# **Identifying Changes in Late Woodland Ceramic Traditions**

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## Abstract

The MacNichol site in northern Ohio is a Late Woodland period site with radiocarbon dates indicating occupations from approximately AD 740-1100 and again from approximately AD 1340-1460. The large gap between the earlier and later occupations of the site coincides with a known inflection point in the ceramic traditions of the region, making this site uniquely suited to studying the material culture of the region before and after this transition occurred. However, to date no formal analysis has been made of the ceramic assemblage collected from Area B of the site, due to complications in excavation. By modeling this assemblage through cluster analysis and regression models incorporating newly submitted radiocarbon dates, we can better understand if a significant change in ceramic style did occur over this time, as well as what attributes of the ceramics can best indicate such a change.

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## 1. Introduction and Background

### *1.1 Overview*

In the Southwestern Lake Erie region, stretching across northwestern Ohio and southeastern Michigan, the Late Woodland period is considered to have lasted from AD 500-1300 (Stothers and Abel 2002). As in other regions, the Late Woodland here was dominated primarily by hunter-gatherer-fisher groups moving seasonally around the landscape, with some small-scale maize cultivation. Although some degree of movement of the region's various cultures occurred throughout the Late Woodland period, a significant inflection point, evidenced by sudden changes in ceramic technologies and other material culture, occurred around AD 1250 (Stothers and Abel 2002). This is particularly evident at sites in the Maumee River Valley of northern Ohio, where a new ceramic tradition known as the Wolf Phase appears to rapidly replace previous traditions at this time. In order to better understand the changes that occurred in the ceramic-making sequences at this time, it is important to study sites with long occupational histories including ceramics from both before and after this tradition; one such site is the MacNichol site in northwestern Ohio.

The Late Woodland period marked a significant transitional period in the prehistory of North America. People in this period were seasonally mobile, taking advantage of plentiful natural resources while living in relatively small settlements. Small-scale cultivation of maize and other crops began during this time, setting the stage for later intensification and full-blown agriculture in the following Mississippian period. Although large Mississippian population centers such as Cahokia developed in other regions as early as AD 800, the Late Woodland tradition continued in the southwestern Lake Erie Basin until as late as AD 1400 (Stothers and Abel 2002). This time was not without change, however; evidence suggests that several distinct groups existed concurrently at this time and were variously affected by northward moving Upper Mississippian cultural influences (Stothers and Abel 2002). The complex interactions between these groups and traditions remains unclear but may be better understood through the study of ceramic assemblages.

The production of ceramics is often viewed by archaeologists as a complex and socially embedded process known as the chaîne opératoire (Quinn 2013; Sillar and Tite 2000). This term refers not only to the technical operational sequence of steps taken to produce pottery, but also to the ways in which these steps are understood at a social level. Ethnographic parallels have suggested that the choices made during ceramic production are heavily influenced by culture and tradition. For example, temper (additional material mixed into the clay before creating a vessel) is often used to strengthen a vessel and ensure more efficient thermal conduction. Beyond this physical advantage, however, the choice in the type of temper used is influenced by traditions within a group, the materials available, the intended use of the vessel, and the potter's perception of the quality this temper provides (Sillar and Tite 2000). Ceramic artifacts are therefore often a marker of a particular group; the many choices made throughout the production process reflect a particular set of geographic and social influences that can vary widely from group to group (Quinn 2013). By closely studying the choices made in the production of ancient pottery, we can better understand the social contexts in which it was made and make inferences about the groups who made it.

### *1.2 Ceramic Traditions of the Late Woodland*

The Late Woodland in the Western Lake Erie Basin is characterized by two contiguous ceramic traditions: the Western Basin Tradition and the Sandusky Tradition (Stothers and Abel

2002). The Western Basin Tradition (WBT) originated along the northwestern point of Lake Erie and Lake St. Clair, spreading south and east by AD 700 (Stothers and Abel 2002). The tradition is divided into four phases, spanning from AD 500-1350. During the first two phases (AD 500-1000), WBT peoples practiced a mixed subsistence strategy and were seasonally mobile. Starting with the Younge Phase (AD 1000-1250), WBT peoples seem to have made increasing use of maize cultivation, as evidenced in part by a shift in ceramic morphology; vessels changed from being short and globular to more upright and cylindrical, indicating a change in function from cooking to storage (Stothers and Abel 2002). Additionally, settlement patterns shifted from lake coasts to inland rivers, including the Maumee River Basin, where fishing and farming could be practiced together. This trend continued with the subsequent Springwells Phase (AD 1200-1350), where evidence suggests the development of interior, fortified villages (Stothers and Abel 2002).

