 2.2a variation within agricultural resources (culturally and environmentally determined); and 2.2b: non-agricultural resources (relatively environmentally determined). Once these questions are answered, a more comprehensive discussion of 2.2c: the nature of Oneota subsistence systems can be undertaken more easily.

2.2a Does each Oneota Locality equally rely on agricultural resources?

To answer this question, there are three lines of evidence from which may be drawn. The most direct evidence is the isotopic data. However, these data only indicate reliance on maize, and do not provide data on agricultural C3 pathway plants. Also, isotopic data are not available at all sites, or even localities. Where samples are present, the sample sizes are typically small. While the isotopic data provides a very good first look at the issue, it must be used in conjunction with other types of data. The second line of evidence comes from macrobotanical remains. As discussed in Chapter 4, comparisons among sites or taxa can be tricky, so determining the actual dietary contribution of any resource is difficult with macrobotanical remains alone. When isotopic and macrobotanical data are dovetailed, it is possible to make much stronger inferences.

Sites with isotopic data do not always have macrobotanical data so the following discussion will largely focus on trends within localities. Table 7.7 joins the δ^{13}C data with the macrobotanicals. The first two data columns display the 95% confidence interval for localities where isotopic data are available. The remaining columns show the range of variation in the macrobotanical data, which is broken down into the basic categories (domesticates; cultigens; nutshell; fruits; other seeds).

Table 7.7: δ^{13}C and macrobotanical density data. Isotopic data are C4 plants percent of protein in the diet. Macrobotanical data count per 10 liters.

Locality	**% Maize**		**Density Domesticates**		**Density Cultigens**		**Density Nutshell**		**Density Fruits**		**Density Other Seeds**	
	2σ Min	**2σ Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Koshkonong	29.14	68.86	13.32	48.61	11.43	14.59	8.86	9.16	0.54	0.66	1.16	1.58
La Crosse	19.09	57.25	1.4	13.21	2.66	45.02	0.56	23.79	0.05	9.17	0.92	2.38
Red Wing	21.56	62.06	84.99		11.83		0.88		0.54		49.81	
Langford	41.71	60.11	4.05	15.00	0.12	0.43	7.71	14.57	0.06	0.15	1.14	3.00
Middle Fox	-		2.81	33.55	0.57	2.9	3.09	331.29	0.20	0.32	0.23	5.16
Door	-		0.00	1.27	0.05	0.06	2.89	9.23	0.18	1.09	0.30	0.45
Fisher	-		78.66		4.81		34.62		7.42		13.7	
Waupaca	-		9.21	46.52	0.47	18.73	4.73	76.15	0.30	1.03	0.47	3.95
Late Woodland	2.67	54.01	0.14	6.36	0.00	0.27	0.27	105.96	0.00	0.62	0.00	0.24
Middle Mississippian	2.86	82.32	47.91	311.89	0.89	64.32	38.24	42.36	0.61	0.67	0.87	10.63

A cursory look at the density levels or the isotopes support the same answer. Agriculture is not relied upon to the same degree in each locality. However, variation within localities makes it difficult to define clear patterns. With ubiquity levels (Table 7.8), intralocality patterns are a bit clearer but not easily reconciled with the other evidence. Based on isotopes, Koshkonong maize reliance trends higher than any of the other Wisconsin localities, but lower than Langford values. Furthermore, there is overlap in each of the confidence intervals, and no locality can be distinguished from any other based on any one line of evidence.

Koshkonong/Western Wisconsin Comparison: While the two-sigma range for Koshkonong overlaps with La Crosse and Redwing, it averages about 10% higher than La

Crosse and roughly 5% greater than Red Wing. Densities of domesticates are greater at both KCV and CBHC than at any of the La Crosse comparative site. However, the Bryan site in the Red Wing Locality has a domesticate density roughly twice that of KCV and roughly six times greater than CBHC. Koshkonong has remarkably high domesticate ubiquity levels (95-100%), which is marginally greater than Bryan (75%), and considerably greater than La Crosse (30-60%). Taken together, the earlier localities (i.e., Red Wing and Koshkonong) are likely more reliant on domesticates than La Crosse.

Table 7.8: Ubiquity by Taxa Category

Locality	Site	Domesticates	Cultigens	Nutshell	Fruits	Other	Maize
Koshkonong	KCV	95%	100%	79%	58%	95%	95%
	CBHC	100%	100%	100%	43%	95%	100%
Middle Fox	Soggy Oats	50%	50%	75%	25%	75%	50%
	Schrage	63%	23%	51%	17%	23%	63%
Waupaca	Burley Brew	60%	40%	70%	20%	40%	60%
	Dambrowski	77%	31%	65%	23%	23%	77%
	BBTL	60%	50%	78%	26%	76%	60%
Door	Citgo	0%	14%	71%	14%	29%	0%
	Pamperin Park	19%	4%	67%	52%	33%	19%
Langford	Washington Irving	89%	11%	100%	22%	30%	67%
	Zimmerman	92%	8%	67%	25%	43%	92%
Fisher	Hoxie	74%	71%	42%	32%	71%	72%
Redwing	Bryan	75%	46%	14%	19%	45%	74%
La Crosse	OT	49%	10%	59%	70%	30%	40%
	Filler	60%	78%	62%	8%	70%	58%
	Tremaine	30%	40%	5%	20%	11%	29%
Late Woodland	Centra 53/54	6%	17%	17%	17%	6%	6%
	Murphy	71%	18%	65%	0%	35%	71%
	River Quarry	91%	0%	91%	9%	0%	91%
Middle Mississippian	Aztalan	83%	50%	83%	67%	50%	83%
	Lundy	92%	31%	76%	20%	24%	92%

However, this data set is a good reminder of the issues of intersite comparisons of macrobotanical remains (e.g., Hastorf and Popper 1988). Given the similarity of the isotope values at CBHC and Red Wing sites, and the large difference in density values, the raw density values alone are clearly not good indicators of relative importance of maize. In addition to issues of preservation and context, another factor that must be considered is the time-scale represented by the two lines of evidence. In most contexts, refuse pits contains trash from a relatively narrow range of time. The density values then represent the diet in that short span of time. Furthermore, following the Schlep-Effect, the bulk of the pits context is likely refuse from activities in proximity to the pit itself. Isotopes, on the other hand, represent years of consumption as it takes many years before bone collagen totally turns over, roughly 30 years in humans (Harkness and Walton 1972; Libby et al. 1964; Stenhouse and Baxter 1977, 1979). The location in which food is eaten is also irrelevant. Therefore, in most cases, the isotopes are representative of long-term and wide-ranging human actions. Conversely, an isotopic data point reflects the consumption patterns of a single individual whereas most refuse pits will reflect the consumption patterns of several people, perhaps a household, clan, or other social group. So, the isotopes are simultaneously providing data on a both broader and more constrained set of human activities. Even if there were no issues of preservation or context, we should not expect a direct linear relationship between macrobotanical and isotopic datasets. Ubiquity levels, in this case, did follow the isotope values, but did not indicate how different the assemblages were; i.e., they provide ordinal level data only.

Cultigen (Table 7.9) densities are similar in Koshkonong and Red Wing though they are much more ubiquitous in Koshkonong samples. La Crosse sites are highly diverse. OT and Filler have densities roughly half as high as Koshkonong, but Tremaine is three times greater. Ubiquity levels are also variable, ranging from 10-78% and the variation in ubiquity does not correspond with the density levels. In the Koshkonong Locality, wild rice dominates the cultigens with modest levels of goosefoot at CBHC. All other cultigens appear to be minor inclusions. For

Redwing, goosefoot stands out with high densities and modest ubiquities. The remaining cultigens have a minimal presence in the Bryan site's assemblage.

Table 7.9: Comparison of cultigens among Western Wisconsin and Koshkonong Locality sites: NB: little barley includes undifferentiated little barley/wild rice and the values may over estimate its importance in the Koshkonong Locality

Site	**Measurement**	**Goosefoot**	**Sunflower**	**Wild Rice**	**Little Barley**	**Erect Knotweed**	**Barnyard Grass**	**May Grass**
Bryan	Density (ct./10l)	9.97	1.05	0.30	0.39	0.10	-	-
	Ubiquity	43%	12%	7%	7%	3%	-	-
Tremaine	Density (ct./10l)	-	-	1.41	42.83	0.66	0.06	-
	Ubiquity	-	-	9%	33%	7%	3%	-
Filler	Density (ct./10l)	11.04	-	13.20	-	0.24	2.04	-
	Ubiquity	56%	-	52%	-	8%	16%	-
OT	Density (ct./10l)	2.32	-	2.85	0.18	-	0.06	0.06
	Ubiquity	6%	-	3%	3%	-	3%	1%
CBHC	Density (ct./10l)	3.85	-	9.13	0.09	0.04	0.01	-
	Ubiquity	76%	-	86%	19%	15%	5%	-
KCV	Density (ct./10l)	0.74	-	7.88	0.53	0.04	-	0.02
	Ubiquity	63%	-	89%	37%	5%	-	5%

Despite the physical proximity of the La Crosse sites, there is a considerable amount of variation within the macrobotanical assemblages. The isotopes reflect some diversity in the diet, with $\delta^{13}C$ values ranging from -16.4‰ to -11.6‰ (23%-55% maize/protein). However, even the lowest values indicate a heavy reliance on maize. If the high goosefoot model, from question 1.2 above, is adjusted so that 23% of the protein is derived from maize, 35% of the calories from maize. With this model, goosefoot would account for another 22% of the calories. If the goosefoot was actively cultivated, then these two alone would account for more than half of caloric intake. Filler also includes beans, squash, and several other cultigens. So even if the residents relied on maize to a lower degree than the residents at CBHC, it does not necessarily mean that they relied on agriculture to a lower degree. Rather, the La Crosse agricultural system appears to be more diverse and included either a wider suite of plants or at least the other taxa accounted for a larger proportion of the diet.

The landscape in the La Crosse and Koshkonong localities are nothing alike and the settlement patterns are very different, yet both highlight the economic centrality of agriculture. Koshkonong is situated in the formerly glaciated portion of the state while La Crosse is in the Driftless area (L. Martin 1965). According to Sasso (1993:327), "at the core of the [La Crosse] Oneota subsistence was the cultivation of maize, beans, squash in specially prepared fields or agricultural plots located in fertile bottomland soils, and in perhaps, sandy locations atop terraces." Several ridged agricultural sites have been identified in the La Crosse valley and surrounding region, but represent only one aspect of a multi-tiered settlement system (Sasso 1989: 1993). Based on the agricultural potential model, most of the farmable lands were restricted to the bottomlands, and most of the terrace soils are excessively drained and do not hold sufficient water. Arable land in La Crosse is considerably rarer than in Koshkonong.

In Sasso's (1989; 1993) settlement system model he describes three types of relevant sites. Major villages were placed on terraces overlooking, but with immediate access to the bottomland soils. Satellite hamlets were placed in analogous settings that allowed the interconnected communities to expand their access to arable land. The final site type is agricultural sites. The most common are ridged fields, which improved soil arability and harvest reliability (Gallagher 1992; Gallagher and Sasso 1987; Riley and Freimuth 1979; Sasso and Brown 1987; Sasso 1987, 2003b).

In Koshkonong, sites could be easily placed with access to arable land in diverse edaphic settings. If each of the Koshkonong sites were concurrently occupied, then the network of villages would have magnified the amount and diversity of arable soils. To accomplish this phenomenon in La Crosse, populations were distributed over a wider area and several sites and across site types. In both localities, fields were significantly modified to increase arability and in some cases ridged fields were constructed. While this means may have varied between the localities, one of the major goals of site placement remained the same; ensure access to significant amounts of arable land in a variety of settings. While it is unknown if hamlets were used in the same way, the relationship between major villages and arable land is similar in La Crosse and Red Wing. There was also a network of habitation sites that linked back to major villages such as Diamond Bluff and Bryan (Fleming 2009).

Koshkonong/Eastern Wisconsin Comparison: Most localities in eastern Wisconsin do not have any isotopic data. Therefore, the macrobotanical remains are more important for understanding the role of agriculture in this region. The same issues of density and ubiquity discussed for the La Crosse comparison exist here, but without isotopic data from all localities, it is not possible to counteract the issues in the same way.

Like in Western Wisconsin, there is a considerable amount of variation both within and between localities. The Door Peninsula/Green Bay region sites of the Wolf River Tradition appear to be the least focused on agriculture. One of the two sites have no domesticates, and the other has the lowest density of domesticates of any of the comparative Oneota sites. Both sites also have the lowest densities of cultigens. Domesticates at CBHC are more than 10 times greater. Because at least one of the sites has been interpreted as a winter camp, and the second is possibly winter only, it is tempting to attribute the low density to seasonality. However, maize is highly storable, as are many cultigens. It does not seem logical to invest significant amounts of labor into agriculture and then not eat the food in any measurable quantity. While nutshell density is modest, the levels are not sufficiently high to suggest that either site was a nut processing camp. The site reports do not suggest any special function for the sites, so it is unlikely the dietary indicators are due to restricted set of actions occurring on site.

Ubiquity levels are also very low. At Pamperin Park, fewer than one-in-five features contained any domesticate, and fewer than one-in-twenty contain cultigens. Only one erect knotweed seed was found in a single context at Citgo. For these two sites, there is little data to suggest that maize was consumed to the same degree as in other localities. While La Crosse area sites generally had low densities of maize, it was always much more ubiquitous than at these sites. Maize is present in 76% more features and cultigens are present in 86% more at KCV than the most ubiquitous of the Door sites.

In the Middle Fox Passage macrobotanical remains of domesticates and cultigens are more plentiful than in Green Bay. Among the Middle Fox Passage sites, domesticates are present in more than half of the features, and cultigens in a quarter. Densities are also much higher in the Middle Fox than Green Bay, but both densities and ubiquities are lower than either Crescent Bay or KCV.

While the macrobotanical remains at Schrage do not match those in the Koshkonong Locality, the region contains some of the most extensive sets of raised agricultural fields known (Sasso 2001, 2003b). With the incredible investment of labor required to create the ridged fields, it is hard to imagine a scenario where agriculture was not a major component of the locality diet. Furthermore, numerous hoes have been recovered from sites in the region. The number and distribution of the hoes underscores the importance of the agricultural pursuits (Sasso 2014). The ubiquity levels are also comparable or greater than at La Crosse sites, where maize contributed as much as 55% of the protein in the diet. While there may have been some temporal or geographic variation within the locality, agriculture contributions were likely on par or greater in the Middle Fox than in La Crosse.

In the Waupaca Locality, domesticate and cultigen ubiquities are on par, if not greater than at the Schrage site. Densities are also greater than at Schrage, and are generally on par with the Koshkonong Locality. The cupule to kernel ratios as the sites are sufficiently different; enough that Hamilton et al. (2010:260) suggested that agricultural fields were placed differently between the two sites. At BBTL, the ratio suggests that much of the maize processing occurred onsite, and very little occurred at Dambrowski. Despite being further from agricultural fields and showing little evidence of maize processing, Dambrowski has greater ubiquity of maize (76% vs. 60%) and densities (41.8 vs. 10.4 ct./10 liters). Squash is also important at all three sites. Cultigens account for a very small portion of the Dambrowski assemblage, but goosefoot, barnyard grass, and erect knotweed made are present in modest densities at Burley Brew and BBTL. Agriculture provided a significant amount of food to the residents' diet though the agricultural system appears to be very different from that of the Koshkonong or Middle Fox localities.

In sum, each locality seems to have had a different agricultural system of production. Koshkonong groups utilized fields immediately adjacent to their habitations and available evidence suggests that they rarely created ridged fields. Processing occurred on site, and agricultural plants were recovered in great densities and ubiquities. Isotopes confirm that maize was a major component of the diet in the region. In the Waupaca and Middle Fox localities, agriculture was also of great importance though apparently without the need to grow and process all the crops in the main villages.

In the Green Bay region, the comparative sites show little evidence that agriculture or even horticulture were major aspects of the diet. Densities and ubiquities were very low, and access to arable land was likewise low. If only one variable was low, it would be insufficient to infer that agriculture was less important. However, all three lines of evidence point to that conclusion. This inference needs to be confirmed though analysis of larger villages in the region.

Not only did the method of farming vary, the types of supplemental plants also varied. While Waupaca and Middle Fox sites do have wild rice, it is in small quantities not comparable to Koshkonong. Furthermore, these other sites seem to rely on other cultigens, such as barnyard grass, to a greater degree than Koshkonong. The one uniting cultigen is goosefoot. Only this taxon is significantly present in all three localities.

Koshkonong/Illinois Comparison: Given its southern location, Koshkonong has long thought to have had closer connections to Illinois groups than its northern neighbors (e.g., Gibbon 1972a:175). Schneider (2015) has noted some evidence of interaction between groups in the two regions; there are a few vessels in Koshkonong with Fisher-like traits, but of local manufacture.

Langford isotopes suggest that they consumed as much, if not possibly more maize than their Koshkonong neighbors. However, with only two dogs sampled from Koshkonong, further research is needed. Also, all the isotope samples, human and dog, came from the Upper Illinois River valley, so this trend may not extend to the other Langford Localities. Furthermore, there are no published values from Fisher populations so the Langford isotopes may not be representative of all Upper Mississippians in northern Illinois.

The macrobotanical assemblage at Zimmerman is consistent with a high reliance on domesticated crops (Table 7.9). Maize is ubiquitous, though in somewhat lower densities than CBHC. Squash is present in one-third of samples, more than twice the ubiquity or density as CBHC. The assemblage contains few cultigens, which is consistent with most other Langford sites (Egan 1988; Jeske 1990). Nut densities are also lower than in the Koshkonong locality.

There is no isotopic data from Zimmerman; however, it is close to sites with isotopic data, such as Gentleman Farm and MSQ. Given its proximity and the consistency of the Langford isotopes across four sites (e.g., Emerson et al. 2005, 2010), Zimmerman occupants likely consumed similar amount of maize. With the lack of cultigens and lower nut levels, the high meat model likely most closely fits the Upper Illinois River subsistence strategy. The $\delta^{15}N$ values support this interpretation (μ=9.69‰). Where Koshkonong groups used maize to replace calories from meat, Upper Illinois Langford groups appear to have used maize instead of EAC crops and wild plants.

Like Zimmerman, Irving has a near absence of cultigens. Relative to Koshkonong, nut densities are low. However, like Koshkonong, acorn is the densest nut type at Irving, while absent from Zimmerman. Squash is present in one-quarter of samples, but at densities on par with CBHC. Maize is present in three-quarters of features, but kernels are fewer than 1 kernel/10 liters. As noted above, densities do not always faithfully reflect dietary contribution. However, with values this low, the importance of maize must be questioned, at least relative to other Langford sites. It is possible that hinterland groups, living in the Fox River valley, relied on maize to a lower degree than the Illinois River valley. Additional research is required to test this inference. If so, Jeske's (1990:232) assertion that Irving represents a horticultural base camp for a logistically mobile group is supported. Rather than relying heavily on agriculture, the residents may have heavily exploited local resources and expanded their catchment through satellite sites such as Cooke (e.g., Jeske 1990:233).

Hoxie Farm, a Fisher site, does not have any accompanying isotopic data and is situated in a heavily developed region, so only the macrobotanical data are available. The assemblage contains some of the densest floral deposits of any Upper Mississippian site. Domesticates are present in great densities (78.66 ct./10 liters; exceeded only by Lundy) and ubiquities (74%).

Unlike their neighbors, cultigens are present in high ubiquities (71%) and great density (34.62 ct./10 liters). Nuts are a common occurrence (42% ubiquity) at a modest density (4.81 ct./10 liters). Even with a single line of evidence, these values indicate a major reliance on agricultural foods. It would be unsurprising if future isotopic data demonstrate a reliance on maize, similar or greater than Langford groups. The cultigen assemblage is heavily dominated by goosefoot (85% of cultigen seeds recovered), though is supported by moderate levels of erect knotweed. There are one or two seeds of several other taxa, but not in sufficient numbers to suggest that they made a serious dietary contribution.

In summation: these Langford groups appear to have relied on maize to a similar, if not slightly greater degree than their Koshkonong neighbors. Maize was supplemented with squash, but EAC plants are lacking. Rather, increased hunting and/or fishing seems to have taken the place of cultivation. In short, the agricultural system was intense and focused on southern domesticates which was primarily supplemented by faunal resources. A similar, but potentially less intense, agricultural system was practiced in the Fox River valley. Hoxie Farm suggests a Fisher pattern like Koshkonong in general composition, i.e., heavily reliant on maize, beans, squash, and cultigens. However, the densities are generally greater at Hoxie, and the suite of cultigens is not the same.

Koshkonong/Late Woodland Comparison: The Woodland sites contain too much cultural, functional, and geographic variation to determine a clear pattern. However, they generally show a much lower reliance on maize. Of the non-collared ware sites, maize seems to have been inconsequential. The isotopes from Nitschke indicate that insufficient maize was consumed to alter the isotopic signature. The Centra 53/54 site contains a single maize kernel, and a total of four cultigen seeds. The data from these two sites support the generally accepted theory that the

Madison ware producing Late Woodland groups were relatively mobile and relied heavily on foraging rather than farming (see Stevenson et al. 1997). This interpretation of Madison ware producing groups is supported by the low $\delta^{13}C$ value of the Nitschke dog (<3% of protein).

River Quarry and Murphy, are both winter encampments, and both collared-ware sites. However, they show two very different patterns with both the lines of evidence at odds (i.e., macrobotanical and landscape). River Quarry is the least like the Koshkonong sites. Given it is a winter occupation site, that is not surprising. The macrobotanicals are congruent with a maize and nut focused diet. Maize and nutshell are each present in 91% of contexts. Nutshell is more than 50% denser at River Quarry than KCV. Maize is present in a modest 5.57 kernel fragments per 10 liters. While much lower than even CBHC, it is denser than many Oneota sites, including La Crosse, where maize accounted for at least 20% of the protein. Both nuts and maize are easily stored, so they are logical crops to find in a winter camp. There are few other taxa present, no cultigens, and a single fruit seed. Agricultural crops accounted for roughly half of the assemblage, and likely for a large portion of the residents' winter diet.

The Murphy macrobotanical assemblage is dominated by acorn, which account for 95% of the assemblage by count, is present in more than 60% of contexts, and has a density greater than 100 shell fragments per 10 liters. Maize is also present; alone, it would appear to have a significant presence (72% ubiquity, 4.46 ct./10 liters). Next to the acorn, it is easily missed as a minor resource. Unlike River Quarry, the site has several cultigens (3 taxa, 18% ubiquity, 0.24 ct./10 liters). However, they appear unimportant in the assemblage relative to amount of acorn.

The two sites have distinct subsistence signatures. The River Quarry diet consisted almost entirely of maize and nuts in relatively equal proportions. The bulk of the nuts were hickory, and no acorns were present. At Murphy, residents had small amounts of cultigens, modest amounts of maize, and massive quantities of acorn. Like the Koshkonong sites, Murphy residents appear to turn to acorn as a buffer food. At both sites, maize likely contributed substantial calories to the diet, though the proportion is not currently known.

Aztalan also has a collared-ware Late Woodland component that predates the joint Middle Mississippian occupation. However, many of these contexts do not have known flotation volumes, which limits metric comparisons. Picard (2013:193-195) summarizes the general subsistence regime at the site and describes how the two components are distinct. Like River Quarry, hickory was the most important nut resource and it outnumbered maize nearly 2.5 times over. *Chenopodium* was also an important resource, and accounted for most the cultivars in the exclusively Late Woodland component. Barnyard grass was also present. The taxa present indicate a strong reliance on agriculture, supplemented with foraging for nuts and other resources.

Even before the arrival of Middle Mississippians, agriculture was an important resource at Aztalan. The dogs sampled from Aztalan are likely from pre-Middle Mississippian contexts, though at least two, if not all three are likely from the early portion of the joint occupation of the site. They indicate that maize provided between a quarter and a third of the dietary protein. The $\delta^{15}N$ also indicate that meat consumption was relatively low (8.2-9.2‰). Even adjusting for the 0.5‰ dog/human differences noted in Langford samples (Edwards et al. 2017), the values still indicate relatively low meat consumption. Using the model developed for Koshkonong (Figure 7.2), a low meat diet should still reflect a modest caloric input from maize – likely providing more than 25% of the calories for most, if not all individuals.

Koshkonong/Middle Mississippian Comparison: All categories of flora were highly ubiquitous, including both domesticates and cultigens. Domesticates densities are on par with

KCV, where both nutshell (47.91 ct./10 liters) and cultigens (64.32 ct./10 liters) were several times denser than either Koshkonong site. From this, it appears that agriculture was likely even more important at Aztalan than at Koshkonong. Given the relative homogenous environmental setting at Aztalan (Picard 2013), and the clear perception of a threat by the population (e.g., defensive wall, violent deaths, etc.) it is not surprising that the residents would concentrate on aggregated and manageable resources (Barrett 1933; Goldstein and Freeman 1997; Goldstein and Richards 1991; Richards 1992; Rudolph 2009).

On many counts, the Lundy assemblage looks like the Aztalan assemblage. Domesticates (92% ubiquity, 311.89 ct./10 liters) and nutshell (76% ubiquity, 42.36 ct./10 liters) dominate the assemblage. Unlike Aztalan, cultigens are only a minor component (31% ubiquity, <1 ct./10 liters), though small numbers of several cultivated taxa have been identified. The high ubiquity and extreme density of domesticates, and Middle Mississippian isotopes at the site suggest maize was of great importance. However, essentially all the available values are from much further south. It is not clear how similar we should expect the diets in these two regions to be. However, Emerson et al. (2007) argue that the diet at Lundy is comparable to the Middle Mississippian diet in the Central Illinois River Valley. And Buikstra et al. (1994) provide the mean $\delta^{13}C$ values from Dixon Mounds. The overall mean from 32 samples is -11.36‰, which is 57% of the protein in the diet. There are no standard deviations or other summary data provided, so the expected range of variation is unknown. However, given the variation in both Upper and Middle Mississippian populations, it seems likely that a significant portion of the population likely consumed maize far in excess of 57% of their protein intake.

To provide some context, the overall American Bottom mean is 44% of protein. The means from four American Bottom sites were close to the Dixon Mounds mean (52-60%). Their

95% confidence intervals ranged from 31-77% of protein. The Dixon Mounds may have had a much smaller standard deviation, but we do not have that information. Without that information, we can only make the tentative inference that maize provided as much as 71% of the protein. There are also several human isotopes from Aztalan that are thought to date to this time-period. However, the only ones from secure contexts come from mound contexts and are thought to represent high-status individuals (Bender et al. 1981). Therefore, we should not expect them to be representative of the general population.

If the dietary contribution model generated for Koshkonong is modified, we provide some potential caloric bounds of maize. By removing wild rice, changing raw acorn to dried hickory (no raw values were provided by the USDA), and using deer as the proxy for meat the model should roughly approximate the Lundy and Aztalan diets. Hickory acts as the filler variable (like wild rice in the Koshkonong example), automatically adjusting its values to ensure a 2,000-kilocalorie diet. Goosefoot and venison are kept stable, and maize values are adjusted until the protein levels fit. Those eating a low meat diet would likely be eating more maize, so this diet will be calibrated to achieve 71% of protein. This requires 17.5 servings of maize (75% of calories) and 0.6 servings of hickory are needed. The individuals with high meat diets were likely eating less maize. Therefore, the high meat diet (2 servings of venison, 1 of goosefoot), when calibrated for 31%, requires 9.25 servings of maize (40% of calories) and 1.4 servings of hickory. All other likely combinations resulted in caloric contributions between these two extremes. In sum, maize likely contributed 40-75% of the caloric intake for most of the population.

In summary, Middle Mississippian groups relied on maize to a slightly greater degree than did Langford and Wisconsin Oneota populations. Hickory was a common buffer resource for Middle Mississippian groups, and even in small quantities could have provided a considerable number of calories. The importance of cultivars in the agricultural system varies among sites. However, at both sites, Middle Mississippian populations appear to be largely focused on terrestrial plant resources. Wild rice, while present, was insignificant to these people. Population size may explain the greater Middle Mississippian emphasis on maize production. If the populations were much larger at Aztalan or Lundy, then relative to Koshkonong, the agricultural system would need to be intensified.

2.2b Are the non-agricultural resources the same in each locality?

Each of the localities and archaeological cultures seem to rely on a different, but often overlapping, suite of natural resources. The composition of fruit and seed assemblages vary, both by site and by region. Some fruits are quite ubiquitous, and are present in many localities (Table 7.10). For example, *Solanum* is present in 11 localities. The two Langford sites are the only two in this study that do not have any nightshade.

Other fruits, like staff vine (*Celastrus)* or mulberry (*Morus)* are present in only a single locality (Redwing and La Crosse respectively). The number of fruits in a locality vary as well. The Zimmerman assemblage was devoid of fruits; however, their absence is likely a sampling issue. Emerson et al. (2005:88) argue that “the record for fleshy fruits is relatively robust.” Late Woodland, non-collared sites are otherwise at the low end of the spectrum with only two. For Centra, this may be due to small number of features available for analysis. The Middle Fox locality also only has two. Western Wisconsin sites appear to be the most diverse with seven genera in each locality, followed closely by Koshkonong (6) and Fisher/Apple River (5).

