FORM AND FUNCTION: INTERPRETING THE WOODLAND ARCHITECTURE AT THE McCAMMON CIRCLE IN CENTRAL OHIO

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ABSTRACT

Prehistoric architecture in the Eastern United States has been investigated since in the early 1940s when William S. Webb excavated several Woodland structures in Kentucky. For the past 70 years archaeologists have debated the configuration and function of these structures and produced several renderings and reconstructions of their forms based on historic Native American examples, modern Bedouin settlements, and from "archaeological imagination". The premise of this thesis is to offer a comprehensive interpretation for the form and function of the McCammon Circle structure through comparative data on Woodland prehistoric structures in the Eastern United States. The McCammon Circle represents the subsurface remains of a large circular structure, which was excavated by Weller & Associates, Inc. in 2005, that dates to the Middle Woodland period. These remains include various post holes, features (pits/basins), and a somewhat sparse artifact assemblage, including various lithic and ceramic artifacts from the site.

The first part of this study will involve a comparison of the structural attributes of floor area, average posthole diameter, and average posthole depth for each of the 36 analogous structures within the regional study to the McCammon Circle. The McCammon Circle will be placed contextually with the interpretations for form and

function of the other structures in the comparison. The form of the McCammon Circle will be compared to five building forms in the region. The function of the McCammon Circle will then be compared to other researcher's interpretations for the similar structures within the aforementioned comparison. These comparisons will allow for a comprehensive interpretation for the McCammon Circle in regards to the most widely accepted viewpoints in the regional archaeological community. These comparisons indicated that the McCammon Circle was most similar to structures that have been interpreted as unroofed in form and ceremonial in function. I hypothesize that based on the overbuilt, immense nature of the structure, the presence of mica and red ochre, the absence of a midden and cooking hearths, and the lack of an identifiable roof support posthole pattern, as well as the similarity to other ceremonial structures in the region, the original interpretation of the building as a roofed domestic "house" is faulty. A hypaethral "woodhenge" non-mound mortuary facility, serving as a territorial marker in the region as well, is a more plausible reconstruction for the function of the McCammon Circle.

The second part of the study will be to test the ability of an engineering analysis utilizing Euler's formula in determining the possible form of the McCammon Circle. Euler's formula will be used to determine whether or not the structure could have supported a roof by testing the load bearing capabilities of the structural posts. Euler's formula will be used to see whether or not it is applicable to aiding in the interpretation of prehistoric structures in general. This will hopefully allow future researchers to decide whether or not Euler's formula should be included within their own engineering analysis of prehistoric architecture based upon its merits and shortcomings. Euler's formula proved to be unreliable in ascertaining the form of the McCammon Circle because it failed to take into account several other variables, such as horizontal loads and soil dynamics, which are integral to determining possible building form. However, Euler's formula may prove complementary to interpreting prehistoric structural form when combined with other engineering analyses.

The structural engineering analysis of the McCammon Circle may have proved unreliable, however it represents a heuristic endeavor that will hopefully prompt other researchers to look towards engineering principles and analyses for future reconstructions of prehistoric architecture. The significance of this research also lies in the insistence that all conclusions must be grounded in relevant archaeological and ethnographic analogy. Any and all avenues for research that lead to a more accurate and comprehensive understanding of prehistory should be investigated and employed.

Dedicated to my family and friends

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CHAPTER 1

INTRODUCTION

Accurate interpretation of archaeological remains is crucial to the reconstruction of prehistoric life-ways. Archaeologists in the Eastern United States glean their interpretations of Native American cultures from cultural materials such as projectile points, sherds of ceramic vessels, and exotic ceremonial goods. Seminal works by William S. Webb, Don Dragoo, and others used a trait-list approach to describe and classify prehistoric cultures from their material remains (Webb and Baby 1957; Dragoo 1963; Webb and Snow 1974). This approach is incomplete in its ability to accurately interpret the architecture of prehistoric Native Americans. The problem has arisen as a product of incomplete preservation in the archaeological record and from inaccurate and sometimes impossible reconstructions of prehistoric structures by those who have excavated them (Webb 1941a; Marshall 1969). These initial inaccuracies have led other researchers to propagate some faulty structural forms and interpretations for their sites (Baby 1971; Weller 2007). In this study, I will utilize several lines of evidence to offer a comprehensive interpretation for the form and function of the McCammon Circle structure, a Middle Woodland site from Delaware County, Ohio.

These lines of evidence are drawn from a comparison of the structural attributes of floor area, average posthole diameter, and average posthole depth for other similar prehistoric Woodland structures in the Eastern United States. The McCammon Circle will be placed contextually with the interpretations for form and function of the other structures in the comparison. These interpretations have been drawn from ethnographic and archaeological analogs. These comparisons will allow for a comprehensive interpretation for the McCammon Circle in regards to the most widely accepted viewpoints in the regional archaeological community.

In early 2005, Weller & Associates, Inc. excavated site 33DL275 in Delaware County, Ohio. The remains of a large circular structure, the McCammon Circle, was interpreted from excavations at the site (Weller 2007). Only the subsurface remains of the structure survived, therefore the exact structural type was unknown as structural form is best determined by surface evidence. In this study I will also test the ability of an engineering analysis using Euler's formula to determine the possible form of the McCammon Circle. The value of Euler's formula in aiding the understanding of a prehistoric structure will be assessed. An engineering analysis can aid in the accurate reconstruction of a hypothetical structure as derived from excavation by assessing the structural integrity and the structure's ability to resist loads created by the presence of a roof and certain environmental variables. The results of the engineering analysis are limited to aiding in the determination of structural form. For this example, the regional inter-site comparison of the McCammon Circle to other Woodland structures that have been excavated within the Eastern United States will be used in conjunction with an engineering analysis. While the results of the engineering analysis employed were limited, the use of structural engineering principles as a tool to aid interpretation will be shown. This will hopefully allow future researchers to decide whether or not Euler's formula should be included within their own engineering analysis of prehistoric architecture based upon its merits and shortcomings.

Multiple lines of evidence, comparative and engineering, are used to offer the best possible interpretation from the scant remains recovered in the archaeological record at the site. This approach has implications for the understanding of prehistoric architecture, in particular the ability to determine structural form, and reconstructing the function of the hypothetical structure through the use of ethnographic analogs and other archaeological interpretations. I also present new interpretations by cultural historians of some structures excavated early in the 20th century to help indicate the most likely interpretation of the form and function of the McCammon Circle. This research is critical in that it identifies the types of information that need to be documented during fieldwork. These analyses will outline a method archaeologists can use to reconstruct the form and possible functions of prehistoric structures.

CHAPTER 2

STATEMENT OF THE PROBLEM

For the past 70 years archaeologists have debated the configuration and function of prehistoric structures and have published several renderings and reconstructions of their forms (Webb 1941a; Marshall 1969; Baby 1971; Clay 1986; Clay 1987; Niquette et al. 1989; Railey 1991; Fortier 1993; Clay 2007). These reconstructions have shaped the interpretations of the sites where the structures were found, since the physical form and cultural function of the structures has been linked (Faulkner 1977; Railey 1991; Peregrine 1992). One of the first attempts at interpreting the "surviving evidence" from prehistoric Woodland structures was undertaken by William S. Webb (Webb 1941a). Using a trait list approach, Webb created a model of Adena culture as being agriculturally based, although lacking maize, with large sedentary villages that contained several small houses and a few large "town houses" (Webb 1952; Webb and Baby 1957; Webb and Snow 1974; Clay 2007). His rendition of Adena society also entailed early grit-tempered pottery, the construction of mounds and earthworks by highly organized groups, and a culture that had a Mexican origin (Webb 1952; Webb and Baby 1957; Webb and Snow 1974; Clay 2007).

Many of Webb's Adena cultural traits have been disproven, however his influence on the interpretation of prehistoric architecture continues to this day (Niquette et al. 1989; Clay 2005; Clay 2007). Webb created his archetypal structural interpretation of an Adena circular house through his excavations in Kentucky during the 1940s (Webb 1941a). The structure recovered below the Morgan Stone Mound, with its outward slanting double posts and central support post pattern, became the model other archaeologists used to understand structural patterns from their own excavations (Webb 1941a; Clay 2007). The problem with Webb's reconstruction is that the resulting building would be structurally unstable. Clay's examination of the building's architecture suggest that the outward leaning posts cannot support the assumed roof structure (Clay 1998).

Another aspect of Webb's work that has persisted is his dichotomy between structure size and function. In *The Adena People*, Webb and Snow separated circular structures into two trait groups, those 97 ft (29.57 m) or greater in diameter (trait 42) and those 60 ft (18.29) or less (trait 43) (Webb and Snow 1974: 52-53):

> (42) **Post-mold patterns circular, diameter 97 feet or more.**
>
> The structures seem to fall into two classes: those having circles 97 feet or more in diameter, a total of four, and those having diameters of 60 feet or less, a total of nineteen. So far none has been found with diameters between these dimensions. It is suspected that the significance of this division, if it continues to be verified by future excavations, will be found in the fact that the smaller size circles were houses, each of which had a single roof over it, and the larger circles indicate structures not one of which had a single roof over the entire structure because of its excessive diameter.

> (43) **Post-mold patterns circular, diameter 60 feet or less.**
>
> The convenient size dwelling house for Adena seems to have been about 37 feet in diameter, although this dimension varies from 21 to 59.5 feet in houses on different sites. Sixty feet seems to have been about the limit in size which would permit the construction of a roof over all, if indeed they were so large. No roof has ever been found, but its existence is predicated upon the discovery of interior post-molds arranged in a regular patter which might indicate roof supports.

These two traits were used by Webb to determine the likely form and function for circular structures. Those structures falling under trait 42 consisted of unroofed, non-domestic structures, while those buildings fitting into trait 43 represented roofed domestic houses (Webb and Snow 1974). The issue with this dichotomy is that it has survived to today and caused various researchers to inaccurately interpret prehistoric structures at their sites (Baby 1971; Weller 2007).

Webb's dichotomy focuses on structure function and the presence of a roof and the problem in his dichotomy is his lack of solid evidence. Many researchers have acknowledged this problem with Webb's interpretation (Marshall 1969; Seeman 1986; Clay 1987; Niquette et al. 1989; Railey 1991; Clay 1998; Clay 2007), and have sought to enhance our understanding of prehistoric structures through research taken from detailed modern excavations (Marshall 1969; Carskadden n.d.a.), ethnographic analogs (Sturtevant 1975; Abrams 1989), experimental archaeology (Terry 2007), and computer simulations (Eachus 2007).

Having knowledge of ethnographic construction techniques and building forms for a specific region can greatly add to the archaeologist's ability to interpret a structure (Oetelaar 1993; Stewart 2002). For prehistoric North America, there have been several ethnographic and archaeological studies of indigenous building types and their function

(Morgan 1965; Baby 1971; Sturtevant 1975; Faulkner 1977; Morgan 1980; Nabokov and Easton 1989; Fortier 1993). Ethnographic analogs have their limitations and cannot be used as direct representations of prehistoric activity, yet they are commonly used to supplement the interpretation of the archaeological evidence retrieved from a site (Binford 1967; Schuyler 1968; Peregrine 1992; Peregrine 1996; Johnson 1999).

Structural engineering can help to overcome the problems inherent in relying solely on ethnographic analogs and the shortcomings in Webb's classification. Structural engineering represents a sub-discipline of civil engineering that is concerned with the analysis and design of structures and the loads applied to the structures (Heyman 1999; Kassimali 2005). A structural engineering analysis is employed by determining the strengths and weaknesses of prehistoric construction materials and building forms through various principles, equations, and calculations. Structural engineering analyses of prehistoric structures are still rare in Eastern North America. Only a few such studies have been performed using the same engineering analysis (Marshall 1969; Pacheco et al. 2006). These analyses attempted to calculate the horizontal forces applied to prehistoric architecture, yet the results of such an analysis have been questioned (Loten 1970). However, the question remains, what did these prehistoric structures actually look like? As I will test through my analysis of McCammon Circle, Euler's formula will be utilized to assess whether or not certain aspects of prehistoric structures can be shown to have been feasible or not through engineering models to assess their load limits and structural dynamics. The results of the comparison to various archaeological and ethnographic analogs will be coupled with the results of the engineering analysis using Euler's formula. These analyses bypass Webb's simplistic model of simply separating structure function based on size and likelihood of having being roofed and the analyses demonstrate that once a structure is analyzed through a multivariate approach, taking into account a structure's similarity to comparable ethnographic and archaeological analogs and its engineering dynamics, the likely form can be determined, in turn helping to better interpret the building's hypothetical function.

2.1 Site Background

The McCammon Circle is located in a housing development on an inconspicuous rise in Orange Township in south-central Delaware County, Ohio, within what used to be a fallow agricultural field. The site was initially identified in 1984 during controlled surface collection conducted by the Department of Anthropology of the Ohio State University as part of the Central Ohio Archaeological Survey. During the original survey 53 lithic artifacts indicative of core reduction were recovered, but none were temporally diagnostic (Weller 2007). The site was given the Ohio Archaeological Inventory site designation 33DL275.