Meanwhile, the Sandusky Tradition is thought to have originated to the southeast of the Western Basin Tradition, in the area of north central Ohio. Although some interaction may have occurred back and forth between the two traditions, they continued to occupy neighboring regions throughout the Late Woodland while remaining distinct from one another. Around AD 1250, the Sandusky tradition appears to become more dominant in the Maumee River Valley region, while the Western Basin Tradition disperses to the southwest, northwest, and northeast (Stothers and Abel 2002). However, the nature of these cultural shifts has been debated, largely centering around the ceramics of the Wolf Phase.

The Wolf Phase lasted from about AD 1250-1450 and is characterized primarily by the presence of Parker Festooned ceramics, a distinctive type featuring a chevron pattern along collarless and everted vessel rims (Abel 1999). In the Maumee River Basin, Wolf Phase ceramics seem to replace those of the Western Basin Tradition rather quickly, beginning around

AD 1250. The exact origin of these ceramics was debated by scholars following their identification. Initially, Parker Festooned ceramics were thought to have evolved out of the Springwells Phase of the Western Basin Tradition, but later analysis suggested the two styles were contemporary with one another (Stothers and Pratt 1981). Therefore, ceramics of the Wolf Phase are thought to be distinct from the Western Basin Tradition, possibly representing a separate cultural group. Some scholars (e.g., Stothers and Abel 2002) argue that the Wolf Phase was developed to the south of the Maumee River Valley, out of the Sandusky Tradition. They argue that the presence of the Wolf Phase in the Maumee River Valley therefore represents a northward migration of the Sandusky Tradition and, consequently, the displacement of the Western Basin Tradition. Others have argued, however, that the Wolf Phase represents a local adaptation to changing climate conditions (Brose 2000, 2001). These different hypotheses paint very different pictures of the interactions between these two cultural groups and understanding the drivers behind this key chronological inflection point will help answer important questions about the history of the region.

### *1.3 MacNichol Site*

Ceramic data for the present study come from MacNichol Site, a Late Woodland archaeological site on the Maumee River near Toledo, Ohio. The site was excavated as part of a field school run by the University of Toledo, first in 1974, then again in 1978. The site appears to have been initially occupied by Western Basin Tradition peoples, with a later transition in ceramic styles; however, the more specific chronology of this site remains unclear due to issues with dating and stratigraphy.

The initial 1974 excavations of the section of the site designated as Area A revealed several deep, overlapping storage pits, along with post holes situated in such a way as to suggest they could have been part of a drying rack for fish. Based on this and other evidence from excavations, the site has been interpreted as a seasonal fishing camp that was repeatedly occupied throughout the Late Woodland (Burhenn 2019). This is consistent with other known information about seasonal mobility of the Late Woodland; following periods of scattered and sparsely populated winter hunting camps, larger groups would have aggregated along riverbanks in the springtime to take advantage of the large spawning-fish harvest and reunite with more distant kin groups (Stothers and Abel 2002). Ceramics from this area consisted of cord marked, grit-tempered sherds consistent with the pottery of the Western Basin Tradition.

Area B was excavated in the spring and summer of 1978. Earlier that year, flooding and freezing along the Maumee River caused extensive damage to the site, exposing features and artifacts. Following exposure, the site was further damaged by illegal looting. As a result, the 1978 excavation was primarily a salvage project, limiting the amount and type of data recorded (Burhenn 2019). Additionally, the scouring that exposed Area B and subsequent looting made the stratigraphic information unreliable. Ceramics from this area include a mix of both Western Basin Tradition pottery and pottery that appears to be either from a later period or from a different cultural tradition. Due to the limited availability of the data from Area B, previous analyses of the site have not addressed this mixed ceramic assemblage even though the different types present in the collection hold enormous potential for understanding the cultural transitions that took place at the MacNichol site toward the end of the Late Woodland period. The site's location between areas associated with the Western Basin Tradition and those associated with the Sandusky Tradition make it uniquely suited for studying the possible interactions between these groups. Additionally, recently processed radiocarbon dates suggest that the site was unoccupied during the Wolf Phase, therefore providing distinct snapshots of the times immediately before and after this identified transition period.