Many of these fruits are naturally ubiquitous throughout the region so environmental differences are not likely a major factor. Furthermore, there is considerable geographic overlap between some of the groups (e.g., Koshkonong and Aztalan or Langford and Fisher) but they used a different suite of fruits. Koshkonong groups used all three genera that their Aztalan contemporaries used, but also included modest amounts of hawthorn (*Crataegus*) and raspberries (*Rubus*). Raspberries grow wild throughout the region, thrive in the forest edge, and were consumed by the Late Woodland residents prior to the arrival of their southern neighbors. There is no environmental reason that these berries would have been excluded from the Middle Mississippian diet. Perhaps it was a social idiosyncrasy, or perhaps deforestation drove the plant beyond the typical catchment.

Table 7.10: Presence of Fruit General by locality

Archaeological Culture	**Region**	**Locality**	**Fruits**													
			Gaylussacia	**Crataegus**	**Celastrus**	**Frageria**	**Morus**	**Prunus**	**Rhus**	**Rubus**	**Solanum**	**Vaccinium**	**Sandbur**	**Vitis**	**Viburnum**	**Total**
Langford	Fox			x						x		x				**3**
	Illinois															**0**
Oneota	Fisher		x			x			x		x	x				**5**
	Eastern Wisconsin	Koshkonong	x	x				x	x	x	x					**6**
		Middle Fox									x				x	**2**
		Green Bay								x	x			x		**3**
		Waupaca		x					x		x		x			**4**
	Western Wisconsin	Red Wing			x	x		x	x		x	x		x		**7**
		La Crosse	x			x	x	x			x	x		x		**7**
Late Woodland	Collared									x	x			x		**3**
	non-Collared									x	x					**2**
Middle Mississippian	Apple River			x					x	x	x			x		**5**
	Wisconsin							x	x		x					**3**
Total			**3**	**4**	**1**	**3**	**1**	**4**	**6**	**6**	**11**	**4**	**1**	**5**	**1**	

The remaining wild specimens are divided across 28 taxonomic families and 41 genera. Table 7.11 shows the distribution of these other seeds across families. An x indicates that at least one seed of that family was identified, but not to genus. Numbers indicate the number of identified genera in the assemblage. The table shows that there is a great deal of diversity among

Table 7.11: Other Seeds Distribution organized by taxonomic family

Culture	Region	Locality	Other Seeds																											
			Acalypha	Amaranthaceae	Apiaceae	Asteraceae	Brassicaceae	Betulaceae	Caryophyllaceae	Cyperaceae	Euphorbiaceae	Fabaceae	Hydrocharitaceae	Hypoxidaceae	Iridaceae	Lamiaceae	Myricaceae	Nelumbonaceae	Orobanchaceae	Phasaleous	Poaceae	Polygonaceae	Portulacaceae	Rhamnaceae	Rosaceae	Rubiaceae	Solanacea	Typhaceae	Verbenaceae	Violaceae
Lang ford		F		1		1			1	1		1						1			x					1				
		I		1		1	x									x			1				1	1						
Oneota	F			1	x	1	x			2		1	1	1		x				1	2				1		x			
	Eastern	K		1		x	x		1	1	x	x	1							1	1	1						1		1
		F	x			x				1	1	1									x	1			x					
		G												1							x				x					
		W		1		x				1				1	1	1					x				x			1		1
	Western	R		1		2				1											3	1	1						1	
		L		1		x				x		x									x		1			1				
Late Woodland		C		1			1	1									1													
		N						1													x				x	1				
Middle Mississippian		A								1				1							2				1					
		W		1																					1					

localities; however, most families have no more than one or two seeds per site. The grass (*Poaceae*) family is the second most abundant, the most ubiquitous. This family is very large and diverse; though its genera are often difficult to distinguish (Deloit 1970; A. Martin and Barkley 1961; Montgomery 1977). A total of six genera have been identified among the comparative sites, though 78% were only identified to family. These seeds are most common in La Crosse, Red Wing, and Fisher contexts, possibly due, in-part, to their placement on the Prairie Peninsula. However, of the two Langford sites discussed here, *Poaceae* seeds were not plentiful, which given the site placement and geographic overlap of Langford and Fisher groups (Jeske 1989, 1990), the opposite pattern is expected.

Some other taxa of note include Water nymph (*Najas sp.*) in the Koshkonong Locality, Yellow Star grass (*Hypoxis sp.*) found in several localities, and Amaranths (*Amaranthus sp*.) in Red Wing. While not included in the sample from this dissertation, Olsen (2003) has also identified Amaranths from CBHC. Members of the amaranth family are relatively ubiquitous in the sample. However, more than half of the seeds were identified in at the Bryan site. If this trend is present in other Red Wing sites, its substantial use may be a local trait (*sensu* Egan-Bruhy 2014). Yellow Star grass is present in several localities, but is a common only at Fisher and Waupaca locality sites. Like amaranth, the use of this ubiquitous plant seems to be a localized strategy. Waternymph was the most abundant seed in this category, though every seed was from Koshkonong sites. Most of these small seeds were clustered in the bottom of F12-01 and 06. It is not clear what use this plant performed, but the they are present in densities too great to be incidental inclusions. Rather than food, it is possible that they represent the remains of a pit lining (Egan-Bruhy, personal communication). The seeds are far more ubiquitous and numerous at KCV than CBHC. The absence of these seeds elsewhere, while being so numerous in Koshkonong is puzzling.

The single pattern that emerges is that fruits and other seeds are far less numerous than their agricultural, horticultural, or nut counterparts. Many of these seeds represent additions to the diet, while others may have served non-subsistence functions. Given how maize-focused many of the diets are, many of these seeds, particularly the fruits, likely served as seasonal source of variety and flavor in an otherwise homogenized diet. Which flavors, and in what proportions, varied among groups. Environmental differences played a role in plant availability.

However, the range of environmental variation does not perfectly track with the dietary diversity (e.g., *Poaceae* between Langford and Fisher or Aztalan/Koshkonong differences). Local cultural preferences appear to have played a role in determining which plants were chosen for exploitation.

2.2c: In what ways do Oneota subsistence systems vary from each other and from non-Oneota subsistence systems?

This question has been partially answered in previous portions of question 2. For a more comprehensive answer, a PCA of each of the sties was implemented. Like the first PCA, density/ floral category were variables. Because sites, rather than contexts, were objects, it is possible to include ubiquity as variables. The overall model explains 94% of the variation. The first three components, which provide the most useful information, explain 79% (Table 7.12). By varying the combination of components depicted together, variation within and among localities can be highlighted, which allows for better identification of important trends within the dataset.

Table 7.12: PCA Eigenvalues and Variable Loadings for PCA for PCA of all sites

Eigenvalues					
	1. PC	2. PC	3. PC	4. PC	5. PC
Eigen values	3.070	2.018	1.269	0.753	0.385
Explanation %	38.372	25.225	15.864	9.410	4.817
Cumulative explanation %	38.372	63.597	79.461	88.872	93.689
Variable Loadings					
Total Domesticates (log)	0.488	-0.052	0.085	-0.335	-0.562
Domesticate Ubiquity (log)	0.332	0.383	0.176	-0.605	0.050
Total Cultigens (log)	0.426	-0.365	0.158	0.017	0.433
Cultigen Ubiquity (log)	0.356	-0.276	0.505	0.248	0.243
Total Nut (log)	0.393	0.315	-0.128	0.528	-0.150
Nut Ubiquity (log)	0.214	0.575	0.039	0.353	0.016
Total Fruits (log)	0.251	-0.455	-0.437	0.150	-0.398
Fruity Ubiquity (log)	0.283	0.067	-0.688	-0.184	0.504

The first principle component (38% of variation) does not provide a great deal of analytical clarity (Figure 7.4). Broadly, it separates those that have dense deposits (positive values) from those whose assemblages are less dense (negative values). It weights domesticates, cultigens, and nutshell relatively evenly, so those with high densities of all three are ranked highest (e.g., Aztalan), while those that are high primarily in one (e.g., Lundy) still receive a relatively high rank, but are shifted left. Those with few materials overall (e.g., Centra) have highly negative scores. It is notable that most sites cluster with their locality. Despite the variation, the first component demonstrates that there are broadly shared patterns within each locality. Clear exceptions are Soggy Oats (a seasonal camp) and Tremaine. The collared ware sites also trend together, and the non-collared Centra stands separately. While these differences explain over a third of the dataset's variation, the other components help to explain the differences with greater clarity.

The second (25% of variation) and third principle (16% of variation) components are analytically more useful as they provide more nuanced indications of how the assemblages are different (Figure 7.5). Issues of equifinality require that the graphed values be interpreted carefully with the actual data on hand. Technically, the second principle component separates sites with nutshell (both density and ubiquity) and ubiquitous domesticates, from those that have relatively high fruit densities and large cultigen values. However, because maize is common, differences relatively nutshell and cultigen values determine the overall structure of the axis. Negative values indicate that cultigens and/or fruits outnumber nutshell. The Green Bay sites are the two exceptions; their very low domesticate ubiquities (0-19%) pull them to the left side of the graph, despite their proportionally high nutshell.

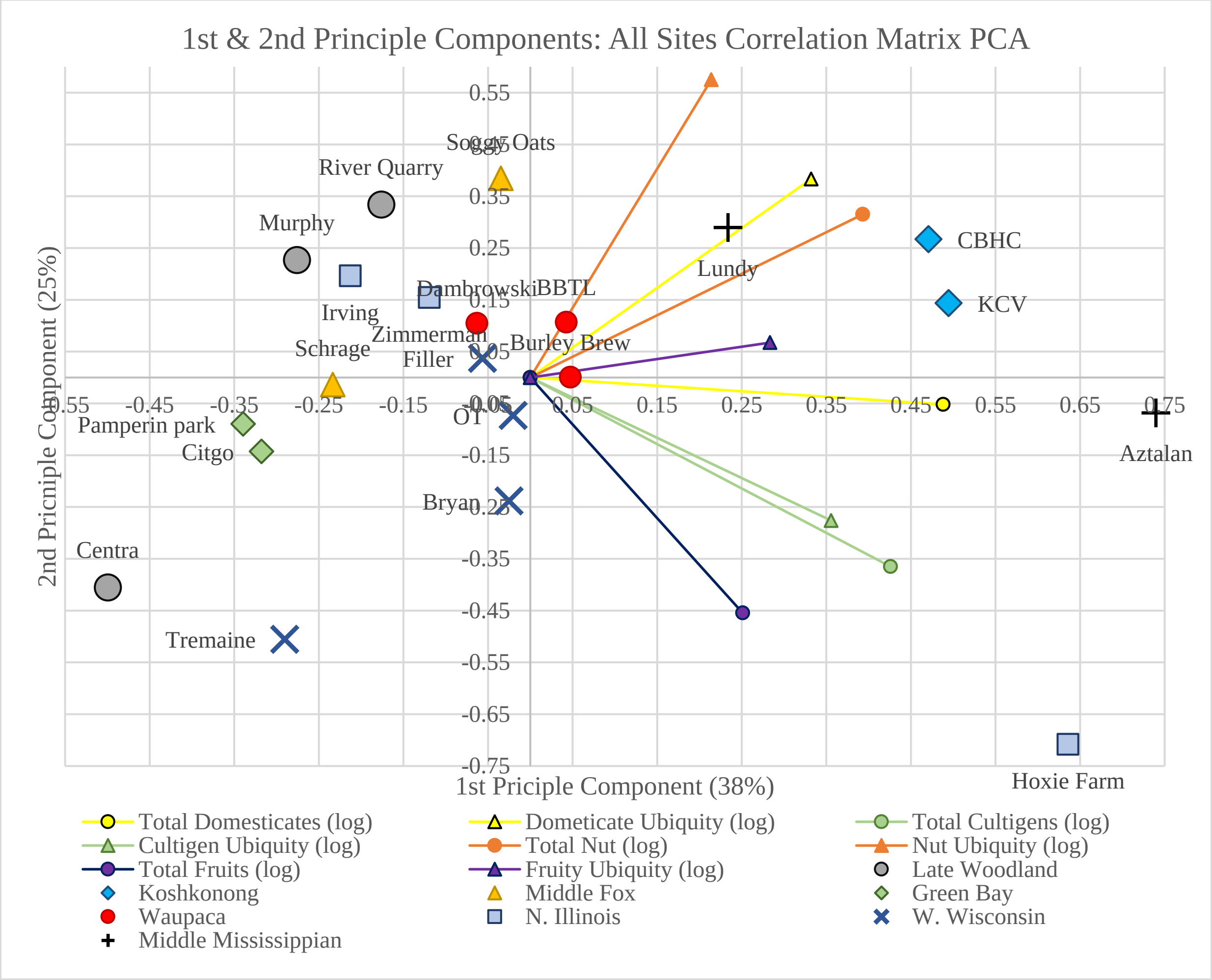


Figure 7.4: First and Second Principle Components: all values standardized with log transforms

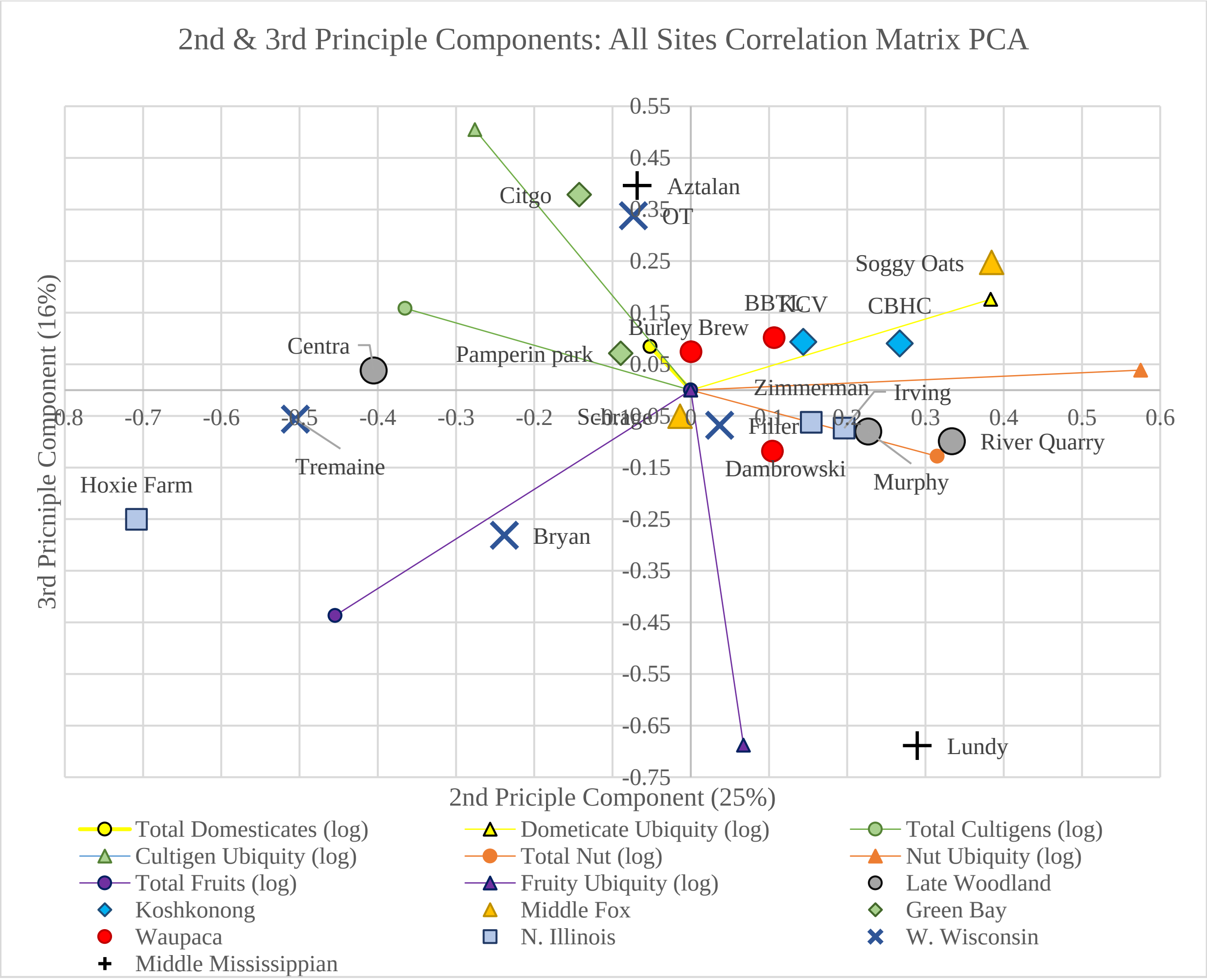


Figure 7.5: Second and Third Principle Components: all values standardized with log transforms

The third principle component (Figure 7.5, y-axis) largely separates sites with greater fruit ubiquities than cultigen ubiquities, though cultigen and fruit density also play a large part. So, sites where fruits are more ubiquitous (e.g., Langford sites) tend to have negative scores. Sites where cultigens are more ubiquitous tend to have positive scores (e.g., Koshkonong). However, sites with very high cultigen densities, but typical fruit densities can get pulled up (e.g., Aztalan) and sites with high levels of both (e.g., Hoxie Farm) get pulled toward the center. In rare cases (i.e., Bryan) very low nutshell ubiquities can pull the value down. One important thing to consider here is that domesticate density is low on both the second and third components. Put simply, the domesticate density is related to the overall density of an assemblage (when there are lots of macrobotanicals, domesticates are dense). Beyond this, domesticate density offers little information about how or why sites and localities vary.

Most of the eastern Oneota sites are all generally near one another, and apart from La Crosse sites, Oneota villages from the same locality tend to group. Generally eastern Wisconsin sites on the right side of the graph and follow the general patterns described above. Except Green Bay sites, eastern sites have a strong pull to the right-side due to their propensity for maize and nutshell.

Koshkonong sites have greater cultigen ubiquity than nutshell, but the combined ubiquity of nutshell and maize, as well as the greater density of nutshell pull them well to the right of the origin. The high cultigen values keep it in the first quadrant. The modest fruit levels do little to affect the score. While maize is important in all Oneota localities (apart from Green Bay), Koshkonong stands out because of its high density and ubiquity of both nutshell and cultigens. As noted before, it is not likely that both were high at the same time. The high nutshell densities are largely from a handful of contexts that may represent times of scarcity during the first half of the regions occupation. Most of the high cultigen density features are from the later-half of the occupation. So, Koshkonong is unique in that it uses both buffering techniques, though not at the same time.

Langford sites are similarly pulled to the right; however, the lack of cultigens at Langford sites also pulls them into the fourth quadrant. Langford sites stand out because of their lack of cultigens, and to a lesser degree their modestly high nutshell ubiquities.

The Waupaca sites are all just to the left of the Koshkonong/Langford sites, though for slightly different reasons. BBTL and Burley Brew have relatively more nutshells than cultigens, pulling them to the right, but their low domesticate ubiquities (60%), pulls them back to the left.

Dambrowski has a significantly lower nutshell density, but the nutshell and domesticate ubiquity, relative to cultigen density or ubiquity help to pull it to the right. Burley Brew is also pulled back to the left because it has a relatively high density of fruit seeds (third highest overall). The Waupaca sites group together because they represent variants on the same theme. They rely on both nutshell and cultigens, though the proportional emphasis is on nutshell (N.B. this does not necessarily mean that nutmeats provided more food than cultigens – these scores are just relative to other sites).

The Middle Fox sites are not well grouped, with Schrage on the far lower left side of the eastern Wisconsin group, and Soggy Oats on the upper right. As a seasonal camp, the assemblage represents two things, food being brought in (likely domesticates) and food being processed (nutshell). This pulls the site to the far right, and while cultigens may not have been plentiful in the assemblage, they outpace fruits, pulling it upwards. Like Burley Brew and BBTL, it has relatively low domesticate densities, and while present in modest densities and ubiquities, Schrage does not have as many nutshell fragments to pull it back to the right. Its cultigens are also quite low, which keeps the site near the origin on both axes. The general pattern noted in Schrage is generally like that seen with Burley Brew.

While in technically in eastern Wisconsin, the Green Bay sites do not fit the pattern expressed by the others. They also break the general trends in noted in the graphs. These sites distinguish themselves with their high nutshell relative to everything else. Despite the high nutshell levels, their low to absent maize pulls them way to the left. The even ubiquity of cultigens and fruits at Pamperin Park helps to keep its y-axis score raised. So, despite the relative proximity of Burley Brew and Pamperin Park, both Green Bay sites represent a unique subsistence system; one where nutshell out represents all other taxa, domesticates included.

Hoxie Farm, the last eastern site, is at the opposite end of the x-axis. Despite the high ubiquity of domesticates, the cultigen levels are high and the nutshell levels low. The high fruit density is also high (roughly five times greater than the second highest) which has a strong leftward pull. The Fisher site then uses the opposite buffering strategy as Langford groups. Langford groups used nuts and not cultigens, with low densities of fruit seeds. The Fisher example has high density of fruits and cultigens, with a high cultigen ubiquity as well.

The Bryan position and subsistence strategy appears similar. Like Hoxie, it has very high domesticate levels, but the cultigen levels are significantly higher than the nutshell levels so it is pulled significantly to the left. Domesticate density has little effect, so their abnormally high maize densities do not pull the sites toward the eastern sites. However, the modest fruit densities are much lower (1/14th) than at Hoxie, so it has a middle position between the Waupaca and Fisher sites. Like Fisher, Hoxie values represent a diet where cultigens are relied on to a great degree, and nutmeats are only a minor resource.

The La Crosse sites are highly scattered. Filler groups closely with the eastern sites, particularly Schrage. Both sites have the similar domesticate ubiquities, and both sites have greater nutshell densities than cultigen. However, cultigens at Filler appear to have been more important. OT represents a different pattern; domesticate ubiquity is low (<50%), cultigen density is high but ubiquity is low, and nutshell is high. Tremaine has low maize ubiquities, which pulls the site far to the left. Its high density of cultigens and low nutshell density pulls it even further over. The relatively high ratio of fruit ubiquity to cultigen ubiquity keeps the y-axis value low. So, Tremaine is a site with little maize and even less nutshell. Cultigens appear to be the most important resource, but its values are not as high as might be expected given the low values of everything else.

Middle Mississippian sites do not cluster together. The PCA suggests that they are at opposite ends of a spectrum of high domesticate utilization. Both Aztalan and Lundy have high domesticate and nutshell densities and ubiquities. However, Lundy is a maize focused subsistence system with nutshell as a backup. Cultigens and fruits are rarely used (31% and 20% ubiquities respectively) and are not used in large densities. While the density of fruits seeds is not high, the proportion of fruit seeds to cultigens is much greater than normal, which is what places Lundy so low on the y-axis. Cultigens are proportionally so unimportant, that even fruit seeds are of comparable levels. However, at Aztalan, cultigens are fairly ubiquitous (50%) and present in the higher densities than any other site. So, while both Middle Mississippian groups focused on a maize centered agriculture, those at Aztalan heavily exploited cultigens and nutshell to bolster their food supplies. Those at Lundy relatively large amounts of nuts, but seem to have largely bypassed the cultigens.

The two collared Late Woodland sites group closely with the eastern Oneota and Langford village sites. The close grouping is largely a product of high nutshell and maize levels coupled with low cultigen levels. In short, the collared-ware diet is very similar to the winter Late Woodland diet. Centra is significantly further away from the other Late Woodland sites on the far-left side of the graph. The first principle component highlighted that it has far fewer materials than all the other sites. However, these two principle components indicate that the composition of the assemblage is also different. Like the Green Bay sites, the leftward position of Centra is largely due to the low domesticate ubiquity, but it is pushed even further left with the low nutshell levels and proportionally large fruit levels. However, the equal fruit and cultigen ubiquity help to moderate its y-axis score. The non-collared ware diet is truly diverse and unfocused; easily distinguished by its low levels of domesticates and relatively even levels of everything else.

Joining the PCA and Isotopic Data: When the isotopic data are joined with the PCA, some minor adjustments need to be made. The following will describe the general subsistence system of each locality in terms of one of the general subsistence strategies: agricultural – with hunting support; agricultural with cultigen support; agricultural with nut support; agricultural with mixed support; mixed economy; foraging.

Without reservation, Koshkonong, Middle Mississippian, Fisher, and Langford sites should all be described as participating in agricultural economies. Based on the floral data, Lundy should be described simply as agricultural, without any modifiers. However, given the isotopic data from other Middle Mississippian sites, it is likely that there were substantial variations within the population. Elites within the society likely had their diet heavily supplemented with meat and possibly cultigens. The lowest ranked members of society likely had a diet consisting of nearly all maize (*sensu* Ambrose et al. 2003). Those with any intermediate status likely saw a greater variety than the lowest ranked members of society but still have a maize focused diet. Because the Apple River Valley had lower population densities than the American Bottom, it is likely that nuts and other wild plants were more widely available than they were in the American Bottom.

Aztalan likely also had a great deal of diversity dependent on one’s position within the social hierarchy. However, the high levels of both cultigens and nutshell suggests that overall there was greater diversity in the diet. Maize still constituted the bulk of the caloric intake, but various cultigens and hickory nuts were used as important secondary resources. The role of meat at the site is not clear, but given the hierarchical nature of the site’s social structure; status was likely linked to meat consumption. Overall, the Aztalan diet looks to have been a diversified agricultural diet.

Koshkonong, Langford, and Fisher groups all appear to have been highly reliant on agriculture, and maize likely contributed similar proportions of the diet (inferred for Fisher as there are no isotopes). However, each group supplemented their diet in unique ways. Early on, Koshkonong groups relied on a mixed support system. Cultigens, namely chenopodium and wild rice were used as supplements regularly. Acorn was also used regularly in low densities and intermittently in mass. The $\delta^{15}N$ levels indicate that these resources were used at the expense of meat in the diet. Meat likely composed only 5-10% of calories consumed. Later samples show that acorn use decreased as wild rice use increased. It is not known if meat use shifted through time. This later subsistence system should be described as cultigen supported.

Langford groups seem to have avoided the use of cultigens (Jeske 1990; Egan 1989), and based on the $\delta^{15}N$ levels, likely supplemented the maize diet with hunting and/or fishing. Both Zimmerman and Washington Irving also suggest that nuts were an important dietary supplement. Domesticate densities at Irving suggest that agriculture may have been less important in the northern Langford hinterlands, though more data are needed before this inference can be made with any confidence.

Hoxie Farm does not have any isotopic data so only the macrobotanical data are available. The high densities and ubiquities of both cultigens and domesticates suggests that the diet was heavily reliant on maize and substantially supplemented with cultigens. Nut meat provided a tertiary resource. This subsistence strategy most closely resembles the late Koshkonong subsistence system, though the nature of the non-domesticate cultivation would have been substantially different. Koshkonong residents relied heavily on wild rice, a plant grown separately from other cultivated plants. Hoxie residents relied on a variety of cultivars; goosefoot most substantially, but erect knotweed was also a commonly used resource. It is not known if Hoxie is representative of other Fisher sites, but as the only one in this sample; Fisher sites should tentatively be described as maize agricultural, supplemented with cultigens.

Red Wing appear to follow a similar pattern as Hoxie and late Koshkonong. Relative to Hoxie, Bryan has similar levels of domesticates, far less nuts, and moderately less cultigens. The δ^{15}N indicate that meat was of greater importance than in Koshkonong, but less than for Langford groups. The δ^{13}C levels indicate maize use was either on par with Koshkonong, if not slightly lower. Regardless, maize was clearly a major component of the diet and the Red Wing subsistence system was clearly centered on maize agriculture, supplemented with cultigens and hunting.

There is no isotopic data for the Middle Fox, Waupaca, or Green Bay localities, so inferences are somewhat more tentative. Maize was clearly important in both Waupaca and Middle Fox localities. However, nuts also appeared to contribute significantly to the diet. Except for Dambrowski, the diet appears to be more mixed agriculture/foraging. Given the difficulties of comparing densities and ubiquities across sites, without isotopes, it is difficult to say what the relative importance of nuts and maize were.

Since Soggy Oats is a nut-processing camp, it is not considered to be representative of the general subsistence patterns in the Middle Fox. Given the regularity with which maize has been found without flotation in the region (e.g., Gibbon 1969, 1971, 1972b; Overstreet 1976, 1981), the large numbers of ridged fields in the region (e.g., Peske 1966; Sasso 2003a), it is difficult to not consider the subsistence system in the Middle Fox maize as agricultural. Based on Schrage, it was heavily supplemented with nuts. Given the importance of this region to Oneota groups and its long occupation span, additional macrobotanical research is needed. Furthermore, isotopes are badly needed to contextualize any such future work so that the subsistence patterns can be described with greater confidence and supporting data. Until then, it will be unclear how important maize was, relative to Koshkonong or other localities.

