Seeing Prehistory through New Lenses: Using Geophysical and Statistical Analysis to Identify Fresh Perspectives of a 15th Century Mandan Occupation

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Seeing Prehistory through New Lenses: Using Geophysical and Statistical Analysis to Identify Fresh Perspectives of a 15th Century Mandan Occupation

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts in Anthropology

by

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ABSTRACT

Great Plains prehistoric research has evolved over the course of a century, with many sites like Huff Village (32MO11) in North Dakota recently coming back to the forefront of discussion through new technological applications. Through a majority of its studies and excavations, Huff Village appeared to endure as the final stage in the Middle Missouri tradition. Long thought to reflect only systematically placed long-rectangular structure types of its Middle Missouri predecessors, recent magnetic gradiometry and topographic mapping data revealed circular structure types that deviated from long-held traditions, highlighting new associations with Coalescent groups. A compact system for food capacity was also discovered, with more than 1,500 storage pits visible inside and outside of all structures delineated. Archaeological applications of these new technologies have provided a near-complete picture of this 15th century Mandan expression, allowing new questions to be raised about its previous taxonomic placement. Using a combination of GIS and statistical analysis, an attempt is made to quantitatively examine if it truly represented the Terminal Middle Missouri variant, or if Huff diverted in new directions. Statistical analysis disagrees with previous conclusions that a patterned layout of structures existed, significant clustering shown through point pattern analysis and Ripley’s K function amongst structures. Clustering of external storage pits also resulted from similar analysis, highlighting a connection between external storage features and the structures they surrounded. A combination of documented defensive features, a much higher estimation of caloric support for a population present, and a short occupation lead us to believe that a significant transition was occurring that incorporated attributes of both the Middle Missouri tradition as well as the Coalescent tradition. With more refined taxonomies currently developing, it is hoped that these data will help in the effort to develop future classifications that represent this complex period in prehistory.
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CHAPTER 1 – INTRODUCTION

During the past 30 years advances in remote sensing and GIS technology have opened the door for new research opportunities; the avenues we can now pursue are seemingly endless. An area well suited to these new methods, the Great Plains provides rich data sets with which we can extract copious amounts of information about past cultures who once occupied this area. Huff Village is one of the many prehistoric Great Plains sites that have been investigated over the past century. Although it has already been subjected to numerous studies, remote sensing techniques have given us the opportunity to push the envelope about what we already know. Previous work at Huff had been fragmented, only occurring at specific locales within the village. Different variables prevented an investigation encompassing the entire village during previous investigations. In 2011 Dr. Kenneth L. Kvamme (et al.) collected both topographic and remote sensing data of the entire settlement at Huff Village. A topographic mapping station recorded the subtle topographic variations on the surface while magnetic gradiometry equipment scanned for features unseen. Post-processed imagery is impressive in that it both enables us to increase the subtle changes in slope, enhance these subtleties, and see completely hidden features. This recent work has provided the missing piece and is the foundation for the following analysis. With new remote sensing data we can now examine the village as a whole and study its most dominant features: storage pits and residence composition. Through the relationship between these key features, we are able to identify the unique role Huff played in Plains prehistory.

A three part defense system protected more than 100 structures at Huff. Its position on the western edge of the Missouri River was a natural fortification that many Middle Missouri cultures took advantage of. Previously, population estimates total approximately 1,000 people occupied Huff at its apex (Wood 1967). The compact system of semi-subterranean structures
surrounded a large central plaza, on the north side of which was a large ceremonial lodge. Central hearths and storage pits filled the voids inside and outside these structures. Ancestral Mandans occupied these structures, relying primarily on a farming subsistence supplemented by hunting and trading. Their occupation occurred between A.D. 1443 to 1465 (Ahler and Kvamme 2000: 117), placing it in a taxonomic framework earmarked by turbulent times.

Storage pits are a signature feature located at permanent Plains village sites. Although they are buried and largely unseen, their presence was essential to the lifestyle these cultures lived. Past excavations and historical accounts have already laid the foundation and explored the different functions of these features. This includes their range in sizes and variability of contents. With new remote sensing data we are now able to build upon this, examining these features on a much larger scale. We begin by identifying their presence via their geophysical reflection. With the multitude of other significant floor features, these pits stand out in the magnetic gradiometry data based on processes they were subjected to. Following their initial identification we can determine how they are distributed via spatial analysis. This could communicate spatial restrictions and locational trends in regards to neighboring features. A summary of these statistics combined with contents and lifecycle will lead to a better estimate of the population supported and the possibility of a significant surplus of foodstuffs.

With the identification of most, if not all, of the structures at Huff available, we are now able to formulate a more multifaceted analysis than previous investigations allowed. A faction of our analysis looks into the previously investigated distribution pattern of structures observed at Huff. Others analyses will examine the range of structural deviations including size, shape, internal components, and geophysical representation in the remote sensing data. Historical accounts and past excavation data both provide support interpreting the variety of geophysical
representations and a foundational knowledge base. Developing the conclusions that integrate with our analysis will hopefully enhance Huff’s representation as a transition stage in Plains prehistory.

Important conclusions in regards to both of these key features at Huff contribute to our knowledge about Plains cultures subsistence capacity. Previously estimates in regards to possible populations present have relied upon house sizes (Wedel 1979) and historical accounts (Fenn 2014). This same method has been applied to Huff throughout the history of its delineation (Wood 1967). As house count grew or decreased so did population estimates. With an accurate count of structures and their measurable area we can now create a more precise population estimations utilizing this methodology. Other population estimates have utilized other features at Plains village sites (Mitchell 2013, Scullin 2007). Now able to examine the extent of the storage capacity at Huff we can see how these estimates compare. The deviations in population estimates based on each method point toward important conclusions that relate to the social landscape surrounding Huff in the 15th century.