### *1.4 Present Analysis*

The present study aims to answer two primary research questions: firstly, did a significant change in the ceramic traditions present at the MacNichol site actually occur after the identified inflection point of AD 1250? And secondly, which attributes of the available ceramic assemblage can be used to identify these changes? These questions were addressed using statistical models combining information from newly submitted radiocarbon dates, as well as the physical properties of the assemblage. More broadly, the goal of this analysis is to address the question of movement and displacement in the region. We hypothesized that, if the makers of Western Basin Tradition pottery were truly displaced during the Wolf Phase, a clear distinction would be apparent between ceramics from before and after this period. That is, the assemblage from after AD 1250 would bear little to no resemblance to the assemblage present at the site before AD 1250, as the new group producing ceramics would be following an entirely different chaîne opératoire. Conversely, we hypothesized that if any identified changes in ceramic traditions were the result of local innovations or cultural transmission, only some variables such as temper and firing environment would be different in the later occupation.

**2. Methods**

*2.1 Materials and Variables*

Ceramics for the present study come from 6 identified features of Area B of the MacNichol site. Samples of organic material were submitted for radiocarbon dating for each studied feature. For the purposes of this analysis, I will be using the median calibrated date from these samples. In total, data from 158 potsherds were collected and analyzed with the majority being body sherds.

Eight variables were identified as relevant to this analysis and are listed in Table 1. Each of the variables was selected for its potential to reveal information about the production process of the ceramics. Rather than easily manipulated decorative features, we selected variables more resistant to change over time to study broader changes in ceramic traditions and reveal information about the chaîne opératoire. A change in temper type, for example, implies other related changes in the production of ceramics such as the availability and procurement process of source materials, the type of firing environment needed, and desired vessel function (Sillar and Tite, 2000). The majority of these variables were measured visually with the aid of reference charts, with the exception of maximum thickness, which was measured using digital calipers. As is typical for ceramic analysis, surface color was coded according to Munsell soil charts using both the specific color code (e.g., “7.5 YR 7/6”) and the broader color category/name (e.g., “reddish yellow”). For this study, five types of temper were recorded: grit (n = 30), seashell (n = 75), black mineral (n = 29), sand (n = 6), and mixed (any combination of the other temper types; n = 18). The black mineral was distinguished from other rock types as it was thought to possibly be biotite; however, the mineral could not be definitively identified without further petrographic analysis. Temper sorting and abundance were recorded to characterize, respectively, the size and amount of temper particles included in the clay; both were determined with the aid of visual reference charts.

**Table 1- Model Variables**

| Variable | Description |
|---|---|
| **Appearance** | |
| External Color | Surface color of vessel exterior as determined by a Munsell soil chart |
| Internal Color | Surface color of vessel interior as determined by a Munsell soil chart |
| Surface Treatment | The way in which the surface was textured: cord/fabric roughened, smooth over cord-roughened, or smoothed |
| **Temper** | |
| Primary Temper | Main type of material included in the clay matrix before firing: grit, shell, black mineral, sand, or mixed |
| Temper Sorting | Evenness of temper particle size, on a scale from 1 (well-sorted) to 4 (poorly sorted) |
| Temper Abundance | Approximate percentage of temper included in the clay matrix |
| **Firing Environment** | Whether the vessel was fired in an oxidized or reduced environment, based on inference from paste color |
| **Maximum Thickness** | Measured in millimeters at the thickest part of the sherd |

*2.2 Statistical Background*

The majority of existing archaeological literature utilizing statistical modeling, particularly of ceramic data, focuses on chronology (Otárola-Castillo et al. 2022). Modeling is a powerful tool in the calibration of radiocarbon dates and the estimation of chronology and, accordingly, its use in these types of analyses has increased in recent decades. Although statistical modeling techniques show equal promise in the evaluation of more qualitative hypotheses, their application in these areas has been limited.