Dambrowski suggests that the Waupaca locality subsistence system should be described as maize agricultural, supplemented primarily with nuts, and small amounts of cultigens. Burley Brew and BBTL appear to be less focused on maize and more mixed. However, given the interpretation of Schrage and Dambrowski, the Waupaca system should likely be interpreted as maize agriculture heavily supplemented with nuts.

The Green Bay sites appear to be less reliant on maize. Even with the difficulties of comparing assemblages across sites, it is hard to envision the residents at Citgo or Pamperin Park growing maize to the same degree as Middle Fox or Koshkonong groups given the results of this analysis. While it is possible that these sites are not representative of the locality, many other authors have posited that these northeastern groups were less reliant on maize. Overstreet (1997:260) notes that maize kernels are often “lacking from Mero Complex sites.” Given the long-standing contention that maize was less important in this region, there is no data to suggest that these sites are atypical of the Green Bay region.

The La Crosse assemblage is more difficult to interpret. Its macrobotanical assemblage exhibits greater variation than eastern assemblages, though the available isotopes suggest relative uniformity. Perhaps future research that incorporates other La Crosse area sites will shed greater light on this issue. For now, what we can say is that $\delta^{13}C$ indicate similar, if slightly lower reliance on maize at La Crosse than at Koshkonong. The small samples make this inference tentative. The $\delta^{15}N$ values suggest that hunting and/or fishing were more important at La Crosse than at Koshkonong, and likely approached the levels seen in Langford samples. The placement of sites relative to arable land and the construction of ridged fields (e.g., Gallagher and Arzigian 1994; Sasso 1989, 1993) emphasize the importance of agriculture, even where the macrobotanical remains may not. The macrobotanical assemblage suggests that maize was heavily supplemented with cultigens and nut meats, supporting Gallagher and Arzigian's (1994) contention that La Crosse agriculture was intensified through diversification.

Both the isotopic and macrobotanical data support the common assertion that non-collared-ware sites in eastern Wisconsin were primarily reliant on foraging whereas collared-ware sites were more sedentary and practiced either maize horticulture or agriculture (e.g., Salkin 2000; Stevenson et al. 1997, Stoltman 2000). Interpretations of these sites are hampered by their seasonality and a lack of isotopic signatures. However, the data at hand suggests a considerable reliance on maize; perhaps on par with some if not most Oneota groups. In the winter, maize was heavily supplemented with nuts. Based on the pre-Mississippian assemblage at Aztalan and other sites not considered here (Picard 2013), a variety of cultigens were also used throughout the year.

Summary: Except for non-collared-ware and Green Bay sites, maize contributed significantly to the diet at all sites analyzed in this project. Depending on when and where, this important resource was supplemented with a variety of resources. Apart from Fisher and Red Wing, mast resources were an important buffer. The greater diachronic clarity in the Koshkonong assemblage suggests that the importance of nuts as a resource varied through time. The Tremaine assemblage also suggests a similar decline in La Crosse. Tremaine, Filler, and OT are all on the same landform, but were occupied at different times. While the Tremaine component was occupied, nut use decreased considerably. Cultigens were also commonly used as a buffer resource, though which cultigens and to what degree varied. In Koshkonong, goosefoot was used, but wild rice was by far the most important cultigen. By the later-half of the Koshkonong occupation, wild rice was second only to maize. Fisher groups relied more heavily on goosefoot. La Crosse groups relied on a variety of cultigens. Langford groups avoided cultigens all-together. Fruits provided a minor component of the diet and likely a needed variety of flavor. The fruits chosen also varied from group to group. This variation appears to be as much cultural as environmental.

Question 3: Does the Koshkonong Oneota subsistence system reflect that of a group utilizing risk management strategies?

As discussed in Chapter 3, risk management strategies are a necessary part of any subsistence system, but one size does not fit all (*sensu* Kipnis 2002). The nature and types of strategies used can be informative about the source and severity of the managed risks, and the underlying cultural processes (Halstead and O’Shea 1989a, 1989b; Hart 1993; Cashdan 1990a, 1990b). Therefore, we must determine what types of risk management strategies were employed. It is necessary to identify the sources of risk in the Koshkonong Locality.

Environmental risks are ubiquitous, and can range from hail storms, to droughts, and from insect infestations to fungal infections. Moisture is a key factor. To borrow an astronomical term, crops require a ‘Goldilocks’ zone, where moisture levels are just right; neither too much nor too little, the last and first frosts each year must be sufficiently spaced (Doolittle 2002:121). The upland farming practiced throughout much of the Koshkonong Locality would be particularly threatened by drought and killing frosts, which is especially true for the lighter soils that are the easiest to turn with digging sticks (Heidenreich 1978:375; O'Shea 1989:64). While these factors could be mitigated (e.g., drainage ditches, irrigation, ridged fields), it would be a labor-intensive proposition.

In addition to the normal variation, major climate shifts were in motion in the 9th and 10th centuries as the Medieval Warm Period shifted into the Little Ice Age (Lamb 1982; Stahle and Cleavland 1994). In the Koshkonong Locality, temperatures peaked near AD 950 and cooled until AD 1350, near the end of the Oneota occupation of the region (Figure 7.6). July temperatures dropped nearly one degree Celsius before slowly climbing again until roughly AD 1550. January temperatures dropped even more, from -8.5 to less than -9.5 °C (McEnaney and Bryson 2005). For reference, global temperatures have risen 0.8 °C since 1880 (Melillo et al. 2014). In addition to cooling temperatures, annual precipitation and evaporation rates varied widely, leaving the available precipitation fluctuating regularly. This trend occurred throughout southeastern Wisconsin, though to varying degrees (Figure 7.7). Water was plentiful when Oneota groups began occupying the region, but available water fell. By approximately AD 1125,

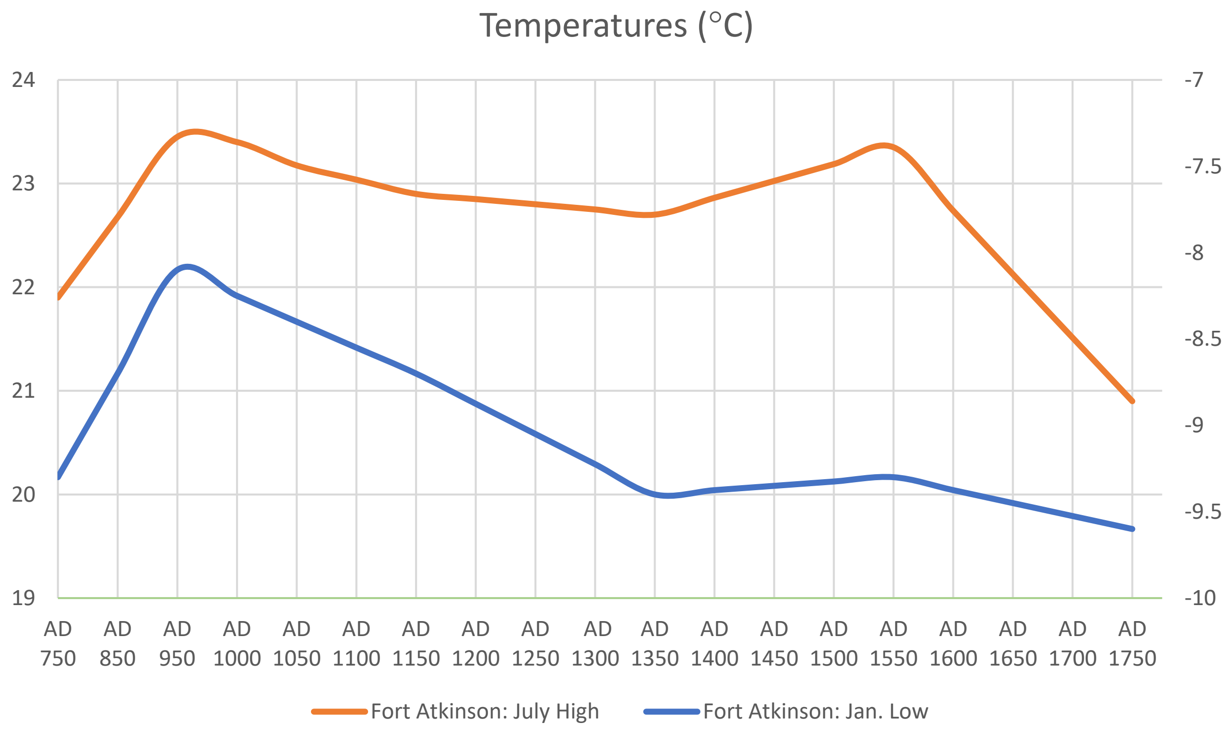


Figure 7.6:Projected mean January and July temperatures(°C) in Fort Atkinson: July temperatures on left, January on right (after McEnaney and Bryson 2005)

drought conditions were likely common. These dry conditions continued for roughly 50 years when water levels slowly began to rise through the first half of the 16th Century (McEnaney and Bryson 2005). It should be noted that these figures show long-term trends, and miss the inter-annual variation which was significant. While the graph shows a 50-year period with falling temperatures and negative rainfall, it does not mean that these conditions were present each year. Dry seasons could occur during wet phases, and the reverse; cold years could be mixed within warm trending phases. It should be seen as a trend for that time period, not a ubiquitous condition.

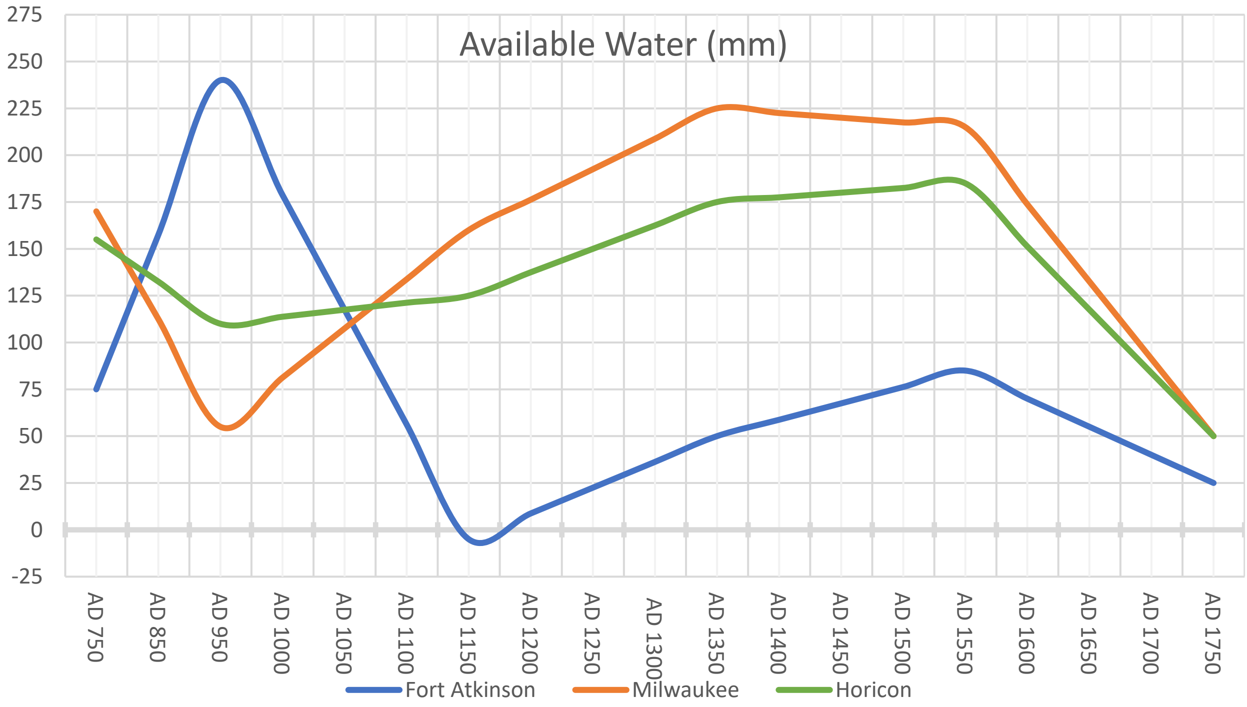


Figure 7.7: Available water (total rainfall – total evaporation) available (mm) in Koshkonong relative to other areas of southeastern Wisconsin (after McEnaney and Bryson 2005)

Environmental risks were not the only issue, the Koshkonong Locality was also subjected to social threats. For approximately the first 200 years Oneota groups lived in the region, the landscape of southeast Wisconsin included three other groups. They include: widely spread non-collared ware producing peoples; scattered collared-ware producing peoples; and one joint

Middle Mississippian/Late Woodland group at Aztalan (Richards and Jeske 2002). Through time, the other groups disappear from the landscape, and it appears that at least some of them may not have gone peacefully.

Relatively few formal burials have been uncovered in the Koshkonong Locality. However, at least one individual died after a violent attack. While formal burials are rare, isolated human remains are somewhat more common (Jeske 2014). One individual at Crescent Bay was shot with an antler-tipped arrow, which chipped the iliac crest of the left innominate (Figure 7.8). The individual was also possibly stabbed several times in the chest. Another good example of violence also comes from CBHC. Multiple elements of an adult cranium were recovered from a refuse pit (Jeske and Sterner-Miller 2014). The cranium showed evidence that it was struck with a blunt

Figure 7.8: Iliac crest with antler projectile in wound from CBHC B12-01

object, potentially a war club (Figure 7.9). These are the clearest two indicators of violence at the sites, but several other burials show evidence of blunt force trauma to the face or other critical regions. In some cases, the evidence of violence is partially obscured by poor preservation (Jeske 2014). Furthermore, prehistoric weapons could often kill while leaving little to no trace on the skeleton (Milner 2005).

When compared to data from Aztalan (Rudolph 2009), the south (e.g., Emerson et al. 2010; Milner et al. 1991; Milner and Smith 1990) and the north (Karsten 2015) a pattern of regional violence emerges. There is no evidence to show who the Koshkonong Oneota were fighting, or how often, but violence was certainly a real threat, at least during certain periods. Even in more peaceful times, they may still have needed to take steps for protection or to minimize contact with hostile groups (Milner 2007; VanDerwarker and Wilson 2016).

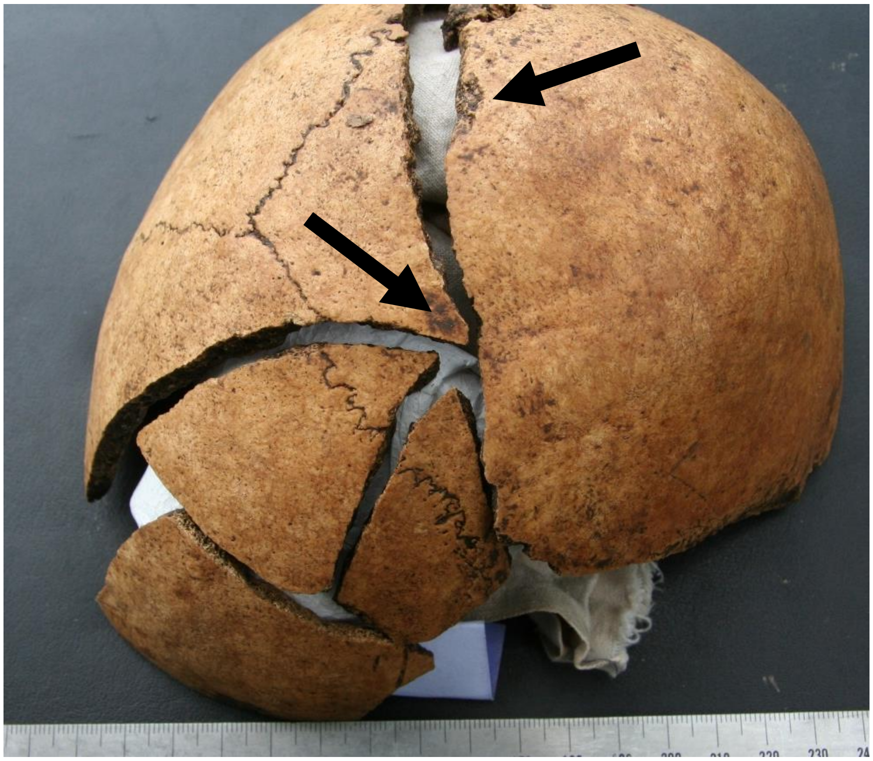


Figure 7.9: cranial elements recovered with evidence of blunt force trauma - from CBHC B14-01

The data clearly indicate that there were several risk factors for Koshkonong Oneota residents. The typical inter-annual environmental variation can require significant efforts to ameliorate (*sensu* Halstead and O'Shea 1989b). When magnified by the alteration of climactic episodes, the environment may have been even less predictable. When combined with the threat of attack, groups living in southeastern Wisconsin would have faced considerable uncertainty and risk factors (Stephens and Charnov 1982). To successfully manage them, similarly extreme management strategies would be required. To understand how these factors affected and interacted with existing social structures and intergroup politics, it is essential to identify what strategies were employed.

3.1– Does the diet in Koshkonong meet expectations of a narrowing diet breadth/increasing focus: through time/compared to Late Woodland groups? Which, if any resources increase through time – aggregated resources or domesticates?

The data comparing Koshkonong sites to Late Woodland sites is somewhat ambiguous, largely due to seasonality issues (see Q2.1a). NTAXA at Koshkonong sites tends to be greater, but this may be due to the long occupational spans of the sites (multiple years vs. seasonal). Using diversity indices, Centra 53/54, the sole non-collared ware site fits expectations. Its diversity indices are significantly higher. Koshkonong, and all other groups assumed to be reliant on maize, have much more focused diet. River Quarry and Murphy both show more focused diets, though being winter occupations, focused diets are expected. The Late Woodland component at Aztalan also has a more focused diversity index; however, the diversity score is largely due to the proportionally large presence of hickory nutshell that depresses its index. Setting aside the nutshell, the diet does not appear to be nearly as focused. Conversely, Koshkonong's joint reliance on maize with a few buffer resources (e.g., wild rice, acorn, goosefoot) pushes the its diversity indices higher. However, an examination of the full dataset indicates that the Koshkonong groups appear to be more heavily focused on maize agriculture (e.g., density and ubiquity) and follow the expected intensification patterns.

Through time the number of identified taxa increases, from 25 in early contexts, to 34. However, the importance of these new taxa is minimal, and the diversity indices show that the diet becomes more focused. Both the Simpson's (0.28 vs. 0.33) and Shannon's (1.75 vs. 1.65) indices indicate that the diet was narrowed as a small number of taxa (maize and wild rice) became increasingly important in the diet. The corresponding reduction in acorn and increase in wild rice can largely be explained the shifting values. Furthermore, at least one of the new species, the domesticate bean, represents a greater focus on agricultural production.

The Aztalan and CBCH isotopes support the interpretation that collared-ware Late Woodland groups consumed less maize than their Oneota neighbors. One of the samples likely predates the Oneota occupation of Koshkonong (2σ cal. AD 901-1026), but two are contemporaneous with the early Oneota dates (2σ cal. AD 1013-1154), and are likely no more than a century older than the two CBHC dogs (2σ cal. AD 1050-1224 & 1156.1228). The highest-maize value from Aztalan dogs is still 5% of protein (0.7‰) lower than the low CBHC dog. There is a roughly 30% of protein (5.1‰) difference between the minimum Aztalan dog and the maximum CBHC. The $\delta^{15}N$ are very close between the two sites, so it does not appear that variation in animal protein should significantly alter the caloric importance of the two samples. While the sample size is small, the data generally support an increased focus on maize for Oneota groups.

The model predicts that maize using groups will intensify and focus their diet on agricultural and/or locally aggregated resources. Relative to Late Woodland groups, Koshkonong sites appear to intensify both sets of resources. Koshkonong has much higher densities and ubiquities of maize and potentially cultivated cultigens. Even if goosefoot and wild rice are thought of as wild plants, then they represent wild aggregated resources which were exploited more intensively. Through time, this process continues in the Koshkonong Locality, the reliance on aggregated non-maize resources continues, with the increased reliance on wild rice, which becomes more abundant (from 4.2 to 14.3 ct./10 liters) and proportionally greater.

The model also predicts that some highly-ranked resources may become over exploited, their rank will drop, and that high ranked resources with large variances will be dropped in favor of lower variance resources. One highly ranked resource, acorn, did drastically drop in rank. Overall nutshell, falls from an average of 38.2 ct./10 liters and 0.23 g/10 liters to 4.45 ct.10/liters and 0.04 g/10 liters. Acorn specifically falls from a mean of 27.42 ct./10 liters and 0.11 g/10 liters to 1.78 ct./10 liters and 0.01 g/10 liters.

It is unclear if acorn became less important because of an intentional choice to intensify wild rice harvests, or as a result of resource depression (e.g., from deforestation). However, I find it likely that a combination of both factors came into play. Nuts and wild rice harvests can fluctuate from year, in some cases wildly (Gardner 1997; Vennum 1988). Given the size and range of available habitats in and around Lake Koshkonong, and its historical prevalence in the lake, it is probable that a portion wild rice stands were productive in all but the worst years (Lapham 1855). It is also possible to cultivate larger and more productive stands. Methods could range from the relatively low-labor practice of spreading seeds, to the much more labor-intensive practice of tending the plants much like one would an agricultural field (Jenks1908; Vennum 1988). So, while wild rice may have had unpredictable variances, it may have been a manageable task to limit the size of the shifts.

Conversely, oak husbandry, while possible, is much more labor intensive and often less effective. It requires a great deal of time to implement, and even more time for the labors to bear fruit, because many trees only produce nuts every few years. It requires clearing the competing flora around each oak tree, which reduces competition. But humans have a limited ability to reduce the effects of fluctuating water levels, or other issues that affect mast production. So, without clearing around and protecting numerous oaks in multiple edaphic settings, it is unlikely that yields would increase significantly (Gardner 1997). If such a task is undertaken, it is possible that the productivity of other resources would be depressed in the process. For example, if oaks are near the edge of a grove, clearing around them would reduce the availability of many berries which prefer forest edge habitats. Furthermore, if oak was used as a building material or firewood, then over the centuries of occupation of the Koshkonong Locality, the number of oak trees would decrease which would reduce the available acorns for harvest. So, acorn represents a resource that would have been prevalent in the area, but deforestation would have slowly increased the search time for the food while its variability would have made it a risky resource on which to depend.

Both wild rice and acorn would have had the additional risk of competition from animals. Historically, birds often were a threat to wild rice harvests (Vennum 1988). However, the birds it drew to the lake could have helped hunters acquire them. Simultaneous waterfowl population control and food procurement could have been advantageous bonus to wild rice harvesting. While birds are not particularly plentiful in the Koshkonong assemblages (Agnew et al. 2016; Edwards 2013; Edwards and Pater 2011; Van de Pas et al. 2015), most of the birds identified have been waterfowl (McTavish, personal communication). Squirrels, deer, and other animals are often competition for nuts, though they would not act as an aggregating draw to the same degree as wild rice (Gardner 1997). So, as acorns fall, foragers would have needed to immediately harvest them; which could conflict with maize harvests.

Comparatively, wild rice harvests are more conveniently timed, and therefore more forgiving to the crowded autumn scheduling. Many stands of wild rice will ripen before the second (i.e., non-green corn) harvest of maize, and will continue to ripen over the course of several weeks. A single stalk will produce numerous seeds, which will take 1.5-2 weeks to ripen, and the peak harvest time is the first half of September (Wisconsin DNR 2016). Therefore, it may be possible to obtain large amounts of wild rice without sacrificing labor to the maize harvest. Furthermore, if labor is needed elsewhere for a day, or even a week, the wild rice stands will likely still be producing significant quantities of wild rice when labor is once again available.

The variance of the macrobotanical assemblage supports acorn as a riskier resource. In early contexts, the acorn count variance was over 3,400. The wild rice variance ranges from 20 to 250. While later contexts exhibit considerable wild rice variance, it is still a fraction of the acorn variance. Acorn density is quite low in later contexts, 7.2 ct./10 liters, but relative to the mean (VMR = 4.0) it is still variable, and is present in low enough quantities that it may not represent intense harvesting, but opportunistic gathering while obtaining fire wood, checking traps, or other tasks in wooded areas.

Given the sharp drop in acorn levels, and the corresponding rise in wild rice, I argue that two of the model’s expectations are met. Due to deforestation (i.e., resource depletion) and inherent risk, Koshkonong groups chose to reduce their reliance on acorns and instead intensified their harvests of wild rice. This may have corresponded with increased efforts to cultivate the plant, though this cannot be confirmed with archaeological data. The model predicts that resource depletion will lead to one or more high-ranked resources dropping in the resource ranking or out of the diet breadth. Acorn remains part of the diet breadth, but after AD 1200 it does not appear to have been a significant resource. Oak trees fit both the expected criteria for a dropped resource; they take many years to grow and there are often years between substantial nut crops (slow regeneration) and represents a risky food source (high variance).

The corresponding rise in wild rice also fits expectations that over time aggregated resources would rise in importance. Wild rice is a highly-aggregated resource, and while its risk levels (variance) may not have been ideal, they were lower than acorn and could have been mitigated though cultivation methods of various intensities.

The model also predicts that reliance on agriculture would increase through time. This expectation is not well supported. The bean is introduced, suggesting that a new facet was added to the agricultural repertoire. However, given the poor preservation potential of beans, it is difficult to judge the importance of a single definitive specimen. It indicates greater agricultural diversity, but not necessarily intensity. Goosefoot levels remain the same. Squash levels are too low do determine a baseline much less a change.

Maize is somewhat ambiguous. The densities of maize kernels in early and late contexts are statistically no different ($p=0.49$, $df=18$). Generally, this would indicate that maize use did not increase through time. However, other changes are present. The proportional importance of maize increases from 46 to 54% of the assemblage. Later contexts have significantly more maize cupules. One potential cause is a shift in maize processing techniques. If so, it is possible that the new technique resulted in proportionally fewer maize kernels preserving.

The diversity indices also suggest a narrowing of the diet breadth. It is not clear if this represents an actual increased production in maize relative to other plants, or just a proportional rise with static production levels. The maize kernel to wood charcoal ratio, which assumes the amount of wood burned is proportional to population size suggests that there is no significant change (Miller 1988). The ratio for both early and late contexts is 0.013 grams of maize for every gram of charcoal. So, the density of maize did not change through time. The ubiquity of maize did not change through time, and we do not have appropriate isotopic data to investigate further. Currently, the data indicate that the importance of maize remained constant through time, while the overall focus on agriculture grew, at least modestly, with the addition of beans. The increased focus on wild rice narrowed the diet, and can still be interpreted as increase reliance on cultivated plants. Overall, the expectation of localized intensification is met; though only partially.

3.2: What evidence is there for storage?

Both Crescent Bay and KCV have numerous pit features, most of which are clustered near house structures. Between the two sites, a total of 147 pits have been identified, with approximately 1,000 m^2 excavated (Table 7.13). Features account for 11% of the total area excavated. Feature depth varies significantly, from a few centimeters beneath the plow zone, to over a meter. This likely represents only a fraction of the features present at the site; approximately 3% of Crescent Bay has been excavated and 0.3% of KCV. So, there is considerable evidence that pits were regularly constructed, but it is not clear how many were used for storage or how many were used concurrently. Of the 147 pits, 25 were classified as shallow basins, i.e., <10 cm below plow zone (Moss 2010). The size of these pits suggests that they were not used for storage, but their original depth is unknown. Some areas, particularly the northern portion of CBHC, have been truncated by plowing and subsequent erosion. Pits that appear shallow may have been moderately deep. Discounting shallow basins, there are still 112 pit features that are large enough to have been used for storage. However, in each case, in the terminal stage of the pits' uselife, they were either emptied or filled with refuse. Therefore, it is possible that at least some of these larger pits were never used for storage.

Table 7.13: Features relative to area excavated

	Excavated	**Features**				
	Area (m^2)	**No Features**	**Total Area (m^2)**	**Mean Area (m^2)**	**Features: Excavation**	**% area**
CBHC	831.6	115	88.7	0.8	0.14	11%
KCV	159.7	32	23.7	0.7	0.20	15%
Total	991.3	147	112.4	0.8	0.15	11%

Estimating intensity is also problematic. Based on ethnographic accounts, each family likely had more than one cache pit at a time. Based on Buffalo Bird Woman's recollections, each extended family household, of roughly 15 people, had four storage pits. In total, they contained roughly one-year's food and were used for many years (Wilson 1917). So, we should expect several pits associated with each house. The number can be expected to grow if the house area was used for longer than a feature's uselife, so it is difficult to set a baseline for the number or sizes of features. In Koshkonong, it is unclear how large households were, so the number/size of features cannot be easily compared to ethnographic examples. The features are often superimposed, creating a difficult palimpsest to untangle. Further complicating the issue, neighboring features can be separated by several hundred years. Given these factors, it is unclear how many storage pits were in use at a given time. So, it is difficult to determine the total amount of storage available to each household. However, given the ubiquity, number, and size of features, storage was important but cannot be further quantified.