The Natural Environment

The natural environment of the Great Plains covers a large geographical area, stretching west from Minnesota to the foothills of the Rocky Mountains. The flora begins as deciduous forests in the Prairie Peninsula (O’Brien 2001: 33), transforming as you move west into the Dakotas, Nebraska and Kansas. Forests become tall, mixed and short grass prairie until the foothills of the Rocky Mountains where the environment is dominated by sand and sagebrush. Limited timber resources were located in low lying river floodplains, utilized for earthlodge and fortification construction. Major river systems travel through this region and bisect the
landscape. Annual precipitation is limited to an average of 16 inches (Wood 1967) making periodic flooding of river systems the main source of nutrients found in the soils. Temperatures are variable and the area can experience extreme fluctuations between the winter and summer months. Of course these conditions, whether it is precipitation or temperature, are not constant and shouldn’t be considered representative of the environment that existed hundreds of years ago (Bamforth 1988: 17). Plentiful bison herds migrated through the Great Plains and were seasonally hunted by mobile groups. They alone provided meat, hides and bone tools. Other species that provided sustenance include fish and other small game. Based on the above influences, there is no doubt that the natural environment transformed many aspects of life for these prehistoric Great Plains cultures.

Located on a large terrace along the western edge of the Missouri River, Huff Village was one of many cultures that successfully adapted and thrived in the Great Plains environment. In supporting such a large population the culture at Huff required expertise in agricultural production to survive during their tenure. Seasonal flooding of the Missouri provided tillable soils rich with nutrients which made farming a possibility. Supporting evidence for farming lies in the bone tools unearthed during previous excavations (Wood 1967: 108). Historical accounts also provide reflections of past farming processes (Fenn 2014: 57-68). Maize was the main crop produced and it was stored for winter months in subterranean bell-shaped pits. Other crops produced included squash, beans, sunflowers and various fruits. Trade and hunting were the other significant sources of sustenance. Environmental variability, including weather cycles, provided challenges for all cultures here as it affected everything from crop yield to available migrating faunal sources. Even through climatic shifts like the Little Ice Age, Huff adapted to ensure survival (Kay 2007, Bamforth 1988, Wood 1998).
The Social Environment

The majority of knowledge about prehistoric plains cultures was composed from the archeology unearthed during the salvage years of the 1950s-60s. Before this, research opportunities were pursued by George F. Will, Alfred Bowers, William Duncan Strong and notable others for many years (Winham and Calabrese 1998: 269). Using the extensive salvage archeological data, Lehmer (1971) compiled this information and produced what he termed the Middle Missouri Tradition. For many years this was the most referenced and comprehensive work that had been produced to date. Lehmer (1971), Caldwell (1964) and Willey and Phillips (1958) were just some of the researchers who attempted to create a refined and organized system of prehistoric cultural sequences. Challenges arose when they were confronted by the enormous amount of information produced during those salvage years (Johnson 2007: 10-11). Not only did the scale provide issues, but also what Johnson termed as “problem-oriented research.” This research only focused on the imminent destruction of these sites and not from specific theoretical problems (Johnson 2007: 11). As salvage archeology started to wane theoretical questions and research began to build upon this foundation.

Since its introduction in the area, technologies such as remote sensing have metaphorically unearthed a mountain of new information about Great Plains sites. This information delves into village organization, spatial proximity within village fortifications, and the construction of representative features such as storage pits and ceremonial centers. Over the years there has been extensive research conducted not only on Huff Village, but a great deal of other sites on the Great Plains, mostly within the Knife, Heart and Cannonball regions (Johnson 2007: 13). No longer is Lehmer’s taxonomy all encompassing, because this new data has created new temporal and spatial divisions in the Middle Missouri tradition. For example, Ahler’s (1993)
research in the Heart and Knife regions has provided more specific classifications of the cultures in those areas. In order to utilize this “in progress” taxonomy, I employ several sources, including Johnson’s summary, for the purpose of portraying the most up to date information (Winham and Calabrese 1998, Johnson 2007, Mitchell 2011). A broad overview such as this will not delve too deep into Plains village taxonomic complexity. The purpose here is only to introduce an outline of temporal assignments as well as their archeological representations for comparison against those found at Huff.

Plains cultures moved into the western Prairie Peninsula and the lower regions along the Missouri River around A.D. 1000 (Winham and Calabrese 1998: 278, Mitchell 2011: 80). Although their origins are a topic of dispute (Johnson 2007: 98-99), they are represented in what has been termed the Initial Variant of the Middle Missouri tradition (IMMV), which is further divided into Eastern and Western variants (Lehmer 1971). Further divisions into phases and components exist, but are not relevant to this discussion. Radiocarbon dates reflect that IMMV groups flourished from A.D. 1000 to 1300 (Johnson 2007: 101, Toom 1992). These groups were sedentary and mobile, reliant to a degree on a horticultural subsistence made possible by their village locations along various river systems supplemented with hunting of local fauna. Excavations reflect that they lived in large rectangular semi-subterranean structures, sometimes within fortification features. Remarkably, their source for lithic material was heavily focused on Knife River Flint, a source not local to IMMV groups. Influences from distant polities are represented in ceramic styles, such as those present in Cahokia (Mitchell 2011: 85). Two examples of IMMV sites are the Dodd site and Mitchell site.