In early 2005, as an employee of Weller & Associates, Inc., I was a member of a Phase I survey team which relocated the site through surface collection of plowed transects (Weller 2005b). An irregular basin feature was uncovered during the furrow plowing. In conjunction with a moderately diverse artifact assemblage, the site was subjected to further cultural resource management investigations. Weller & Associates mitigated the site in 2005 after realizing it would be destroyed by the proposed development (Weller 2007). A comprehensive examination of the site was completed through the implementation of an excavation strategy that included shovel test unit excavation across the entire site, mechanical stripping of approximately 62 percent of the site, feature identification and excavation within the mechanically stripped area, as well as several laboratory analyses (floral, radiocarbon dating, ceramic, protein residue, and lithic). Only three fragments of unidentifiable faunal remains were recovered from the excavations, therefore a faunal analysis was not performed (Weller 2007). The lack of faunal remains could represent unsatisfactory conditions for preservation or a limited range of activities at the site.

The component of the site that is the focus of this paper is the prehistoric "domestic" structure identified during data recovery (Figure 2.1). Weller & Associates, Inc. uncovered the subsurface remains of a single-posted circular structure measuring 15.30 meters in diameter. The floor of the structure included several basin and pit features, as well as postholes of various shapes and sizes. The postholes at the site were separated into two groups, deep postholes (structural/internal/external) ranged in depth between 38.10 and 71.10 cm, while shallow postholes (internal/external) ranged in depth between 10.10 and 33.00 cm. The separation of the two posthole designations by slightly more than 5.00 cm allowed for their distinct classification as representing two different functions for the groups of postholes. The position of the non-structural features showed no discernable pattern relative to the 35 postholes that created the outer ring of the structure. In fact, some of the features overlapped the structural postholes. The structure lacked an identifiable internal roof support posthole pattern, as well as a defined central support posthole, even though an identifiable roof support posthole pattern is a hallmark trait that has been recovered from various other prehistoric structures in the region (Webb 1941a; Webb and Baby 1957; Baby 1971; Webb and Snow 1974; Fortier 1985; Fortier 1993). Neither midden deposits nor cooking hearths were present. The principal investigator for Weller & Associates, Inc. (Ryan Weller) assigned a “domestic” function to the site despite the lack of an internal roof support pattern, midden deposits, and cooking hearths.

The floor area for the McCammon Circle is 183.85 m^2. The structural postholes averaged 27.00 cm in diameter and 48.15 cm in depth. The average distance between the 35 structural postholes was 89.00 cm as well. A total of five radiocarbon dates for the site were obtained from Beta Analytic, Inc., placing the site’s occupation from 173 BC to AD 560. These dates are discussed and listed in Table 3.1 of the next chapter. The artifact assemblage for the site yielded 636 lithic artifacts and 906 ceramic sherds from the initial reconnaissance by the Central Ohio Archaeological Survey including the final mitigation by Weller & Associates. The lithic assemblage consisted of chert debitage, utilized flakes, hafted bifaces, celts, drills, and fragments of mica, as well as an anvil stone, graver, keyhole pendant, and an expanded center gorget (Weller 2005b; Weller 2007). The occurrence of mica, which is generally considered ceremonial in nature, was yet another indicator working against a domestic nature for the structure (Fischer 1974; Steponaitis 1987). The hafted bifaces included Adena Stemmed, Robbins, Lowe Flared base, Matanzas/Fishspear, Kessell Side Notched, Brewerton Side Notched, Snyders, Buck Creek Barbed, and Saratoga Expanding Stemmed types which span the Late

Archaic, Early Woodland, Middle Woodland, and initial Late Woodland periods (Justice 1987). The majority of the lithic assemblage (74 percent) consisted of artifacts made from local Delaware chert (Weller 2007). The low frequency of Flint Ridge chert (12 percent) in the artifact assemblage is aberrant to what is generally encountered at Middle Woodland Hopewell sites in central Ohio, therefore an Adena affiliation is considered more likely (Weller 2007).

Additional evidence for an Adena affiliation is in the slate artifact assemblage and ceramic assemblage. The expanded center gorget and keyhole pendant recovered are generally associated with the Adena culture (Dragoo 1963; Weller 2007). The attributes of the ceramic assemblage (thickness, lack of decoration, rim and base morphology) are consistent with what is classified as Adena (Bush 1975; Carskadden and Morton 1989; Schweikart 2003; Weller 2007). One interesting aspect to the ceramic assemblage was the presence of red ochre on the interior of some of the sherds recovered from a feature at the site. Red ochre is often affiliated with burial/ceremonial contexts during the Woodland period (Webb and Baby 1957; Webb and Snow 1974; Schlarb 2005).

Based on the artifact assemblage, radiocarbon dates, and structural characteristics the McCammon Circle was interpreted as a "non-Hopewell Middle Woodland occupation that has Adena traits" (Weller 2007: 69). Several researchers have found evidence for contemporaneous Adena and Hopewell habitation, therefore the designation of the McCammon Circle as a Middle Woodland Adena site is not without precedent (Potter Otto 1979; Vickery 1979; Greber 1991; Abrams 1992; Carskadden and Morton 1997; Schweikart 2003). Various researchers have indicated problems with using the

Woodland taxonomic units of Adena and Hopewell (Applegate 2005; Burks 2005; Clay 2005; Greber 2005). Darlene Applegate states "[o]ur understanding of the Woodland period archaeological record has changed dramatically as archaeologists have documented a great deal of formal and temporal diversity in what previously were considered fairly monolithic and chronologically sequential lifeways...our ability to communicate effectively about this variation has been hampered by the use of outdated and ambiguous archaeological units that now have multiple meanings or lack empirical basis" (Applegate 2005: 1). The problems inherent in defining the parameters for the Woodland time frames and cultural units (i.e. Early Woodland, Middle Woodland, Adena, Hopewell) is beyond the scope of this study, therefore the temporal and cultural affiliation for the McCammon Circle has been taken directly from the excavating archaeologist's designation (Weller 2007). Despite the lack of a midden or extensive amounts of artifacts, a miniscule faunal assemblage, the presence of mica, the lack of an identifiable roof support posthole pattern, and the presence of red ochre on the interior of some ceramic vessel fragments the McCammon Circle was originally interpreted as a domestic "house" (Weller 2007). I will show that this structural explanation is based on antiquated interpretations; consequently the McCammon Circle should be viewed as a ceremonial/ritual structure.

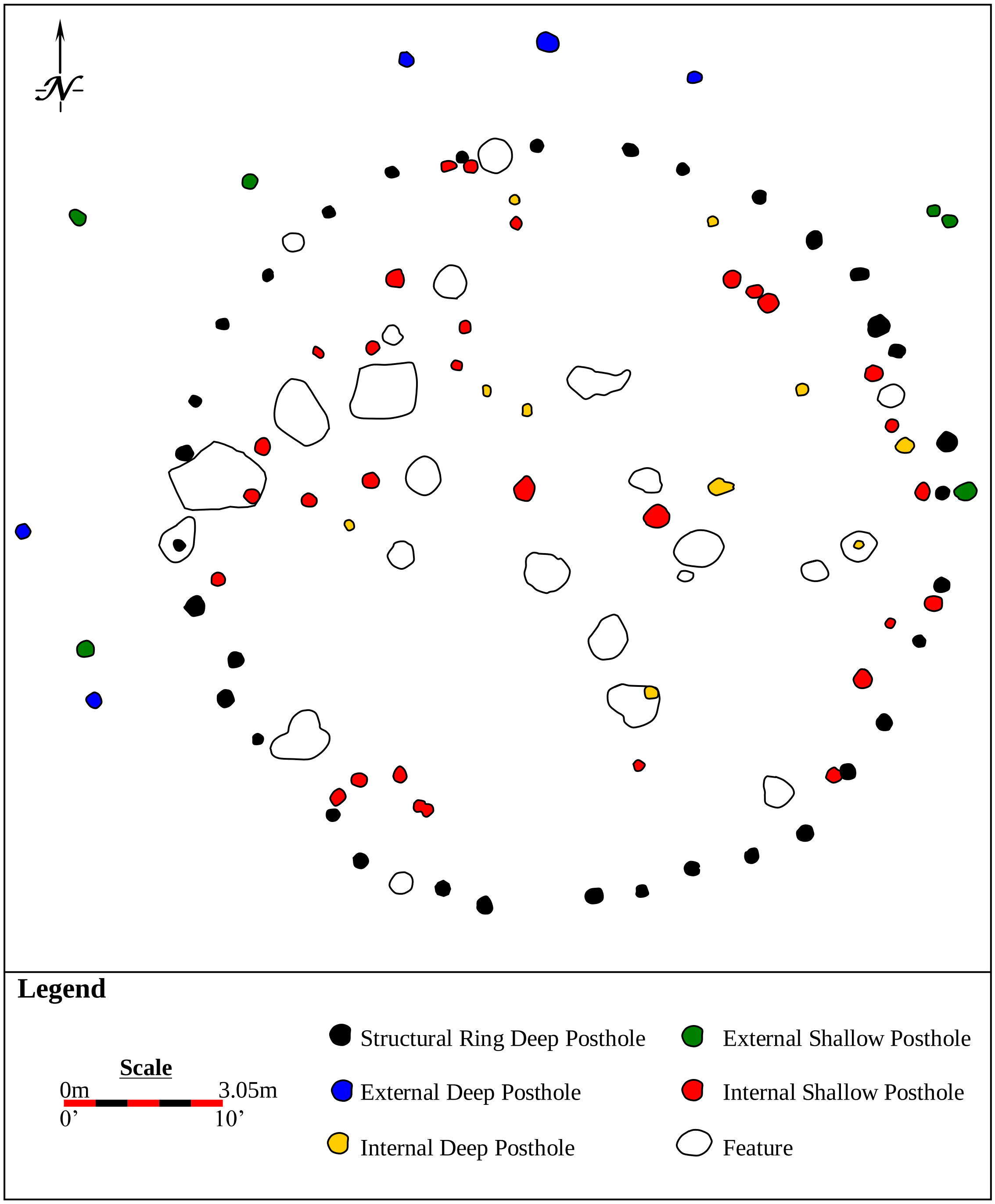

Figure 2.1. Structure plan for the McCammon Circle (33DL275).

CHAPTER 3

METHODS

3.1 Literature Review

In order to provide a comprehensive interpretation of the structure excavated at the McCammon Circle, I conducted a literature review of comparable sites in the region. From this I created a list of criteria for comparison between sites (Table 3.1). As a cautionary note, I would like to indicate that there are some disadvantages to taking a regional perspective for this study instead of a global perspective. By relying solely on regional interpretations concerning form and function of prehistoric architecture, the actual structural variation prevalent during prehistory is restricted to those forms that other researchers have identified. The analytical frameworks and paradigms used for the previous interpretations can bias the results of the new study (Johnson 1999). Recently, researchers have been attempting to take a more universal approach to understanding prehistoric life-ways and they have sought to enhance our understanding of diversity in the archaeological and ethnographic record instead of focusing solely on similarity (Kelly 1995).

These shortcomings of relying on a regional comparison, however, do not invalidate this form of comparison. By recognizing the limitations inherent in a regional comparison one can make a better informed interpretation concerning the structural forms offered for the comparable sites.

The first criterion was the presence of a prehistoric structure of analogous age. Since the McCammon Circle dates to the transitional period between the Early and Middle Woodland period in the Eastern U.S. (173 BC to AD 560), structures from both periods were included in the comparison. The time frame for comparison is roughly 1000 BC to AD 650. The second criterion was the presence of a circular structural floor plan, however a few sites were included in Table 3.1 that had a rectilinear floor plan because of their geographic proximity to central Ohio and/or their relative temporal affiliation.