3.3 Is there evidence for the employment of other risk management strategies?

The data support interpreting the physical and political environments in the Koshkonong Locality as risky. Thus far, several predicted risk management strategies have been identified: intensification; storage; exchange; raiding. Rather than broadening the diet breadth through diversification, Koshkonong groups focused on agriculture, wild rice, and acorn. These aggregated resources were stored in large cache pits. There is evidence of limited interaction with other Oneota groups, and possibly some Late Woodland ones. However, this interaction does not appear to have been regular or significant. Evidence also suggests that intergroup violence was a reality to the Koshkonong population; though it is unclear who attacked them, or which group was the aggressors. The evidence does not directly indicate that they raided others. However, the cyclical nature of warfare in the Late Prehistoric suggests that if attacked, Koshkonong groups would have retaliated (Dye and King 2007; Emerson 2007; Milner 2007; Snow 2007). Even if raiding acted as a poor buffering strategy, i.e., did not bolster food reserves (*sensu* Halstead and O'Shea 1989b), the cyclical nature would have limited the viability of other risk management strategies (Hart 1993).

Mobility: As noted in Chapter 3, an examination of mobility patterns should provide insight into the nature of relative risk severity. An examination of the settlement-subsistence data support social risk aversion as the primary threat in the Koshkonong Locality. The Koshkonong settlement system is the flattest, i.e., least numbers of site types, and most physically constrained of any Oneota locality examined. Neighboring groups to the south (Langford), west (La Crosse and Redwing), and northeast (Green Bay) used seasonal mobility, special purpose campsites, and others to increase catchment ranges or otherwise expand their presence or control of the landscape.

To use La Crosse as an example, the use of hamlets to expand access to arable land, inland extractive camps to procure resources, and the relocation of villages to more sheltered regions in the cold season marks a high degree of logistical mobility and a modest degree of residential mobility. In times of intergroup conflict or resource scarcity, each trip to a logistical camp represents an opportunity to be ambushed by opposing groups. Each hamlet represents a vulnerable target where people can be killed and resources stolen or destroyed. The fact that the La Crosse groups were willing and able to take such risks indicates that the risk level was acceptably low. Researchers have demonstrated that when there is a significant and persistent threat of attack people tend to constrict their catchment ranges and take defensive postures, even when it has negative impacts on health and social relationships (for worldwide archaeological, historic, and ethnographic accounts see VanDerwarker and Wilson 2016a). Regionally, such actions are most evident in the Central Illinois River Valley, where both Middle Mississippian and Oneota populations severely altered subsistence practices and landscape use patters with serious health consequences (Milner 1991; Milner 2007; Milner et al. 1991; VanDerwarker and Wilson 2016b).

The dispersed nature of the La Crosse settlement system should not be conflated with a low-risk for intergroup hostilities. The evidence clearly indicates there was. The construction of palisades throughout the region are solid indicators that the people were concerned about attacks (Sasso 1989; Stevenson 1985). Skeletal remains indicate that conflict resulted in severe injury and death, and dismemberment of numerous individuals (Blaine 1979; Holtz-Leith 2006). Sasso (1989:283) suggests that the aggregation of population near La Crosse was a response to the risk of attack. Strength in numbers was an important aspect of the defensive strategy. Perhaps the large numbers of people in the La Crosse Locality, which based on site density was likely several times larger than Koshkonong (Wisconsin Historical Society 2011), provided a sense of safety to work parties venturing to extractive camps and those living in hamlets. And it may have been a sufficient deterrent to justify the security.

It is also important to note that most of La Crosse's occupation span is post-AD 1400. As noted in Chapter 2, at or just after AD 1400 most Oneota localities were abandoned, the Middle Mississippian occupation at Cahokia was abandoned, and Late Woodland groups have vanished from the landscape. Populations are largely aggregated in La Crosse, Middle Fox, and near Chicago/Calumet area. These large buffer zones may have provided sufficient additional security to justify the broader settlement system. When regional conflicts flared, populations could retreat to the more defended village locations and return to their dispersed pattern when it ebbed (Brown and Sasso 2001).

In contrast, the Koshkonong groups were clustered on the landscape surrounded by three different cultural groups. Compared to La Crosse, these neighbors were physically close. Even if populations were smaller, the presence of so many groups would have increased competition for land and resources. This competition could breed easily breed hostilities in lean times (Halstead and O'Shea 1989; Keeley 2016; Wilson and VanDerwarker 2016). Such competition likely accounts for the relatively small number of Oneota sites in the region, the placement of villages on defensible locations, and the placement of many extractive sites between, rather than beyond the main villages. If each Oneota village at KCV, Carcajou Point, and on the CBCH ridge (either CBHC, Schmeling, or Crabapple Point) were simultaneously occupied, it would create a defensive perimeter around the highly productive lands between the sites, thereby minimizing risk and territorial footprint while maximizing subsistence potential. Trips outside of this perimeter were apparently few or very short, as there are only four potential logistical camps outside of the core Oneota territory (see Figure 3.7). Koshkonong residents did not travel away from their villages or establish small-scale habitations in the same way that La Crosse, Langford, or Red Wing groups did (Fleming 2009). While the risk of an ambush or raid was real in each area, the Koshkonong groups appear to have reacted the most strongly. Of the expected responses to raiding (Table 7.14), Koshkonong exhibits all the predicted responses that can be readily seen in the archaeological record. Clear palisades are the only exception – Carcajou Point is the only site that has shown any potential evidence of a palisade (Overstreet 1978). Furthermore, it does not show clear evidence of redoubts, ditches, or other characteristics that could clearly indicate the features were defensive (Keeley et al. 2007). The locality does show evidence of population aggregation in defensive locations and restricted movement on the landscape (see also McTavish 2016). Unfortunately, it is not possible to see seasonal shifts in labor, increased weaponry, or flight from enemies with the available archaeological data.

Table 7.14: List of common responses to raiding present in Koshkonong Locality

Responses to raiding	**Present**
Palisades – especially with redoubts	?
Settlements in defensive locations	x
Aggregated populations	x
Restricted movement on landscape	x
Seasonal scheduling of labor for defense	?
Increased evidence of weaponry	?
Fleeing region from enemy	?

This pattern is true for all the Oneota regions in this study. While groups to the north of Koshkonong (i.e., Waupaca and Middle Fox) may not have moved villages seasonally, their settlement networks are still more diverse and far reaching. In the Middle Fox, numerous site types (e.g., nut processing sites like Soggy Oats) have been identified throughout the region; many are far from the apparent core-habitation area near the major lakes. Either the greater number of people in the region (based on site density) or their relationship with neighbors made the Middle Fox residents feel sufficiently safe to venture away from their main villages (Wisconsin Historical Society 2011).

The Waupaca system is less clear, but still shows the same pattern. The village sites are located away from arable land and major lakes or wetlands. This suggests a willingness on the part of the Waupaca Locality residents to travel further from home to obtain resources than Koshkonong groups. Given the high-levels of maize, it appears that the resources were being exploited to a similar degree. This required farmers to travel longer distances from villages. The site distribution is also more dispersed than in Koshkonong. Nearly six kilometers, as the crow flies, separate Burley Brew from Blinded by the Light. This does not include other sites in the locality that did not have comparative floral data, which are even more dispersed. On the other hand, Carcajou Point is separated from Crab Apple Point by less than 3,500 meters, with Crescent Bay, Schmeling and Parnell in between.

The Koshkonong groups appear to have limited mobility, even by Oneota standards. While other Oneota groups used dynamic settlement systems, the Koshkonong system was relatively flat, with much of the labor occurring at or near to the main village sites. For example, there are several small sites (e.g., Blue Heron) located between the bluff-top Crescent Bay/Schmeling sites and the wetland shores of Koshkonong (Hunter 2003). These sites have yielded low densities of Oneota sherds and no evidence for features. They likely represent small work sites or short-term camps.

The only example that appears more extreme is Aztalan. Unlike Koshkonong or other hinterland Middle Mississippian localities, no network of allied villages has been established for this Middle Mississippian site. The only other site with appreciable numbers of sherds is Bethesda Lutheran home, located 15 km away, which consists of series of features with approximately 10 Lohmann phase vessels (Hendrickson 1996). Like Koshkonong, subsistence resources appear to have been heavily exploited from the area immediately surrounding the site. While Koshkonong had a flat settlement system of several sites, Aztalan’s apparently consisted of a single large, heavily-fortified village. The two samples with the most extreme violence avoidance settlement-systems are very close. Their proximity and corresponding defensive postures is not likely a coincidence. The lack of trade goods between these two close neighbors is striking. The prevalence of trauma on skeletons in both areas is notable. The lack of exchange suggests that these were people in disconnected social networks. If they were connected in such a manner, then there should be some evidence of interaction (trade, marriage, fictive kin). And despite decades of research in both localities, nothing suggesting trade has been found. While there is some symbolic overlap (Schneider 2015), the designs are distinct and are more likely to represent different ideas about how to portray regional ideologies (Edwards and Jeske 2015). Intermarriage or shared ceremonies should include greater similarities (e.g., Hart et al. 2017; Stone and Downum 1999). In these dissociated conditions, even if no blows were ever exchanged between these two groups, the presence the other would have been a significant risk. Add mobile foragers and semi-sedentary farmers to the list and both groups would have had ample risk of developing boundary disputes if they utilized the same settlement systems used by other Oneota groups (Allen 1996; O'Shea et al. 2002; Stone and Downum 1999).

However, these other Woodland groups were present throughout eastern Wisconsin in the 11th through 13th centuries (Stevenson et al. 1997). Aztalan is the one variable that Middle Fox, Waupaca, and Green Bay groups would not have had to contend with, at least not to the same degree. The extreme behavior must have begun in large part from the Middle Mississippian complex on the Crawfish. However, the pattern continues into the 14th century after the abandonment of Aztalan, and the disappearance of Late Woodland groups from the landscape. It is possible that those in Koshkonong felt threatened by other Upper Mississippian groups for the entire occupational span. Research by Jeske and colleagues (2016, 2017) has demonstrated that the Koshkonong Locality is the most isolated Upper Mississippian group in Wisconsin or northern Illinois. In Wisconsin, all Oneota localities are connected to all other Oneota localities at the 30km level. That is, the boundaries of each locality are either within 30 km of another, or there are intervening sites separated by no more than 30 km. The Koshkonong Locality sites are each further than 30km from any other Upper Mississippian sites, including in northern Illinois. Even a series of sites in along the Wisconsin River connects La Crosse/Red Wing sites with the eastern localities.

In summation, the identified settlement system in the Koshkonong Locality indicates that the residents felt that the threat of an enemy attack was greater than the threats posed by environmental risk. They apparently felt threatened more than most other groups examined as they restricted mobility to a significant degree. This threat is visible for the entire occupational span of the region. It is unclear if other Upper Mississippian groups were consistently seen as a threat, and what role Aztalan and Late Woodland groups played in creating the stress-induced response on the part of the Koshkonong residents. It is likely that the political situation in the region evolved through time and the Koshkonong residents' political networks shifted. However, the perception of a threat was ubiquitous; so even in times when violence levels were low the Koshkonong settlement system remained unchanged.

Diversification: While the Koshkonong risk-management repertoire does not include the most obvious form of diversification, the broadening of diet breadth, it does include several diversification strategies, primarily agricultural ones. Spatial diversification is one means of reducing inter-annual variance (Marston 2011:192-193), often referred to as field distribution or scattering, is among the most reliable diversification methods (e.g., Goland 1993; Marston 2011; McCloskey 1972, 1991; Winterhalder 1990).

Crop Diversification: Agricultural diversification was also achieved through crop diversification, a common practice worldwide (e.g., Marston 2011). During the early portion of Oneota occupation of the Koshkonong Locality, maize and squash were both grown. These crops have different growing lengths and nutritional needs so the loss of one would not necessarily lead to the loss of the other. Radiocarbon dates confirm that beans were added to the ensemble by no later than AD 1400. Using all three crops could provide additional calories, and the squash and beans would have provided needed variety of nutrients to a largely maize based diet. For example, beans could provide necessary amino acids lacking in maize (Kaplan 1965:360), in addition to the well documented benefits of growing all three plants in the same field (Gallagher 1992; Gallagher and Sasso 1987; Hart 2008; Harwood 1979; Monaghan et al. 2014; Mt. Pleasant 2010; Mt. Pleasant and Burt 2010).

It is impossible to know specifically how the three plants were grown together in the Koshkonong Locality; if grown in the same field (intercropped), grown separately, but rotated through the same fields (sequentially cropped), or if there was no overlap. However, the intercropping and sequential cropping account for the bulk of historic and ethnographic accounts; when sufficiently detailed, historical accounts of intercropping is nearly unanimous, though ethnographic accounts from the Plains are less consistent. There, beans and maize were often grown together, but squash was separated (Doolittle 2002;144-145,156-157). Given the ubiquity of the two systems and the benefits that they engendered, it is likely that one of the two systems were used prehistorically.

According to Doolittle (2002:145), intercropping two or three plants is not an easy task. It requires effective timing given the variation in growing season. The need to stagger either planting or harvest and work around the growing crops can increase labor requirements up to three-fold. If Doolittle’s assessment is accurate, this was a costly system, but given its historic ubiquity, it likely paid for itself through greater crop yields. If so, it would have reduced the need for field fallowing, allowing for larger plantings and greater harvests for longer periods. These harvests would apparently include healthier crops and a more nutritionally diverse diet. Given the proportionally large role of maize, the long occupation of the locality, and the stability of maize in the diet such a system would have been essential. In fact, intercropping or some level of crop rotation would almost certainly have been necessary in order to maintain high maize yields for the roughly 400-year occupation span.

It also appears that diversification was achieved through diversifying the maize itself. Historically, many types of maize were grown in the Eastern Woodlands (Cutler and Blake 1969; Doolittle 2002; Fritz 1992; Hart 1999; Hurt 1987; King 1994). Based on the angle, it is possible to differentiate the number of rows, and at least approximate some of the different types of maize grown. While charring affects the angle, it typically does so in a predictable manner (King 1994). Because of the overlap in the number of rows in various maize breeds (see Cutler and Blake 1969; King 1994), in the Midwest, they are generally divided into two types: low-row flint with northeastern origins, and high row pop with southern origins (e.g., Fritz 1992). Both high row and low row varieties have been identified at both KCV and CBHC confirming that this diversification strategy was used. However, because the specific breed cannot be determined, I am wary of making any more specific claims about the merits of either type or the proportions in which they were grown.

Classification of Diversification Strategies:

When we examine the risk management categories: diversification, mobility, storage, exchange, raiding, and intensification, there is solid evidence for several. Mobility is the least established by the evidence. Those with the strongest evidence appear to have been part of what O'Shea (1989) referred to as simple diversification systems because they do not include outside groups. It includes the regular variant (i.e., occurred regularly) such as storage or intense agriculture. It also includes simple episodic strategies, or those that occur when agricultural outputs are insufficient.

Simple Strategies: For example, diversification through field scattering, intercropping, etc. would have occurred regularly. Low level diversification through the consumption of berries and other minor components would have been an annual affair. Higher level diversification, such as fish, acorns, and wild rice may have been regularly present but episodically intensified. In the case of the latter two, acorn harvesting begins as episodic and ends regular; where wild rice harvesting begins as a regular strategy and ends as episodic. While the plants are used as a regular buffering mechanism, they are consumed in relatively lower amounts than their episodic peaks. During these low times, variance is low, indicating that they were a consistent part of the diet. During the episodic phase, variance jumps to levels at least 50 times greater. In short, the plants have baseline use levels, but from time to time, the amount spikes. At this time, I cannot conclusively demonstrate that high acorn or wild rice values are directly correlated with low amounts of maize, but the PCA generally supports this pattern (Clusters 3, 4 and 5 in Chapter 4). In most cases when maize levels are low, nutshell or wild rice levels tend to increase.

Conversely, it appears that storage was consistently a regular strategy. Storage pits would have been used to store surplus all year. Additional stores may have been held within the houses themselves. Intralocality exchange was likely regular, though it likely would have intensified in times of need so long as the resource failure did not affect everyone in the locality.

Complex Strategies: Two types of complex strategies are defined: intergroup trade and raiding. The evidence of both are limited, and it is unclear how often either system was used. While the threat of raids apparently elicited a significant response, it is unknown if they occurred often. Given the large quantities of agricultural materials recovered, they did not prevent people from completing their essential tasks (Stone and Downum 1999:123). Even if Koshkonong groups were raiding regularly, it seems unlikely that they could successfully steal and transport significant quantities of food. The evidence of exchange is also limited; while it is notoriously difficult to archaeologically assess the success of trade on buffering, there is little to indicate that it was substantial.

What trade did exist is of an unknown nature. According to Gibbon (1995), we should expect local trade to include pottery, nets and storable foods. Of these, nets are unlikely to survive, and the food would be indistinguishable from the local. A total of 30 sherds, less than 0.1% of the 43,000 sherds examined from the Oneota sites at Koshkonong are identified as Woodland, making up a total of seven vessels (Schneider 2015). Of those, one is a surface find at the multi-component Schmeling site, and one is from shallow contexts at KCV, near the base of the plow zone. Of the remaining vessels with solid context, two are from Crescent Bay and four are from Schmeling; hardly enough to suggest any significant trade or interaction. Neither Aztalan nor any Koshkonong sites have any ceramics from the other. Fisher inspired ceramics are present in Schneider's (2015) assemblage, but are about as rare as Late Woodland sherds.

The presence of Oneota pottery at a Late Woodland site in the Madison lakes/Yahara River region 25 km to the west of Crescent Bay, suggests a low-degree of interaction between Koshkonong and Late Woodland groups, or a later expansion from Koshkonong to the Yahara River. For regional trade, Gibbon (1995) argues that manufactured goods or raw materials are also common trade items. The ceramic similarities with Oneota groups to the north also suggests some degree of interaction. There similarities suggest at least low-level interaction but not necessarily what would be expected if the exchange was a major facet of a subsistence strategy. Other manufactured items might include stone tools. However, at CBHC 75% of the stone tools, made from identifiable material, are from local stone (Sterner 2012). At KCV, the values are even more biased toward local production, 96% (S. Wilson 2016). A number of copper artifacts have been recovered from excavations at CBHC, Schmeling, Carcajou Point, and KCV, and copious amounts have been collected through metal detection at the Crab Apple Point site (Pozza 2016). These may represent long distance procurement or trade with groups in northeast Wisconsin, based on Laser Ablation Inductively Coupled Plasma Mass Spectrometry (Hill and Jeske 2011). Alternatively, some or all may have been made from (float copper) carried down by glaciers and left in glacial till. Regardless, the totality of the materials recovered suggests that very limited exchange took place between Koshkonong and outside groups. The final type of trade item in the Koshkonong Locality is galena cubes, which would have come from the southwest, near the modern borders of Illinois, Iowa, and Wisconsin. Galena cubes have been identified in several seasons from Crescent Bay (Schneider 2015:126) and one cube was identified in the 2017 season at KCV. There is little reason to think that the trade for copper or galena was an important aspect of a complex buffering strategy.

Summary: The sum of the risk management strategies indicate that the Koshkonong subsistence system was locally focused. Plants like wild rice and maize were available in the immediate vicinity of the sites, and their productivity could be heavily influenced through human action, and account for the bulk of the diet. Resources that were less available reduced in importance. For example, as larger tracts of land were deforested, hunting of large game like elk would be pushed further from habitation sites and hunting them would become both costlier and more dangerous. Isotopic analyses apparently to confirm, as $\delta^{15}N$ levels indicate relatively low levels of meat consumption by cal. AD 1150. Floral resources that would decrease with forested land also become more scarce (e.g., acorn).

3.4: What details about life in Koshkonong can be inferred from the chosen risk management strategies?

Taken together, the data begin to point in a single direction. The Koshkonong Oneota were relatively isolated. This seclusion was part of reinforcing cycle. The isolation required simple risk management strategies. Simple strategies can encourage isolation because they are only possible when a group maintains territorial integrity (O'Shea 1989; Stone and Downum 1999). This need placed a feedback loop into the cycle which encouraged the continuance of the isolationist system. This lead to profound impacts on intralocality organization, interlocality interaction, and the subsistence-settlement system

Territorial Integrity:

By definition, simple systems require a high-degree of self-sufficiency. That is, simple systems do not include outside groups so the bulk of necessary resources must be provided directly by group members (O'Shea 1989). This self-sufficiency provides a larger measure of stability and flexibility because they do not rely on the cooperation of outside forces, and can adjust practices from year to year. However, they have a limited ability to buffer against severe or sustained localized issues. The strength of a simple system comes from its ability to control or significantly manipulate the local conditions. If other groups are granted or create access to the territory, then that control is lost. If groups cannot protect their farm fields, rice beds, populations, etc., then their ability to influence their production and harvest level is compromised. If other groups enter at will, to take or destroy resources, risk-management strategies fail. Agricultural intensification fails if crops are destroyed, diversification fails if foragers are harassed or foods are stolen. Storage fails if harvests are destroyed or caches looted.

Therefore, boundary security would have been essential for survival in the Koshkonong Locality, but physical security needed to be balanced with food security. Site placement is reflective of these dual requirements. Physical security could be achieved through multiple means; often through total population aggregation. Milner (2007) notes that Iroquoian and proto-Iroquoian groups who were subjected to intense warfare deployed some of the most elaborate and substantial stockades in the Great Lakes region. Historically, each tribe was concentrated in one or possibly two villages (Allen 1996; Bamann et al. 1992). In both circumstances, the reaction to outside threats was to aggregate onto a central position of the landscape. This was often coupled with sizable buffer zones (≥30km) separating one group from another (Lambert 2002; Milner 1999). By aggregating into a single large village, the greater populations offered strength in numbers and acted as a deterrent to attack (Stone and Downum 1999).

The Koshkonong group used an alternative approach; their villages, as many as six, were spread across a 10km^2 area. So, why do some groups aggregate on the landscape and others spread across several sites? I suggest that the nature of the Koshkonong risk management strategy necessitated a different tactic. While the single-settlement system increased physical security, it also increased the risk of catastrophic crop failure or destruction at the hands of an enemy (O'Shea 1989). A single site may be good for defending the people and stores within, but its ability to control the landscape around the site is reduced. By concentrating everyone in a central location the ability to spot or quickly respond to an attack is reduced.
Koshkonong's isolation induced a dual need for boundary control and adequate subsistence; dispersing settlements across the core territory could do both simultaneously. This safety is

derived from the distribution of the population. Dispersed sites increase visibility of the surrounding region by giving the occupants clear lines of site (McTavish 2016). These clear lines of site can discourage small scale attacks and decrease response times if the enemy is spotted. However, it leaves each site more susceptible to a large-scale attack.

The region that would most benefit from the site distribution is the area between them. I argue that this region was the core subsistence area for the locality. I do not to argue that the area beyond was not hunted, farmed, fished, etc. Rather, distribution of sites created dual resource rings. The outer ring represented a greater risk, both in terms of physical safety for the people, and the likelihood of resource destruction. The inner ring represented a safe-zone, a core region where resources could be better protected, which is essentially another form of risk-buffering, or at least a system that could enable more efficient risk buffering. Because of the additional security, the inner ring could be utilized more intensively at a lower risk. For example, agricultural fields could be concentrated in this region. The sites' placement would allow for fields to be established on diverse soils, which would help maintain yields. The outer ring could still host fields, or act as a wild resource catchment area.

By maintaining security, the system could have added increased dietary stability, but this would create a need to maintain this settlement-system. So long at the risk of a large-scale catastrophic attack remained sufficiently low, each village would have been relatively safe. A central bread-basket would have routinely provided a strong subsistence base. But any deviation from this would have increased risk. Further spreading of villages would make them easier targets; further concentration would reduce the collective group's ability to diversify and make their fields more vulnerable to attack. Such a system would have necessitated considerable intralocality communication, coordination, and cooperation.

Intralocality Production and Exchange:

The only way that many of the diversification strategies would work is if people and food were moving among the sites, which is supported by some data. KCV residents had access to backwater and creek resources (Edwards 2010) but still consumed large quantities of fish that came from the lake (McTavish and Edwards 2014). Occupants of Crescent Bay, Schmeling, Parnell, and Carcajou Point could have kept them from gaining access to the lake–both overland or via the creek–but they did not. Some mechanism allowed KCV inhabitants access to lake fish.

In addition, the distinct soils among sites would only have buffered loss if the areas that produced more shared with those that produced less; which would require food moving among the sites. The defensive strategy would only work if the people at each site cooperated with one another. So, what social mechanisms allowed for the food to transfer from one site to the other, and what long-term effects could this generate? Understanding the means of production is key.

Households were likely the basis of subsistence production in the Koshkonong Locality. Given the physical scale and intensity of the agricultural system, household level production is sensible and cross culturally common (Bogaard 2005). Global ethnographic accounts of foragers suggest that large packages of food (e.g., meat) brought in by men are more likely to be shared than small packages of plants foraged by women (Kohler 1993). In short, when agriculture is the domain of women, household production is the norm (Flannery 2002). In the Eastern Woodlands and Great Plains, the bulk of ethnohistoric and ethnographic accounts suggest or imply household production to be the norm for agriculturalists (e.g., Doolittle 2002; G.L. Wilson 1917). Most cases where supra-household groups directed subsistence activities were in ranked-societies with chiefly leaders. In these cases, households controlled a portion of the fields, and another portion were communal; the surpluses from the shared field were stored in communal structures (Scarry and Scarry 2005). The archaeological evidence also supports household production back into the prehistoric. There is no evidence of a communal storage facility at KCV, CBHC, or any other Koshkonong site which indicates that larger political or corporate groups did not control production. Rather, storage pits tend to cluster around habitation structures. Household storage is consistent with household-scale production and risk pooling. Societies that practice group level production and risk pooling, even those with non-communal housing, tend to have a shared storage system so that supplies and distribution can be assessed by everyone (Weissner 1982:174). The clustering of storage facilities around Koshkonong structures is consistent with household production and storage.

So, food and other goods needed to be exchanged among Koshkonong sites to take full advantage of the diversification practices. If household level production was the norm, then households themselves would have to be integrated into the intralocality exchange network. Again, ceramics are a good place to start (e.g., Gibbon1995; Schneider 2015) The stylistic ceramic data suggest close ties among the sites' occupants (Carpiaux 2015, 2018; Schneider 2015). Compositional data indicate that a portion of the pots moved from one site to the others (Schneider et al. 2012). Schneider (2015:360) has suggested that such intralocality exchange should be expected to flow through kinship lines (real and fictive) via reciprocal exchange, and Carpiaux (2018) demonstrates a series of very large cooking vessels indicative of large-group cooking, that could be part of Schneider's proposed exchange systems.

Despite field scattering, variation among household output is to be expected, which would leave some households with less food. In particularly poor years, food supplies may be insufficient. Reciprocal exchange within extended families can help to balance these issues. If families at different sites are connected through kinship, then the full power of the risk-management strategies could be utilized. Halstead and O’Shea (1989b) also argue that such an internal exchange (sensu Gibbon 1995) between sites can only be reliable if imbedded within permanent social structures. Otherwise, risk management systems are “prone to fall into disuse because of the infrequency with which they are activated… [so] there is a strong selective pressure for them to become increasingly embedded within more regular cultural practices,” (Halstead and O’Shea 1989b:5). The costlier the risk management strategy (in terms of lost efficiency), the more embedding the strategies are necessary. The Koshkonong system came with costs associated with time management and maintaining interhousehold cooperation.

To maintain intralocality distribution networks, the exchange would necessarily occur with and without subsistence shortfalls. The kinship lines would need to be embedded with a degree of mutual obligation that would bind the members together and create an expectation of generosity (Mauss 1990). Acts, such as regular feasting can ensure that over production is maintained and routinize the idea of sharing with extended kin (e.g., extended families, clans, or moieties).

The ethnographic and ethnohistoric accounts are filled with descriptions of feasts, which extended-family groups, often clans, were mandated to hold, either annually or for particular occasions (Blair 1911; Densmore 1979; Keesing 1987; Kohl 1985; Lurie 1966, 1978; Radin 1923; Skinner 1921). For example, Radin (1923) recounts several annual Ho-Chunk feasts for renewing war bundles, medicine bundles, and numerous other occasions of clan-held feasts. Typically, each clan had their own distinct feasting traditions; so not only would they serve to bond the members partaking, but could also serve to symbolically separate those from other feasting networks. Other ceremonies, such as the Thunderer chief’s health ceremony, included people from all clans. In each of the ceremonies, the responsibility for the hosting was typically held an individual, but his relatives each had responsibilities for providing certain types of support. The end result, was that extended families were expected to sit down, engage with one another face to face, and in the process, reaffirm the reciprocal bonds that they held with each other, which is evidenced in the KCV ceramics (see Carpiaux 2018).

Risk Management Strategy/Subsistence Shifts

One strength of the simple risk management systems is their flexibility (O'Shea 1989). As environmental conditions shift, so too can the subsistence practices. However, the regular use of certain risk management strategies can also increase the importance of the social institutions that house them, leading to yet other changes (Halstead and O'Shea 1989b). Following this assertion, if reciprocal familial exchange did become an important aspect of the intralocality exchange, then there should be a shift in the importance of extended kin networks.