Disputed origins and terminations are common to all the Middle Missouri variants but with more data being presented from year to year it is becoming more accepted that Extended
Middle Missouri variant (EMMV) groups existed contemporaneously with IMMV groups in certain areas (Mitchell 2011: 85). The locations of EMMV villages are expansive within the Missouri River Valley but appear to be more concentrated in the north (Mitchell 2011: 84, 86). Separation between the two variants in terms of cultural representations comes in the form of ceramic styles and production techniques, lithic sources utilized, and subtle differences in village organization. Village organization appears to have become more uniform, but structure forms still retained many similarities to IMMV. Uniformity is noted by Mitchell to exist in many elements of all EMMV sites such as architecture (Mitchell 2011: 87). Deviations existed in structure size and fortifications employed. EMMV radiocarbon dates extend from A.D. 1200-1400 (Johnson 2007).

In the end, the Terminal Variant represents the final expression of the Middle Missouri tradition (TMMV). We begin to see changes and transitions from long held forms that were introduced in IMMV groups. These transitions consist of changes in population size, structure forms, and the increase in fortification measures employed. EMMV groups began to coalesce into larger populations and settle into heavier fortified villages (Johnson 2007: 180). Many postulate that social pressure from competing groups or changes in climate were the cause for this transformation (Johnson 2007: 111). Dates for the TMMV have been set at A.D. 1300 to 1500 for now (Winham and Calabrese 1998: 282). Huff Village and Shermer remain the two key representations of TMMV sites.

Originally delineated as a sequential development of cultures that represented a combination of both Central Plains and Middle Missouri cultures, the Coalescent tradition is proving to be a more complex representation of Plains peoples. Coalescent cultures emerged on the landscape about 1300, occupying villages contemporaneous with Extended and Terminal
Middle Missouri groups. Researchers acknowledge the lack of information concerning the origins of this strikingly different group (Johnson 2007; Mitchell 2013). Originally divided into four variants by Lehmer (1971), the Coalescent tradition has now been refined into three: Initial, Extended, and Post-Contact (Johnson 2007). While more is known about the Extended and Post-Contact variants, all of them exhibit distinct attributes that represent Coalescent groups as a whole. This includes predominantly circular house forms, largely unfortified villages, and irregularly clustered settlements (Mitchell 2013: 72-73).

Although the emphasis appears to rely heavily on Middle Missouri groups based on the original and current taxonomic placement of Huff village, including the succeeding Coalescent groups is imperative as noticeable similarities with Huff are present. Ancestors of three major cultures are represented in the Middle Missouri and Coalescent tradition: the Hidatsa, Arikara and the Mandan. Both the Hidatsa and Mandan were Siouan speakers, with the Arikara speaking a Caddoan language. A close relationship existed between the Mandan and Hidatsa, something Wood highlighted when he analyzed their origin myths (Wood 1967: 9-11). Over hundreds of years these cultures settled on the edge of the Missouri River and interacted with one another under positive and sometimes negative terms. Their traditions endured until the region became dominated by Euro-Americans. Even though we focus on the continuity in patterns over time, their social environmental was anything but static.

**Previous work**

Although more work is undoubtedly necessary at Huff, the data collected in the past is both extensive and very valuable. This site has been excavated and surveyed with various technologies starting in the 1930’s to the present. One can almost view the transformations in
archeological theories and techniques applied over the course of time. With the first excavations conducted at Huff Village during the late 1930’s, Thad C. Hecker’s preliminary excavations paved the way for other archeologists interested in Huff. This includes notable researchers such as James H. Howard and W. Raymond Wood. Archeological knowledge produced from these early excavations at Huff contributed to the taxonomies composed from the salvage era operations.

The excavations directed by Thad C. Hecker in the late 1930’s were much smaller in scale compared to those produced by later projects. Sponsored and funded in part by the North Dakota State Historical Society, Hecker and George F. Will documented various Plains village sites, including Huff Village. Their initial documentation suggested that there were “streets,” or rows of rectangular-shaped structures (Will and Hecker 1944). At this time, and still true today, depressions of the structures were visible to the naked eye and conveniently guided the placement of their excavation units. Will and Hecker’s excavations focused on a single structure along with portions of walls at two other structures (Will and Hecker 1944: 95). Testing of dirt floors was also explored to obtain additional information about structure composition. The fortification system and its evenly spaced bastions, palisade and ditch were also addressed.

Within the span of a few years two professionals took up where Hecker and Will left off. James H. Howard and W. Raymond Wood excavated Huff with separate teams of researchers, both spurred on by salvage archeology projects. Impending damage from future dammed rivers caused the formation of the Inter-Agency Archeological and Paleontological Salvage Program (Wood 1967: III). Their objective was to recover as much information from these sites along the Missouri River. Previous erosion from wave action had already occurred at Huff prior to Howard’s excavations. Specifically, the Oahe dam was to be the damaging force that would
wash away the eastern edge of Huff Village. Figure 1 depicts where Huff is located in reference to Oahe reservoir today.