Table 3.1. Comparable Structures Identified During the Literature Review.				
Site	Structure			
	Shape	Dia./Dim. (m)	Posthole Pattern	# Postholes*
McCammon Circle (33DL275)[1]	Circle	15.30	Single	35
Dominion Land Company Feature IV (33FR12)[2]	Circle	12.19	Single	48
DECCO-1 (33DL28)[3]	Circle	12.00	Single	40
Truck #7 (11MO200)[4]	Circle	9.75	Single	27
Philo Mound E Structure (33MU77)[5]	Circle	10.36	Paired	19 (38)
Buckmeyer[6,7]	Circle	10.06	Single	9
Haven Yellow House (33DL1448)[8]	Square	5.30 x 5.20	Single	30
Haven Pink House (33DL1448)[8]	Rectangle	8.78 x 6.66	Single	33
Haven Orange House (33DL1448)[8]	Rectangle	11.20 x 11.80	Single	42
Haven Yellow Arc House (33DL1448)[8]	Square	5.71 x 6.70	Single	20
Haven White House (33DL1448)[8]	Oval	6.60 x 15.20	Single	31
Haven Red House (33DL1448)[8]	Square	6.90 x 7.80	Single	31
Haven Blue House (33DL1448)[8]	Rectangle	8.00 x 8.50	Single	38
Brown's Bottom #1 (33RO21)[9]	Square	13.70	Single	48
Lichliter Village House 1[3,10]	Circle	14.63	Single	41
33FR561 House[11]	Circle	6.20	Single	22
Mt. Horeb[12]	Circle	29.57	Paired	70 (138)
Morgan Stone Mound[7,13]	Circle	7.92	Paired	22
Mound Jo 9, Feature 31 (C. and O. Mounds)[14]	Circle	13.11	Paired	21 (42)
Mound Jo 9, Feature 32 (C. and O. Mounds)[14]	Circle	22.25	Paired	20 (40)
Mound Jo 9, Feature 34 (C. and O. Mounds)[14]	Circle	28.35	Paired	24 (48)
Mound Jo 9, Feature 35 (C. and O. Mounds)[14]	Circle	15.30	Paired	18 (36)
Mound Be. 3, Feature 26 (Robbins Mounds)[7,15]	Circle	9.14	Single	49
Mound Be. 20, Feature 1 (Crigler Mounds)[16]	Circle	17.07	Paired	40 (80)
Mound Be. 15, Feature 6 (Riley Mound)[17]	Rectangle	8.38 x 10.67	Paired	21 (39)
Mound Be. 15, Feature 7 (Riley Mound)[17]	Circle	8.84	Paired	18 (35)
Stubbs Structure 1 (33WA1)[18]	Square	5.00 x 8.00	Paired	24 (48)
Stubbs Structure 2 (33WA1)[19]	Circle	7.00	Paired	24 (48)
Stubbs Structure 3 (33WA1)[18]	Circle	8.00	Single	22
Smith (33WA362)[18,20]	Square	8.00 x 8.00	Single	34
33CS468 House[21]	Oval	7.62 x 5.72	Single	15
Niebert Structure 3[22,23]	Circle	9.60	Paired	22 (44)
Bagley Open Site (33DL16)[7]	Circle	7.60	Single	18
Arthur James Mound (33DL14)[7]	Oval	13.70 x 12.80	Single	36
Pierce Open Site (33DL25)[7]	Circle	5.80	Single	26
White Mound II (33DL20)[7]	Circle	4.57 x 4.41	Single	22
Cowan Creek Mound[24]	Circle	13.70	Paired	34 (68)
* Paired postholes were considered as a single unit, however the total number of postholes shown in parentheses.				
[1](Weller 2007); [2](Cramer 1989); [3](Burks 2004); [4](Fortier 1985); [5](Carskadden and Morton 1989); [6](Bush 1975); [7](Hays 1994); [8](Weller 2005a); [9](Pacheco et al. 2006); [10](Allman 1967); [11](Weller 2008a); [12](Webb 1941b); [13](Webb 1941a); [14](Webb 1942a); [15](Webb 1942b); [16](Webb 1943a); [17](Webb 1943b); [18](Cowan et al. 2003); [19](Cowan and Sunderhaus 2002); [20](Sunderhaus et al. 2001); [21](Weller 2008b); [22](Clay and Niquette 1992); [23](Niquette et al. 1989); [24](Webb and Baby 1957)				

The original reports, texts, and figures for the comparable sites in Table 3.1 were used to obtain the measurements and interpretations for the majority of the structures. However, when more recent interpretations of previously conducted excavations were available, such as reinterpretations of Webb's 1940s work (Clay 1998; Clay 2007), I used the newer information. When information was lacking, such as measurements on posthole spacing and number, I calculated the posthole spacing measurement and number of assumed structural postholes from the site layout figures showing the floor plans of the structures.

Original uncalibrated conventional (BP) radiocarbon determinations for the structures were calibrated using the CALIB 5.0 calibration software (Stuiver et al. 2005) to obtain their 2-sigma calibrated (BC/AD) range (Reimer et al. 2004). This allowed for an accurate comparison of dates that have been taken over the past several decades from various laboratories (Table 3.2). As noted previously, the McCammon Circle is from the transitional period between the Early and Middle Woodland periods for central Ohio. The structures used for comparison were drawn from both time periods, ranging from approximately 1000 BC to AD 650 (Figure 3.1). The McCammon Circle and the majority of the structures fall within a 500 year time span from 50 BC to AD 450 (Table 3.2 and Figure 3.1).

Table 3.2. Radiocarbon Dates from Comparable Sites.			
Site*	**Lab Code****	**Conventional Radiocarbon Age (BP)**	**2 Sigma Calibration (BC/AD)**
Arthur James Mound (33DL14)	OWU-331	2630 ± 115	1013 - 410 BC
33FR561 House	Beta-235194	2620 ± 40	895 - 757 BC
33FR561 House	Beta-235195	2620 ± 40	895 - 757 BC
Dominion Land Company Feature IV (33FR12)	SMU-55	2555 ± 100	850 - 405 BC
Dominion Land Company Feature IV (33FR12)	SMU-56B	2440 ± 100	803 - 366 BC
Niebert Structure 3	PITT-0313	2270 ± 40	319 - 207 BC
Niebert Structure 3	SMU-2273	2230 ± 60	401 - 163 BC
Dominion Land Company Feature IV (33FR12)	SMU-54	2210 ± 100	423 BC - AD 5
Buckmeyer	GX-3306	2185 ± 200	770 BC - AD 183
Philo Mound E Structure (33MU77)	TX-2374	2160 ± 60	373 - 53 BC
Haven Blue House (33DL1448)	Beta-197968	2100 ± 40	206 - 36 BC
Morgan Stone Mound	M-2240	2100 ± 140	411 BC - AD 237
Mound Be. 3, Feature 26 (Robbins Mounds)	M-2242	2100 ± 140	411 BC - AD 237
McCammon Circle (33DL275)	Beta-217445	2010 ± 60	173 BC - AD 90
Buckmeyer	GX-3305	1975 ± 200	406 BC - AD 469
33CS468 House	Beta-228058	1930 ± 40	39 BC - AD 139
Haven Yellow House (33DL1448)	Beta-197588	1900 ± 80	57 BC - AD 263
McCammon Circle (33DL275)	Beta-217444	1900 ± 40	AD 23 - 223
Smith (33WA362)	ISGS-5438	1890 ± 70	44 BC - AD 259
Haven White House (33DL1448)	Beta-197590	1890 ± 40	AD 49 - 230
Truck #7 (11MO200)	ISGS-600	1860 ± 75	2 BC - AD 342
McCammon Circle (33DL275)	Beta-211606	1840 ± 50	AD 64 - 260
Stubbs Structure 3 (33WA1)	Beta-166640	1840 ± 40	AD 75 - 255
Haven Yellow House (33DL1448)	Beta-197589	1830 ± 40	AD 79 - 257
Haven Pink House (33DL1448)	Beta-196903	1820 ± 60	AD 66 - 348
Stubbs Structure 1 (33WA1)	Beta-166641	1820 ± 40	AD 85 -259
Truck #7 (11MO200)	ISGS-634	1790 ± 75	AD 73 - 407
Haven Red House (33DL1448)	Beta-196910	1790 ± 40	AD 127 - 345
McCammon Circle (33DL275)	Beta-211607	1770 ± 40	AD 134 - 354
Haven Red House (33DL1448)	Beta-196909	1760 ± 70	AD 120 - 422
Haven Orange House (33DL1448)	Beta-196904	1760 ± 40	AD 208 - 385
Haven Orange House (33DL1448)	Beta-196906	1760 ± 40	AD 208 - 385
Haven Yellow Arc House (33DL1448)	Beta-181489	1750 ± 70	AD 121 - 428
Brown's Bottom #1 (33RO21)	Beta-206205	1750 ± 60	AD 132 - 411
Stubbs Structure 1 (33WA1)	Beta-166639	1750 ± 40	AD 209 - 397

Continued

Table 3.2 (continued)

Site*	**Lab Code****	**Conventional Radiocarbon Age (BP)**	**2 Sigma Calibration (BC/AD)**
Haven Orange House (33DL1448)	Beta-196907	1740 ± 70	AD 122 - 433
Stubbs Structure 3 (33WA1)	Beta-166642	1730 ± 40	AD 224 - 412
Truck #7 (11MO200)	ISGS-703	1720 ± 75	AD 129 - 442
DECCO-1 (33DL28)	NA	1710 ± 50	AD 211 - 433
DECCO-1 (33DL28)	NA	1700 ± 50	AD 221 - 436
Smith (33WA362)	ISGS-5437	1690 ± 70	AD 210 - 539
DECCO-1 (33DL28)	NA	1680 ± 45	AD 242 - 437
Stubbs Structure 2 (33WA1)	Beta-156234	1640 ± 60	AD 311 - 548
McCammon Circle (33DL275)	Beta-210007	1630 ± 60	AD 317 - 560
Lichliter Village House 1	M-537	1600 ± 125	AD 208 - 658
DECCO-1 (33DL28)	NA	1580 ± 50	AD 386 - 596
Stubbs Structure 2 (33WA1)	Beta-156236	1550 ± 60	AD 399 - 634
Brown's Bottom #1 (33RO21)	Beta-206784	1540 ± 40	AD 426 – 600
* See Table 3.1 for applicable references.			
** NA = Information was not available from the sources referenced.			

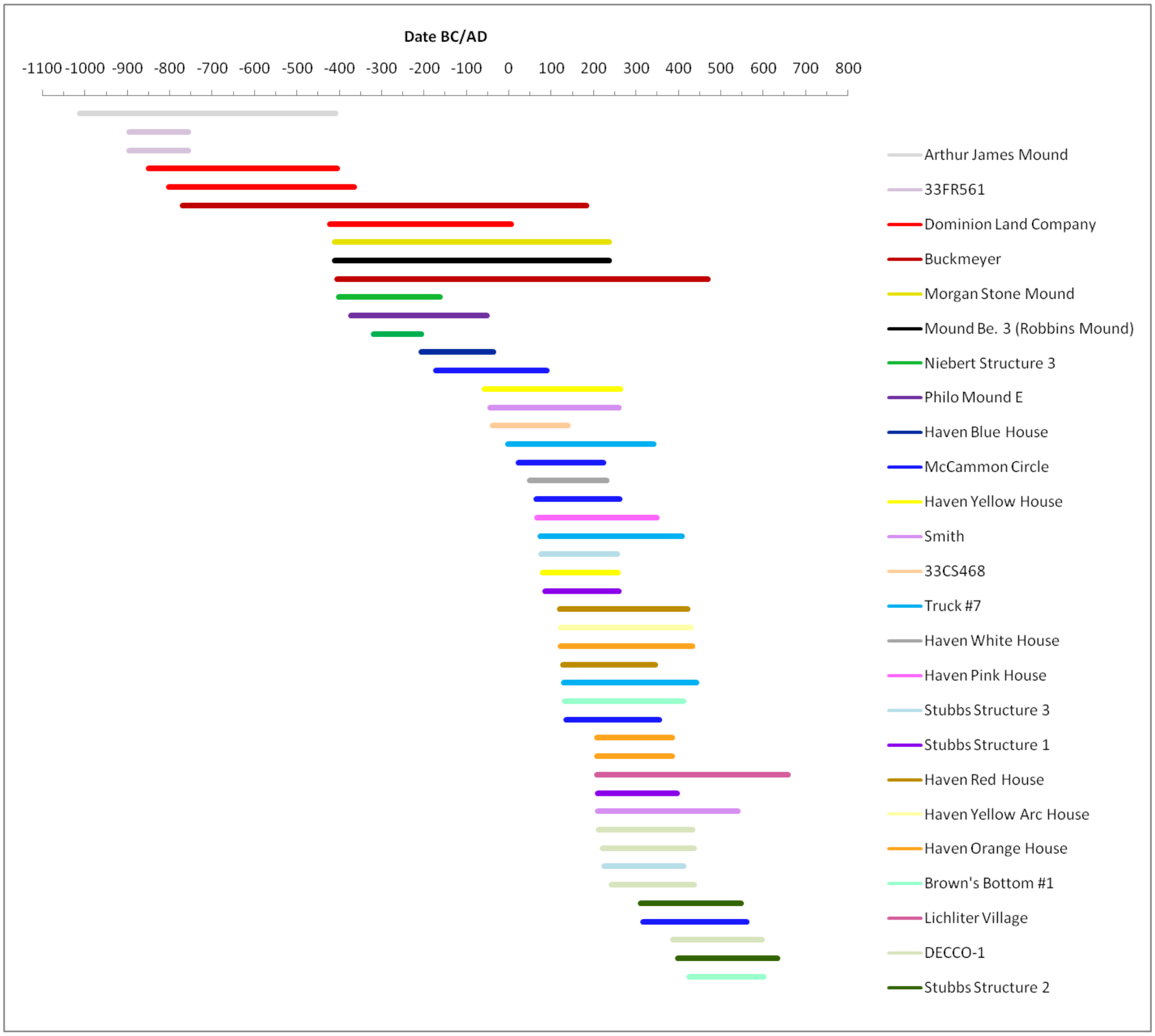

Figure 3.1. Radiocarbon Date Comparison (2-Sigma Calibrated Range).

3.2 Structural Engineering Methodology

One problem inherent in studies of ancient structures is incomplete preservation. Often there are very few lines of evidence that can be used to reconstruct their form and function (Coutts 1977). In the Eastern United States, only subsurface structural features linger to allow a reconstruction of the floor plan. These architectural features include, but are not limited to, wall trenches, postholes, postmolds, and earthen embankments. The information garnered from the excavation, flotation, and various dating methods employed by the archaeologist on these features aids in the reconstruction and interpretation of the structure.