In particular, cluster analysis and logistic regression are well suited for analyzing categorical data related to ceramics. Both methods can be easily adapted to data containing a mixture of categorical and quantitative variables, as is the case with the present ceramic data (Papageorgiou 2020). Additionally, these methods allow for detailed analysis of body sherds; although neck or rim sherds are often considered most diagnostic of a given ceramic type, body sherds still provide valuable information about the materials and techniques used in ceramic production (Quinn 2013). By utilizing a clustering algorithm, an assemblage of body sherds can be grouped into probable groups by maximizing the similarities between a large number of both quantitative and qualitative variables. Following this grouping with logistic regression models then allows for hypothesis testing to determine which of these variables can reliably predict a desired response variable (in this case, the age of the artifact). Taking these results together then allows for inference regarding the nature of the assemblage as a whole.

Cluster analysis is a technique which uses mathematical procedures to group a set of data into homogenous subgroups. This type of analysis is commonly used in archaeology to assist in the generation of typologies and taxonomies of a particular data type (e.g., ceramics) (Hodson 1970). There are a number of techniques by which this can be achieved, but the most basic premise is that objects are grouped according to their similarities with regards to certain variables. For this study, I will be using the Partitioning Around Medoids algorithm from the 'cluster' package in R (Maechler et al. 2022) to identify the most likely clusters of ceramic types present at the MacNichol site and, thereby, to determine whether these ceramic traditions changed between the earlier and later occupations. Partitioning Around Medoids, or PAM, is a type of cluster analysis that uses a Gower distance matrix, making it suitable for mixed-mode datasets (Papageorgiou 2020). Gower distances are measures of weighted dissimilarities between individual observations based on both quantitative and qualitative variables. The PAM algorithm then uses these distances to generate a predetermined number of clusters in which the dissimilarities within clusters are minimized and the dissimilarities between clusters are maximized. Based on the diagnostic measure of silhouette width (Papageorgiou 2020), as well as the goals of this analysis, I chose to generate two clusters with this method. Dissimilarities were calculated based on color, temper qualities, firing environment, thickness, and surface treatment. Date was excluded from this portion of the analysis so the algorithm would remain unbiased.

## 3. Results

### *3.1 Cluster Analysis*

Under my hypothesis of change following the Wolf Phase, I expected that ceramic clusters would closely align with identified features. That is, ceramics associated with late dates will cluster together, as will early ceramics, forming two discrete groups. Since date was not used as a variable in the clustering algorithm, this patterning would suggest an identifiable difference in ceramic type between the early and late phases based purely on physical properties of the sherds.

Following clustering, the group labeled Cluster 1 contained a total of 112 sherds, while Cluster 2 contained a total of 46 sherds. A t-SNE visualization for the clustering, provided in Figure 1, enables the visualization of highly dimensional data such as this ceramic dataset by mapping differences in the data onto a two-dimensional plot. The axis labels in this diagram represent distances between data points and do not have a directly meaningful interpretation beyond placing data points near one another based on similarity. This visualization confirms that the clustering algorithm did, in fact, group similar sherds together. Summary visualizations are additionally given for the primary temper types and the firing environment of each cluster (Figure 2). Broadly speaking, Cluster 1 consisted primarily of shell-tempered sherds fired in a reduced environment, while Cluster 2 sherds were tempered with grit and other materials and fired in an oxidized environment.