![map of Huff Village and Oahe reservoir](image)

**Figure 1.** Overview map showing location of Huff Village (32MO11).

In the summer of 1959, James H. Howard and his crew conducted archeological investigations in several areas within Huff. Excavations focused on the southwestern (Bastion D) and southeastern (Bastion A) bastions, two structures, including the large ceremonial structure, and numerous test pits (Howard 1962). The artifacts excavated indicated that farming and hunting were paramount to the inhabitants of Huff. As far as a larger overview, their initial characterization of the layout was similar to that of Will and Hecker’s (1944): the structures were aligned in a regular pattern, creating the illusion of streets. Remnants of the defensive works found in the excavated bastions allowed Howard to build a more accurate picture of social environment during this time: one in which the population was prepared for periodic attacks from conflicting groups.
A year later W. Raymond Wood (1967) started his excavations, his results providing the most valuable data set from Huff Village that had been produced to date. With funds provided by the Smithsonian Institution, Wood and his crew undertook the monumental task of excavating nine structures (Houses 3-4 and 6-12), a portion of the fortification ditch, portions of the northeast and southeast palisade, as well as test pits inside and outside of the fortification walls (Wood 1967: 29). The majority of the excavations focused on the eastern edge of the village, as Howard’s had been. Through aerial photography Wood was able to visually identify 103 structures that occupied Huff Village. The imagery also displayed the fortification ditch with its systematically spaced bastions. Important conclusions were made concerning the various elements of Huff compared to similar sites. Elements of concern consisted of earthlodge shape, village structure, as well as fortification components and their relation to increasing regional warfare during the fifteenth century (Wood 1967).

Even with these substantial data sets Huff was far from being understood as a complete entity in Middle Missouri prehistory. For all of the destruction that occurs during excavations, felt to be a downfall in archeology, important technologies have emerged within the past 30 years that are aimed at acquiring archeological data without a significant amount irreversible damage. In 1999, Kenneth L. Kvamme, with University of Arkansas, in conjunction with Stanley A. Ahler, with the PaleoCultural Research Group, conducted a geophysical survey at Huff (Ahler and Kvamme 2000). For the geophysical survey, Kvamme and crew employed a fluxgate magnetometer to survey $7,100 m^2$ in an area south of the ceremonial lodge. Additionally, they focused an electrical resistance survey on a $1,600 m^2$ area within the magnetically surveyed area. Coring several of the magnetic anomalies Ahler was able to identify the source of these anomalies (primarily hearths and storage pits) within 16 to 17 structures (Ahler and Kvamme
His investigation also involved the excavation of two storage pits near House 19. The contents of these pits produced knowledge of their life cycle. Not only did it inform them of what was stored there, but how it utilized from when they were constructed until they were abandoned and filled. (Ahler and Kvamme 2000: 58-62). Radiocarbon dating was also employed by Ahler, which significantly refined the chronology for Huff village. Comparison of six dates led Ahler to conclude that a more accurate and narrower range of occupation would have been A.D. 1443 to 1465 (Ahler and Kvamme 2000: 117).

Due to the success of the previous geophysical surveys at Huff, Kvamme returned in 2009 to continue what he had started 10 years before. This geophysical investigation was conducted by the Archeo-Imaging Lab of the University of Arkansas under the direction of Kvamme (Kvamme et al 2009). With the assistance of a crew a mobile topographic mapping station was used to produce a Digital Elevation Model (DEM) of the entire site. From the first investigation in the 1930’s onward, researchers had mainly used the visible location of features to place their excavations. During Wood’s investigation a contour map was produced of House 19 allowing us to see the slight slope variations of the structure without excavating (Wood 1967: 54-55). In addition to the DEM a magnetic gradiometer survey was employed within the entire site, including the fortification system. After computer processing, the images produced with both the DEM and the magnetic survey were astonishing (Figure 2). From these data sources we are able to see hidden structures and increase the number of structures from the 110 reported by Wood to 116 (Kvamme et al 2009: ii). It became clear to archeologists, including myself, that Huff was not finished in its quest to provide new insights into its prehistory.
Figure 2. a) Digital Elevation Model of Huff in grayscale b) Magnetic gradiometer imagery from Huff Village

Geophysical Methodology and Data

It was known early on through previous investigations at Huff that remote sensing could provide additional information about the village as a whole. Expedient survey and non-destructive methods are only a few of the benefits of geophysical mapping of archeological sites. Magnetic gradiometry has been successful because of these factors, but also because it has the ability to identify subsurface features based on natural inherent properties of the earth. Soils have natural magnetic properties that when altered, either by movement or firing, change their composition (Kvamme 2006: 208). Past cultures altered these natural properties of the soil when villages were constructed. Construction processes include: the excavation of subterranean house floors, hollowing and filling of pit features, and the creation of fortifications. Accumulation of soils increases magnetism and the same is true for the opposite, a decrease in magnetic signature is the result of soil removal (Kvamme 2007: 212). Storage pits in particular exhibit a strong
magnetic signature due to a significant accumulation of topsoil, sometimes at large depths more than a meter. Shallower features like the ditch and palisade components of the fortification exhibit lighter magnetic signatures, but are still readily visible in the magnetic gradiometry data. Signatures of magnetic features are represented by their nanotesla value, abbreviated nT. Kvamme (2006: 209) notes that many archeological features range in the ±5nT range, but can also be represented by very low values as well.

Magnetism of cultural features can also be detected through a process called thermoremnant magnetism (Kvamme 2006: 207). This occurs when soils and other materials are subjected to heat. In this instance, fires created in central or auxiliary hearths. Burning structures also reflect high thermoremnant magnetism. Often metal artifacts are detected during magnetic gradiometry surveys. These artifacts produce a distinctive dipole signature. Strong positive and negative dipole readings are related to the north and south poles and their relationship with the earth’s magnetic field (Kvamme 2006 and 2007). Unfortunately, too often metal artifacts are determined to be a result of modern trash lying on or in shallow depths beneath the surface. Their strong signatures can obscure deeper deposits that are culturally significant (Kvamme 2007: 213).