Structural engineering analysis increases the amount of information that can be extracted from the archaeological record. Structural engineering is a sub-discipline of civil engineering that is concerned with the analysis and design of structures and the loads applied to the structures (Heyman 1999; Kassimali 2005). It is applied to the study of prehistoric architecture in order to assess the ability of a hypothetical reconstruction to be structurally plausible through equations and calculations. Specifically, it allows for factors such as roof bearing capacity and structural integrity to be assessed (Marshall 1969). Basic information such as the shape of the structure can be seen in the remaining floor plan (Webb 1941a; Baby 1971). More detailed information regarding the construction materials can be collected from the flotation analyses (Weller 2007). The radiocarbon dating of materials recovered from subsurface features allows for the age of the structure to be estimated (Pacheco et al. 2006). However, it is through the use of structural engineering principles that the finer details of the structure can be distinguished. Through a calculation of the possible loads a prehistoric structure would have to support, the ability of the construction materials to bear the loads can be estimated (Marshall 1969; Breyer et al. 2003).

Form helps to understand the function of any prehistoric structure and what type of activities likely occurred within the confines of the building. Many researchers accept that structures containing roofs are more likely domestic in nature, while unroofed structures are more likely ceremonial (Webb and Snow 1974; Niquette et al. 1989). A roof is needed to keep inhabitants out of inclement weather during all seasons and to keep heat in a building during the harsh winter months. The lack of a roof leads one to infer a more ephemeral and non-domestic nature for a given structure (Niquette et al. 1989). While the presence of a roof does not determine what activities were possible within a given structure, the absence of a roof is more significant when it comes to the function of a prehistoric building.

Whether or not a roof could have been supported can be addressed using structural engineering principles. The first step is to determine the weight of a hypothetical roof, then to verify whether or not the structural posts could support the roof load. The simplest estimate of the roof load involves the product of the weight of the materials assumed for the roof per square meter and the floor area for the structure (Marshall 1969). Estimation for a snow load can be added to the roof load calculation when a more permanent occupation is being considered. This conglomerate of the dead load and environmental load accounts for a comprehensive estimate of the roof load for the prehistoric structure (Kassimali 2005).

Structural engineering principles come into play when considering whether or not the structural support posts will bear the estimated roof load. Euler's formula can be used to compute the load bearing capabilities of these posts (Beer et al. 2006). Euler's formula is calculated using the equation:

$$\boxed{P_{cr} = \frac{\pi^2 EI}{(KL)^2}}$$

The formula takes several factors into consideration: modulus of elasticity, moment of inertia, effective length factors based on column type, and column length. Modulus of elasticity (E) is a measurement of the amount of stress a material will absorb before plastic deformation or failure occurs (Beer et al. 2006). This capacity varies from species to species of wood and can vary between hardwoods and softwoods (United States

Department of Agriculture 1999). Modulus of elasticity is measured in megapascals (MPa), which is a unit of pressure that must to be converted into kilogram/cm^2 for the Euler's formula calculations. Moment of inertia (I) is a measurement of the capacity of a post to resist bending in relation to the surface area of the post (Beer et al. 2006). The moment of inertia is calculated using the formula:

$$\boxed{I = (\tfrac{1}{2}\pi)(r^4)}$$

In the equation, r is the symbol for the radius of the post, and the moment of inertia is measured in cm^4. The next variable considered in Euler's formula is the effective length factor of the post (K). The effective length factor is determined by the type of post construction. Since the post is made of wood and has the ability to flex and move a minor amount due to expansion and contraction, it is considered to be a pinned-pinned post, which has a K value of 1.00 (Beer et al. 2006). The final variable that is needed to perform calculations with Euler's formula is the length of the post (L).

The value computed using Euler's formula is symbolized as P_{cr} and is a unit of mass denoted in kilograms. P_{cr} represents, in a perfect world, the average weight each structural post could bear without failing. This value can then be compared to the estimated weight of the roof load on a per post basis (P) from the earlier calculations for roof weight. If $P < P_{cr}$ then the structural posts could support the estimated weight of the roof and the structure would be considered stable. However if $P > P_{cr}$ then the posts would fail under the roof load and the structure would be considered unstable (Beer et al. 2006).

CHAPTER 4

DATA

4.1 Structural Data Comparisons

In modern day architectural evaluation, there are copious amounts of information that can be recorded and assessed for any one structure. In contrast, the amount of information that can be recorded and calculated concerning a prehistoric structure is much less. The amount of structural data shrink further when you consider that not every archaeologist records and calculates the same types of measurements for each structure. However, commonly the lack of information is often a product of incomplete preservation, not a result of inadequate excavation. Even with these roadblocks, there are several measurements that are a part of nearly every excavation that can allow for the comparison of prehistoric structures. These include structure floor area, structural posthole diameter, structural posthole depth, and the distance between the structural postholes. Each of these structural attributes places the structure with the context of similar prehistoric structures. This can help to interpret the function and form of structure should Euler’s formula prove to be lacking in its applicability to interpreting prehistoric architecture. The value in comparing several structural attributes is that it is yet another line of evidence that allows for an inference to the best explanation for the form and function of a structure (Fogelin 2007). These data for the McCammon Circle and relevant comparable structures identified in the literature review are displayed in Table 4.1.

Table 4.1. Relevant Statistics for Comparable Structures.				
Site*	**Structure Floor Area (m^2)**	**Structural Posthole Statistics (cm)****		
		Average Diameter	**Average Depth**	**Average Distance**
McCammon Circle (33DL275)	183.85	27.00	48.15	89.00
Dominion Land Company Feature IV (33FR12)	116.75	12.70	60.96	76.20
DECCO-1 (33DL28)	113.00	NA	NA	106.80
Truck #7 (11MO200)	71.00	13.52	16.07	114.00
Philo Mound E Structure (33MU77)	84.30	17.78	12.70	91.44
Buckmeyer	79.49	12.70	39.37	335.28
Haven Yellow House (33DL1448)	27.60	8.30	12.10	62.00
Haven Pink House (33DL1448)	58.50	14.00	17.50	86.70
Haven Orange House (33DL1448)	132.30	15.20	20.80	90.00
Haven Yellow Arc House (33DL1448)	38.00	8.89	6.10	80.00
Haven White House (33DL1448)	78.79	14.20	13.40	92.00
Haven Red House (33DL1448)	54.00	16.20	16.00	81.00
Haven Blue House (33DL1448)	68.90	14.20	13.40	72.00
Brown's Bottom #1 (33RO21)	187.60	22.25	34.00	122.00
Lichliter Village House 1	168.10	15.24	60.96	102.20
33FR561 House	30.24	26.40	6.81	84.77
Mt. Horeb	688.13	27.43	60.96	131.99
Morgan Stone Mound	49.27	12.19	91.44	113.08
Mound Jo 9, Feature 31 (C. and O. Mounds)	134.99	17.07	51.82	NA
Mound Jo 9, Feature 32 (C. and O. Mounds)	388.82	19.51	57.91	NA
Mound Jo 9, Feature 34 (C. and O. Mounds)	631.24	18.59	64.01	NA
Mound Jo 9, Feature 35 (C. and O. Mounds)	183.85	19.81	64.01	NA
Mound Be. 3, Feature 26 (Robbins Mounds)	65.61	36.58	42.67	51.82
Mound Be. 20, Feature 1 (Crigler Mounds)	228.85	30.48	91.44	134.11
Mound Be. 15, Feature 6 (Riley Mound)	89.41	NA	NA	152.40
Mound Be. 15, Feature 7 (Riley Mound)	61.38	NA	NA	167.64
Stubbs Structure 1 (33WA1)	40.00	14.50	21.00	NA
Stubbs Structure 2 (33WA1)	49.00	10.00	13.00	NA
Stubbs Structure 3 (33WA1)	50.27	NA	NA	NA
Smith (33WA362)	64.00	NA	NA	84.70
33CS468 House	34.23	18.62	20.06	146.80
Niebert Structure 3	72.38	22.95	25.50	60.00
Bagley Open Site (33DL16)	45.36	18.00	18.00	133.50
Arthur James Mound (33DL14)	137.73	19.00	22.00	121.92
Pierce Open Site (33DL25)	26.42	16.00	20.00	72.85
White Mound II (33DL20)	20.15	NA	NA	67.06
Cowan Creek Mound	147.41	NA	NA	138.43
* See Table 3.1 for applicable references.				
** NA = Information was not available from the sources referenced.				

Several researchers have indicated the ability to separate site function based upon settlement type (Wiant et al. 1986; Niquette et al. 1989; Dancey and Pacheco 1997; Lazazzera 2004). While each researcher uses different categories when separating settlement types (i.e. village, hamlet, ritual camp, specialized ceremonial) a functional distinction between domestic sites and ceremonial sites is always present. This distinction between domestic and ceremonial sites is evident for Adena/Early Woodland sites (Niquette et al. 1989; Hays 1994). The domestic/ceremonial dichotomy is evident within prehistoric structures inferred at the sites as well (Niquette et al. 1989; Hays 1994; Lazazzera 2004). Through the excavation of structures at the Fort Ancient site, Adrienne Lazazzera has shown that certain structural characteristics are indicative of a domestic or ceremonial function (Lazazzera 2004). Domestic sites represent archaeological deposits that are considered everyday habitations. These sites occasionally contain patterns of postholes and features that are interpreted as the remains of domestic structures, however structural patterns are not always present at domestic sites. Ceremonial sites consist of archaeological deposits interpreted as ritual in connotation. These sites also occasionally contain patterns of postholes and features that are interpreted as the remains of ceremonial structures.

Domestic sites have several hallmarks that are identifiable within the archaeological record. These sites are generally ephemeral and small in size, representing small group settlements that are typically apart from mounds and burial contexts (Niquette et al. 1989; Railey 1991; Hays 1994). A variety of feature types that represent various, everyday activities are present at domestic sites, including hearths, storage pits, and middens (Niquette et al. 1989; Hays 1994). At domestic sites the lithic and ceramic assemblages are relatively diverse containing large amounts of debitage (Hays 1994). Duncan Falls (Carskadden and Gregg 1974), Calloway (Niquette et al. 1987), McGraw (Prufer 1965), Haven (Weller 2005a), 33FR561 (Weller 2008a), and 33CS468 (Weller 2008b) are all sites that are generally considered domestic in nature.

Domestic structures are the remains of constructions at sites where everyday activities, such as food processing/storage and tool production, took place. These structures are found at base camps, hamlets, and villages and have a low occurrence of features that display activities outside of general, everyday use. A variety of feature types are present at the relatively small, ephemeral domestic structures (Hays 1994; Lazazzera 2004). Domestic structures have a midden relatively close, and often times gulley trash dumps nearby as well (Lazazzera 2004). These buildings are not as rigidly constructed in comparison to their ceremonial cousins and they generally show signs of repair or rebuilding, various other maintenance activities, and spatial planning (Niquette et al. 1989; Lazazzera 2004). The lithic, ceramic, floral, and faunal assemblages indicate domestic activities and a high density of tool types are recovered for domestic structures (Lazazzera 2004). The standard woodland period domestic structure size is 3.6 to 13.6 m in diameter, with a median floor area of 40-50 m^2 (Steponaitis 1987).

Ceremonial sites have characteristics that are identifiable within the archaeological record as well. These sites contain relatively sparse amounts of cultural remains such as lithic debitage, yet they often have fragments of cremated human remains, indicating some aspect of mortuary related behavior (Niquette et al. 1989). Prepared hearth basins are also lacking from ceremonial sites, however other types of features that are generally considered domestic may occur (i.e. storage pits) (Niquette et al. 1989). These domestic features may occur, yet they represent a narrow range of activity and were likely used for ceremonial endeavors (i.e. ritual feasting) (Clay 1983). Niebert (Niquette et al. 1989; Clay and Niquette 1992), Dominion Land Company (Cramer 1989), Philo Mound E (Carskadden and Morton 1989), Smith (Sunderhaus et al. 2001), and the many Adena mounds excavated by Webb (Webb 1941b; Webb 1941a; Webb 1942a; Webb 1942b; Webb 1943b; Webb 1943a) are all sites that are generally considered ceremonial in nature.

Ceremonial structures represent the remains of buildings at sites where multiple ritual activities took place (i.e. mortuary processing and ceremonial feasting) (Niquette et al. 1989; Lazazzera 2004). They are generally circular, unroofed constructions that share a general similarity to ceremonial circular earthworks (Niquette et al. 1989). Ceremonial structures are commonly found at ritual camps, seasonal camps, mortuary centers, and earthworks and often contain burials, specialized lithic, ceramic, floral, and faunal assemblages (Lazazzera 2004). These constructions represent relatively large corporate structures which are more substantially built than their domestic counterparts (Lazazzera 2004). A low density of artifacts consisting of more exotic/specialized forms, the lack of midden accumulation, low diversity of subsistence remains, and more specific tool manufacture and raw material use are all characteristics of ceremonial structures (Lazazzera 2004). Domestic features representing a limited range of activities and specialized features are often present (Lazazzera 2004). Ceremonial structures may have been temporarily occupied during ritual events or may have never been occupied and solely used as symbolic structures (Lazazzera 2004).