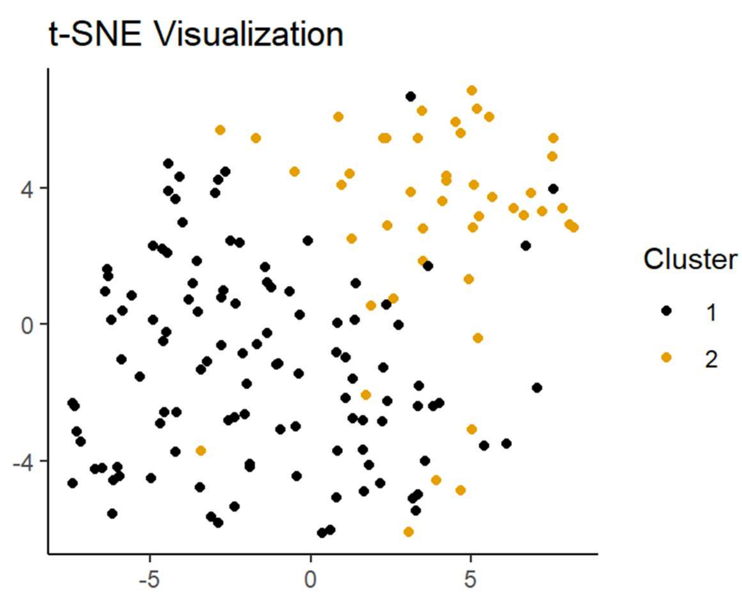


*Figure 1- Two-dimensional visualization of clustering results*

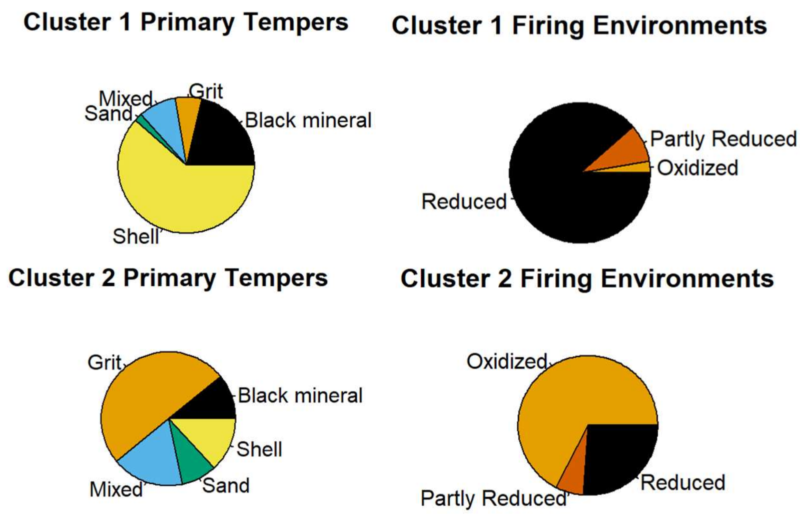


*Figure 2- Pie charts of temper type and firing environment by cluster*

In order to answer the question of whether a change in ceramic traditions occurred at the MacNichol site after AD 1250, the associated radiocarbon dates for each sherd were reattached to the clustered dataset. The distribution of dates for each cluster is shown in Figure 3. The majority of sherds assigned to Cluster 1 had an associated radiocarbon date after the known inflection point of AD 1250, with two outliers belonging to earlier contexts. Cluster 2, however, was split approximately evenly between the early and late contexts, with 17 sherds having dates pre-AD 1250 and 29 sherds having dates post-AD 1250. An odds ratio test showed that the differences between the clusters were statistically significant ($p < 0.05$). That is, a sherd assigned to Cluster 1 by the algorithm on the basis of its physical properties was significantly more likely to have an associated radiocarbon date after AD 1250 than a sherd assigned to Cluster 2.