Subsistence System Shifts:

The above noted shift from acorn to wild rice as a primary buffer is the biggest example of a subsistence shift, which expected given the local focused risk-management strategy. If the residents were following efficiency models, the deforestation noted in section 3.1 above, should occur most intensely near the villages (Lee 1969; Vita-Finzi and Higgs 1970). Not just because the firewood would be easiest to gather from there, but because agricultural fields placed near the sites (for efficiency and/or defense) would necessitate tree clearance from much of the area around the sites. The inner ring would receive a greater proportion of these activities, both because it is a safer area, and closer to all sites (i.e., more efficient), whereas the outer rings are only near to only one site. This would lead to increased rates of deforestation than in the outer regions. As an aquatic resource, there would be no competition over space between wild rice and agriculture. So, if no actions were taken, the efficiency of wild rice should remain the same, while the efficiency of mast resources should decrease. Because wild rice output can be intensified with relatively minimal effort, it is even more advantageous. That is, harvests can be increased without significantly expanding foraging range, not only increasing the marginal efficiency of the plant, but also its safety factor.

The shift in the cupule: kernel ratio and increased density of maize cupules, coupled with the consistent maize kernel density, may indicate that this pattern shifted after AD 1200. The increased cupules indicate that a greater amount of maize was processed on site. While the model predicted an increase in agricultural production, there are several functional reasons that this may not have been feasible. In the Central Illinois River Valley (CIRV), maize production remained stable, even as warfare forced groups to withdraw from territories away from major villages (VanDerwarker and Wilson 2016b). There, it is thought that all the available arable land within a safe distance of the village was in use, so intensification was not possible. In fact, if field areas cannot be expanded then some researchers have suggested that we should not expect to see an increase in intensity.

> Finally, the history of agriculture should not be seen as an inexorable linear progression of increasing intensity: if the earliest agriculture was itself labour intensive, further intensification in later periods is unlikely, and any increased production is likely to have been through other processes, such as expansion and/or extensification. The direction, as well as the rate, of change may have varied, depending on the prevailing economic and cultural conditions at different times and places, and the possibility of reversals in the direction of change should be entertained, with agriculture becoming more or less intensive depending on local circumstances. (Jones 2005:174)

So, if the threat, or perceived threats to safety in the Koshkonong Locality did not diminish after the abandonment of Aztalan, then there is little reason to expect an increase in maize output. Per Jones (2005:174), intensification without physical expansion of fields may have been too labor intensive. Benn (1995:120) indicates that the increase labor investment took place during the Late Woodland, with the adoption of maize. Without significantly larger populations or a drastic reorganization, increased labor investments may not have been feasible. VanDerwalker and Wilson (2016) suggest that Middle Mississippian groups in the CIRV may have had to increase labor to maintain productivity, otherwise the minimal fallowing periods would have reduced the overall productivity. In Koshkonong, shifting labor from the fields to the rice beds may have been the better choice. The marginal return on increased labor investment for wild rice would have been relatively high (Jenks 1988) and could reduce wild rice variance. So, if food production could be intensified more efficiently by shifting to wild rice, then there is no reason to expect that maize would be intensified.

The shift in kernel: cupule ratio (Table 7.15) appears more extreme than it is. Overall, in the early dated contexts, maize cupules are relatively rare, accounting for less than 25% of maize recovered. Cupules become much more common in later contexts, accounting for roughly half of the identified maize. However, this distinction is in large part due to KCV F12-01 which has a large sample so it has a strong impact on the overall early ratio. When all of the samples with radiocarbon dates are plotted, a general negative trend can be seen, but it is not as extreme as the dichotomous view suggests (Figure 7.10).

Table 7.15: Kernel: Cupule Ratio through time

Time-Period	**Kernel Count**	**Cupule Count**	**Ratio (ct.)**	**Kernel Weight (g)**	**Cupule Weight (g)**	**Ratio (wt.)**
Overall	9,749	8,147	1.20	84.13	74.30	1.13
Early	4,241	1,661	2.55	35.58	13.50	2.64
Late	3,229	2,711	1.19	28.47	22.60	1.26

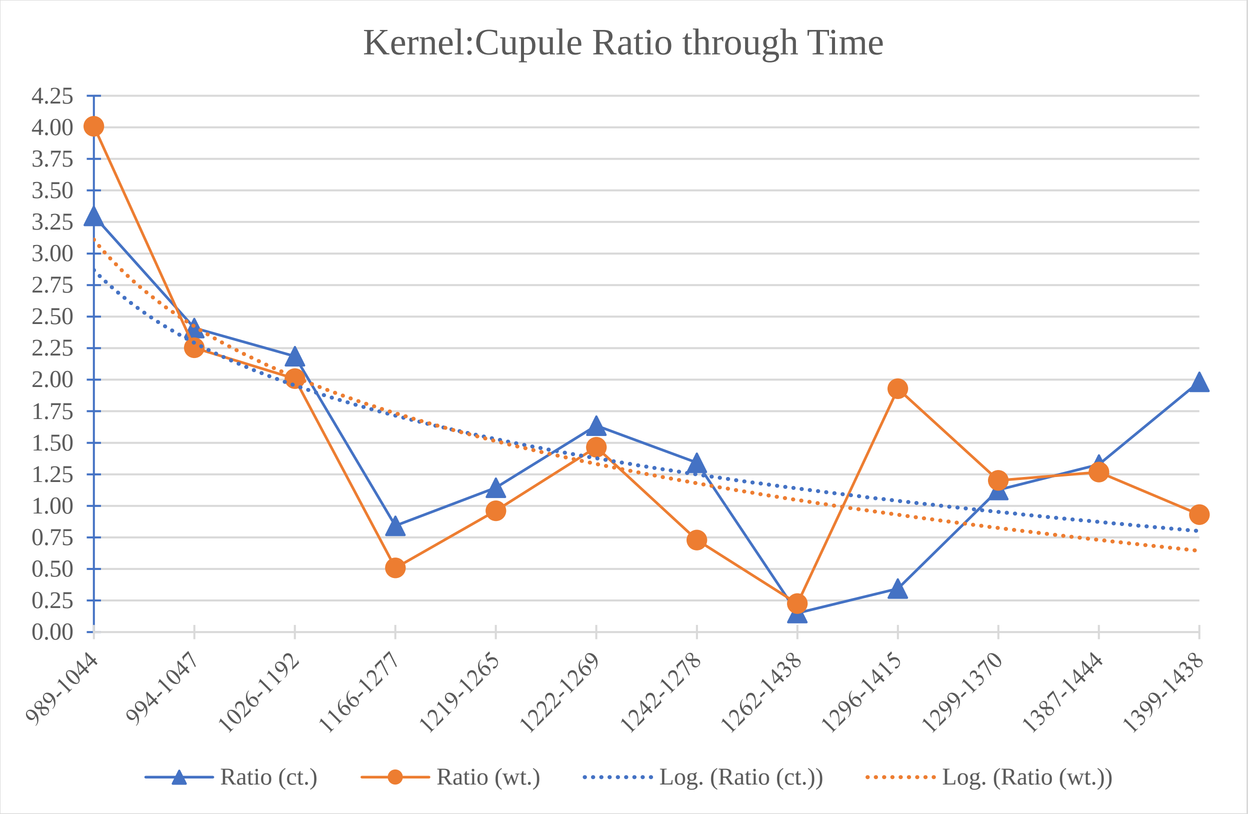


Figure 7.10: Kernel to cupule ratios through time - including linear trend lines (dotted) – includes samples with at least 100 maize fragments

While the increase may simply be related to the deforestation. As firewood became increasingly scarce, maize cobs were used as fuel more often. However, maize cobs are much less dense than wood, and is unlikely to make a significant impact the required firewood volume. The second potential explanation is related to increasing hostilities. If violence was increasing, then the farmers may have reduced the amount of time spent away from the protection of the village. Processing the maize at home would help to do this.

Little is known about the nature of violence trends in the Koshkonong Locality. It is unclear when it started, if it became more severe through time, if it fluctuated, or dissipated. However, there are some basic indicators that can be used to draw inferences. For example, Aztalan is occupied by Middle Mississippians from roughly AD 1100 until shortly after AD 1200 (Picard 2013; Richards and Jeske 2002; Zych 2013). Given that the palisade was burned multiple times and the skeletons show evidence of violent trauma, it is likely that escalating violence was a contributing factor to the site's abandonment (Goldstein and Freeman 1997; Rudolph 2009). To the south, Milner and colleagues (1991) indicate that major violence begins at roughly AD 1300 with the regional movement of Oneota populations. Finally, the entire Koshkonong locality is abandoned shortly after AD 1400, it is unlikely that the root causes sprang up overnight. Rather, their roots are likely in the preceding century or even centuries. So, there appears to be a general trend towards increasing violence, with potential flare-ups around AD 1100 when Middle Mississippians arrive, and potentially again at AD 1200 when they depart. AD 1300 may have also seen an uptick in violence as people to the south began to move about the landscape, though it is unclear what impact it would have had as far north as the Koshkonong Locality.

While the kernel to cupule ratio trends downward, it also fluctuates. Several of these fluctuations do seem to align with the times of expected jumps in violence; however, it is dangerous to definitively associate these two. First, the vagaries of the radiocarbon record make it difficult to determine the actual order of pit usage; many have a considerable overlap at the two-sigma level. Second, there are several reasons for the potential shifts, which can include seasonal variation, pit function, among others. For example, KCV F12-01 is likely the earliest dated pit in the Koshkonong Locality. It has the highest ratio of kernels to cupules (3.3 ct. – 4.0 wt.); but individual zones within the pit vary from Zone-M with a ratio of 0.7 by weight to Zone-L with 8.1 by weight. Therefore, I will limit my interpretations to overall tends. The proportion of cupules tends to increase through time; this indicates that people processed more maize on site, which possibly reflects increased perceptions of threat in the region.

Summary: The three shifts indicated above suggest that the general practice of local-resource reliance, boundary maintenance, and minimizing travel away from village sites increased through time. While maize agriculture did not increase, wild rice use did which is indicative of greater reliance on aggregated resources (rice over acorn) and may indicate that maize levels could not be realistically increased without increasing the distance between villages and fields. The ratio of kernels to cupules also indicates that people were doing more activities at the villages, which is consistent with responses to increasing violence. While these practices would help to maintain physical safety, and could minimize inter-annual production variance, they increased the chances that a regional climactic episode could have devastating effects. In short, the emphasis on local resource procurement enhanced physical safety, but a severe drought or large-scale hail storm could have devastating impacts. In such situations, only significant storage and a well-developed social network could help to ameliorate the effects.

Social Shifts:

Halstead and O'Shea (1989b) have asserted that social institutions with embedded risk management strategies are subject to change. If reliance on the strategies increase, so too does the reliance on that institution(s). If subsistence strategies need to be altered, it will require alterations to the social institutions for the subsistence shifts to take place. As described above, the kin networks were heavily integrated into subsistence and risk management systems. Households were integral in organizing labor pools, particularly during planting and harvests. Intra-locality exchange would have proceeded through extended kin networks. Households would have managed surplus. Essentially, kin networks were integrated with the subsistence and risk management strategies at almost every level. Therefore, it is likely that Koshkonong kin networks underwent alterations or transformations as subsistence systems shifted and risk management techniques were altered. Many such shifts may be archaeologically visible, though our ability to recognize them within the archaeological record may be limited.

One common area of speculation is in gender relations. Given the gendered nature of the subsistence system, Oneota researchers have often argued that the rising role of agriculture would have increased the status of women in society (e.g., Hollinger 1995; O'Gorman 2010; Overstreet 1981). As agriculture (women's labor) became increasingly important relative to hunting (men's labor), the role of women shifted in society, potentially even resulting in a shift to matrilineal/matrilocal residence patterns.

Others, such as Benn (1995) have argued that Oneota marks a shift in the other direction. In the Late Woodland, there was relative gender balance, but women's influence began to wane as territorial disputes lead to increasing warfare. He argues that violence was in-part present because warfare was codified into the male role. Snow (2007) makes a similar point about Iroquoian groups to the east. For Snow, warfare was the primary form of male social currency. For a man to raise his station or earn the right to marry, he first had to prove his capabilities as a warrior.

There is insufficient data to determine the relative roles of men and women within the Koshkonong Locality. However, the locally focused intense settlement system would have created a new gender dynamic. The increasingly important role of women in the economic sphere could have raised their status, particularly if they were able to control access to the agricultural surplus as did Iroquoian women (Heidenreich 1978). However, the social and economic importance of the physical security, likely provided by men, may have offset any gains. In addition to warfare, hunting may have become a form of costly social signaling for men (e.g., Bliege et al. 2005:226; Gmelch 1992; Hawkes1990). Ethnographically hunting was not only considered a male activity, it was often tied with male status (e.g., Radin 1923; Skinner 1921). In the case of the Koshkonong Locality, overhunting of animals within the core area could have happened relatively quickly, which means that a portion of the hunting expeditions would have to occur at a distance from habitation sites. Given the distance and threat of attack, a successful hunt could have performed a similar role as a war party in generating social capital (e.g., Snow 2007). It is beyond the scope of this dissertation to follow out this line of inquiry any further, but it should be noted that the subsistence practices did not operate in a vacuum. They would have impacted and in return been impacted by intragroup power dynamics.

If intragroup exchange was a significant factor, then it should be reflected in the importance of extended kin networks. Carpiaux (2018) has noted that F12-06, a late feature (circa AD 1400) has more very large vessels (>40cm orifice diameter). These very large vessels are also found in earlier features, though not with the same frequency. Orifice diameter is often thought to be associated with the number of people being fed, so increases in vessel size is either associated with larger households where more mouths are being fed on a regular basis, or feasting where large numbers of people are being fed intermittently (Betts 2006; Blitz 1993; Turner and Lofgren 1966). The increasing number of large pots at KCV may be associated with larger households; however, the feature also contains many examples more typically sized pots (<35cm orifice diameter) suggesting that much of the cooking was for a single household, but larger pots were occasionally needed to cook for a bigger group, such as for feasting (Carpiaux 2018).

The ceramic data suggest that feasting may have increased in importance through time; though additional research is necessary to confirm. If so, this supports my contention that feasting served as a mechanism to encourage overproduction of food and maintenance of intralocality kinship networks. Through time, the accumulation of shortages would reinforce the need for intersite food sharing, labor pooling, and overproduction whenever possible. Therefore, feasting may have occurred more often to reinforce the social bonds that facilitated these actions, or feasting may have included larger groups (e.g., entire moiety instead of only clan) of people to increase the efficiency of such cooperative networks. The movement of pottery among sites is another example of intralocality exchange. While petrographic data show movement, the data cannot demonstrate if its intensity changed through time (Schneider et al. 2012).

Question 4: Does the Oneota subsistence regime support a relationship between cultural complexity and agriculture?

Despite the long-held belief, the data do not support a relationship between agriculture and cultural complexity. The macrobotanical and isotopic data agree, Oneota groups ubiquitously grew substantial amounts of agricultural crops and subsisted heavily on maize. Maize likely constituted between 45 and 75% of the caloric intake for Koshkonong residents. By any reasonable metric, they were agriculturalists. Yet, their social organization shows no evidence of measurable hierarchy, leaders appear to have influence rather than power, and settlements are not organized into chiefly networks. Furthermore, there is no evidence of monumental architecture, or extreme population densities.

In a systematic analysis of burials from eastern Wisconsin Oneota and Langford sites, Foley Winkler (2011:170-171) argues that they “have a relatively egalitarian socio-political structure” and continues to assert differences among burials are the result of horizontal social differences, not vertical ones, “representing an egalitarian system with achieved social status.” She argues that corporate group membership (e.g., clan or lineage) likely cross cut all other identities and accounts for much of the variation in the burial data. Brown (1967) also argue that larger corporate identity affected burial characteristics; they suggest that a phratry or moiety system are evidenced in Langford burial practices. So, burials contain evidence for extended family networks and corporate level control, but nothing suggests that one corporate group has greater control than all the others.

Oneota groups also lack any evidence of monumental architecture. The closest example is burial mounds, such as found at Walker Hooper, which were morphologically no different form conical Woodland era mounds (Gibbon 1972; Jeske 1927). Langford sites are often associated with mounds (e.g., Brown 1967; Fowler 1940; Griffin 1948; Langford 1927), though there is nothing to suggest any serious level of centralized social control. Certainly nothing like what is present in Middle Mississippian contexts (Emerson 1991, 1992, 1999; Goldstein and Freeman 1997; Green 1997; Griffin 1967; Pauketat 1994, 2004; Young and Fowler 2000).

Settlement systems also show marked difference in levels of political stratification. Middle Mississippian sites show highly hierarchical multi-tiered settlements, with differing levels of political control and access to religious infrastructures at each tier (Emerson 1992; Fowler 1978). While some Oneota settlement systems are complex and multi-faceted, they do not contain this embedded hierarchical power structure. In La Crosse, hamlets appear to be associated with major villages (Sasso 1989), but there is no evidence that the settlement system was established in a manner that would allow for the control of people, ceremony, and labor through it. While simpler relative to the American Bottom, even most hinterland Middle Mississippian localities (e.g., Central Illinois River Valley and Apple River) use a version of this system (Emerson 1991). Oneota localities are often at the opposite end of the power continuum; for example, in the Koshkonong locality, it appears that the settlement system was more heterarchical than hierarchical. There is no evidence that one site had more political or religious control than the others.

The total weight of the evidence demonstrates that Oneota represents a lifeway or series of lifeways that emphasizes achieved status over ascribed. Political power is dispersed over multiple corporate groups rather than funneled through one. These are sentiments shared by many (e.g., Benn 1989; Gallagher and Arzigian 1994). And yet, they are maize agriculturalists, with agricultural goods accounting for at least half of their diet. When cultigens are included, that proportion rises precipitously. While possibly never reaching peak Middle Mississippian levels, many members of Oneota societies consumed as much or more maize as a large portion of people in Middle Mississippian societies. To grow sufficient maize would have required the mobilization of large portions of the labor force. Every spring and fall, essentially every able-bodied woman would need to be at work in the fields for long hours each day. Every time a new field would be cleared, the male labor was likely included. With such agriculturally reliant diets, and agriculturally focused subsistence systems, the egalitarian nature of these groups appears to contradict the commonly assumed relationship between agriculture and cultural complexity.

Defining Agriculture and its Effects

If reliance on agriculture is not a good measure of cultural complexity, what is the relationship between them? Price and Bar-Yosef (2011:S171) argue that agriculture involves "changes in the structure and organization of societies," and that it is "a totally new relationship with the environment. Humans truly begin to harness the earth… farmers utilize the landscape intensively and create a milieu that suits their needs." They continue (2011:S172) to identify factors that they see as important to the development of agriculture which include sedentism, population density, resource abundance, constraints of movement (social or geographic), processing/storage technology, and last on the list wealth accumulation and argue that competition would often lead to wealth and status differentiation at the individual or household level. Their description of agriculture fits the situation in the Late Prehistoric midcontinent well.

Social groups reorganized from the mobile hunter-forager system of the Effigy mound builders, to the somewhat more nucleated collared ware producers and the much more sedentary and nucleated Oneota groups (Richards and Jeske 2002). This would have required a shift in labor organization to accommodate the changes in resource availability and the greater sedentism (Benn 1989, 1995).

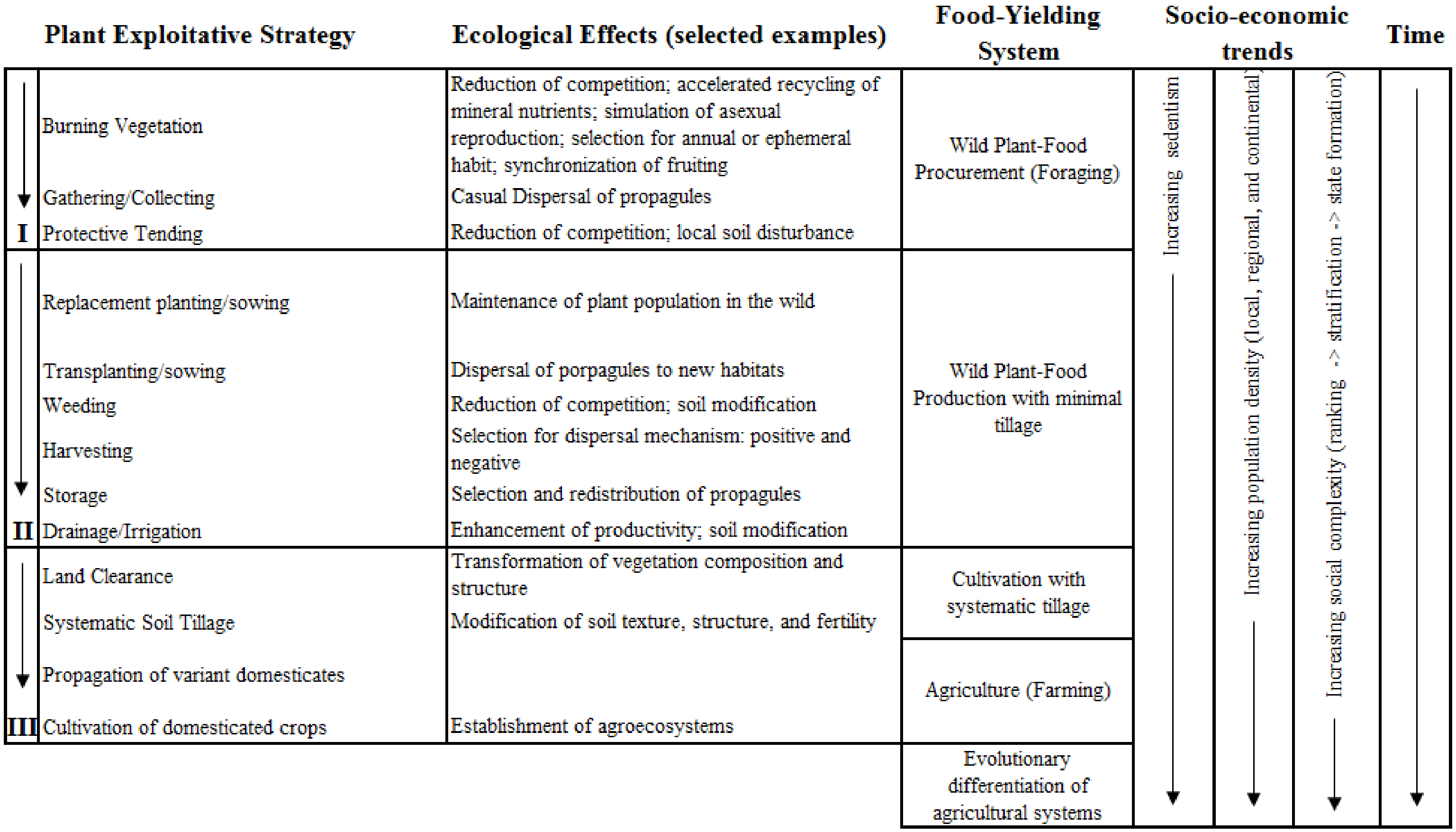
It also represents a new relationship with the environment. People were no longer moving across the landscape regularly. Some of the first year-round sites in the region were occupied during this transition. Landscapes had to be cleared, burned, and modified to a degree that was never needed previously (Wagner 2003). So why does Middle Mississippians, and groups in the Near East and elsewhere so often develop social inequality (Price 1995)? The one variable missing in the Oneota sites is evidence of wealth accumulation. For some reason, it appears that Oneota groups do not allow, or outside factors prevent, any single household or lineage from obtaining greater levels of wealth or power. This difference is reflected in the isotope variances. An examination of the standard deviations shows that Oneota groups consumed maize and meat at much more equal levels. The Oneota samples with the lowest δ^{13}C received roughly 20% less protein form maize than the highest. This pattern is consistent among most Oneota localities. And while a 20% difference is not insignificant, it is only a fraction that is typically seen within any single Middle Mississippian site. Mississippian elites were able to control access to meat and other alternatives to maize. As a result, the non-elites in major sites like Cahokia and their lowland farming hamlets had access to few other resources (Ambrose et al. 2003). The non-elites in the hinterland sites fared somewhat better, as their distance from the major towns afforded them greater access to nuts, berries, and other wild resources (Hedman et al. 2002).

Maize is present and important in both Wisconsin/Northern Illinois and the American Bottom prior to the development of this complex system or the appearance of Oneota groups on the landscape. Late Woodland groups in both areas ate maize extensively (Clauter 2012; Egan-Bruhy 2009; Emerson and Titelbaum 2000; Green and Nolan 2000; Jeske 1992; Johannessen 1993; Kelly 2002; Munson 1987; Rindos and Johannessen 2000; Salkin 2000; Theler and Boszhardt 2000). Both groups were undergoing the transition to a maize based subsistence system concurrently, yet developed distinct forms of surplus management and political leadership. So, the transition to a maize based economy cannot be the driving factor. Perhaps different population densities or ideologies were at work.

Perhaps one of the reasons we do not see the expected ramifications of such a monumental shift is because we are over simplifying the transition, and reducing it to the dichotomous agriculture or non-agricultural (Smith 2001). Smith (2001:3-4) states that because of this dichotomous approach, “scholars will attempt to categorically relegate or displace to one side or the other any anomalous in-between societies.” When societies are grouped in such ways, it can mask variation within patterns and trends. A great deal of research has been spent trying to understand what Smith (2001) calls the Middle Ground, the continuum between those who rely entirely on wild foods and those that rely entirely on domesticated ones. But even recognizing that there is a middle ground does not necessarily eliminate our biases. For example, Harris (1989) develops an evolutionary framework to understand the transition from forager to agriculture (Figure 7.11). However, the assumption that agriculture requires social ranking or stratification is built into the model.

A comparison of Oneota agricultural practices with the model belies this assumption. The first criterion of Harris’ level three is land clearance resulting in altered vegetation compositions.

The oak savannahs surrounding most eastern Oneota sites would have necessitated clearance. Wagner's (2003) research indicates that clearance though fire may have been occurring since the Archaic, and Dorney and Dorney (1989) suggest that the oak savannahs may have actually been the product of regular fires. The second criteria: systematic soil tillage that modifies soil texture, structure, and fertility. The construction of corn hills is assumed to have occurred in many locations. This action is accomplished through a tilling like action and has many of the same benefits but with reduced effort (Doolittle 2002; Hurt 1987). Other Oneota groups went to the next level, and constructed ridged fields. These large features certainly modified the soils and provided numerous benefits to fertility (Gallagher and Sasso 1987; Gallagher et al. 1985, 1987; Riley and Freimuth 1979). The third criteria, that which distinguishes cultivation from agriculture, is the production of domesticated crops, especially the production of different varieties of domesticated crops. Oneota groups, and even their Late Woodland ancestors produced at least two varieties of maize. In the pre-Mississippian occupation of Aztalan, both high and low row variants have been identified (Picard 2013). Using other definitions of agriculture often produces a similar result; Oneota groups were agricultural. In the system developed by Zvelebl (1996), agriculture is any system where domesticates and cultigens



	Plant Exploitative Strategy	Ecological Effects (selected examples)	Food-Yielding System
	Burning Vegetation	Reduction of competition; accelerated recycling of mineral nutrients; simulation of asexual reproduction; selection for annual or ephemeral habit; synchronization of fruiting	Wild Plant-Food Procurement (Foraging)
	Gathering/Collecting	Casual Dispersal of propagules	
I	Protective Tending	Reduction of competition; local soil disturbance	
	Replacement planting/sowing	Maintenance of plant population in the wild	Wild Plant-Food Production with minimal tillage
	Transplanting/sowing	Dispersal of porpagules to new habitats	
	Weeding	Reduction of competition; soil modification	
	Harvesting	Selection for dispersal mechanism: positive and negative	
	Storage	Selection and redistribution of propagules	
II	Drainage/Irrigation	Enhancement of productivity; soil modification	
	Land Clearance	Transformation of vegetation composition and structure	Cultivation with systematic tillage
	Systematic Soil Tillage	Modification of soil texture, structure, and fertility	
	Propagation of variant domesticates		Agriculture (Farming)
III	Cultivation of domesticated crops	Establishment of agroecosystems	
			Evolutionary differentiation of agricultural systems

Figure 7.11: Schematic diagram of people-plant interactions within a domestication continuum after Harris (1989:17, Figure 1.1) – Roman numerals indicate increasing energy inputs

together account for more than half of the diet. Or Ford's, where agriculture is a combination of field techniques and use of domesticates (Ford 1985).