The structures used for comparison with the McCammon Circle have been interpreted as either ceremonial or domestic in function. These structures have been inferred from the patterns of postholes and features at the various archaeological sites. The most recent and/or generally accepted interpretation concerning the form and function of the 36 analogous structures is shown in Table 4.2. Of the 36 comparable structures, 15 structures are interpreted as domestic (42 percent), while the remaining 21 structures are considered ceremonial in function (58 percent).

Table 4.2. Interpreted Form and Function for Comparable Structures		
Site*	Structure**	
	Form***	Function
McCammon Circle (33DL275)	??	??
Dominion Land Company Feature IV (33FR12)	NA	Ceremonial
DECCO-1 (33DL28)	NA	Domestic
Truck #7 (11MO200)	SBCP	Domestic
Philo Mound E Structure (33MU77)	NA	Ceremonial
Buckmeyer	W/BS	Ceremonial
Haven Yellow House (33DL1448)	NA	Domestic
Haven Pink House (33DL1448)	NA	Domestic
Haven Orange House (33DL1448)	NA	Domestic
Haven Yellow Arc House (33DL1448)	NA	Domestic
Haven White House (33DL1448)	NA	Domestic
Haven Red House (33DL1448)	NA	Domestic
Haven Blue House (33DL1448)	NA	Domestic
Brown's Bottom #1 (33RO21)	NA	Ceremonial
Lichliter Village House 1	NA	Domestic
33FR561 House	W/BS	Domestic
Mt. Horeb	HW	Ceremonial
Morgan Stone Mound	HW (WA)	Ceremonial (Domestic)
Mound Jo 9, Feature 31 (C. and O. Mounds)	HW (WA)	Ceremonial (Domestic)
Mound Jo 9, Feature 32 (C. and O. Mounds)	HW (WA)	Ceremonial (Domestic)
Mound Jo 9, Feature 34 (C. and O. Mounds)	HW (WA)	Ceremonial (Domestic)
Mound Jo 9, Feature 35 (C. and O. Mounds)	HW (WA)	Ceremonial (Domestic)
Mound Be. 3, Feature 26 (Robbins Mounds)	HW (WA)	Ceremonial (Domestic)
Mound Be. 20, Feature 1 (Crigler Mounds)	HW (WA)	Ceremonial (Domestic)
Mound Be. 15, Feature 6 (Riley Mound)	HW (WA)	Ceremonial (Domestic)
Mound Be. 15, Feature 7 (Riley Mound)	HW (WA)	Ceremonial (Domestic)
Stubbs Structure 1 (33WA1)	NA	Domestic
Stubbs Structure 2 (33WA1)	NA	Domestic
Stubbs Structure 3 (33WA1)	NA	Domestic
Smith (33WA362)	NA	Ceremonial
33CS468 House	W/BS	Domestic
Niebert Structure 3	HW	Ceremonial
Bagley Open Site (33DL16)	NA	Ceremonial
Arthur James Mound (33DL14)	NA	Ceremonial
Pierce Open Site (33DL25)	NA	Ceremonial
White Mound II (33DL20)	NA	Ceremonial
Cowan Creek Mound	HW (WA)	Ceremonial (Domestic)
* See Table 3.1 for applicable references.		
** NA = Information was not available from the sources referenced. Most recent interpretation of form and function used, original interpretation in parentheses.		
***Function Legend WA = Webb's Archetypal W/BS = Wigwam/Bent Sapling SBCP = Straight Beam with Center Post HW = Hypaethral Woodhenge		

The layout of the subsurface structural features allows for the shape and size of the structure to be determined. These are the attributes that the majority of interpretations about a structure are based upon (Table 3.1 and Table 4.1). However, the researcher must remember that these represent basic assumptions as to the form and function of a building, and they are by no means deterministic in nature (Loten 1970; Vencl 1971). Of the 36 structures used for comparison with the McCammon Circle, 23 had the floor plan of a circle, three were ovals, four rectangular, and six had a square floor plan (Table 3.1).

Many researchers have used form to identify the possible function of a structure and to make interpretations about the sociopolitical and economic aspects of a prehistoric culture (Webb and Snow 1974; Seeman 1986; Abrams 1989; Peregrine 1992; Abrams and Bolland 1999). Through the use of archaeological and ethnographic analogs, researchers have shown that curvilinear domestic structures are generally indicative of smaller ephemeral sites that lack extensive agriculture, while rectilinear domestic structures represent larger, more permanent settlements that have intensive agriculture (Peregrine 1992). Some researchers argue that there is an association between form and function because as societal complexity increases the need to subdivide life also increases (Peregrine 1992). Rectangular structures allow for easier subdivision than curvilinear structures, thus indicating increased social complexity in societies with rectangular structures than those with curvilinear ones (Peregrine 1992).

Other researchers have identified various structural shapes as indicative of certain time periods and/or cultural groups (Baby 1971; Fischer 1974; Webb and Snow 1974;

Clay 1987; Niquette et al. 1989; Fortier 1993; Hays 1994; Clay 2007). In Andrew Fortier's review of prehistoric architecture in the American Bottom, he states that "structures generally evolve from irregular to oval to square to rectangular" (Fortier 1993: 271). As far as the prehistoric architecture in the Ohio valley is concerned, Raymond Baby showed that Adena/Early Woodland structures were circular in shape, while Hopewell/Middle Woodland and Fort Ancient/Late Woodland houses have square and sub-rectangular floor plans (Baby 1971). Increased social complexity has been suggested as the reason for these architectural trends (Peregrine 1992). The above discussion of form is important because it shows the multitude of information that can be ascertained about a structure merely from its form. The identification of the structural form allows for a calculation of the floor area of a structure, which is integral to determining the weight of a hypothetical roof during the engineering analysis. The identification of form and calculation of floor area also allows for a comparison between sites as to the relative size differences between multiple structures. This comparison between structures can help a researcher to compare their interpretation for the function of a prehistoric structure with the interpretations for other similar structures in the region by various other researchers.

A calculation of the floor area for a structure allows the comparison of prehistoric structures of various shapes and sizes. Figure 4.1 graphically depicts the floor area of sites listed in Table 4.1. The structures indicated as red bars on the graph have been interpreted as domestic, while the structures indicated as blue bars have been interpreted as ceremonial in function (Table 4.2). The McCammon Circle is indicated as a yellow bar on the graph to make it stand out amongst the group. From the standpoint of a structural engineering analysis, floor area is a critical variable in the calculation whether or not a structure could have supported a roof (Marshall 1969). It allows the researcher to assess an estimated roof weight for a structure, including the weight of the construction materials and of a hypothetical environmental load from snow. The trend indicated from the floor area when coupled with the interpretation of the function of the structure indicates that those structures considered domestic in nature are relatively smaller, while those interpreted as having a ceremonial function are relatively large. The smallest structure in the comparison was the building recovered below White Mound II (20.15 m^2) and the largest structure was the double-posted Mt. Horeb behemoth (688.13 m^2), with the average floor area for the 37 structures at 127.05 m^2. The McCammon Circle lies towards the larger end of the spectrum, with a floor area of 183.85 m^2. All of the structures with a floor area larger than that at the McCammon Circle (Mt. Horeb; Mound Jo. 9, Feature 35; Brown's Bottom #1; Mound Be. 20, Feature 1; Mound Jo. 9, Feature 32; Mound Jo. 9, Feature 34) are considered to be ceremonial in nature (Clay 1986; Seeman 1986; Yerkes 1988; Niquette et al. 1989; Clay 1992; Hays 1994; Clay 2007). A comparison of floor area between the sites and McCammon Circle helps to interpret the function of the structure. It shows that the size of the McCammon Circle is in line with structures that have been interpreted as ceremonial in function. While not deterministic of the function of the McCammon Circle, floor area does allow us an inference to the best explanation for the form and function of the structure (Fogelin 2007).

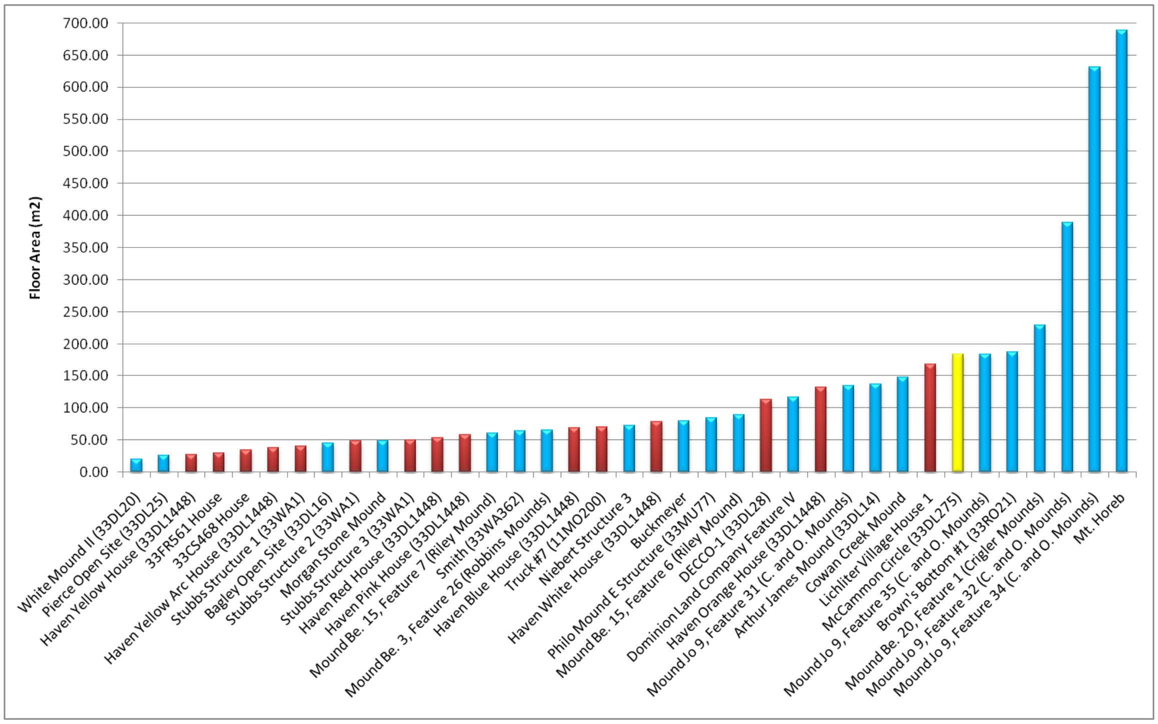

Figure 4.1. Floor Area Comparison (Blue = Ceremonial; Red = Domestic).

Floor area gives an idea as to the overall size and function of a structure, while measurements of the structural posts can allow the archaeologist to assess the energy investment and durability of the structure. The larger and deeper the post, the larger the energy expenditure involved in the construction of the building. Energy expenditure is a complex dimension, including "energy expended in procuring raw materials, transporting those materials to the site of construction, manufacturing components of the structure, and actually assembling the structure" (Abrams 1989: 54). Not only do post size and depth indicate energy investment in a structure, they help to determine the type of construction that was structurally feasible and the relative permanency of the structure as well. The size of the post directly affects the moment of inertia (*I*) factor in Euler's formula, which calculates the ability of a post to withstand the weight of an estimated roof and snow load.

The average posthole diameters for the structure comparison show a broad range of dimensions (Table 4.1; Figure 4.2). The structures indicated as red bars on the graph have been interpreted as domestic, while the structures indicated as blue bars have been interpreted as ceremonial in function (Table 4.2). The McCammon Circle is indicated as a yellow bar on the graph to make it stand out amongst the group. The trend indicated from the average posthole diameter when coupled with the interpretation of the function of the structure indicates that those structures considered domestic in nature have smaller postholes, while those interpreted as having a ceremonial function contain relatively larger postholes. The structure with the smallest average posthole diameter was Yellow House at the Haven site (8.30 cm), which is located to the northwest of the McCammon Circle in Delaware County. The largest average posthole diameter was found to the south in Boone County, Kentucky at Mound Be. 3 of the Robbins Mound complex (36.58 cm). The McCammon Circle falls within the large range for average posthole diameter at 27.00 cm, while the average posthole diameter for the structures in the comparison that have these measurements recorded is 17.98 cm. As with floor area, those structures on the large end of the range are considered to be from a ceremonial context (Clay 1986; Seeman 1986; Yerkes 1988; Niquette et al. 1989; Clay 1992; Clay 2007). Only three structures have average posthole diameters larger than McCammon Circle, and all three structures are interpreted as having a ceremonial function (Clay 1986; Seeman 1986;

Niquette et al. 1989; Clay 2007), therefore average posthole diameter allows us another inference to the best explanation for the form and function of the structure as well (Fogelin 2007).