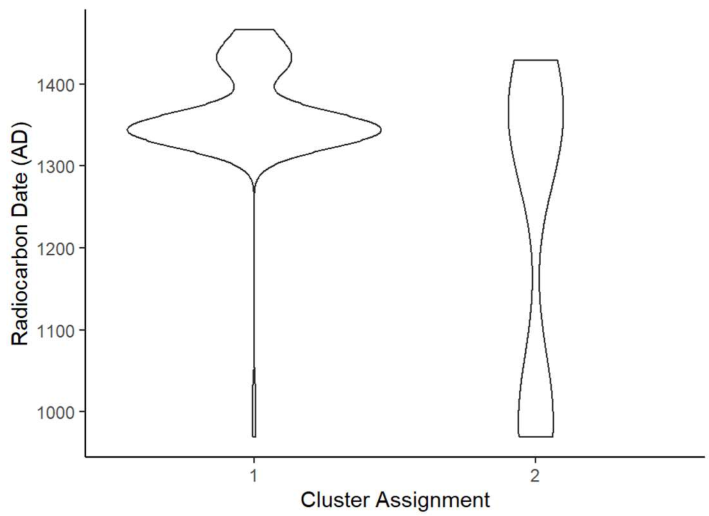


*Figure 3- Violin plot of radiocarbon date by cluster assignment*

### *3.2 Regression Models*

To address the question of which specific qualities changed over time, I utilized several linear and binary logistic regression models. The models were constructed to identify which variables could be used to predict the age of the ceramics as a linear function of the continuous radiocarbon dates. Of the eight variables analyzed, only primary temper type and firing environment proved to be significant predictors of radiocarbon date (see appendix for coefficient and p-value estimates). In particular, the presence of grit temper and the use of reduced firing methods were significant in predicting radiocarbon date. These variables additionally proved to be significant predictors in a binary logistic regression model predicting cluster assignment, implying that these variables were the most influential in the clustering algorithm.

These results show that the clustering algorithm, while ignoring the known dates, identified temper and firing environment as important characteristics by which to group the ceramic assemblage. Additionally, these characteristics, as well as the cluster assignment itself, proved to be significant predictors of date. This implies that between the early and late occupations of the MacNichol site, the most salient changes in ceramic production after AD 1250 were in the firing environment and types of temper used, with an increase in reduced firing and a decrease in the use of grit temper, associated with an increased use of shell.

## 4. Discussion

### *4.1 Summary of Findings*

The results above clearly demonstrate that the ceramics at the MacNichol site were significantly different in the later occupation than in the early occupation. The clustering algorithm clearly defined two distinctive “types” of ceramics: the first occurred almost entirely after AD 1250 and showed an increased use of shell temper and reduced firing environments, whereas the second occurred in both site occupations and featured a broader range of temper types and primarily oxidized firing environments. This suggests that while there was a change in type following AD 1250, the type of ceramics produced in the earlier occupation continued to be made throughout the later occupation of the site.

The clustering algorithm proved beneficial in its unbiased nature; by using only the available physical information about the potsherds, I was able to identify patterning without relying on prior assumptions of the changes that occurred over time. Additionally, this allowed me to make use of the data available from body sherds, rather than the more typically diagnostic, but less common, rim and neck sherds. Although this study was unfortunately limited in the relatively small number of pre-AD 1250 ceramics compared to post-AD 1250 ceramics, it has shown that clustering algorithms are a useful method for future ceramic studies.

*4.2 Implications*

Although some (e.g., Stothers and Abel 2002) have posited that the changes in the ceramic traditions in this region following AD 1250 are the result of the displacement of local populations, the persistence of the "older" tradition of pottery identified by Cluster 2 suggests that the use of shell temper and reduction firing may have been the results of local innovation or cultural exchange, rather than complete displacement. Brose (2005) suggests that these changes are the result of geographically differing influences from Fort Ancient traditions, which is to say that these ceramics and the social changes they imply do not reflect a forceful displacement by Sandusky Tradition peoples, but rather represent a local adaptation to spreading influence from the Fort Ancient culture. Therefore, although the ceramics at the MacNichol site suggest a shift in production to what might be described as a more "Mississippian" style, the continued presence of older traditions suggests a local adaptation and the incorporation of new traditions rather than a complete displacement by southern aggressors.

The specific implications of shell tempering remain unclear. Although it is strongly associated with Mississippian cultures, studies have not demonstrated a clear technological advantage over other calcium carbonate tempers, such as limestone (Pollack et al., 2008). Therefore, cultural and even religious explanations have been proposed. Interestingly, the observed increase in reduction firing may actually be explained by the presence of shell temper. Experiments suggest that shell tempers are more prone to overfiring and are therefore better fired in a reduced environment (Pollack et al., 2008; Feathers 1989). This “package” of shell temper and reduced firing both suggest a significant change in the ceramic production process, further suggesting the possibility of outside cultural influences in the later occupation of the MacNichol site.