So, Oneota groups meet all the criteria set to be considered fully agricultural yet do not contain any of the listed markers of increased cultural complexity listed by Harris (1989) and assumed or implied by many others. The question becomes why? Clearly, there is an issue with some of the models. While moving away from the false dichotomous systems, elements of the old unilineal evolution paradigms (e.g., Buckland 1878; Morgan 1877; Tylor 1881) were revived with a processual twist. The Oneota examples show that such models need to be multilinear; they need to allow for divergent choices and outcomes. Gallagher and Arzigian (1994:184) move toward this. They suggest the Oneota lack of agricultural specialization is the distinguishing factor. Specialized programs emphasize one or two resources at the expense of others. This, they argue is associated with increasing cultural complexity. They suggest that Oneota groups used an alternative approach, and intensified agriculture with diversification. This distinction, they felt, was associated with more egalitarian practices, slower population growth, and lower incidences of malnutrition.

However, this argument does not fully capture the patterns described in previous chapters. For example, Aztalan and Koshkonong sites exhibit similar levels of specialization (i.e., similar diversity indices, densities, ubiquities, etc.). In fact, by the second half of the occupation span, the focus on wild rice and maize could be construed as a significant specialization. Yet, Aztalan exhibits evidence for considerable social stratification not present in any Oneota groups (Birmingham 2005; Goldstein and Freeman 1997). Unfortunately, it is beyond the scope of this project to speculate about the full range of factors that may have led Oneota groups to develop both agriculture and an egalitarian framework while Middle

Mississippian groups developed a ranked system. Furthermore, there is currently insufficient data to come to any clear conclusions. The answers likely lie much early than AD 1050 and the appearance of shell-tempered pots. This line of inquiry necessitates a fuller understanding of the long-term cultural trajectories that Oneota and Middle Mississippian ancestral groups traveled.

Regardless of why, the data presented above are clear, agriculture is not necessarily associated with cultural complexity or social inequality. Egalitarian groups are fully capable of modifying their environment, taking a highly active role in their subsistence system, and producing significant quantities of agricultural goods. On a *per capita* basis, egalitarian groups appear to be capable of producing similar amounts of food. The difference in their agricultural system is one of distribution, not of production. While it could be argued that lower population densities among Oneota groups means that agriculture was not as intense, I take issue with this on two points. First, essentially anything a larger group of people do is going to appear more intense. Just because 20 people can do twice the work of 10, it does not mean that the smaller group is less invested or reliant on the products of that labor. Second, if agriculture is to be measured in total output, then perhaps population density is the key factor in determining cultural complexity, not subsistence practices (e.g., Winterhalder and Kennett 2009's scales of economy). If so, then I would argue that agriculture arises when people have a need (real or perceived) and the means (technological, social, and environmental) to produce more food than their natural environment can support. In many cases, it is associated with increasing population densities; and then traditional arguments and assumptions may apply. In other cases, it can occur in groups with small population densities. In the low population density scenarios, there is no reason to assume that the adoption of agriculture will be followed by increasing levels of social inequality, monumental architecture, or other traditional markers of cultural complexity.

8. Conclusions

Introduction:

This dissertation has examined subsistence strategies in the western Great Lakes region during the Late Prehistoric. Its focus is on Upper Mississippian risk management strategies, particularly in the Koshkonong Locality, as seen in macrobotanical remains, isotopes, and settlement systems. It used comparative data from eight Upper Mississippian localities, as well as four Late Woodland sites and two Middle Mississippian. The dissertation directly addressed four primary research questions.

1) What were the primary subsistence strategies in the Koshkonong Locality?
2) Is Koshkonong subsistence strategies are representative of other contemporaneous groups in southern Wisconsin and northern Illinois?
3) What is the nature of the Koshkonong risk management strategies and what are possible social repercussions of such actions?
4) Were Oneota groups were agriculturally reliant, and if so, did it influenced the development of a ranked or stratified social system?

Assessing the Theoretical Model

The model established in Chapter 3 was designed to simulate a group that was under both environmental and social stress. Under combined threats of warfare and climate, maize agriculturalists such as the Koshkonong Oneota are expected to react to threats in particular ways. Because maize had been an established part of the western Great Lakes system for at least a century, established Oneota agriculturalists are expected to have a reduced diet breadth, and a subsistence system increasingly focused on maize (and other agricultural products), aggregated wild resources. Increased use of storage, raiding, and larger populations are all expected as well.

Significant numbers of storage pits were constructed at the study sites, but it is unclear if storage increased through time. Evidence for violence and population size is similarly unclear.

However, the evidence does suggest a highly-focused diet. The decreasing kernel to cupule ratio indicates additional labor was conducted from the safety of villages, which supports an increasingly violent landscape. Maize accounted for half, or more, of the overall diet. This was buffered with other domesticates like beans and squash. Goosefoot was also cultivated in the locality. Wild aggregated resources, such as acorn and wild rice were extensively used. These resources likely account for 75% or more of the diet's calories. Through time, use of acorn, and nuts in general, decreases in favor of wild rice. This likely corresponds with increasing deforestation, which would decrease the aggregation of nuts and their proximity to villages. The corresponding rise in wild rice may reflect its stable location and density relative to the village sites. It is possible that the residents of the Koshkonong Locality also took steps to increase its yield through cultivation practices (Jenks 1901; Vennum 1988).

The model explains most, but not all, of the patterns identified in the data. Given the overall correspondence; the premises of social and environmental stressors are supported. The minimal mobility in the locality suggests that the threat of warfare was severe. Environmental risks did not disappear, but were mitigated through a variety of less-extensive means.

Conclusions:

The Koshkonong Locality: The groups living in the Koshkonong Locality were faced with many threats, but the perceived risk of attack was among the greatest. Responses to perceived threats are strongly reflected in the subsistence and settlement systems. Numerous risk management strategies were employed, most centered on intensive resource acquisition. Agriculture was used intensively, to a greater degree than contemporaneous Late Woodland groups, and apparently nearly on par with Middle Mississippian neighbors. Regardless of the definition used, both lines of data support the interpretation that the residents of the Koshkonong Locality were maize agriculturalists (Ford 1985: Harris 1989; Zvelebil 1996). This taxon was the densest and most ubiquitous in Koshkonong's macrobotanical assemblage. Isotopes suggest that it accounted for at 40% or more of the protein intake, and as much as 75% of the caloric intake. In addition to maize, squash, beans (in later contexts), and *Chenopodium* were grown in the locality (Olsen 2003). Wild rice was consumed to a significant degree, and was likely cultivated by the locality residents. In the various models, these cultivated crops accounted for as much as 85% of the calories in the diet, and likely accounted for at least 70%, except possibly in rare instances (e.g., famine). Meat resources likely accounted for no more than 15% of the diet, and wild plants likely accounted for no more than 10-20%, depending on the model.

The planting, tending, and harvesting activities would have required tremendous amounts of labor, particularly in the spring and autumn. Women likely were the ones to complete most of these labors. While there is no direct evidence, men's economic labor was likely centered on hunting, defense, and retaliatory war raids. Both men and women likely took part in craft production, ritual activities, and a variety of non-subsistence activities but these are beyond the scope of this dissertation.

Despite differences within the sites' assemblages, the macrobotanical remains typically clustered closer together on multivariate tests than sites in other localities, suggesting that the residents shared a similar mental template for how to get food and what foods to eat. They likely also shared food with each other, creating a tightly knit social network. This network of sites would have relied on one another to a significant degree, not only for subsistence aid, but also for defense. Such close connections were almost certainly maintained through reciprocal relations, which would be reaffirmed through feasts, marriages, and other structured social obligations. This intralocality network also appears to be the largest social group within the primary risk buffering network, indicating that they used a simple buffering system (i.e., one society).

The use of a simple system, and local network reliance is also reflected in the settlement system, which is small and flat. The locality consists of several village sites that likely acted as the base camps for most activity. The small number and geographic range of the ephemeral camps indicates that when the days' work was done people typically returned to the villages, rather than making multi-day trips for work. The evidence of exchange is also minimal. This necessitates maintaining territorial integrity. This was enabled by the distribution of sites; which were situated where they could effectively maintain territorial integrity while maximizing spatial diversity. The space between the sites would be a safer territory where much of their agricultural activities likely took place. Over time, work was increasingly done at the village sites. Remains of maize cobs suggests that in later contexts, there was more on-site processing of agricultural goods, rather than in the fields. So, it is likely that as intergroup tensions increased, people did not rely on the safety of this core territory and took further steps to increase security of both the people and their harvests.

The data suggests ways that the social interactions may have been affected by these risks and mitigation strategies. However, there are few strong indicators of the nature of social interactions and social institutions that would have been at work in the locality. Gender dynamics were likely in flux, with the value of each genders' labors providing complementary value. Kinship networks would have been essential to maintain the social integrity of the locality, but there is little data available to interpret how the networks were organized or how they operated. To date, the most we can say is that the locality represents a close knit, and relatively (but not totally) closed social system.

Regional Trends: On a basic level, the Koshkonong Locality is representative of most contemporaneous Oneota localities. The data indicate that Waupaca, Middle Fox, Langford, Red Wing, and Fisher groups were all highly agricultural, and concerned with both defense and climactic threats. There is variation among these groups; each followed a version of this basic Oneota template. Much like each group followed a basic template for ceramics but had their own local and unique style (Schneider 2015), such was also the case with subsistence. Most appear to have consumed as much maize as those living in Koshkonong, though hunted to a somewhat greater degree. Each group also had its own blend of wild plants as a buffering resources. For example, Langford groups did not use cultivated starchy/oily seeds (Egan 1988, 1993; Jeske and Hart 1988). Fisher and northern Wisconsin sites (Waupaca and Green Bay) stand out with their use of yellow star grass (Egan-Bruhy 2001b, 2010b, 2012; Egan-Bruhy and Nelson 2013). Koshkonong sites also to exemplify the general trends most strongly – their focus on local resource acquisition is the most extreme and the settlement pattern supports it. They appear to be the most defensive and insular of the contemporaneous Oneota groups examined.

The Wolf River tradition sites near Green Bay do not seem to follow the general model. These sites' assemblages do not suggest that maize was particularly important, and the sites were not placed to maximize access to arable land. The slightly later La Crosse sites appear to rely on maize to a slightly lower degree and hunting/fishing more than in Koshkonong. This may be a result of a shift towards mobility to allow for increased bison hunting (e.g., Boszhardt 2000; Gibbon 1972a). La Crosse sites appear to fit well with description intensification through diversification argued by Gallagher and Arzigian (1994), where Koshkonong looks to more to be intensification through focalization.

Late Woodland groups appear to have consumed less maize than Oneota. The limited data here supports the contention that non-collared ware groups were more mobile and relied more on hunting and gathering than horticulture or agriculture. The groups living on collared ware sites (excluding Aztalan) were more seasonally mobile than most Oneota groups, definitely more than Koshkonong. Agriculture (or horticulture?) was important, but less than for Oneota groups, except possibly for Wolf-River sites (at least those near Green Bay). Maize was a significant resource, providing as much as half the calories for some individuals.

The Middle Mississippian sites clearly were occupied by maize agriculturalists. The assemblages consistently had some of the highest maize ubiquities and the highest densities. However, there was regional variation in buffering resources and techniques. It is difficult to quantify their maize reliance relative to Oneota groups. The isotopic data from the American Bottom suggest that low-status urban individuals consumed more maize than any Oneota individuals. However, high-status Middle Mississippians consumed little maize and significantly greater quantities of meat (Ambrose et al. 2003). Everyone living in outlying sites consumed a wider array of plant foods (Hedman et al. 2002). Given the position of Lundy and Aztalan in the hinterland, and the floral diversity in the assemblages, particularly at Aztalan, it seems likely that most of those living at the sites did not eat the extreme levels of maize seen in the American Bottom. However, on average, they may have consumed slightly more maize than most people living at Oneota sites.

Middle Mississippian groups are known for developing complex social hierarchies, constructing monumental mounds, instituting ranked settlement systems (except Aztalan), and congregating in dense population centers (Griffin 1985:63). All are common markers for social complexity. However, there are no indications that the contemporaneous development of agriculture within the Oneota world was linked to such traits. Therefore, I argue that Oneota represents an exception to tendency for groups to develop more complex forms of political organization as they begin to rely more on agriculture (e.g., Harris 1989). It is not clear why Middle Mississippian and Oneota populations developed such distinct social institutions and forms of political organization. Initial population density, and several other social and economic factors are likely at play. However, maize agriculture does not seem to be the key catalyst (*sensu* Fritz 1992), nor does agriculture require such complexity or hierarchy to develop.

Implications of Research:

This dissertation makes significant impacts in four ways. 1) It is the first application of the Canine Surrogacy Approach in the western Great Lakes (see Edwards et al. 2017). This approach allows for the acquisition of important data without the destroying human remains. Destruction of human remains is a growing ethical concern among archaeologists (Wilson 2008), particularly when invested communities, such as descendant Native American groups, are opposed to such treatment. CSA offers a means to avoid such destruction without sacrificing research goals. 2) This dissertation is a rare combination of dietary isotope and macrobotanical data, thus allowing for stronger and more holistic inferences (*sensu* Wylie 2000). 3) The isotope data is the first region-wide measure of Upper Mississippian maize consumption. This marks a major step towards understanding Upper Mississippian subsistence systems, and variation in maize consumption and hunting practices. 4) The application of isotope, botanical, and settlement data calls attention to important aspects of interaction within the Koshkonong Locality.

Future Research:

There are several important directions that future research needs to take. They can be divided into several broad categories: field work, macrobotanical research, isotopic research.

While the Crescent Bay Hunt Club has been well excavated, most Oneota sites in the Koshkonong Locality have not been excavated to the same degree. KCV is the next closest, but there is insufficient area excavated to identify any site organization or structure. Even smaller proportions of Carcajou Point, Schmeling, and Crab Apple point have been excavated. Each of these sites occupy a distinct portion of the Koshkonong landscape. While CBHC and KCV floral assemblages appear to be similar, larger portions of the sites need to be tested and analyzed to ensure the patterns noted in this dissertation are accurate. Purnell is totally unexcavated, yet is situated on the lowest and wettest location of any Koshkonong site. Environmentally, it is the opposite of KCV. If any environmental distinctions exist between sites, it should be between KCV Purnell. Once each of these sites has been adequately excavated and analyzed, regional trends identified in this dissertation can be put to the test. While there are few encampments, or other logistical sites in Koshkonong, they need to be more fully explored to determine if there are intact deposits, what the site function was, and how diet varied among different site types.

While CBHC may be the most systematically and completely excavated site, with flotation samples from each pit feature, only a fraction of the features has been analyzed. Additional research at KCV and CBHC is needed to better understand the functional differences among features, and spatially/temporally through the sites’ excavations. Other sites should also be tested to so that the full range of variation within the Koshkonong locality can be determined. There are unanalyzed flotation samples from Schmeling and Carcajou Point. Additional excavations are necessary to analyze other Koshkonong area sites. Additional macrobotanical analysis is also necessary in other localities. In many localities, few to no sites have any macrobotanical analysis. One village site in the Middle-Fox is insufficient, especially given both its geographic and temporal span. The absence of macrobotanical research in the Grand River sites, known well for their well-documented ceramics and mortuary practices, makes comparative interpretations difficult. Finally, additional work is needed to better understand Late Woodland subsistence; particularly during the 11th Century as Oneota sites are first being occupied.

The need for additional isotopic research is ubiquitous. Samples from every locality are necessary, as are additional samples from the localities already tested. Researchers critical of isotopic analyses (e.g., Hart 1999) are quick to point out that each isotope is reflective of an individual, not necessarily the population. Until sufficiently large samples are available, the full range of diversity among localities will remain in question.

While the botanical focused research likely accounted for a large proportion of the diet, it still only represents part of the picture. Zooarchaeological data are needed, and should be incorporated with the botanical and isotopic data to provide a holistic interpretation of Oneota subsistence, and how it is interconnected with other facets of Oneota societies and lifeways. Zooarchaeological data are already available for some localities, (e.g., Theler 1989, 1994), and comprehensive integrative research projects are underway in others (e.g., McTavish's upcoming comparative Langford/Koshkonong dissertation). With a more substantial archaeobotanical and isotopic dataset, coupled with the zooarchaeological data, it will finally be possible to answer the now 35-year-old question posed by Brown (1982), 'what kind of economy did the Oneota have?'

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Appendix A: Macrobotanical Data

Context Information and Charcoal

Feature #	Zone	FXN	Liters	%sorted Lt.	% sorted Hvy.		Wood Charcoal ct.	Wood Charcoal wt.	Bark Charcoal ct.	Bark Charcoal wt.
KCV										
FF12-01	E	Both	101	25	25		*12722*	*129.93*	*216*	*5.200*
FF12-01	I	Both	211	12.5, 6.25	3.125		*30863*	*443.221*	*344*	*10.024*
FF12-01	L	Both	10	100	100		1175	19.151	37	0.463
FF12-01	M	Both	7	100	100		2755	17.201	46	0.0813
FF12-01	P	Both	81	25	25		*12454*	126.438	*78*	*1.519*
FF12-06	A2	Both	143	25	12.5		*19788*	241.408	*160*	*19.88*
FF12-06	B	Both	284	12.5	12.5		*52518*	632.32	*400*	*2.080*
FF12-06	D	Both	4	100	100		*542*	4.273	*12*	*0.070*
FF12-06	E	Lt	2	100			388	2.420	15	0.088
FF12-06	G	Both	16	100	100		1720	33.957	32	0.256
FF12-06	I	Both	6	100	100		1054	9.245	0	0
FF12-06	L	Both	22	100,50	100,50		5480	86.182	67	1.557
FF12-06	O	Both	28	50	50		8480	100.752	79	96.886
FF12-06	Q	Both	7	100	100		2546	28.998	21	0.319
FF12-06	R	Both	16	100	100		6142	51.056	140	1.565
FF12-06	S	Both	1	100	100		18	0.083	2	0.01
FF12-06	V	Both	68.5	100,50	25		*6822*	*110.722*	51	0.869
FF12-06	W	Both	18	100	50		4516	55.34	13	0.435
FF12-26	n/a	Both	79	50	100,12.5		*6870*	*76.362*	*118*	*1.218*
CBHC										
FF00-11		Both	304	x	x		*4710*	*57.340*	*7*	*0.030*
FF00-11	B	Both	126.5	x	x		*1283*	*15.620*	*1882*	*10.880*
FF00-26	B	Both	189.5	x	x		*5604*	*68.230*	*0*	*0.000*
FF02-25	x	Both	57	25	100		*3046*	*43.830*	*32*	*0.230*
FF04-03		Both	27	100	50		2510	15.490	7	0.044
FF04-14	1	Both	42	50	25		*6433*	*84.183*	*0*	*0.000*
FF04-14	2	Both	38	x	x		*8260*	*118.120*	*208*	*2.680*
FF04-14	3N	Both	10	100	100		2287	27.736	1	0.042
FF04-14	4	Both	54	25	25		*15320*	*203.036*	*56*	*1.092*
FF04-14	5	Lt	50	50			*3130*	*35.324*	*26*	*0.164*
FF04-14	6N	Both	7	100	x		*2909*	*28.800*	*96*	*0.560*
FF04-15	A	Both	174	12.5	6.125		*21040*	*235.120*	*32*	*0.280*
FF04-15	C	Both	105	100, 10	100		*6126*	*748.200*	*91*	*0.450*
F04-22	x	Both	950	16.5	33		*43346*	*640.550*	*662*	*1.002*
FF06-63	A	Both	145	10	7.5		*7210*	*80.500*	*180*	*1.800*
FF06-63	B	Both	32	10	7.5		*3040*	*39.700*	*450*	*2.500*
FF06-63	C	Both	33	10, 100	100		*333*	*4.130*	*59*	*0.430*
F10-14	n/a	Both	300	12.5	100		*15879*	*167.466*	*304*	*2.592*
F10-19	n/a	Both	110	50	50		*6250*	*95.696*	*18*	*0.142*

Feature #	Zone	FXN	Liters	%sorted Lt.	% sorted Hvy.		Wood Charcoal ct.	Wood Charcoal wt.	Bark Charcoal ct.	Bark Charcoal wt.
F10-29	n/a	Both	375	6.25	100		*18273*	*221.038*	*1*	*0.001*
F10-98	n/a	Both	88	25	25 100		*6794*	*76.117*	*72*	*0.496*

Nutshell

Feature #	Zone	Nutshell total ct.	Nutshell total wt.	*Carya* ct.	*Carya* wt.	*Corylus* ct.	*Corylus* wt.	*Juglans* ct.	*Juglans* wt.	*Juglandaceae* ct.	*Juglandaceae* wt.	*Quercus* ct.	*Quercus* wt.
KCV													
FF12-01	E	117	0.804	17	0.388	0	0	0	0	0	0	100	0.416
FF12-01	I	664	4.053	72	0.744	0	0	0	0	0	0	592	3.309
FF12-01	L	6	0.014	0	0	0	0	0	0	0	0	6	0.014
FF12-01	M	3	0.016	0	0	0	0	0	0	0	0	3	0.016
FF12-01	P	102	1.274	62	1.046	0	0	0	0	0	0	40	0.228
FF12-06	A2	243	2.318	89	1.884	0	0	0	0	0	0	154	0.434
FF12-06	B	369	4.871	304	4.784	1	0.039	0	0	0	0	64	0.048
FF12-06	D	0	0	0	0	0	0	0	0	0	0	0	0
FF12-06	E	0	0	0	0	0	0	0	0	0	0	0	0
FF12-06	G	14	0.197	13	0.167	0	0	0	0	1	0.03	0	0
FF12-06	I	2	0	0	0	0	0	1	0	0	0	1	0
FF12-06	L	11	0.099	0	0	0	0	0	0	7	0.098	4	0.001
FF12-06	O	16	0.15	0	0	0	0	0	0	0	0	16	0.15
FF12-06	Q	2	0.008	0	0	0	0	0	0	0	0	2	0.008
FF12-06	R	1	0.004	0	0	0	0	0	0	0	0	1	0.004
FF12-06	S	0	0	0	0	0	0	0	0	0	0	0	0
FF12-06	V	5	0.048	0	0	0	0	0	0	0	0	5	0.048
FF12-06	W	3	0.008	0	0	0	0	0	0	0	0	3	0.008
FF12-26	n/a	4334	19.315	53	1.445	0	0	0	0	0	0	4281	17.87
CBHC													
FF00-11		61	0.66	33	0.46	1	0.01	10	0.09	0	0	17	0.1
FF00-11	B	74	0.58	15	0.28	3	0.05	1	0.04	23	0.1	32	0.11
FF00-26	B	9	0.045	1	0.01	0	0	0	0	7	0.03	1	0.005
FF02-25	x	12	0.14	0	0	3	0.05	0	0	9	0.09	0	0
FF04-03		567	2.781	66	0.66	53	0.277	13	0.065	0	0	435	1.779
FF04-14	1	112	0.418	70	0.216	4	0.02	0	0	0	0	38	0.182
FF04-14	2	28	0.175	0	0	3	0.02	22	0.15	0	0	3	0.005
FF04-14	3N	13	0.057	0	0	1	0.007	1	0.008	0	0	11	0.042
FF04-14	4	16	0.42	16	0.42	0	0	0	0	0	0	0	0
FF04-14	5	6	0.04	0	0	6	0.04	0	0	0	0	0	0
FF04-14	6N	4	0.02	0	0	0	0	4	0.02	0	0	0	0
FF04-15	A	108	0.464	0	0	0	0	0	0	0	0	108	0.464
FF04-15	C	54	0.335	0	0	1	0.005	35	0.22	0	0	18	0.11
F04-22	x	261	2.2	35	1.38	0	0	0	0	104	0.36	122	0.46
FF06-63	A	340	2.5	70	0.7	0	0	10	0.4	0	0	260	1.4

Feature #	Zone	Nutshell total ct.	Nutshell total wt.	*Carya* ct.	*Carya* wt.	*Corylus* ct.	*Corylus* wt.	*Juglans* ct.	*Juglans* wt.	*Juglandaceae* ct.	*Juglandaceae* wt.	*Quercus* ct.	*Quercus* wt.
FF06-63	B	950	5.3	110	1.8	0	0	0	0	190	1.2	650	2.3
FF06-63	C	66	0.38	1	0.01	0	0	0	0	5	0.04	60	0.33
F10-14	n/a	396	1.873	19	0.223	2	0.011	0	0	0	0	375	1.639
F10-19	n/a	72	0.526	8	0.256	0	0	0	0	0	0	64	0.27
F10-29	n/a	464	2.381	66	0.92	0	0	15	0.317	0	0	383	1.144
F10-98	n/a	65	0.399	21	0.219	0	0	8	0.064	0	0	36	0.116

Zea mays

Feature #	Zone	*Zea mays* Total ct.	*Zea mays* Total wt.	*Zea mays* Kernel Fragments ct.	*Zea mays* Kernel Fragments wt.	cf. Kernel Fragment ct.	cf. Kernel Fragment wt.	Cupule/Glume ct.	Cupule Glume wt.	cf. Cupule/Glume ct.	cf. Cupule Glume wt.	Cob Fragment ct.	Cob Fragment wt.
KCV													
FF12-01	E	1295	9.997	1017	7.848	0	0	278	2.149	0	0	0	0
FF12-01	I	856	7.561	650	6.184	0	0	200	1.184	0	0	6	0.193
FF12-01	L	61	0.1787	32	0.159	0	0	29	0.0197	0	0	0	0
FF12-01	M	50	0.289	24	0.117	0	0	26	0.172	0	0	0	0
FF12-01	P	708	6.725	556	5.501	0	0	152	1.224	0	0	0	0
FF12-06	A2	1158	7.66	821	5.136	0	0	337	2.524	0	0	0	0
FF12-06	B	2896	26.408	1534	14.416	0	0	1346	11.704	0	0	16	0.288
FF12-06	D	74	0.439	31	0.194	0	0	43	0.245	0	0	0	0
FF12-06	E	49	0.553	5	0.1	0	0	41	0.357	0	0	3	0.096
FF12-06	G	157	1.617	100	1.33	0	0	57	0.287	0	0	0	0
FF12-06	I	22	0.211	7	0.106	0	0	15	0.105	0	0	0	0
FF12-06	L	182	1.943	115	0.911	6	0.026	50	0.292	0	0	11	0.714
FF12-06	O	96	0.68	32	0.176	0	0	64	0.504	0	0	0	0
FF12-06	Q	130	0.733	38	0.175	0	0	92	0.558	0	0	0	0
FF12-06	R	107	0.776	67	0.453	0	0	40	0.323	0	0	0	0
FF12-06	S	0	0	0	0	0	0	0	0	0	0	0	0
FF12-06	V	244	2.106	147	1.013	0	0	84	0.701	0	0	13	0.392
FF12-06	W	95	0.511	69	0.36	0	0	25	0.145	0	0	1	0.006
FF12-26	n/a	276	3.268	108	1.136	0	0	166	1.67	0	0	2	0.462
CBHC													
FF00-11		151	1.82	77	1.32	0	0	74	0.5	0	0	0	0
FF00-11	B	102	0.96	54	0.65	0	0	48	0.31	0	0	0	0
FF00-26	B	260	2.23	34	0.41	0	0	224	1.81	0	0	2	0.01
FF02-25	x	149	1.57	140	1.46	0	0	9	0.11	0	0	0	0
FF04-03		87	0.488	54	0.29	0	0	33	0.198	0	0	0	0
FF04-14	1	392	3.111	296	2.375	0	0	92	0.706	0	0	4	0.03
FF04-14	2	156	2.05	34	1.09	6	0.26	101	0.63	15	0.07	0	0
FF04-14	3N	108	1.247	67	0.803	0	0	41	0.444	0	0	0	0
FF04-14	4	744	10.15	556	4.604	0	0	188	5.546	0	0	0	0

Feature #	Zone	*Zea mays* Total ct.	*Zea mays* Total wt.	*Zea mays* Kernel Fragments ct.	*Zea mays* Kernel Fragments wt.	cf. Kernel Fragment ct.	cf. Kernel Fragment wt.	Cupule/Glume ct.	Cupule Glume wt.	cf. Cupule/Glume ct.	cf. Cupule Glume wt.	Cob Fragment ct.	Cob Fragment wt.
FF04-14	5	156	1.444	78	0.796	0	0	74	0.62	0	0	4	0.028
FF04-14	6N	61	0.37	33	0.28	19	0.06	9	0.03	0	0	0	0
FF04-15	A	1160	9.224	912	6.8	0	0	232	1.856	0	0	16	0.568
FF04-15	C	366	2.76	135	1.2	0	0	231	1.56	0	0	0	0
F04-22	x	1091	10.15	627	6.39	144	0.64	300	2.12	0	0	20	1
FF06-63	A	280	2	120	0.6	0	0	160	1.4	0	0	0	0
FF06-63	B	20	0.1	10	0.05	0	0	10	0.05	0	0	0	0
FF06-63	C	15	0.095	14	0.09	0	0	1	0.005	0	0	0	0
F10-14	n/a	2262	15.645	366	2.672	0	0	1847	10.959	0	0	49	2.014
F10-19	n/a	946	10.54	94	1.128	0	0	820	8.27	0	0	32	1.142
F10-29	n/a	548	6.832	314	2.882	0	0	234	3.95	0	0	0	0
F10-98	n/a	386	3.931	206	1.927	0	0	156	1.104	0	0	24	0.9