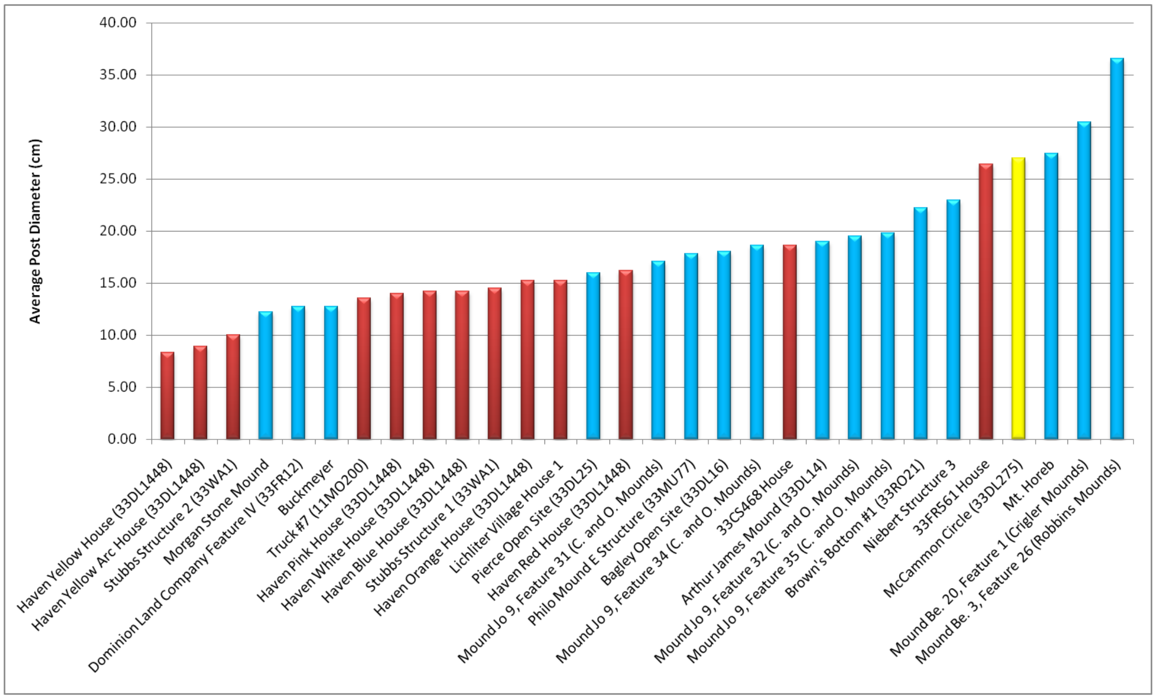

Figure 4.2. Average Posthole Diameter.

The average posthole depth comparison between the 37 structures indicates a wide range of measurements as well (Table 4.1; Figure 4.3). As mentioned earlier, the post depth helps to indicate the relative permanency of and the level of energy investment in the structure (Abrams 1989). The structures indicated as red bars on the graph have been interpreted as domestic, while the structures indicated as blue bars have been interpreted as ceremonial in function (Table 4.2). The McCammon Circle is indicated as a yellow bar on the graph to make it stand out amongst the group. The trend indicated from the average posthole depth when coupled with the interpretation of the function of the structure indicates that those structures considered domestic in nature have relatively shallower postholes, while those interpreted as having a ceremonial function contain relatively deeper postholes. The shallowest structural postholes belong to Yellow Arc House at the Haven site (6.10 cm). The structure under Mound Be. 20 at the Crigler Mound group and the structure below Morgan Stone Mound had the deepest structural postholes (91.44 cm) in the cohort. The average structural posthole depth for the comparable structures is 34.74 cm. The structural postholes at the McCammon Circle are again at the larger end of the range at 48.15 cm in average depth, placing the structure in the company of the majority of other structures that are considered non-domestic and ceremonial in nature (Clay 1986; Seeman 1986; Yerkes 1988; Niquette et al. 1989; Clay 1992; Clay 2007). As with floor area and average posthole diameter, average posthole depth allows yet another inference as to the best explanation for the form and function of the McCammon Circle (Fogelin 2007).

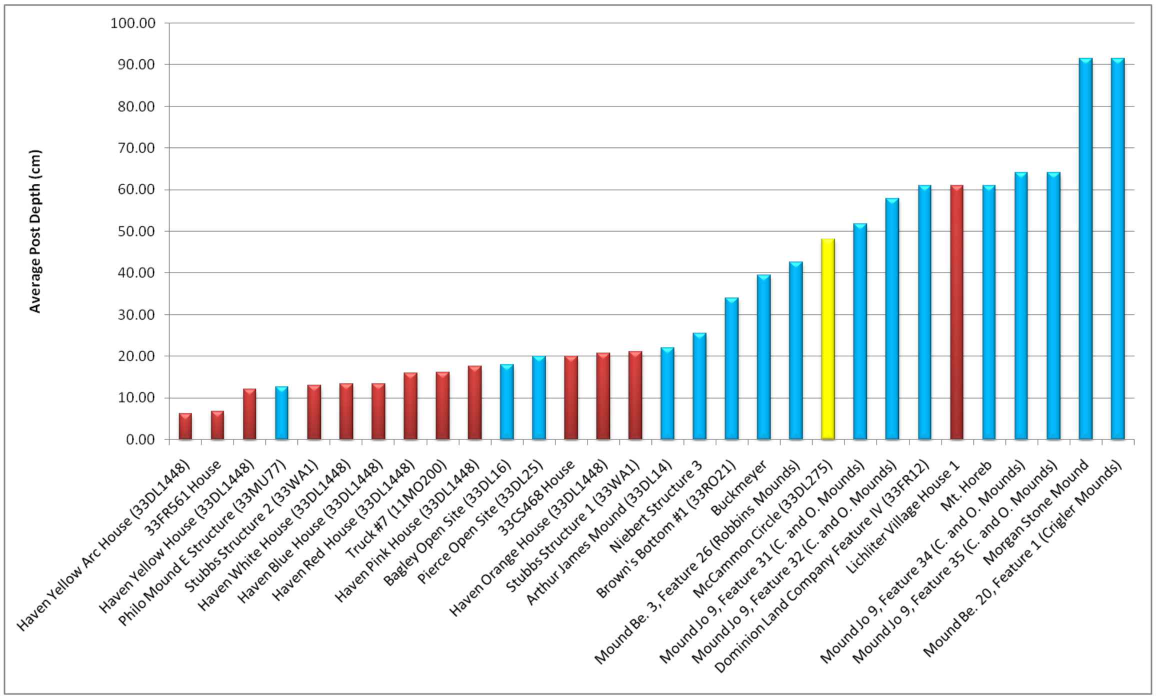

Figure 4.3. Average Posthole Depth Comparison.

The distance between structural postholes, while not utilized within the present engineering analysis, can possibly be used to determine the stability of a prehistoric structure. However, this structural attribute did not provide any insight within the current study as to the function and form of the McCammon Circle. This measurement is included within the current study as a courtesy to future researchers who may need the measurement for future engineering analyses. The structures indicated as red bars on the graph have been interpreted as domestic, while the structures indicated as blue bars have been interpreted as ceremonial in function (Table 4.2). The McCammon Circle is indicated as a yellow bar on the graph to make it stand out amongst the group. The average spacing between structural postholes for the comparable prehistoric structures indicates a wide range of measurements (Table 4.1; Figure 4.4). The structure with the narrowest average space between postholes was the structure below Mound Be. 3 of the Robbins Mound complex (51.82 cm). The widest gap between structural postholes was witnessed at the Buckmeyer site (335.28 cm). This immense spacing is far removed from the second largest posthole gap encountered as a part of one of the structures below the Riley Mound (167.64 cm). When the anomalous Buckmeyer structure is removed from consideration, the average posthole spacing for the group is 100.91 cm. Average posthole spacing is the only structural data category in which the McCammon Circle resides on the smaller end of the range (89.00 cm).

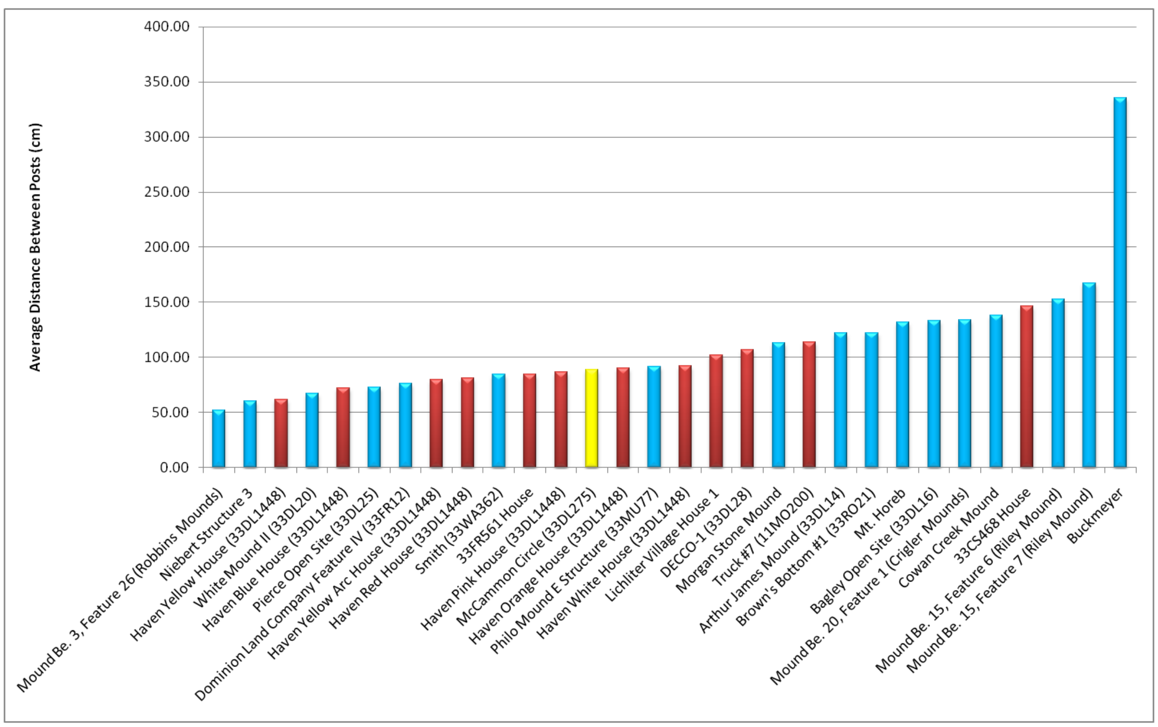

Figure 4.4. Average Distance Between Postholes Comparison.

In summary, while not necessarily directly influencing the structural engineering analysis undertaken on the McCammon Circle, a comparison of the four aforementioned structural attributes (floor area, average posthole diameter, average posthole depth, and average distance between postholes) helps to place the structure within the archaeological context of other similar prehistoric structures. The comparison reveals that the McCammon Circle is more similar to other sites that have been interpreted as ceremonial based upon floor area, average posthole diameter, and average posthole depth. The McCammon Circle is in the 83^{rd} percentile in regards to floor area, the 90^{th} percentile concerning average posthole diameter, and the 70^{th} percentile in regards to average posthole depth. The McCammon Circle is larger in floor area and average posthole diameter than all of the structures in the comparison that have been considered to have a domestic function. Lichliter Village House 1 is the only structure interpreted as domestic that has a structural attribute larger than the McCammon Circle (average posthole depth). It is also the potentially the youngest structure in the comparison based on its 2 sigma calibration (AD 208 to AD 658). This comparison allows for comprehensive interpretation of the structure in the event that the Euler's formula proves incapable of accurately determining the form of the structure.

4.2 Engineering Data

One of the factors that affect the outcome of the engineering formulations is the degree of preservation at archaeological sites, and the variable preservation rates of different kinds of construction materials. The type of wood used for construction material for the McCammon Circle was not ascertained from the archaeobotanical analysis for the site. Instead, the analysis was only able to determine that a hardwood variety was used for construction (Weller 2007).

As a variable, unidentified wood created an interesting dilemma since the type of wood affects the modulus of elasticity (*E*) variable in Euler's formula. Since the analyst at least narrowed the wood taxa to a hardwood variety, we can assume that one of the local hardwoods was used. The next step was to determine which hardwoods were most prevalent during the prehistoric Native American epoch. Several researchers have attempted to reconstruct the pre-European contact flora of the Eastern U.S. (Ogden 1966; Gordon 1969; Shane et al. 2001). Robert Gordon gives an approximation of the various tree species present in the forests of Ohio during prehistoric Native American times and estimates the dominant tree species consisted of black walnut, sugar maple, white oak, red oak, chinquapin oak, white ash, hackberry, and basswood (Gordon 1969). Of those listed by Gordon as dominant tree species, all except for chinquapin oak are still major resources of hardwood for the timber industry in the Northern U.S. and Appalachia (United States Department of Agriculture 1999). To determine the modulus of elasticity needed for the engineering calculations, a wood handbook (United States Department of Agriculture 1999) was consulted to attain the *E* values for the tree species described by Gordon (Gordon 1969). Since the true wood species could not be identified during the archaeobotanical analysis, an average modulus elasticity value was calculated from those *E* values and used for the Euler's formula calculations (E = 9091.30 MPa).