It is clear that further study in this region is needed to better understand the potential social changes that occurred toward the end of the Late Woodland period. Future analysis of these ceramics using thin-section petrography will be a focus moving forward, with the goal of obtaining more finely detailed information. Additionally, other sites should be considered in conjunction with the MacNichol site to provide a broader view of the surrounding area. For example, the nearby Williams #2 site seems to have been occupied during the uninhabited phase at the MacNichol site (see appendix for radiocarbon dates). Applying a similar analysis as outlined above to this site could reveal crucial information about the changes occurring in the region around AD 1250. The site’s proximity may additionally provide insight to potential changes in settlement patterns during this time. Although this study has suggested that there was not complete displacement of the people living at the MacNichol Site following the Wolf Phase, more research is necessary to better understand the complex dynamics of the Lake Erie Basin.

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**Appendix**

*1A. Regression Coefficients*

Linear model predicting radiocarbon date with temper & firing environment:

| Factor | Estimate | p-value | Significant at $p < 0.05$? |
|---|---|---|---|
| Grit temper | -156.00 | 1.02e-07 | yes |
| Mixed temper | 35.01 | 0.2534 | no |
| Sand temper | -271.75 | 2.08e-08 | yes |
| Shell temper | -9.63 | 0.6649 | no |
| Mixed firing | 52.27 | 0.1331 | no |
| Reduced firing | 49.72 | 0.0242 | yes |

Logistic model predicting cluster assignment with temper & firing environment:

| Factor | Estimate | p-value | Significant at $p < 0.05$? |
|---|---|---|---|
| Grit temper | 2.48422 | 0.00539 | yes |
| Mixed temper | 1.38205 | 0.15638 | no |
| Sand temper | 0.05579 | 0.97078 | no |
| Shell temper | -1.60103 | 0.10633 | no |
| Mixed firing | -3.47971 | 0.00256 | yes |
| Reduced firing | -4.88393 | 2.39e-07 | yes |

*1B. Radiocarbon Dates (bolded dates indicate newly processed samples used in this study)*

| Site | Calibrated Age | Context | References |
|---|---|---|---|
| MacNichol | AD 740 +/- 90 | Area A – Pit 9 | Stothers, 1975 |
| MacNichol | AD 920 +/- 60 | Area A – Pit 9 | Stothers, 1975 |
| **MacNichol** | **AD 969** | **Area B -- Unit 10, Feature 21** | |
| **MacNichol** | **AD 1015** | **Area B -- Unit 9A, Feature 19** | |
| MacNichol | AD 1060 +/- 80 | Area A – Pit 11 | Stothers, 1975 |
| **MacNichol** | **AD 1098** | **Area B -- Unit 19, Feature 56** | |
| MacNichol | AD 1100 +/- 85 | Area A – Pit 10 | Stothers and Pratt, 1981 |
| Williams 2 | AD 1220 +/- 60 | Pit No. 5 | Stothers, 1973; Stothers and Pratt, 1981 |
| **Fort Meigs** | **AD 1270** | **Area 5 -- Trench 4, Feature 2** | |
| Williams 2 | AD 1310 +/- 65 | Pit No. 6 | Stothers, 1973; Stothers and Pratt, 1981 |
| Fort Meigs | AD 1340 +/- 50 | Area 1 – Trench 1 (D = 12-18 in.) | Stothers, 1975 |
| **MacNichol** | **AD 1344** | **Area B -- Unit 3, Feature 3** | |
| **MacNichol** | **AD 1345** | **Area B -- Unit 9, Feature 18** | |
| Williams 2 | AD 1360 +/- 75 | Refuse pit | Stothers, 1973; Stothers and Pratt, 1981 |
| **MacNichol** | **AD 1429** | **Area B -- Unit 1, Feature 2** | |
| Fort Meigs | AD 1425 +/- 70 | Trench B | Kordeleski, 2018 |
| Fort Meigs | AD 1440 +/- 55 | Area 1 – Trench 1 (D = 6-12 in.) | Stothers, 1975 |
| **MacNichol** | **AD 1466** | **Area B -- Unit 1, Feature 1** | |
| **Fort Meigs** | **AD 1558** | **Area 5 -- Trench 3, Feature 35** | |
| Fort Meigs | AD 1610 +/- 80 | Unknown | Kordeleski, 2018 |