The magnetic gradiometry survey was completed in 2009 over 5.03 acres of Huff Village. Instrumentation utilized was a Bartington 601 dual-sensor fluxgate gradiometer (Kvamme et al 2009). This particular instrumentation allows for both very subtle magnetic signatures to be recorded and large areas to be covered in a short period of time. This makes it ideally suited for survey at Huff and other Great Plains prehistoric sites. Post-processing of the data was completed by Dr. Kvamme prior to this analysis. This included various processes, many of which corrected survey defects and enhanced the interpretability of the data (Kvamme et al
The resulting imagery plays a key role in our identification and analysis of both structures and potential pit features.

Topographic mapping of the surface at Huff helped to accurately locate all of the depressions, long utilized for the verification of house locations (Kvamme et al 2009). Wood (1967: 54) also recognized the importance of recording these subtle depressions, his mapping of House 19 showed a slightly irregular rectangular house shape that was wider at one end. In order to survey all of the surface variations in the village, including fortification features, a topographic mapping station and a portable receiver transected across 5.1 acres of the village. The data was then used to create a Digital Elevation Model, or DEM.

Similar to a conventional total station, a robotic total station allowed Kvamme and his crew to collect elevation measurements quickly and accurately. From a Trimble 5600, the stationary robotic total station, data was recorded using a reflector rod that communicated real-time data concerning the subtle elevation changes. Survey of the entire village was completed in 30 meter square blocks. Moving slightly slower than one meter per second, the mobile reflector rod transected across these blocks in a zig-zag pattern. A total of 76,788 measurements were recorded of the ground surface (Kvamme et al 2009).

The initial processing of the data, completed by Kvamme (2009: 6-8), included the reduction of data clusters, an inevitable result of survey technique and obstacle avoidance. Processing also included the creation of a Triangulated Irregular Network or TIN model. This enabled Kvamme to generate a raster DEM from the TIN model, with an impressive vertical accuracy of a centimeter (Kvamme et al 2009: 6). Some post processing of the DEM was completed to reduce the visual effects of striping that result from the transecting pattern employed. Other post processing was completed by Kvamme and myself in order to “de-trend”
the DEM, meaning that the natural slope of the terrace landform was subtracted by the elevation variations of surface features in the village. The result is a raster image that shows the surface variations of the house and fortification features on a level surface. This process was completed using the “DETREND” function in the Terrset IDRISI program.

Both the magnetic gradiometry data and the DEM are used to accomplish many tasks in the following chapters. They are also utilized in an attempt to clarify some of the long held questions about Huff. Analysis in the following chapters focuses mainly on storage features and structural variability. Both chapters 2 and 3 look through various aspects of previous excavations, similar Middle Missouri and Coalescent sites, and historical accounts to see if there are commonalities or inconsistencies when compared to recent remote sensing data. Further analysis like feature variation and distribution analysis is employed to see what we can learn from the remote sensing data that may uphold or deviate from widely held conclusions about Huff. It is clear that Huff is representative of a transitional period within Plains prehistory. Our goal here is to highlight these aspects at Huff that further solidify its place as such.
CHAPTER 2 – PITS

Common at most prehistoric Great Plains sites, pits contain an extraordinary amount of information about the people that constructed and used them. This includes information regarding their agriculture systems, economic environment, and habitation activities. Other than discussing their types and contents, there has been a lack of dialogue specific to storage pits up until recently (Wiewel 2017). Historical accounts are one of the many sources that can provide some insight into their functionality and capacity. Most of knowledge comes from what archeological excavations have extracted, documenting the specific details of these features both outside and inside of house structures. Through recent geophysical surveys, we can begin to expand our analyses and take a more in-depth look at their patterning. With such an emphasis on defensive measures, seen through increased fortification and population aggregation at sites like Huff, did storage capacity translate to economic viability or reserves? First, we must attempt a more accurate measure of storage capacity at Huff, utilizing recent magnetic gradiometry data. With data it may also be possible to quantitatively analyze the distribution of these features throughout the village. This may produce a better representation of this Terminal Middle Missouri variant site and lead to new questions regarding surpluses.

This analysis will begin by investigating pits represented in two important sources of information: references in historical accounts and documentation through past excavations. Historical data can be useful as it provides multiple lines of evidence illustrating the role corn held in prehistoric Plains economies. Native testimonies have also given insight into details not otherwise understood through archeological methods. Past excavations documented multiple types of pits amongst a variety of other floor features present at Huff. Comparing similarities
seen at other Middle Missouri Tradition sites, as well as Coalescent Tradition sites, show the continued use of similar forms over time.

Storage pits specifically will be the focus of this analyses but it is pertinent that we address the variety of pits one might find at Middle Missouri sites. Over the past 60 years, excavations revealed multiple types of pits and other floor features. When comparing these excavations, it is clear their research designs and intent developed over time, later excavations focusing more intensely on the locations and specifics of pit structure and contents. Even though this compilation of storage pit data is lacking in regards to large-scale analysis of village organization, it will help us provide context about the specific placement and function of these features both inside and outside habitation areas.

**Past Excavation Details**

Of the many investigations that occurred at Huff over the past 60 years, four are particularly important due to their focus in documenting subterranean floor features. Will and Hecker (1944), Howard (1962), Wood (1967), and Ahler and Kavame (2000) recorded floor features through varying levels of excavation, evolving from a large-scale analysis into a small-scale focus. Although Will and Hecker’s excavation of House 5 lacks specifics concerning pit size and composition, Wood aptly summaries his findings and clarifies what types of floor features were encountered (1967: 39-42). Howard’s (1962) and Wood’s (1967) excavations of Houses 1 through 12 are by far the most comprehensive, their measurements used in later analysis including size statistics. Lastly, Kavame and Ahler’s investigation focuses on the identification of floor features in a smaller portion of the village. Efforts focused on ground-
truthing magnetic anomalies through the excavation of two pits identified inside and outside of House 19.