Once I determined the modulus of elasticity, there remained one other variable that I needed in order to calculate Euler's formula: the average length of the structural posts used in constructing the McCammon Circle. While the depth of the postholes at the McCammon Circle is available there is no direct way to determine how far above ground the structural posts extended. Instead you would have to perform several mathematically complex analyses that are beyond the premise of this current study, which is determining the applicability of Euler's formula to prehistoric architecture (Beer et al. 2006; Das 2007). Since no whole posts were preserved in the archaeological record, an estimation of the length of the structural posts is required as a proxy measure. A proxy measure estimating the length of the structural posts is all that is needed to test the usefulness of Euler's formula. A few researchers have estimated the height of prehistoric structures from ethnographic and archaeological evidence (Webb 1941a; Marshall 1969; Sturtevant 1975). James Marshall estimated the height of the Pike House, in Illinois, to be 1.22-1.83 meters (Marshall 1969: 168). William Webb used the width of the burned area and ash scatter around the posthole pattern to estimate the height of the structure below Morgan Stone Mound, in Kentucky, to be 1.98 meters (Webb 1941a: 236). From historical drawings and notes compiled in 1761, William Sturtevant estimated the height of a wigwam in Connecticut to be around 3.20 meters (Sturtevant 1975: 440). Based on these previous estimates of height, a value near the middle of the estimates was used for the McCammon Circle calculations (2.44 meters). Because of the lack of a preserved structural post, a general estimation of L from other researcher's work was the only way to achieve a substantiated height. The attempt to arrive at an estimated height by altering

Euler's formula to solve for L proved unfruitful. This occurred because of the relative strength of the hardwood, which directly affects the modulus of elasticity (E), coupled with the large average diameter for the posts, which directly affects the moment of inertia (I), resulted in a calculated L that was well beyond a realistic amount for any prehistoric structure. This represents one of the problems when using general engineering formulations on prehistoric structures: occasionally unreliable results. Therefore I went back to the anthropological realm of ethnographic and archaeological interpretations for an estimate that was more acceptable and realistic given what is currently known about prehistoric Native American structures.

Having all of the necessary values, I calculated the vertical load each post could withstand without failure using Euler's formula. A breakdown of the values used in the calculation is as follows:

Modulus of Elasticity (E) = 92,705.46 kg/cm^2

Moment of Inertia (I) = 52,174.10 cm^4

Effective Length Factor (K) = 1.00

Length of Post (L) = 243.84 cm

The P_{cr} value calculated from Euler's formula equaled 802,879.05 kg. This calculates that each 2.44 meter post could withstand nearly 803,000 kg of weight. Researchers have estimated that a posthole is likely 30-50 percent larger than the affiliated post (Fortier 1985). However, since the average post diameters were calculated from the size of the posthole instead of actual posts themselves, I chose to recalculate the

P_{cr} value assuming the average post was only 50 percent the size of the average posthole. Therefore the 50 percent marker was chosen in order to determine the minimum possible amount the average post at the McCammon Circle could theoretically hold. When the average diameter of a structural post is reduced by half, the Moment of Inertia value utilized within the Euler's formula calculation reduces to $I = 3{,}260.88\ \text{cm}^4$. This in turn reduces the P_{cr} value to 50,179.92 kg, a 94 percent reduction in the amount of weight each structural post could support before failure.

Armed with the P_{cr} value for the best and worst case scenarios for the McCammon Circle, the next step in determining whether or not the structure was roofed is to estimate the weight of a hypothetical roof. Through historic analogs and archaeological evidence, most researchers presume prehistoric structures were roofed with combinations of logs, brush, bark, and mud (Baby 1971; Webb and Snow 1974; Sturtevant 1975). Marshall's calculations for the Pike House estimated that such a roof would weigh at least 48.82 kg/m^2, given an estimation of the amount and type of construction materials used for a roof (Marshall 1969). The McCammon Circle must include an estimation for the weight of a snow load, as the archaeobotanicals indicate that the site possibly represents a year round occupation and likely a winter occupation (Weller 2007). Marshall estimated the weight of a 25.4 cm deep snow load to be 24.41 kg/m^2 based on the average weight of snow. The simplest calculation for a hypothetical roof for any prehistoric structure is a direct translation of floor area. Using Marshall's estimates for the weight of roofing materials (48.82 kg/m^2) and for the weight of a 25.4 cm deep snow load (24.41 kg/m^2) relative to the floor area of the structure (183.85 m^2), the total weight of the roof was calculated to be 13,463.34 kg. With the McCammon Circle being comprised of 35 structural posts, each post would be required to handle an average of 384.67 kg of roof load.

The calculations indicate that the presence of a roof was at least within the realm of possibility. The P_{cr} value for the smallest assumed post size at the McCammon Circle (50,179.92 kg) was more than 130 times the P value (384.67 kg) for the estimated roof weight. Given the sheer size of the posts and their relative strength, the structure would have been easily able to resist the vertical load created by a hypothetical roof. However, Euler's formula indicates that the McCammon Circle could have sustained a roof, this is in no way deterministic. Euler's formula simply estimates the ability of the structural posts to withstand the vertical load created by the weight of a hypothetical roof, it does not take into account several other factors that determine whether or not a structure could support a roof. For example, the ability of the soil at the site to bear the weight of a roof needs to be taken into account as well.

Terzaghi's Bearing Capacity Theorem measures the effects of soil compressibility by testing the soil's ability to withstand the vertical load applied to the soil by a post (Das 2007). There are several soil compressibility factors for a post which help find the ultimate bearing capacity of the soil including cohesion shear strength, confining stress from the soil, and the specific strength of the soil below the post (Das 2007). These factors are all functions of the soil friction angle which indicates the ability of the soil to withstand the vertical loading from the post. The higher the friction angle the stronger the soil because the more friction the less likely the soil will shift or settle (Das 2007).

The ability of a structure to withstand horizontal forces, such as wind load, needs to be assessed as well in order to determine whether or not a specific structural form was possible. Horizontal forces are absent from a structural engineering analysis solely employing Euler’s formula. One possible avenue to check the ability of a structural post to withstand a wind load is through application to cantilever post with symmetric loadings or uniform wind pressure (Beer et al. 2006). Basically, the portion of the post above ground will act as a cantilever beam by having the tributary area of the wind applied to it acting as an applied load on the post and having the embedment of the post acting as the fixed support (Beer et al. 2006). The soil has to maintain the strength of the overturning moment of the post, otherwise failure will occur and the post will not stand (Beer et al. 2006).

Application to cantilever post with symmetric loadings or uniform wind pressure and Terzaghi's Bearing Capacity Theorem represent only two of a multitude of structural engineering analyses and principles that could be coupled with Euler’s formula and applied to the analysis of a prehistoric structure to attain an accurate reconstruction of its form. The premise of the current study was to exclusively test the ability of Euler’s formula to determine the possible form of the McCammon Circle. Euler’s formula, by itself, was unable to accurately determine the form of the structure. It failed to take into account horizontal forces, however other researchers have indicated that a post is more likely to succumb to horizontal loads than vertical loads (Marshall 1969). Euler's formula also did not take into account the soil dynamics of the site where the structure was built. Given the shortcomings inherent in Euler's formula, it should not be relied upon as the sole indicator of a structure's form. However, as the colloquial saying goes, you should make sure not to throw the baby out with the bathwater. Euler's formula may not be applicable to the interpretation of prehistoric building form alone, but coupled with other engineering principles and analyses it may prove fruitful in its complementary ability to assess structural form integrity. This study will hopefully allow future researchers to decide whether or not Euler's formula should be included within their own engineering analysis of prehistoric architecture based upon its merits and shortcomings.

While the aforementioned structural engineering analysis employed for McCammon Circle proved unreliable, the potential usefulness of engineering principles and analyses to understanding prehistoric architecture has been shown. Other researchers have utilized engineering models and formulations to aid in the interpretation of architecture, both prehistoric and historic, across the globe from several disparate cultures and civilizations (Landels 1978; Parry 2005; Joshi and Infinity 2008). However only a few researchers have attempted it for Eastern North American structures (Marshall 1969; Pacheco et al. 2006). Hopefully this study will spur other researchers in this region to test engineering models and apply engineering principles to their excavations in the future.

CHAPTER 5

INTERPRETATIONS

5.1 Interpretation of Form

Before interpreting the function of the McCammon Circle, the physical form of the building must be addressed. The structural engineering analysis performed on the structure had unreliable results. It indicated through Euler's formula that a roof was structurally feasible given the large size of the posts relative to the estimated weight of the roof. However, solely relying on Euler's formula for interpreting the form of a prehistoric structure was proven to be an unreliable engineering analysis. Therefore, while a roof may have been possible, several researchers have indicated that the large prehistoric circular structures found throughout the region were likely unroofed spaces (Seeman 1986; Niquette et al. 1989; Clay 1992; Hays 1994; Carskadden n.d.a.).

The presence of a roof is not the only factor when considering the form of a structure. Other structural attributes such as the presence of a roof support posthole pattern, posthole diameter, posthole depth, and overall floor area contribute to more comprehensive interpretation of form. Comparing the McCammon Circle to other structures based on the aforementioned structural attributes offers an inference to the best explanation for the form of the structure (Fogelin 2007).

The McCammon Circle represents a rather substantial prehistoric circular structure. The building was a single post construction made with relatively large, deep, vertical posts. The building was 15.30 m in diameter, which based upon the results of the structural engineering analysis using Euler's formula could have supported a roof though the structure lacked an identifiable pattern of internal roof support postholes. Armed with the archaeological evidence and structural engineering analysis results stating what building form was possible for the McCammon Circle, the next step is to determine which form was most likely.

I have compiled five pre-existing renderings of possible building forms from the structures that were used in the aforementioned structural comparison (Table 5.1). There are five building forms represented throughout the geographic region within a comparable temporal affiliation to the McCammon Circle. While this list may not include every prehistoric structure type, it includes the forms that share structural similarities with the McCammon Circle (Table 3.1). These five building forms include Webb's structurally unsound reconstruction from the Morgan Stone mound (Webb

1941a), the tent-like Bedouin example from the Pike House (Marshall 1969), a wigwam/bent sapling structure from the East Coast (Sturtevant 1975), a straight beam with center post rendering from Illinois (Fortier 1985), and a hypaethral “woodhenge” depiction that has been the most recent interpretation for the sub mound structures from Kentucky (Seeman 1986; Niquette et al. 1989; Clay 1992; Carskadden n.d.a.).

Table 5.1. Hallmarks of Each Structural Form Compared to the McCammon Circle.

Structural Form	Floor Plan	Posthole Pattern	Posthole Profile
McCammon Circle	**Circular with no identifiable roof support posthole pattern**	**Single**	**Vertical**
Webb's Archetypal[1]	Circular with central four posthole roof support pattern	Double	Outward Sloping
Tent-like[2]	Directly opposed postholes with no roof support posthole pattern	Single	Outward Sloping
Wigwam/Bent Sapling[3]	Circular to oval with no roof support posthole pattern	Single	Outward Sloping
Straight Beam with Center Post[4]	Circular with one central roof support posthole and an aligned, interior support posthole pattern	Single	Vertical
Hypaethral Woodhenge[5]	Circular with no roof support posthole pattern	Single or Double	Vertical or Outward Sloping

[1](Webb 1941a); [2](Marshall 1969); [3](Sturtevant 1975); [4](Fortier 1985);
[5](Seeman 1986; Niquette et al. 1989; Clay 1992; Carskadden n.d.a.)

All except for the tent-like example for the Pike House are represented among the structures included in the aforementioned structure comparison (Table 4.2). The tent-like form found at the Pike House is not represented in the above structure comparison because the structural attributes necessary for the comparison were lacking from the literature (average posthole diameter, average posthole depth, average distance between postholes). The form was kept for the structural form comparison to the McCammon Circle because it offered another possible interpretation of form for prehistoric structures in the region and in reverence to James Marshall's Pike House article (Marshall 1969) that initially brought the use of engineering analyses to prehistoric architecture to my attention.

Webb's archetypal building form was initially interpreted for the majority of his sub mound constructions (Morgan Stone Mound; the C. and O. Mound structures; Mound Be. 3, Feature 26; Mound Be. 20, Feature 1; and the Riley Mound structures) (Webb 1941a; Webb 1942a; Webb 1942b; Webb 1943b; Webb 1943a). Recently these structures, along with Mt. Horeb, Cowan Creek Mound, and Niebert Structure 3 have been interpreted as hypaethral structures (Seeman 1986; Niquette et al. 1989; Clay 1992; Carskadden n.d.a.). The wigwam/bent sapling form has been attributed to Buckmeyer, 33CS468 House, and 33FR561 House (Bush 1975; Hays 1994; Weller 2008a; Weller 2008b). The Truck #7 structure was the only example of the straight beam with center post construction method within the literature review, however this method has been recognized for structures found in the southern Plains region of the U.S. (Hoffman 1969; Fortier 1985). The remainder of the structures from Table 4.2 did not specify a building form from the sources referenced.

With regards to Webb's archetypal reconstruction, the McCammon Circle lacks several comparable characteristics. Based on the posthole profiles and floor plan, the McCammon Circle lacks the outward leaning paired postholes and the central four posthole roof support pattern that define the structure found beneath Morgan Stone mound. The diameter of the McCammon Circle is nearly twice that of Webb's "Adena house" (15.30 m and 7.92 m respectively). The fact that several researchers have indicated the structural instability of Webb's reconstruction and it's "construction technique that is virtually unique in North American Indian architecture" (Hays 1994: 70), the likelihood that the McCammon Circle represents a structure similar to Webb's fanciful form is remote.