Other Domesticates

Feature #	Zone	*C. pepo* Rind ct.	*C. pepo* Rind wt.	*C. pepo* Seed ct.	*C. pepo* Seed wt.	*P. vulgaris* ct.	*P. vulgaris* wt.	*Nicotiana* ct.
KCV								
FF12-01	E	0	0	4	0.096	0	0	0
FF12-01	I	0	0	0	0	0	0	0
FF12-01	L	0	0	0	0	0	0	0
FF12-01	M	0	0	0	0	0	0	0
FF12-01	P	0	0	0	0	0	0	0
FF12-06	A2	0	0	0	0	0	0	12
FF12-06	B	0	0	0	0	0	0	0
FF12-06	D	0	0	0	0	0	0	0
FF12-06	E	0	0	0	0	0	0	0
FF12-06	G	0	0	0	0	0	0	0
FF12-06	I	0	0	0	0	0	0	0
FF12-06	L	0	0	3	0.025	2	0.081	0
FF12-06	O	0	0	0	0	0	0	0
FF12-06	Q	0	0	0	0	0	0	0
FF12-06	R	0	0	0	0	0	0	0
FF12-06	S	0	0	0	0	0	0	0
FF12-06	V	0	0	0	0	1	0.05	2
FF12-06	W	5	0.006	0	0	1	0.57	0
FF12-26	n/a	0	0	0	0	0	0	0
CBHC								
FF00-11		0	0	0	0	0	0	0
FF00-11	B	1	0	0	0	0	0	8
FF00-26	B	0	0	0	0	0	0	12
FF02-25	x	0	0	0	0	0	0	0
FF04-03		0	0	0	0	1	0.02	0

Feature #	Zone	*C. pepo* Rind ct.	*C. pepo* Rind wt.	*C. pepo* Seed ct.	*C. pepo* Seed wt.	*P. vulgaris* ct.	*P. vulgaris* wt.	*Nicotiana* ct.
FF04-14	1	0	0	0	0	0	0	0
FF04-14	2	0	0	0	0	0	0	0
FF04-14	3N	0	0	0	0	0	0	0
FF04-14	4	0	0	0	0	0	0	0
FF04-14	5	0	0	0	0	0	0	0
FF04-14	6N	0	0	0	0	0	0	0
FF04-15	A	0	0	0	0	0	0	0
FF04-15	C	0	0	0	0	0	0	0
F04-22	x	13	1.03	0	0	0	0	0
FF06-63	A	0	0	0	0	0	0	0
FF06-63	B	0	0	0	0	0	0	0
FF06-63	C	0	0	0	0	0	0	0
F10-14	n/a	8	0.112	32	0.04	0	0	0
F10-19	n/a	0	0	0	0	0	0	0
F10-29	n/a	0	0	0	0	0	0	0
F10-98	n/a	0	0	8	0.092	0	0	0

Cultigens

Feature #	Zone	*Chenopodium*	*cf. Chenopod*	*Echinochloa*	*Hordeum pusillum*	*Hordeum/Zizania*	*Phalaris caroliniana*	*Polygonum sp.*	*Polygonum erectum*	*Zizania Aquatica*	*cf. Zizania aquatica*
KCV											
FF12-01	E	0	4	0	4	0	0	4	0	16	0
FF12-01	I	16	0	0	0	0	0	0	0	96	32
FF12-01	L	1	0	0	0	0	0	0	0	3	0
FF12-01	M	2	0	0	0	0	0	0	0	4	0
FF12-01	P	8	0	0	0	0	0	0	0	28	0
FF12-06	A2	0	0	0	4	32	0	0	0	152	0
FF12-06	B	0	0	0	0	0	0	0	0	248	5
FF12-06	D	0	0	0	0	0	0	0	0	9	4
FF12-06	E	0	0	0	0	0	0	0	0	0	2
FF12-06	G	0	0	0	0	0	0	0	0	6	0
FF12-06	I	0	0	0	0	0	0	0	0	1	0
FF12-06	L	23	0	0	0	0	0	0	0	65	0
FF12-06	O	2	0	0	0	0	0	0	0	0	0
FF12-06	Q	1	0	0	1	0	0	0	0	16	0
FF12-06	R	4	1	0	1	0	2	0	0	13	0
FF12-06	S	0	0	0	0	6	0	0	0	0	0
FF12-06	V	7	0	0	0	8	0	0	0	105	0
FF12-06	W	11	0	0	0	2	0	0	0	10	0
FF12-26	n/a	2	0	0	0	0	0	0	0	22	0
CBHC											
FF00-11		174	0	0	0	0	0	0	0	0	0

Feature #	Zone	*Chenopodium*	*cf. Chenopod*	*Echinochloa*	*Hordeum pusillum*	*Hordeum/Zizania*	*Phalaris caroliniana*	*Polygonum sp.*	*Polygonum erectum*	*Zizania Aquatica*	*cf. Zizania aquatica*
FF00-11	B	0	27	0	0	0	0	4	0	145	0
FF00-26	B	68	0	0	0	0	0	0	0	0	1
FF02-25	x	0	0	0	0	0	0	0	0	1	0
FF04-03		6	0	0	0	0	0	1	0	8	0
FF04-14	1	0	0	0	0	12	0	0	0	50	0
FF04-14	2	16	0	0	0	0	0	0	0	121	92
FF04-14	3N	7	0	0	0	0	0	0	0	2	0
FF04-14	4	24	0	0	0	4	0	0	0	216	0
FF04-14	5	10	0	0	0	2	0	0	0	14	0
FF04-14	6N	0	0	2	0	0	0	0	0	28	0
FF04-15	A	160	0	0	0	0	0	0	0	136	0
FF04-15	C	0	0	0	10	0	0	0	0	160	0
F04-22	x	546	0	0	0	0	0	0	0	43	0
FF06-63	A	50	0	0	0	0	0	0	0	0	0
FF06-63	B	0	0	0	0	0	0	0	0	0	10
FF06-63	C	3	0	0	0	0	0	0	0	0	0
F10-14	n/a	32	0	0	0	0	0	0	8	409	0
F10-19	n/a	40	0	0	0	0	0	0	0	30	0
F10-29	n/a	64	0	0	0	0	0	0	0	176	0
F10-98	n/a	12	0	0	0	0	0	0	0	24	0

Fruits

Feature #	Zone	*Crataegus*	*Frageria*	*cf. Gaylussacia baccata*	*Prunus pensylvanica*	*Prunus nigra*	*Rhus*	*cf. Rhus*	*Rubus*	*Sambucus*	*Solanum*
KCV											
FF12-01	E	0	0	0	0	0	0	4	0	0	0
FF12-01	I	0	0	0	0	16	0	0	0	0	0
FF12-01	L	0	0	0	0	0	0	0	0	0	0
FF12-01	M	0	0	0	0	0	0	0	0	0	0
FF12-01	P	0	0	0	0	0	0	4	0	8	0
FF12-06	A2	0	0	0	0	0	0	0	0	0	0
FF12-06	B	0	0	0	0	0	0	0	0	0	0
FF12-06	D	0	0	0	0	0	0	0	0	0	0
FF12-06	E	0	0	0	0	0	0	0	0	0	0
FF12-06	G	0	0	0	0	1	0	0	0	1	0
FF12-06	I	0	0	0	0	0	0	0	0	1	0
FF12-06	L	0	0	0	0	0	0	0	0	0	2
FF12-06	O	0	0	0	0	0	0	0	0	4	0
FF12-06	Q	0	2	0	0	0	0	0	0	0	0
FF12-06	R	0	1	0	0	2	2	0	0	6	0
FF12-06	S	0	0	0	0	0	0	0	0	0	0

Feature #	Zone	*Crataegus*	*Frageria*	*cf. Gaylussacia baccata*	*Prunus pensylvanica*	*Prunus nigra*	*Rhus*	*cf. Rhus*	*Rubus*	*Sambucus*	*Solanum*
FF12-06	V	0	0	0	0	0	0	0	0	2	0
FF12-06	W	0	0	0	0	0	0	0	0	0	0
FF12-26	n/a	2	0	0	0	0	0	2	0	0	0
CBHC											
FF00-11		0	0	0	1	1	0	0	0	0	0
FF00-11	B	0	0	0	0	0	0	0	4	0	0
FF00-26	B	0	0	0	0	0	0	0	0	0	0
FF02-25	x	0	0	0	0	0	0	0	0	0	0
FF04-03		0	0	0	0	0	0	0	0	0	0
FF04-14	1	0	0	0	0	0	0	0	14	0	0
FF04-14	2	0	0	0	0	0	0	0	0	0	20
FF04-14	3N	0	0	0	0	0	0	0	0	0	0
FF04-14	4	0	0	0	0	0	0	0	0	0	0
FF04-14	5	4	0	0	0	0	0	0	0	0	0
FF04-14	6N	0	0	0	0	0	0	0	0	0	0
FF04-15	A	0	0	0	0	0	0	0	0	0	0
FF04-15	C	0	0	0	0	0	0	0	0	0	0
F04-22	x	32	0	0	0	0	0	0	0	0	32
FF06-63	A	0	0	0	0	0	0	0	0	0	0
FF06-63	B	0	0	0	0	0	0	0	0	0	0
FF06-63	C	0	0	1	0	0	0	0	0	0	0
F10-14	n/a	8	0	0	0	0	0	0	24	0	24
F10-19	n/a	0	0	0	0	0	0	0	0	0	0
F10-29	n/a	0	0	0	0	0	0	0	0	0	0
F10-98	n/a	0	0	0	0	0	0	0	24	0	24

Other Seeds Part 1

Feature #	Zone	*Acalypha*	*Amaranthus*	*cf. Amaranthus*	*Apiaceae*	*Asteraceae*	*cf. Asteraceae*	*Brassicaceae*	*Brasenia schreberi*	*Moehringia*	*Cyperaceae*	*Euphorbiaceae*	*Ipomea*	*Lamium*	*Najas*	*Panicum*	*cf. Panicum*	*Poaceae*	*Potentilla*
KCV																			
FF12-01	E	0	0	4	0	0	0	0	0	0	0	0	0	0	##	0	4	0	0
FF12-01	I	0	16	16	0	0	0	0	0	0	32	0	0	0	96	0	0	0	0
FF12-01	L	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
FF12-01	M	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0
FF12-01	P	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	4
FF12-06	A2	0	0	0	0	0	0	0	4	0	0	0	0	0	20	0	0	8	0
FF12-06	B	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0
FF12-06	D	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
FF12-06	E	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
FF12-06	G	0	0	0	0	6	0	0	0	0	0	0	0	0	1	0	0	0	0
FF12-06	I	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0

Feature #	Zone	*Acalypha*	*Amaranthus*	*cf. Amaranthus*	*Apiaceae*	*Asteraceae*	*cf. Asteraceae*	*Brassicaceae*	*Brasenia schreberi*	*Moehringia*	*Cyperaceae*	*Euphorbiaceae*	*Ipomea*	*Lamium*	*Najas*	*Panicum*	*cf. Panicum*	*Poaceae*	*Potentilla*
FF12-06	L	0	0	0	0	0	2	0	0	0	0	0	0	0	4	4	0	2	0
FF12-06	O	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	6	0
FF12-06	Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FF12-06	R	0	2	0	0	2	0	1	0	0	3	0	0	0	0	2	0	3	0
FF12-06	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FF12-06	V	0	0	0	0	0	0	0	1	0	0	0	0	0	##	0	0	0	0
FF12-06	W	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0
FF12-26	n/a	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CBHC																			
FF00-11		1	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	1	0
FF00-11	B	0	0	0	0	0	0	4	0	0	0	1	0	0	0	0	0	28	8
FF00-26	B	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0
FF02-25	x	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
FF04-03		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FF04-14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FF04-14	2	0	0	0	0	0	8	0	0	1	0	4	0	1	8	0	0	0	0
FF04-14	3N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FF04-14	4	0	0	0	4	0	0	0	0	0	0	0	0	0	56	0	0	0	0
FF04-14	5	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	2	0
FF04-14	6N	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
FF04-15	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FF04-15	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	10	0
F04-22	x	0	0	66	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0
FF06-63	A	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0
FF06-63	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0
FF06-63	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
F10-14	n/a	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F10-19	n/a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
F10-29	n/a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F10-98	n/a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Other Seeds Part 2

Feature #	Zone	*Rosaceae*	*cf. Rosaceae*	*Scirpus*	*Seteria*	*Silene*	*Strophstyles helveola*	*cf. Strophstyles helveola*	*Viola*	*Verbena*	Unidentified Seed Type	Unidentifiable
KCV												
FF12-01	E	4	4	0	0	0	0	0	0	0	8	0
FF12-01	I	0	0	0	0	0	0	0	0	0	0	48
FF12-01	L	0	0	0	1	0	0	0	0	0	0	1
FF12-01	M	4	0	0	0	0	0	0	0	0	0	0
FF12-01	P	4	0	0	0	0	0	0	0	0	8	8

Feature #	Zone	*Rosaceae*	*cf. Rosaceae*	*Scirpus*	*Seteria*	*Silene*	*Strophstyles helveola*	*cf. Strophstyles helveola*	*Viola*	*Verbena*	Unidentified Seed Type	Unidentifiable
FF12-06	A2	0	0	0	0	0	4	0	0	0	0	0
FF12-06	B	0	0	0	0	0	0	0	0	0	0	0
FF12-06	D	1	0	0	0	0	0	0	0	0	0	0
FF12-06	E	0	0	0	0	0	0	0	0	0	0	0
FF12-06	G	1	0	0	0	0	0	0	0	0	0	0
FF12-06	I	0	0	0	0	0	0	0	0	0	0	0
FF12-06	L	0	0	0	0	0	0	0	0	0	0	6
FF12-06	O	2	0	0	0	0	0	0	0	0	0	4
FF12-06	Q	0	0	0	0	0	0	0	0	0	0	5
FF12-06	R	2	0	4	1	0	0	0	0	0	2	10
FF12-06	S	0	0	0	0	0	0	0	0	0	0	0
FF12-06	V	0	0	0	0	0	0	0	0	0	0	4
FF12-06	W	0	0	0	0	0	0	0	0	0	0	10
FF12-26	n/a	0	0	0	0	2	0	0	2	0	0	0
CBHC												
FF00-11		0	0	0	0	0	0	0	0	0	0	20
FF00-11	B	0	0	0	0	0	0	0	0	0	0	8
FF00-26	B	0	0	0	0	0	0	0	0	0	4	0
FF02-25	x	0	0	0	0	0	0	0	0	0	0	4
FF04-03		0	0	0	0	0	0	0	0	0	2	0
FF04-14	1	0	0	0	0	0	0	0	0	0	4	12
FF04-14	2	8	0	0	0	0	4	10	0	4	2	0
FF04-14	3N	0	0	0	0	0	0	0	0	0	0	0
FF04-14	4	0	0	0	0	0	0	0	0	0	0	16
FF04-14	5	4	0	0	2	0	0	0	0	0	12	0
FF04-14	6N	0	0	0	0	0	0	2	0	0	0	0
FF04-15	A	0	0	0	0	0	0	0	0	0	64	8
FF04-15	C	10	0	0	0	0	0	0	0	0	2	10
F04-22	x	40	0	0	0	0	0	0	20	0	6	##
FF06-63	A	0	0	0	0	0	0	0	0	0	0	20
FF06-63	B	0	0	0	0	0	0	0	0	0	0	20
FF06-63	C	0	0	0	0	0	0	0	0	0	0	10
F10-14	n/a	0	0	0	0	0	0	0	0	0	8	34
F10-19	n/a	0	0	0	0	0	0	0	0	0	0	0
F10-29	n/a	0	0	16	0	0	0	0	0	0	0	0
F10-98	n/a	0	0	0	0	0	0	0	0	0	0	2

Other Floral Remains Part 1

Feature #	Zone	Bud ct.	Bud wt.	Fungus ct.	Fungus wt.	Herbaceous Stem ct.	Herbaceous wt.	Monocot Stem ct.	Monocot Stem wt.	Peduncle ct.	Peduncle wt.	Pine Scales ct.	Pine Scales wt.
KCV													

Feature #	Zone	Bud ct.	Bud wt.	Fungus ct.	Fungus wt.	Herbaceous Stem ct.	Herbaceous wt.	Monocot Stem ct.	Monocot Stem wt.	Peduncle ct.	Peduncle wt.	Pine Scales ct.	Pine Scales wt.
FF12-01	E	0	0	337	1	0	0	0	0	8	0	0	0
FF12-01	I	0	0	738	2	0	0	0	0	0	0	0	0
FF12-01	L	0	0	13	0	1	0.001	0	0	0	0	0	0
FF12-01	M	0	0	31	0	0	0	0	0	0	0	0	0
FF12-01	P	0	0	56	0	4	0.001	0	0	0	0	0	0
FF12-06	A2	0	0	292	1	0	0	0	0	0	0	0	0
FF12-06	B	0	0	1785	6	16	1.136	0	0	0	0	0	0
FF12-06	D	1	0	1	0	0	0	0	0	0	0	0	0
FF12-06	E	0	0	0	0	0	0	0	0	0	0	0	0
FF12-06	G	0	0	31	0	0	0	0	0	0	0	0	0
FF12-06	I	0	0	14	0	0	0	0	0	0	0	0	0
FF12-06	L	1	0	23	0	1	0	0	0	1	0	0	0
FF12-06	O	0	0	108	0	0	0	0	0	0	0	0	0
FF12-06	Q	0	0	64	0	0	0	3	0	0	0	0	0
FF12-06	R	0	0	7	0	0	0	2	0	0	0	0	0
FF12-06	S	0	0	0	0	0	0	0	0	0	0	0	0
FF12-06	V	0	0	4	0	0	0	0	0	0	0	0	0
FF12-06	W	1	0	45	0	0	0	0	0	0	0	0	0
FF12-26	n/a	0	0	53	0	0	0	0	0	98	1	0	0
CBHC													
FF00-11		0	0	16	0	25	0.07	0	0	0	0	0	0
FF00-11	B	4	0	6	0	0	0	28	0	0	0	0	0
FF00-26	B	1	0	1	0	0	0	0	0	0	0	0	0
FF02-25	x	0	0	27	0	0	0	4	0	0	0	0	0
FF04-03		0	0	0	0	0	0	0	0	0	0	5	0
FF04-14	1	0	0	29	0	0	0	0	0	1	0	0	0
FF04-14	2	0	0	38	0	0	0	0	0	1	0	0	0
FF04-14	3N	0	0	2	0	0	0	0	0	0	0	0	0
FF04-14	4	0	0	156	0	0	0	0	0	0	0	0	0
FF04-14	5	0	0	2	0	0	0	0	0	0	0	0	0
FF04-14	6N	0	0	29	0	0	0	0	0	0	0	0	0
FF04-15	A	0	0	328	1	0	0	0	0	0	0	0	0
FF04-15	C	0	0	42	0	0	0	0	0	40	0	0	0
F04-22	x	20	0	107	0	0	0	120	0	0	0	0	0
FF06-63	A	0	0	20	0	0	0	0	0	0	0	0	0
FF06-63	B	0	0	0	0	0	0	0	0	0	0	0	0
FF06-63	C	0	0	0	0	0	0	2	0	0	0	0	0
F10-14	n/a	8	0	18	0	0	0	3	0	8	0	40	0
F10-19	n/a	0	0	84	0	0	0	0	0	0	0	2	0
F10-29	n/a	0	0	93	0	0	0	2	0	0	0	0	0
F10-98	n/a	0	0	36	0	0	0	0	0	0	0	0	0

Other Floral Remains Part 2

Feature #	Zone	Rhizome ct.	Rhizome wt.	Tuber (Aquatic) ct.	Tuber (Aquatic) wt.	Tuber (Terrestrial) ct.	Tuber (Terrestrial) wt.	Twig ct.	Twig wt.	Poaceae Stem ct.	Poaceae Stem wt.	UNID Organic ct.	UNID organic wt.
KCV													
FF12-01	E	0	0	0	0	0	0	0	0	0	0	10	1
FF12-01	I	0	0	0	0	0	0	0	0	0	0	16	0
FF12-01	L	0	0	0	0	0	0	0	0	0	0	0	0
FF12-01	M	1	0	0	0	0	0	0	0	0	0	5	0
FF12-01	P	0	0	0	0	0	0	0	0	0	0	8	0
FF12-06	A2	0	0	8	0	0	0	0	0	0	0	56	1
FF12-06	B	0	0	0	0	0	0	0	0	0	0	32	1
FF12-06	D	0	0	0	0	0	0	0	0	0	0	1	0
FF12-06	E	0	0	0	0	0	0	0	0	0	0	0	0
FF12-06	G	0	0	0	0	0	0	0	0	0	0	3	0
FF12-06	I	0	0	0	0	0	0	0	0	0	0	0	0
FF12-06	L	0	0	1	0	0	0	2	0	0	0	12	0
FF12-06	O	0	0	8	0	0	0	0	0	1	0	24	0
FF12-06	Q	0	0	0	0	0	0	0	0	0	0	0	0
FF12-06	R	0	0	0	0	0	0	0	0	0	0	6	0
FF12-06	S	0	0	0	0	0	0	0	0	0	0	0	0
FF12-06	V	0	0	1	0	0	0	0	0	0	0	16	0
FF12-06	W	0	0	0	0	0	0	0	0	0	0	7	0
FF12-26	n/a	0	0	0	0	0	0	0	0	4	0	8	0
CBHC													
FF00-11		0	0	0	0	0	0	0	0	0	0	0	0
FF00-11	B	0	0	0	0	0	0	0	0	63	0	0	0
FF00-26	B	0	0	0	0	0	0	0	0	0	0	0	0
FF02-25	x	0	0	0	0	0	0	0	0	32	0	0	0
FF04-03		0	0	0	0	0	0	0	0	14	0	0	0
FF04-14	1	0	0	0	0	4	0	0	0	0	0	0	0
FF04-14	2	0	0	0	0	0	0	0	0	0	0	0	0
FF04-14	3N	0	0	0	0	0	0	0	0	1	0	0	0
FF04-14	4	0	0	0	0	16	1	0	0	48	0	0	0
FF04-14	5	0	0	0	0	0	0	0	0	14	0	0	0
FF04-14	6N	0	0	0	0	0	0	0	0	0	0	0	0
FF04-15	A	0	0	0	0	24	2	0	0	24	1	0	0
FF04-15	C	0	0	11	0	1	0	0	0	161	1	0	0
F04-22	x	0	0	0	0	0	0	0	0	72	2	0	0
FF06-63	A	0	0	0	0	0	0	0	0	120	0	0	0
FF06-63	B	0	0	5	0	0	0	0	0	150	1	0	0
FF06-63	C	0	0	3	0	0	0	0	0	16	0	0	0
F10-14	n/a	0	0	0	0	8	0	0	0	64	0	8	0
F10-19	n/a	0	0	0	0	0	0	0	0	12	0	0	0
F10-29	n/a	0	0	0	0	0	0	0	0	1	0	0	0
F10-98	n/a	0	0	0	0	0	0	0	0	0	0	4	0

Appendix B: CSA Isotopes

ACRF	Site	Context/Lot #	Taxon	Skeletal Element
3572	CBHC, 47JE904	F10-14	*C. familiaris*	lt rib
3573	CBHC, 47JE904	F10-11	*C. familiaris*	zygomatic
3574	Diamond Bluff, 47PI2	Sq. G	*C. familiaris*	lt mandible
3575	Diamond Bluff, 47PI2	Sq. Z	*C. familiaris*	lt mandible
3759	Valley View, 47LC34	1979.1852.0 F99	*C. familiaris*	mandible frag
3760	Valley View, 47LC34	1979.942.463 F106	*C. familiaris*	mandible frag
3761	Pammel Creek 47LC61	1984.1637.41 F180	*C. familiaris*	mandible frag
3762	Sanford, 47LC394	1991.1658 F59	*C. familiaris*	mandible frag
3763	Sanford, 47LC394	1991.2321 F516	*C. familiaris*	mandible frag
	Duplicate Run			
3764	Sanford, 47LC394	99.1504.01 F37	*C. familiaris*	mandible frag
3765	OT, 47LC0262	1988.56.1219.2 F3	*C. familiaris*	skull frag
3766	OT, 47LC0262	1988.56.1219.1 F3	*C. familiaris*	mandible frag
3767	OT, 47LC0262	1988.56.909.3 F3	*C. familiaris*	skull frag
3768	OT, 47LC0262	1988.56.909.1 F3	*C. familiaris*	skull frag
3769	OT, 47LC0262	1988.56.909.2 F3	*C. familiaris*	skull frag
3791	Aztalan, 47JE1	Spec 1	*C. familiaris*	lt mandible
3792	Aztalan, 47JE1	Spec 2	*C. familiaris*	rt mandible
3793	Aztalan, 47JE1	Spec 3	*C. familiaris*	lt mandible

ACRF	δ^{13}C ‰	δ^{15}N ‰	Wt% C	Wt% N	C:N	Atomic	Wt %
	vPDB	vAIR			Ratio	C:N	Collagen
3572	-11.7	9.0	41.3	15.2	2.7	3.2	6.5
3573	-13.7	8.1	42.6	15.4	2.8	3.2	4.1
3574	-12.1	8.9	40.1	14.6	2.7	3.2	5.8
3575	-14.0	9.0	41.9	15.2	2.8	3.2	7.5
3759	-11.6	9.4	40.8	14.8	2.8	3.2	7.2
3760	-13.8	8.8	40.8	14.8	2.8	3.2	12.6
3761	-16.4	8.8	42.2	15.4	2.7	3.2	4.5
3762	-13.6	9.0	45.6	16.3	2.8	3.3	16.3
3763	-14.9	8.7	39.4	14.1	2.8	3.3	3.1
3763	-14.9	8.6	38.6	13.8	2.8	3.3	
3764	-14.0	9.3	42.3	15.0	2.8	3.3	5.3
3765	-13.7	9.5	43.9	15.6	2.8	3.3	6.3
3766	-13.7	9.5	38.9	13.4	2.9	3.4	3.3

ACRF	δ^{13}C ‰	δ^{15}N ‰	Wt% C	Wt% N	C:N	Atomic	Wt %
	vPDB	vAIR			Ratio	C:N	Collagen
3767	-15.4	8.6	37.2	13.2	2.8	3.3	3.4
3768	-14.9	8.6	40.8	14.8	2.8	3.2	4.1
3769	-15.6	8.6	40.5	14.8	2.7	3.2	6.5
3791	-15.1	8.3	43.2	15.6	2.8	3.2	4.6
3792	-14.4	9.2	40.8	14.9	2.7	3.2	5.8
3793	-16.2	8.2	42.4	15.5	2.7	3.2	7.2

ACRF	AMS Lab Code	^{14}C Age	1σ Error	Cal 2σ Age Range AD	Confidence interval Median
3572	D-AMS021779	854	21	1156-1228	1191
3573	D-AMS021780	866	24	1050-1224	1182
3574	D-AMS021781	870	19	1054-1219	1180
3575	D-AMS021782	685	27	1270-1387	1292
3759	D-AMS021787	485	22	1413-1445	1429
3760	D-AMS021783	437	19	1430-1467	1445
3761	D-AMS021784	543	20	1323-1429	1406
3762	D-AMS021785	540	21	1323-1431	1407
3763	D-AMS021786	648	24	1283-1392	1355
3764	D-AMS021788	466	21	1419-1450	1435
3765	D-AMS021789	415	19	1438-1487	1455
3766	D-AMS021790	305	27	1491-1649	1561
3767	D-AMS021791	418	19	1437-1486	1453
3768	D-AMS021792	250	20	1636-1797	1654
3769	D-AMS021793	361	19	1455-1631	1515
3791	D-AMS021794	942	24	1029-1154	1097
3792	D-AMS021795	1049	26	901-1026	996
3793	D-AMS021796	976	31	1013-1154	1084

Curriculum Vitae

Department of Anthropology
University of Wisconsin-Milwaukee
3413 N. Downer Ave., Sabin Hall 390
Milwaukee, WI 53211
wedwards@uwm.edu

EDUCATION

Ph.D., Anthropology, UW-Milwaukee: Scheduled Dec. 2017
Dissertation Title: *Risky Landscapes: An Assessment of Oneota Agricultural Risk Management Strategies in the Koshkonong Locality*

GIS Graduate Certificate, UW-Milwaukee: Dec. 2010

M.S., Anthropology, UW-Milwaukee: May 2010
Thesis Title: *Oneota Settlement Patterns Around Lake Koshkonong in Southeast Wisconsin: An Environmental Catchment Analysis Using GIS Modeling*

B.A., History, Sociology/Anthropology, UW-Parkside: May 2007

PUBLICATIONS

Peer Reviewed Publications

Edwards IV, Richard W., Robert Jeske, Joan Brenner Coltrain

2017 Preliminary Evidence for the Efficacy of the Canine Surrogacy Approach in the Great Lakes. *Journal of Archaeological Science: Reports* 13:516-525.

Edwards IV, Richard W.