Apart from their methodical differences, each excavation uncovered three main types of pit features: basin-shaped pits, bell-shaped pits, and cylindrical pits. Each of these varied in size and contents from one structure to another. Other common floor features included central or primary hearths, auxiliary hearths, irregular-shaped pits, and rock or stone filled basins. Interconnected and overlapping pits occurred in a few but not in every structure excavated. Other unique recorded features include hearths in pits, concentrations of stone, basin-shaped pits within irregular-shaped pits, and unidentified pits. Table 1 illustrates how many of each of these features were present in the houses excavated. The range of features within each structure varied, many exhibiting features not common in other structures and others littered with multiple types.

Table 1. Dominant pit features excavated during previous investigations in 11 houses (Wood 1967)

<table>
<thead>
<tr>
<th>Floor Features</th>
<th>Totals</th>
<th>Mean</th>
<th>s.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin-shaped pit</td>
<td>70</td>
<td>6.36</td>
<td>4.74</td>
</tr>
<tr>
<td>Bell-shaped pit</td>
<td>46</td>
<td>4.18</td>
<td>2.60</td>
</tr>
<tr>
<td>Cylindrical pit</td>
<td>99</td>
<td>9.00</td>
<td>7.58</td>
</tr>
<tr>
<td>Primary/Central Fireplace</td>
<td>10</td>
<td>0.91</td>
<td>0.30</td>
</tr>
<tr>
<td>Auxiliary Fireplace</td>
<td>27</td>
<td>2.45</td>
<td>2.25</td>
</tr>
</tbody>
</table>

The quantities of cylindrical pits far outnumber other floor features in many of the houses. Although the exact purpose of these pits is unknown, it is clear they are a common feature utilized. Of the cylindrical pits recorded in 10 of the houses excavated, 99 were identified, an average of almost 10 per structure. Depths for the cylindrical pits in House 1 were not included in Wood’s data and House 5 exhibited no cylindrical pits at all according to Wood’s (1967) interpretation of Will and Hecker’s (1944) excavation notes. Due to this missing information, the pits recorded in these structures were not included in the data outlined in Table
2. Even with this missing information, the data shows that over one-third of the pits present inside structures were cylindrical (Figure 3). Excavated contents of these pits consisted mainly of mixed earth, but the cylindrical pits in seven of the 10 houses contained ash, bone, charcoal, clay, granite rocks, and mixed earth with artifacts (Wood 1967). Apart from bone, Wood notes an absence of food remnants from the filled material (1967). This could translate into function of these pits compared to bell-shaped storage pits and basin-shaped pits and how they may have been retired in a different fashion. It is plausible they used cylindrical pits for storage for different types of materials, although a more detailed excavation would bolster this conjecture.

**Table 2.** Cylindrical storage pit measurements obtained from previous excavation data (Will and Hecker 1944, Howard 1962, and Wood 1967)

<table>
<thead>
<tr>
<th>Cylindrical Pit Measurements</th>
<th>Min (cm)</th>
<th>Max (cm)</th>
<th>Mean (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td>9.14</td>
<td>121.92</td>
<td>34.44</td>
</tr>
<tr>
<td>Diameter</td>
<td>15.24</td>
<td>137.16</td>
<td>36.27</td>
</tr>
</tbody>
</table>

**Figure 3.** Percentage of cylindrical, basin, and bell-shaped pit types excavated

Basin-shaped pits were the second-most constructed pit type documented in 10 of the structures excavated. A total of 71 pits were excavated, making up 33 percent of the total pits excavated, an average of seven basin-shaped pits per structure. House 9 exhibited no basin-
shaped pits and Houses 1 and 2 both had basin-shaped pits, but due to their absence of depth measurements, they were not included in the depth and diameter measurements in Table 3.

Table 3. Basin-shaped storage pit measurements obtained from previous excavation data (Will and Hecker 1944, Howard 1962, and Wood 1967)

<table>
<thead>
<tr>
<th>Basin-Shaped Pit Measurements</th>
<th>Min (cm)</th>
<th>Max (cm)</th>
<th>Mean (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>12.19</td>
<td>188.97</td>
<td>58.21</td>
</tr>
<tr>
<td>Width</td>
<td>9.14</td>
<td>124.96</td>
<td>51.20</td>
</tr>
<tr>
<td>Depth</td>
<td>9.14</td>
<td>67.06</td>
<td>22.25</td>
</tr>
</tbody>
</table>

The contents that filled these basin-shaped pits were very similar to the material filling cylindrical pits. Their excavated contents composed of mixed earth including some ash, granite rocks and clay (Wood 1967). Will and Hecker (1944) allude to the basin-shaped pit present in House 5 functioning as a pottery firing area due to the presence of granite rocks (Wood, 1967: 41). He also notes the presence of postholes in many of these pit types. Wood (1967) supports the hypothesis that these pits were built prior to construction of the house, retired when the structure was erected, or used in some function for structure repair.