The McCammon Circle also lacks the evidence to support the assertion that it had the tent-like roof similar to the Pike House. The main lines of evidence in support of the roof type at Pike House were outward slanting structural posts that were directly opposed to each other and a lack of an internal roof support pattern. As discussed earlier, the McCammon Circle lacked outward slanting structural postholes. Marshall borrowed his idea for a tent-like roof from modern Bedouin examples, however other researchers have noted that nomadic peoples generally do not leave subsurface architectural remnants, such as structural support postmolds/holes (Vencl 1971). When discussing different types of circular structures in comparison to the Niebert Circles, Charles Niquette states "[o]ne cannot even postulate Marshall's somewhat unsatisfactory skin covering for the Adena structure short of joining the tops of all posts in some fantastic and improbable cat's cradle" (Niquette et al. 1989: 163).

The sheer size of the McCammon Circle makes a tent-like roof made from hides highly unlikely as well. Marshall states that "[s]hallow postholes are all that are needed" for this building form, however the structural postholes at the McCammon Circle are quite deep and required extensive energy investment, which is juxtaposed to Marshall's expedient construction technique (Marshall 1969: 169). Given these incompatibilities with Marshall’s rendering, there is no reason to suggest a tent-like construction for the McCammon Circle.

When it comes to a wigwam/bent sapling style of construction, the McCammon Circle still fails to fit the criteria needed. Bent sapling buildings have outward sloping postholes “to aid resistance against the stress set up when the tops are bent inward” (Sturtevant 1975: 443), however the McCammon Circle consists of vertical postholes. Secondly, the large diameter of the structure would require saplings that were nearly 25 m in length and could withstand the stress placed on them by the bending. Finally, at an average of 27.00 cm in diameter, the posts used for constructing the McCammon Circle can hardly be referred to as saplings. Although theoretically possible, this construction method is considered structurally implausible for the McCammon Circle given the substantial nature of the structure and its posts.

Through excavations at the Truck #7 site, Andrew Fortier has suggested a building method which involves straight beams from the structural support posts to a single roof support post in the center of a circular structure (Fortier 1985). This construction method also contains an aligned, interior support posthole pattern. The McCammon Circle lacks the required central support posthole for the aforementioned construction method (Weller 2007). The McCammon Circle lacks the aligned interior support posthole pattern as well. Similar to the wigwam/bent sapling construction method, this building form is considered unlikely given the evidence recovered from the McCammon Circle.

A reanalysis of Webb's sub mound Kentucky structures by various other researchers has indicated they likely represented hypaethral constructions (Seeman 1986; Niquette et al. 1989; Clay 1992; Clay 2007; Carskadden n.d.a.). A hypaethral structure has a roofless central space or is wholly open to the sky. Structures following this form are typically sizable in floor area with large-diameter, deep posts (Seeman 1986; Niquette et al. 1989; Hays 1994; Clay 2007). The McCammon Circle fits the general criteria of this form based on its structural attributes.

The most likely interpretation for the form is that of the hypaethral structure. There are several lines of evidence that indicate the absence of a complete roof. As indicated on Figure 2.1, there is no definable central roof support posthole pattern within the large circular structure. The structural engineering analysis showed that the posts for McCammon Circle were far greater in size and strength than necessary for a roofed structure. The excavating archaeologist, Ryan Weller, also states that the“[i]rregular placement of the internal *support* posts seems like an attribute that would be aberrant for a group that created such a circular structure” (Weller 2007: 73 emphasis added). A hypaethral structure has been interpreted for Webb’s sub mound structures that share similar structural attributes (floor area, average posthole diameter, average posthole depth) when compared with the McCammon Circle in the previous structural data comparison section of this study (Table 5.2) (Niquette et al. 1989; Clay 1992; Clay 2007).

Table 5.2 Structural Attribute Comparison to McCammon Circle Based on Structural Form.

Structural Form	Average Floor Area (m^2)	Average Posthole Diameter (cm)	Average Posthole Depth (cm)
McCammon Circle	**183.85**	**27.00**	**48.15**
Tent-like*	116.75	NA	NA
Wigwam/Bent Sapling	47.99	19.24	22.08
Straight Beam with Center Post	71.00	13.52	16.07
Webb's Archetypal	198.08	22.03	66.19
Hypaethral Woodhenge	228.45	22.73	61.08

*Average Posthole Diameter and Depth were not noted in the source referenced for the Pike House, however it was noted that small, shallow posts were all that was needed for the structural form (Marshall 1969).

McCammon Circle appears to be similar in design to other structures in the region and several researchers have concluded that most if not all large circular structures were unroofed buildings (Seeman 1986; Niquette et al. 1989; Clay 1992; Hays 1994; Carskadden n.d.a.). Christopher Hays states “[d]iameters of these buildings are often larger than the size of most Woodland period houses and, the post holes are often spaced too far apart to support a stable wall. These structural attributes suggest that many of them were unroofed structures…" (Hays 1994: 71). Charles Niquette states "it is difficult to view all or even most as roofed enclosures. Rather they were unroofed…" (Niquette et al. 1989: 177). R. Berle Clay confirms this assertion with the statement "[s]ome feel that the Adena circular structures could not have supported a roof' (Clay 1986: 584).

5.2 Interpretation of Function

When comparing the McCammon Circle to the 36 analogous structures from the literature review, a distinctive trend is revealed: the structure falls on the large end of the ranges for floor area, average posthole diameter, and average posthole depth. The majority of the structures on the larger end of these ranges have been interpreted ceremonial in nature (Table 4.2). In regards to floor area, the McCammon Circle is larger than 30 (83 percent) of the comparable structures. It is only smaller than Brown's Bottom #1, which has been interpreted as a non-domestic structure, and five sub mound structures from Webb's Kentucky excavations, which have recently been reinterpreted as ceremonial structures (Seeman 1986; Yerkes 1988; Niquette et al. 1989; Clay 1992; Hays 1994; Pacheco et al. 2006). The McCammon Circle falls in the 90th percentile in the structural comparison for average posthole diameter as well. Only three structures in the group had a larger average posthole diameter, each of which was a sub mound ceremonial structure. Concerning the average posthole depth, again the McCammon Circle lies within the upper range of the group (70th percentile), in the company of Webb's sub mound Kentucky structures, as well as the Dominion Land Company Feature

IV, which was interpreted as a ritual structure, and Lichliter Village House 1, which was considered domestic in nature (Allman 1967; Cramer 1989; Burks 2004).

Several researchers have reached a similar conclusion to my own in regards to the function of large structures. Construction of such a large structure would require substantial energy expenditure, which is lacking in Woodland domestic habitations (Clay 2007). Concerning Webb's sub mound circular structures, Clay states "one is forced to admit that, by the size of their interior roofed spaces and the massiveness of their wall posts, many of the Adena submound structures (if domestic), represent the most substantial houses so far identified in the prehistoric Ohio Valley. In light of prevailing models of local architectural evolution, this would argue that the circular structures were not domestic" (Clay 1986: 584). If the interpretation of the McCammon Circle as a hypaethral structure is correct, the absence of a roof detracts from its possibility of retaining a domestic function as well. Charles Niquette echoes a similar conclusion to my own when discussing the function of circular post structures:

> Circular post structures in Adena form a generic class with broadly similar construction. While they potentially were used in many different ways, they functioned similarly throughout Adena. They represent "intensification" of social life through group ritual. They were concrete, spatial foci of ceremonial life in an otherwise dispersed settlement system. As discussed previously, it is difficult to view all or even most as roofed enclosures. Rather they were unroofed …Their lack of roofs argues persuasively for their non-domestic function (Niquette et al. 1989: 177).

An additional line of evidence that supports a ceremonial affiliation for the McCammon Circle is the fact that the structure lacked a midden (Weller 2007). The absence of this feature in conjunction with the copious construction costs inherent in building the structure diminishes the likelihood of it being a domestic habitation. Other researchers have acknowledged that the absence of significant midden deposits near structures can help supplement a non-domestic designation (Clay 1983; Niquette et al. 1989). The structure also lacked any features that were considered cooking hearths, which was considered “intriguing and difficult to understand” (Weller 2007: 19).

Exotic artifacts recovered from the site also denote a ceremonial function for the structure. Mica was recovered from three features in the structure. Mica is generally considered a ritual artifact used in mortuary-related activities (Steponaitis 1987). The occurrence of mica at Adena and Hopewell sites in the central Ohio Valley was tabulated by Fred Fischer (Fischer 1974). He compiled the artifact inventories for 419 sites and found mica present at 45 of the sites. At those sites with mica, there were four occurrences (0.01 percent) of mica at habitation sites, 243 occurrences (6.7 percent) in burial contexts, 3,359 occurrences (92.3 percent) in artifact caches, and 32 occurrences (0.09 percent) at sites of an undetermined nature. When artifact caches and undetermined sites are removed from the compilation, only two percent of the recovered mica was found at habitation sites with the rest (98 percent) coming from burial/ritual contexts. The frequency of mica found in non-domestic contexts implies a similar burial/ritual interpretation for the McCammon Circle. Ceramic sherds with red ochre on the interior were also found within a feature at the McCammon Circle. Red ochre has been shown to be associated with pigments used in various mortuary-related activities (Webb and Snow 1974; Hays 1994; Schlarb 2005). The occurrence of red ochre is also indicative of a ceremonial function for the McCammon Circle.

Many researchers have arrived at the conclusion that large circular structures represent ceremonial activity areas that were unroofed. R. Berle Clay has suggested that some structures may have functioned as astronomical observatories (Clay 1986), while others promote the notion of the buildings serving as non-mound mortuary facilities (Seeman 1986; Niquette et al. 1989; Carskadden n.d.a.). Some researchers have also indicated that ceremonial constructions served as territorial markers for prehistoric cultures (Charles and Buikstra 1983; Railey 1991; Waldron and Abrams 1999). The territorial marker designation was initially espoused for burial mounds, cemeteries, and earthworks, however it is completely possible that a structure of such immense size and permanence, like the McCammon Circle, could have functioned in a similar fashion. I hypothesize that the McCammon Circle functioned as a non-mound mortuary facility, similar to Niebert Structure 3 and Philo Mound E Structure. Other researchers have indicated that human remains are not required for a mortuary designation to be assessed to a site, therefore the absence of human remains at McCammon Circle does not detract from its mortuary-related function (Richmond and Kerr 2005). The McCammon Circle is similar to other mortuary-related structures based on its structural attribute comparison and it lacks the subsequent construction of a mound which usually occurred (Table 4.1 and Table 4.2). The structure likely also served as a territorial marker indicating land ownership by non-Hopewellian peoples in a Hopewell area (Vickery 1979). While the exact function of the McCammon Circle and other comparable structures may never be fully understood and is always rightfully open to debate, the current archaeological evidence, at a minimum, suggests a non-domestic ceremonial function for the building.

CHAPTER 6

CONCLUSION

One of the goals of this paper was to better interpret the structural form of the McCammon Circle through a comprehensive regional comparison to other prehistoric structures and to test the applicability of using Euler's formula to aid in the interpretation of form. Using engineering analyses, suggested reconstruction can be tested for its plausibility, however solely relying on Euler's formula proved unreliable. While the aforementioned structural engineering analysis of the McCammon Circle showed that a roof was possible, a more accurate interpretation of the form of a prehistoric structure was reached when it was compared to similar structures in the region through three attributes (floor area, average posthole diameter, average posthole depth) and their associated interpretations. Through the comparison of analogous structures through the above structural attributes, the McCammon Circle is best interpreted as having a hypaethral woodhenge form. Despite the unreliable results from the engineering analysis, in regards to the benefits inherent in an engineering approach, Slavomil Vencl concludes:

> It provides an opportunity to determine the floor plans of those structures not damaged by loss of surface layers or by imperfect archaeological excavation. The application of engineering principles will doubtlessly improve the detail and exactness of future reports. A wide use of this and other techniques should help to overcome the narrow concept of archaeology which contributes only to the history of kitchen utensils and burial customs (Vencl 1971: 454).

The second goal of this research was to offer a better interpretation in regards to the function of the McCammon Circle. By comparing the structure to other Woodland constructions through the aforementioned three structural attributes, I indicate that the original interpretation of the building as a roofed domestic "house" is faulty. A non-mound hypaethral "woodhenge" used for mortuary-related and possibly other ceremonial endeavors is a more plausible reconstruction for the function of the McCammon Circle. The structure possibly served as a territorial marker in the region as well, indicating group ownership of the surrounding land by non-Hopewellian peoples in a strongly Hopewell region (Vickery 1979; Charles and Buikstra 1983). The overbuilt, immense nature of the structure, the presence of mica and red ochre, the absence of a midden and cooking hearths, and the lack of an identifiable roof support posthole pattern, as well as the similarity to other ceremonial structures in the region, all support the aforementioned form and function designations.

While any interpretation about a prehistoric building is subject to debate, the interpretations that can be drawn from comparisons to prehistoric and ethnographic buildings coupled with engineering modeling can greatly enhance our understanding of prehistoric Adena-Hopewell architecture and settlement systems. This type of analysis can also contribute to archaeological theory concerning Middle-Range Theory and the use of analogy to understand the past from present examples (Peregrine 1996; Johnson 1999). This represents a great opportunity for experimental archaeology to answer questions that are left ambiguous in the archaeological record.

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