2009 The North American Fur Trade World System. *Field Notes: A Journal of Collegiate Anthropology* 1(1):46-64.

Manuscripts in Preparation

Edwards IV, Richard W., and Robert Jeske, Developing Agriculture in Egalitarian Landscapes. In final preparation for submission to *American Antiquity* in December 2017.

Edwards IV, Richard W. Friend, Food, Companion: An Examination of a Dog's Roles in Oneota Village Life. In final preparation for submission to the *Midcontinental Journal of Archaeology* in December 2017.

Edwards IV, Richard W. Agriculture in the Koshkonong Locality: An Examination of Oneota Agricultural Practices. In preparation for submission to *Midcontinental Journal of Archaeology* in March 2018.

Edwards IV, Richard W. Minimizing Risk in Violent Landscapes. In Preparation for submission to *Journal of Anthropological Archaeology* in July 2017.

Research Reports, Professional Journals

Edwards IV, Richard W., Natalie C. Carpiaux, Robert Jeske
In Press Archaeology around Wisconsin: University of Wisconsin-Milwaukee-Pima. *Wisconsin Archeologist.*

Jeske, Robert J., Richard W. Edwards IV, Katherine M. Sterner-Miller and Robert Ahlrichs
2015 Archaeology around Wisconsin: University of Wisconsin-Milwaukee-Pima. *Wisconsin Archeologist* 96:123-125.

Jeske, Robert J., Seth A. Schneider, Elizabeth K. Spott and Richard W. Edwards IV
2013 Archaeology around Wisconsin: University of Wisconsin-Milwaukee-Pima. *Wisconsin Archeologist* 94:280-281.

Jeske, Robert J., Seth A. Schneider, Richard W. Edwards IV and Elizabeth K. Spott
2011 UWM Field School: Crescent Bay Hunt Club and Koshkonong Creek Village Sites *Wisconsin Archeologist* 90:85-88.

Technical Reports

Jeske, R.J., K.M. Sterner, D.M. Strange, R.W. Edwards, R.E. Ahlrichs
2017 Report on the Discovery of Human Remains at the Crescent Bay Hunt Club (47JE904), Jefferson County, Wisconsin, Report of Investigations 454. University of Wisconsin Milwaukee Archaeological Research Laboratory, Milwaukee, Wisconsin.

Edwards, R.W. IV, and R.Jeske
2016 Report on the Discovery of Human Remains at the Koshkonong Creek Village (47JE379), Jefferson County, Wisconsin, Report of Investigation 247. University of Wisconsin-Milwaukee Archaeology Research Laboratory, Milwaukee, Wisconsin.

Jeske, R.J. and R.W. Edwards IV
2014 Report on the Discovery of Human Remains at the Koshkonong Creek Village Site (47JE 379), Jefferson County, Wisconsin. Report Investigation 220. University of Wisconsin-Milwaukee Archaeological Research Laboratory, Milwaukee, Wisconsin.

Edwards IV., R.W. and T.J. Zych
2011 Spatial Analysis of Features. In *Final Report: Archaeological Monitoring and Recovery of Sub-Roadbed Deposits at the Schrage Site, Calumetville, Wisconsin* edited by Seth A. Schneider and John D. Richards pp. 131-136. Archaeological Research Laboratory Report of Investigations #180. Historic Resource Management Services, Archaeological Research Laboratory, University of Wisconsin-Milwaukee. Milwaukee, Wisconsin.

Jeske, R. J., K. M. Foley Winkler, D. M. Winkler and R.W. Edwards IV
2010 *Human Skeletal Remains and Material Culture Recovered from the Jaco Site (47Je1192) in Jefferson County, Wisconsin*. Reports of Investigation 172. University of Wisconsin-Milwaukee Archaeological Research Laboratory, Milwaukee, Wisconsin.

ACADEMIC AWARDS, GRANTS, AND FUNDING

University of Wisconsin-Milwaukee

2016: National Science Foundation: Dissertation Improvement Grant ($11,528)
2016: University of Wisconsin-Milwaukee Distinguished Dissertator Fellowship ($28,334)
2014: Anthropology Department Preliminary Dissertation Grant ($1,200)
2011-2014: ASU Travel Grant
2009-2014: Teaching Assistant
2013: Graduate School Travel Grant ($800)
2012: Lambda Alpha Anthropology Honors Society
2011: Graduate School Travel Grant ($1,000)
2010: Phi Kappa Phi Honors Society

University of Wisconsin-Parkside

2007: Phi Alpha Theta, History Honors Society
2005-2007: Zanoic Family Scholarship (~$9,700)
2004-2007 : Provost's List
2006: Undergraduate Research Apprenticeship Program Grant
2003-2004: Dean's List

PRESENTATIONS

Organized Symposia

2016
(Edwards, Richard and Madeline McLeester) Paleoethnobotany Workshop. Organized workshop at the Midwest Archaeological Conference, Iowa City, Iowa. October 7th 2016.

2015
(Edwards Richard, and Robert Jeske) Oneota Landscapes of the Lake Michigan Basin. Symposium presented at the Midwest Archaeological Conference, Milwaukee, WI. November 6th 2015.

2014
(Edwards, Richard, Katherine Sterner-Miller, and Robert Jeske) A Look Around the Lake: Recent Archaeological Investigations in the Lake Koshkonong Region of Southeastern Wisconsin. Symposium presented at the Midwest Archaeological Conference, Champaign-Urbana, IL. October 3rd 2014.

2013
(Edwards, Richard, Susan Kooiman, Erin Benson, Andrew Upton, Aaron Comstock, and Shawn Dunham) Student Workshop: Getting the Job. Symposium presented at the Midwest Archaeological Conference, Columbus, OH. October 25th 2013.

2012
(Edwards, Richard and Seth Schneider) Koshkonong Region Archaeology: Investigations into the Past of Southeastern Wisconsin. Symposium presented at the Midwest Archaeological Society, East Lansing, MI. October 19th 2012.

(Comstock, Aaron, Richard Edwards, Susan Kooiman, Nicole Raslich, Andrew Upton, Heather Walder, and Robert Sasso) Students' Workshop: Publishing: What, When, Where, and How? Symposium presented at the Midwest Archaeological Society, East Lansing, MI. October 20th 2012.

2011
(Walder, Heather and Richard Edwards) Building Your Career in Archaeology. Symposium presented at the Midwest Archaeological Society, La Crosse, WI. Oct. 15, 2011.

Professional Presentations
2017
(Edwards, Richard, Robert Jeske) How Much is Enough? Evaluating the role of Maize in the Late Prehistoric of the Prairie Peninsula. Papers presented at the Midwest Archaeological Conference, Indianapolis, Oct. 20, 2017.

(Carpiaux, Natalie, Richard Edwards) Pits, Pots, and Paleobot: Feature Analysis at the Koshkonong Creek Village. Paper Presented at the Midwest Archaeological Conference, Oct. 20, 2017.

(Milosavljevic, Tania, Hannah Blija, Sean Gleason, Richard Edwards) The Koshkonong Style: An Examination of the 2017 KCV Ceramic Assemblage. Paper Presented at the Midwest Archaeological Conference, Oct. 21, 2017.

(Greiff, AmySue, Drew Agnew, Richard Edwards) Fauna for Thought: A Preliminary Comparative Analysis of Subsistence among Households. Poster Presented at the Midwest Archaeological Conference, Oct. 20, 2017.

(Jeske, Robert, Katherine Sterner, Richard W. Edwards, Hannah Blija, Samantha Bomkamp, Tania Milosavljevic) Ten Seasons Later, The Crescent Bay Hunt Club and Wisconsin Oneota Lifeways. Paper Presented at the Midwest Archaeological Conference, Oct. 21, 2017.

(Edwards, Richard) Oneota Risk Management Strategies and Agricultural Practices. Papers present at the Society for American Archaeology, Vancouver, British Columbia. March 30, 2017.

(Jeske, Robert J, Seth Schneider, Richard Edwards, Katherine Sterner, Rachel McTavish) Strangers in a Strange Land, The Lake Koshkonong Oneota Locality in Context. Paper presented at the Society for American Archaeology, Vancouver, British Columbia. March 30, 2017.

2016
(Edwards, Richard) Oneota Agricultural Systems of the Koshkonong Locality. Paper presented at the Midwest Archaeological Conference, Iowa City, Iowa. October 7, 2016.

(Jeske, Robert, Seth Schneider, Richard Edwards, Katherine Sterner, Rachel McTavish) Strangers in a Strange Land, The Lake Koshkonong Oneota Locality in Context. Paper presented at the Midwest Archaeological Conference, Iowa City, Iowa. October 8, 2016.

(Edwards, Richard) Dog Human Symbiosis in the Great Lakes: Preliminary Evidence for the efficacy of the Canine Surrogacy Approach. Paper presented at the International Council of Zooarchaeology: Stable Isotope in Zooarchaeology Working Inaugural Group Meeting, Athens, Georgia. March 4, 2016.

2015

(Edwards, Richard) Dog-Human Symbiosis: Archaeological Evidence from the Great Lakes. Paper presented at the 59th Annual Meeting of the Midwest Archaeological Conference, Milwaukee, Wisconsin. November 7, 2015.

(Edwards, Richard and Robert Jeske) Lake Koshkonong Locality's Place in the Oneota Cultural Landscape of the Lake Michigan Basin. Paper presented at the 59th Annual Meeting of the Midwest Archaeological Conference, Milwaukee, Wisconsin. November 6, 2015.

(Jeske, R. J. and Richard, Edwards) Oneota of the Western Lake Michigan Basin: The Deep Periphery. Paper presented at the 59th Annual Meeting of the Midwest Archaeological Conference, Milwaukee, Wisconsin. November 6, 2015.

(Edwards, Richard) Dog-Human Symbiosis: Archaeological Evidence from the Great Lakes. Paper presented at the University of Wisconsin-Milwaukee Anthropology Student Union Colloquium. March 14, 2015

2014

(Edwards, Richard) Digging Deep for Answers: 2014 Excavations at the Koshkonong Creek Village. Paper presented at the Midwest Archaeological Conference, Champaign-Urbana, IL. Oct. 3, 2014.

(Carpiaux, Natalie, and Richard Edwards) Koshkonong Creek Ceramics: A Preliminary Pottery Analysis. Paper presented at the Midwest Archaeological Conference, Champaign-Urbana, IL. Oct. 3, 2014.

(McTavish Rachel and Richard Edwards) An Analysis of Variation in Oneota Watershed Exploitation in the Lake Koshkonong Locality. Paper presented at the Midwest Archaeological Conference, Champaign-Urbana, IL. Oct. 3, 2014.

(Torgerson, Rebecca, Richard Edwards, and Katherine Sterner-Miller) Retracing Old Footsteps: A Recent Pedestrian Survey at the Bent Elbow Farm. Paper presented at the Midwest Archaeological Conference, Champaign-Urbana, IL. Oct. 3, 2014.

(Edwards, Richard) An Examination of Canid Remains from the Crescent Bay Hunt Club. Paper presented at the 79th Annual Meeting of the Society for American Archaeology, Austin, TX. April 27, 2014.

2013
(Edwards, Richard) Wisconsin Oneota Faunal Exploitation: A Case Study from the Crescent Bay Hunt Club (47JE904), Lake Koshkonong, Southeastern Wisconsin. Paper presented at the 78th Annual Meeting of the Society for American Archaeology, Honolulu, HI. April 6, 2013.

2012
(Edwards, Richard and Rachel McTavish) A Tail of Two Fishes: Oneota Fish Exploitation at the Koshkonong Creek Village Site (47JE379) and the Crescent Bay Hunt Club (47JE904). Paper presented at the Midwest Archaeological Conference, East Lansing, MI. Oct. 19, 2012.

(Edwards, Richard and Elizabeth Spott) An Oneota Village in an Upland Setting: 2012 Excavations at the Koshkonong Creek Village Site (47JE379). Paper presented at the Midwest Archaeological Conference, East Lansing, MI. Oct. 19, 2012.

(Jeske, Robert and Richard Edwards) Differential Land Use Patterns in the Rock River Watershed: Horicon Marsh versus Lake Koshkonong. Paper presented at the 77th Annual Meeting of the Society for American Archaeology, Memphis, TN. April 19, 2012.

(Edwards, Richard and Kim Pater) What's on the Menu: An Updated Analysis of Oneota Subsistence at the Crescent Bay Hunt Club (47JE904). Paper presented at the Anthropology Student Union Annual Colloquium, Milwaukee, WI. March 4, 2012.

2011
(Schulenburg Marcus, and Richard Edwards) Preliminary Ceramic Analysis of the Gibson Site (Door County, WI). Paper Presented at the Midwest Archaeological Conference, La Crosse, WI. Oct. 15, 2011.

(Edwards, Richard and Kim Pater) What's on the Menu: An Updated Analysis of Oneota Subsistence at the Crescent Bay Hunt Club (47JE904). Paper presented at the Midwest Archaeological Conference, La Crosse, WI. Oct. 15, 2011.

(Edwards, Richard and Thomas Zych) Pits, Open Spaces, and Artifact Distributions: A Spatial Analysis of the Schrage Site. Poster Presented at the 76th Annual Meeting of the Society for American Archaeology, Sacramento, CA. April 1, 2011.

2010
(Pater, Kim, Richard Edwards, and Elizabeth Spott) An Updated Interpretation of the Koshkonong Creek Village Site. Paper Presented at the Annual Midwest Archaeological Conference, Bloomington, IN. Oct. 21, 2010.

(Edwards, Richard) GIS Catchment Analysis of Oneota Settlement Patterns near Lake Koshkonong, Southeast Wisconsin. Paper presented at the 75 Annual Meeting of the Society for American Archaeology, St. Louis, MO. April 16, 2010.

(Edwards, Richard, and Marcus Schulenburg) A GIS Analysis of Three Red Ochre Burials in Southeastern Wisconsin. Poster Presented at the Annual Midwest Archaeological Conference, Iowa City, IA. Oct. 16, 2009.

(Edwards, Richard) A GIS Environmental Analysis of the Northwest shore of Lake Koshkonong. Paper presented at the 3rd Annual Anthropology Student Union Student Colloquium, Milwaukee, WI. Feb. 7, 2009.
2008

(Edwards, Richard) GIS Analysis of Schmeling Site. Paper presented at the Annual Midwest Archaeological Conference, Milwaukee, WI. Oct. 17, 2008.

2007
(Edwards, Richard and Robert Sasso) Findings from the initial ceramic analysis of the Vieau Fur Trade Post in Franksville, WI. Paper presented as a poster at the UW Symposium for Undergraduate Research and Creative Activity, Menominee, WI. April 20, 2007, UW Posters in the Rotunda, Madison, WI. April 18, 2007, and the UW Parkside Student Showcase, Kenosha, WI. April 13, 2007.

Invited Public Lectures

2016 Late Prehistoric Dogs of Wisconsin Guardians, Workers, Friends and Food. Invited Speaker at the Kenosha County Archaeological Society, Kenosha, WI.

2016 Diet, Dogs, and People: A Test of the Canine Surrogacy Approach and its Implications for Great Lakes Archaeology? Invited speaker at the Blue Ridge Archaeological Guild, Dahlonega, GA.

2015 Oneota in the Koshkonong Locality. Invited speaker at the Local History Class at the Edgerton High School, Edgerton WI.

2014 Buried Answers: Excavations at the Koshkonong Creek Village (47JE379). Invited talk at the Kenosha County Archaeological Society. Kenosha, WI.

2014 Oneota in the Koshkonong Locality. Invited speaker at the Local History Class at the Edgerton High School, Edgerton WI.

2014 Great Lakes Prehistory: A Brief Introduction. Invited lecture for the American Quaternary Association’s 2014 Summer Quaternary Short Courses, Kenosha WI.

2014 Culture and Food Choice: A Koshkonong Locality Case Study. Invited talk at the Kenosha Public Museum Annual Archaeology Month Lecture, Kenosha WI.

2014 Oneota in the Koshkonong Locality. Invited speaker at the Local History Class (Spring) at the Edgerton High School, Edgerton WI.

2013 Oneota in the Koshkonong Locality. Invited speaker at the Local History Class (Fall) at the Edgerton High School, Edgerton WI.

2013 Koshkonong Creek Village Site: An Upland Oneota Habitation in the Lake Koshkonong Locality. Invited talk at the February Meeting of the Charles Brown Archaeological Society, Madison, WI.

2013 Koshkonong Creek Village Site: An Upland Oneota Habitation in the Lake Koshkonong Locality. Invited talk at the January Meeting of the Wisconsin Archeological Society, Milwaukee, WI.

2012 Oneota Settlement Patterns Around Lake Koshkonong in Southeast Wisconsin: An Environmental Catchment Analysis Using GIS Modeling. Invited talk at the January Meeting of the Ritzenthaler Archaeological Society, Oshkosh, WI.

UNIVERSITY TEACHING EXPERIENCE

Adjunct Lecturer: Carroll University, Waukesha, WI

General Education

2012-Present: Cross Cultural Seminar 100: *Wisconsin's First Peoples: Native Americans of Wisconsin*

2017-Present: Cross Cultural Seminar 399: *Cross Cultural Experience – White Earth Anishnaabe*

2017-Present: Cross Cultural Seminar 199: *Cultural Survey*

2013-2017: *Cross Cultural Seminar 101*

Department of Communications and Sociology

2010-2012: *Sociology 110: Introduction to Cultural Anthropology*

Adjunct Faculty: College of Lake County, Grayslake, IL

Department of Anthropology

2015-2016: Anthropology 121: *Introduction to Anthropology*

2016: Anthropology 221: *Introduction to Cultural Anthropology*

Associate Lecturer: University of Wisconsin-Parkside, Kenosha, WI

Department of Sociology and Anthropology

2014: *Sociology/Anthropology 100: Introduction to Anthropology*

2014: *Sociology/Anthropology 204: Human Evolution*

Instructor: University of Wisconsin-Milwaukee, Milwaukee, WI

Department of Anthropology

2011: *Anthropology 103: Digging up the Past: Approaches to Archaeology*

Teaching Assistant: University of Wisconsin-Milwaukee, Milwaukee, WI

Department of Anthropology

2017: Anthropology 535: *Archaeological Ceramic Analysis*

2010, 2012, 2014, 2017: Anthropology 567*: Archaeological Field School:* Instructor – Robert Jeske, PhD

2010, 2012: Anthropology 562*: Techniques and Problems in Archaeology: Introduction to Archaeological Mapping:* Instructor – Brian Nicholls, M.S.

2011: Anthropology 305*: The Celtic World: Instructor Patricia Richards, PhD*

2010: Anthropology 566*: Archaeological Analysis and Report Preparation:* Instructor – John Richards, PhD

2009 Anthropology 213*: American Indians of Wisconsin:* Instructor – Patricia Richards, PhD

Department of Biological Sciences

2012-2014: Biological Sciences 202*: Anatomy and Physiology I:* Instructors: Andrew Petto, PhD and Selvakumar Ramakrishnan PhD

RESEARCH INTERESTS

Landscape Archaeology
Foodways (Paleoethnobotany & Zooarchaeology)
Agriculture and Cultural Complexity
Late Prehistoric Great Lakes Archaeology (Focus Oneota)
Isotopic Bone Chemistry
Human-Dog Relationship
Settlement Systems Analysis
Geographic Information Systems (GIS)
Eastern Woodlands Prehistory
Late Archaic Burial Practices (Focus Red Ochre Burials)
Late Iron Age/Romano-British Settlement Systems

ARCHAEOLGOICAL EXPERIENCE

Skeletal Excavation Experience

2012/2017	Crescent Bay Hunt Club: 47JE0904/47BJE0201
2014/2016	Koshkonong Creek Village: 47JE0379 47BJE0263
2013	Milwaukee County Institutional Grounds: 47MI0527/47BMI0076
2009	Jaco Site: 47JE1192/47BJE0228
2009	Schrage Site: 47FD0581/47BFD0201

Supervisor Experience

2012-Present	Field Director, 47JE379, Koshkonong Creek Village Site
2015	Project Archaeologist, Commonwealth Cultural Resource Group – Phase I Surveys
2014	Field Supervisor, UW-Milwaukee Field School
2014	Field Supervisor, Nitschke Garden Bed Site – Public Archaeology Project
2013	Field Supervisor, BMI-0076, Milwaukee County Institutional Grounds Cemetery
2013	Survey Crew Chief, Highway 26, Jefferson County, Wisconsin Phase I Surveys
2012	Field Supervisor, UW-Milwaukee Field School
2011	Field Supervisor, Nitschke Garden Bed Site – Public Archaeology Project
2010	Field Supervisor, UW-Milwaukee Field School
2007	Field Supervisor, UW-Parkside Field School

Archaeological Field Experience

2009-Present	Project Member: Program in Midwest Archaeology. Under the Supervision of Robert Jeske, PhD, RPA (University of Wisconsin-Milwaukee).
2012-Present	Field Director: Project in Midwest Archaeology. Excavations at the Koshkonong Creek Village Site. Robert Jeske, PhD, RPA as principle investigator
2015	Project Archaeologist: Commonwealth Cultural Resource Groups. Supervision and solo survey of DOT, DNR, and other cultural resource phase 1 projects. Mapped/recorded sites, affected areas of cemeteries, etc. within project areas.
2014	Field Supervisor: University of Wisconsin-Milwaukee Archaeological Field school. Lake Koshkonong Oneota Complex, Jefferson County, WI. Under the supervision of Robert Jeske, PhD, RPA.

2014	Field Supervisor: Nitschke Garden Beds project, Dodge County, WI. Under the supervision of Kira Kaufmann, PhD and Robert Jeske, PhD, RPA.
2013	Field Supervisor: Historic Resource Management Services. Excavations at the Milwaukee County Institutional Grounds. Patricia Richards PhD as principle investigator.
2013	Crew Chief: Historic Resource Management Services. Phase 1 Surveys in Jefferson County, Wisconsin State Highway 26 Corridor.
2012	Field Supervisor: University of Wisconsin-Milwaukee Archaeological Field School. Lake Koshkonong Oneota Complex, Jefferson County, WI. Under the supervision of Robert Jeske, PhD, RPA.
2011	Volunteer Archaeologist: Nitschke Garden Beds project, Dodge County, WI. Under the supervision of Kira Kaufmann, PhD and Robert Jeske, PhD, RPA.
2010	Field Supervisor: University of Wisconsin-Milwaukee Archaeological Field School. Lake Koshkonong Oneota Complex, Jefferson County, WI. Under the supervision of Robert Jeske, PhD, RPA.
2009	Volunteer Archaeologist: Nitschke Garden Beds project, Dodge County, WI. Under the supervision of Kira Kaufmann, PHD and Robert Jeske, PhD, RPA.
2008	Field Technician: Great Lakes Archaeological Research Company. Under the Supervision of Ralph Koziarski, MS.
2007	Field Supervisor: University of Wisconsin-Parkside Archaeological Field School: Vieau Fur Trade Post, Franksville, WI. Under the Supervision of Robert F. Sasso PhD, RPA.
2006	Field School: University of Wisconsin-Parkside Archaeological Field School: Vieau Fur Trade Post, Franksville, WI. Under the supervision of Robert F. Sasso PhD, RPA.

Archaeological Laboratory Experience

2009-Present	Project Member: Program in Midwest Archaeology. Under the Supervision of Robert Jeske, PhD, RPA (University of Wisconsin-Milwaukee).
2013-Present	GIS Analysist: Late Iron Age/Romano-British Settlement System Spatial Analyses; working in concert with Alexis Jordan MS, Lara Ghisleni MS, and Shaheen Christi, MA.
2015	Laboratory Technician: Commonwealth Cultural Resource Group. Flotation analysis under the Supervision of Katie Egan-Bruhy PhD, RPA.
2014	Zooarchaeological Analysis: Crescent Bay Hunt Club: Osteological analysis of a dog burial. Understanding the Oneota Human Dog Relationship. Under the Supervision of Robert Jeske, PhD, RPA (University of Wisconsin-Milwaukee).
2014	Volunteer Archaeologist: Aztalan Princess Burial: Shell Bead Analysis, Milwaukee Public Museum, Milwaukee, WI. Under the Supervision of Rachel C. McTavish, M.S.
2013	Zooarchaeological Analyst: Crescent Bay Hunt Club: Investigation into the role of mammals in the Oneota diet. Under the Supervision of Robert Jeske, PhD, RPA (University of Wisconsin-Milwaukee).
2012	Artifact Processing Supervisor: Supervised student and volunteer processing of artifacts from 2012 UWM Field School. Under the Supervision of Robert Jeske, PhD, RPA (University of Wisconsin-Milwaukee).

2012	Zooarchaeological Analysis: Koshkonong Creek Village Site: Identification of fish exploitation patterns in upland Oneota sites. Under the Supervision of Robert Jeske, PhD, RPA (University of Wisconsin-Milwaukee).
2012	GIS Analyst: Mapping and analyzing spatial patterns of cultural deposits at the Koshkonong Creek Village Site. Under the Supervision of Robert Jeske, PhD, RPA (University of Wisconsin-Milwaukee).
2011	Zooarchaeological Analysis: Jaco Site, faunal identification. Under the Supervision of Robert Jeske, PhD, RPA (University of Wisconsin-Milwaukee).
2011	Undergraduate Supervisor: Schmeling Zooarchaeology Analysis. Under the Supervision of Robert J, Jeske PhD, RPA (University of Wisconsin-Milwaukee).
2011	Paleoethnobotany Internship: Commonwealth Cultural Resources Group Inc. Under the Supervision of Kathryn Egan-Bruhy, PhD, RPA.
2009-2010	GIS Analyst: Identification and Interpretation of Koshkonong Locality Oneota Settlement Patterns. Under the supervision of Robert Jeske PhD, RPA. And Brian Nicholls, MS, RPA (University of Wisconsin-Milwaukee).
2008-2009	Field/GIS Technician: Historic Resource Management Services. Under the supervision of Brian Nicholls, MS, RPA.
2006-2007	Laboratory Research: Ceramic Analysis of the Vieau Fur Trade Post, Franksville, WI, at the University of Wisconsin-Parkside. Under the supervision of Robert F. Sasso, PhD, RPA.
2005	Laboratory Research: Artifact Processing of Vieau Fur Trade Post, Franksville, WI, at the University of Wisconsin-Parkside. Under the Supervision of Robert F. Sasso, PhD, RPA.

Museum Experience

2006	Museum Intern: Kenosha Public Museum. Inventory and accessioning of new materials in preparation for the construction of the Kenosha Civil War Museum. General exhibit maintenance. Under the supervision of Gina Radant, Curator of Collections.

PROFESSIONAL SERVICE

2017-Present: Wisconsin Archaeological Survey: Board Member
2016-Present: Wisconsin Archaeological Survey: Webmaster
2011-2013: Member of Student Committee – Midwest Archaeological Society
2010-2012: Program Chair – Wisconsin Archeological Society
2008-2010: Editor – Field *Notes: A Journal of Collegiate Anthropology*, Volumes 1 & 2

DEPARTMENT/UNIVERSITY SERVICE

2012: Graduate Student Advisory Council – University of Wisconsin-Milwaukee
2008-2011: Webmaster Anthropology Student Union (UW-Milwaukee)
2008-2010: President of the Anthropology Student Union (UW-Milwaukee)
2005-2007: President of the Parkside Anthropological Society

TRAINED ANALYSIS METHODS

Geographic Information Science/Systems
Paleoethnobotany
Zooarchaeology
Archaeological Mapping
Ceramic Analysis

OTHER RELEVANT SKILLS

ArcGIS (Graduate Level Certificate in Geographic Information Systems)
SPSS, R, and SYSTAT statistic programs
Trimble GPS units
Archaeological mapping and mapping equipment (Total Station, Optical Transit, Plane Table, and Compass)
Microsoft Windows (Including MS Word, PowerPoint, and Excel)
Adobe Creative Suite

TEACHING AREAS

Introduction to Anthropology/Archaeology
Archaeological/Anthropological GIS and/or Mapping
Archaeology Lab Methods
Archaeology Field School
Paleoethnobotanical Methods
The Prehistory of Food

PROFESSIONAL / EDUCATIONAL AFFILIATIONS

2012: Wisconsin Archaeological Survey
2011: Register of Professional Archaeologists
2008: Society of American Archaeology
2008: Midwest Archaeological Conference
2007: Wisconsin Archeological Society
2007: Anthropology Student Union
2005: Parkside Anthropological Society

PROFESSIONAL REFERENCES

Robert Jeske, PhD
Professor of Anthropology
University of Wisconsin-Milwaukee
3413 N. Downer Ave
Milwaukee, WI 5321
jeske@uwm.edu
(414) 640-2062

Robert F. Sasso, PhD
Associate Professor of Anthropology
University of Wisconsin-Parkside
900 Wood Rd.
Kenosha, WI 53144
sasso@uwp.edu
(262) 595-2169

Ellen Barclay, PhD
Associate Dean, Director of General Education
Carroll University
100 N. East Ave.
Waukesha, WI 53186
ebarclay@carrollu.edu
(262)-524-7107