Based on past excavations and historical accounts, bell-shaped pits are the most studied, their function representing more than a simple storage container. From excavations, we can conclude that, upon retirement, these pits were periodically filled with refuse from the structures inhabitants (Wood 1967). Refuse consisted of cultural debris including but not limited to the following: modified animal bone, fire cracked rock, pottery sherds (Ahler and Kvaamme 2000: 58-62). Numbers and sizes of bell-shaped storage pits varied from structure to structure at Huff, the range of these sizes detailed in Table 4. Excavation data from 11 structures detail the 46 bell-shaped storage pits present (Wood 1967). These 11 structures had an average of 4.18 storage pits, but as is true with the other pits present, the number excavated varied. House 9 exhibited only a single bell-shaped storage pit and Houses 1 and 3 had up to eight storage pits.
Table 4. Bell-shaped storage pit measurements obtained from previous excavation data (Will and Hecker 1944, Howard 1962, and Wood 1967)

<table>
<thead>
<tr>
<th>Bell-Shaped Pit Measurements</th>
<th>Min (m)</th>
<th>Max (m)</th>
<th>Mean (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td>0.36</td>
<td>1.88</td>
<td>0.98</td>
</tr>
<tr>
<td>Base Diameter</td>
<td>0.48</td>
<td>1.88</td>
<td>1.24</td>
</tr>
<tr>
<td>Opening Diameter</td>
<td>0.36</td>
<td>1.70</td>
<td>1.01</td>
</tr>
</tbody>
</table>

From their counts and measurements, it appears that house size did not dictate the number of storage pits present. A large number of pits are present in House 12, which Wood documents as being square in shape (Wood 1967: 51). House 9 exhibited a single storage pit but the shape of this house was unclear (Wood 1967: 49). House 4, 5, and 10 were rectangular but had the second lowest number of pits. In structures where a particular type of pit was limited, a larger number of other types filled their voids. Preferences for one type of pit over another are apparent but the reasoning for this is unclear. Were families in these households smaller, thus a lower need for storage room or were they focused on different social activities?

Due to the sheer number of anomalies visible through the geophysical data, it is unlikely that all features were constructed, used and retired at the same time. From the excavation and geophysical data, it appears that storage pit features experienced stages of expansion. This includes adding new pits and retiring those that were no longer useful. Even though it is impossible to determine a storage pit’s lifespan, it seems as if this stretch of time may not have been too extensive due to the most current radiocarbon dates for Huff (Ahler and Kvaamme 2000). From their initial construction, storage pits likely experienced external factors that determined their fate. Wall stability was likely the most common issue, caving in at weaker spots due to either construction error, weakening from overhead foot traffic, or fossorial rodents. Ahler recognized this malfunction during his excavation of Feature 501 in House 19 (2000). It was both the offset orifice and the irregularly shaped western and southern sidewall that led to this
conclusion (Ahler and Kvanme 2000: 58). Although Scullin (2007: 87) suggests short term occupation sites have an absence of overlapping pits, Huff adversely exhibits a variety of overlapping pits even though most recent dating places occupation of the village at less than a 50 years (Ahler and Kvanme 2000). The presence of overlapping pits may have been more a result of their instability, extending failed walls to fix structural issues. Other issues may have come from smaller occupants of the Plains. Although not as severe as the Norwegian rat that infiltrated and annihilated storage pits after European contact, other burrowing animals may have had an impact on the structural stability of storage pits (Fenn 2014: 292).

**Historical Documentation**

A valuable source of information, like Scullin’s (2007), is Gilbert L. Wilson’s (1987) account of Buffalo Bird Woman’s Garden. Detailed descriptions of bell-shaped storage pit construction and use help in estimating how much food could be stored, what kinds of foods were stored, where these pits were located, and how long they were utilized. Based on her account, these pits took two to three days to construct, but were utilized extensively (Wilson 1987: 87). Locations chosen were primarily outside of structures, explaining that rodents were an issue inside houses (Wilson 1987: 95-96). Those built inside houses primarily stored valuable commodities. Goods stored in exterior pits included primarily corn, but were also filled with berries, grains, meats, seeds, and squash. Access to the contents was limited as most of them sealed and completely filled to protect them from natural elements like weather, overhead traffic, as well as invading parties (Wilson 1987: 93). No details, apart from their long-term use, document when these pits were no longer deemed useful for storage, and how they were filled.
Fluctuations in economic relationships are largely responsible for the changes we see in village composition and population changes in the Extended and Terminal Middle Missouri Tradition sites. Mitchell (2007) highlights Mandan cultures as the driving force behind much of the economic interactions during the fifteenth through the later 17th century. Similar instances can be found in many of the historical accounts documenting interactions with Missouri River groups into the 1700s. It is through these historical accounts that we can learn more about the storage capacity of villages like Huff. More importantly, they can inform us about corn surplus commodities and what part they played in ceremonial and economical transactions.

Corn and other farmed foodstuffs were an essential balance to the diet of peoples who lived on the Great Plains. Hunters who focused on bison as a main part of their subsistence would not have been able to support their caloric needs on bison alone. Corn was a valuable commodity that was both supporting Middle Missouri villages and providing wealth in the economic system that they were involved in. Elizabeth Fenn (2014: 229-243) traces this distribution of wealth through the historical accounts of European travelers, those expeditions being the first to document the complex and expansive commercial operations of Plains cultures. Through these historical accounts, she illustrates the wealth of the Mandan, Arikara, and Hidatsas peoples resulting from extensive surpluses of corn that they bestowed upon multiple outside groups. A common theme throughout these accounts is the marketability of goods, specifically foodstuffs. Surpluses are evident when Fenn (2014: 229-243) utilizes more than five historical sources that specifically document these excesses, many of these expeditions encountering these cultures throughout the 1700’s into the early 1800s. Through these accounts, we see large populations with both the means to support their populations, supply neighboring
communities, and engage in ceremonial activities that all involved the same central commodity: corn.

**Middle Missouri and Initial Coalescent Pit Features**

When compared to Late Woodland groups, the degree of horticulture and reliance on a sedentary lifestyle are hallmarks of Middle Missouri groups. The ability to store food, support growing populations, and develop surpluses likely increased over time as well. Although an investigation into the details of subterranean food storage is somewhat limited due to the lack of storage pit specific excavations, there are key pieces of information we can glean from the following. Through this information, we may be able to follow the development of storage pits over time, highlighting their different functions and characteristics.

Early Middle Missouri tradition (MMT) sites such as those belonging to the Initial Middle Missouri variant (IMMV) utilized pits inside and outside their habitation areas. Winham and Calabrese (1998: 285) describe Initial Variant Mill Creek/Over and Great Oasis-phase structures, some having up to 35 bell-shaped storage pits. More site-specific excavations have pushed the envelope on the utilization of pits, both inside and outside of structures. Karr et al. (2011) describes outdoor living and working spaces and house features during their investigation of the Mitchell Site. Their excavation revealed the pits outside of structures utilized for culinary purposes, storage areas, and refuse containers. Specific culinary processes included using them as large roasting pits (Karr et al. 2011: 284). More recently Karr et al. (2015) have found a basin-shaped pit utilized as what they interpret as a “bone grease processing station”. This brings to light the ways past MMT cultures were using these subterranean spaces.
Similar to Huff Village, the excavation at the Paul Brave (32SI4) site was a part of the Inter-Agency Archeological and Paleontological Salvage Program in the 1950s. This investigation by Wood and Woolworth (1964) details the numerous floor features at this Extended Middle Missouri Variant site, including features both inside and outside of structures. Of note are the 14 bell-shaped storage pits that were uncovered within House 1 excavations (Wood and Woolworth 1964: 7). Interestingly, their depths only reached up to 2 feet or 60 centimeters deep. Excavations at House 2 uncovered slightly different results, a smaller number of pits within the house, with more located along the perimeter outside this house. We see a similar variety of subterranean floor features recorded at Huff.

Throughout the Middle Missouri tradition, it is clear that floor features have remained constant. This is also evident in contemporaneous Initial Coalescent groups. Comparatively, differences between Coalescent groups and Middle Missouri peoples are marked by stark contrasts in house form. Storage pit features at sites like Arzberger show us that the continuing use of these traditional storage pit types. Spaulding (1959) documents the variation in pit features through the excavation of Houses 1 through 4, including some of the unusual pit types seen at MMT sites. Important pit characteristics of note include Spaulding’s (1959: 21) descriptions of the location of cache pits in House 2 primarily congregated toward the entrance. With the presence of circular house forms at Huff this may help to determine entrances to these structures, explored in Chapter 3.

Even though we see such drastic changes in architectural styles, we see continual use of key pit styles over a significant amount time. Further studies investigating counts of pits per house in these same sites over time could determine if a standard number of pits have a relationship with the house sizes built. Until such a study exists, we must use the data at hand.
For the benefit of Great Plains prehistory, we have been able to obtain valuable information through remote sensing technology. Analyzing these data will help in supporting Huff’s position as representative of a time where economic and social interactions were intensifying.

**Magnetic Feature Interpretation**

Visibly speckled with magnetic anomalies it is clear that past ground disturbing activities have created a wonderful representation of Huff’s past. This analysis begins by identifying the number of potential storage pit features, then examining their magnetic values. Geographic Information Systems (GIS) allow archaeologists and a multitude of other professionals to analyze complex data sets in a quick and efficient manner. The following analysis employed the ArcGIS 10.4.1, Terrset IDRISI, and R programs. Initially the process started by simply using the magnetic measurements, in nanoteslas, to outline the geophysical manifestations. The use of visual clues like the location of central hearths helped to identify the presence of neighboring features as well. Disturbances from a variety of sources tend to appear in the magnetic data, including iron artifacts and modern disturbances. These disturbances and those anomalies skewed by them were not included in the following analysis.

Starting this process began with uploading the magnetic gradiometry data as an ASCII file into ArcMap, which had to be transformed into a raster image in order to spatially analyze its anomalies. Once transformed, you can increase maximum values in the properties of the raster to allow fainter magnetic anomalies to become stronger. In comparison, lowering values isolates stronger magnetic anomalies. Depending on the adjusted values, patterns appear and alignments become visible. Figure 4 b and c illustrate how setting higher magnetic values isolate then highlight stronger magnetic anomalies. When these values are lowered, Figure 4 a, muted wall
Figure 4 a through c. Comparison of minimum and maximum magnetic values used to aid in anomaly identification. Red outline indicates structure shape.
features become accentuated. These alignments, paired with the Digital Elevation Model (DEM), helped to determine where structures were located. Once these structures locations were determined, it started to become clear floor features represented by the most prominent magnetic anomalies. Keeping with the structure numbering system put in place from the first excavations, an identifying sequential number was assigned to the remaining Houses.

Many features within specific areas of the village are not included in the following analysis. This includes structures and anomalies that are completely and partially within the area adjacent to the river. This 100-foot wide area was intentionally leveled in order protect the site from further erosion after the 1960’s excavations were completed (Wood 1967). Excluding these features prevents skewing data in the following analysis. Other disturbances visible throughout the village include previous excavation areas and iron artifacts. Iron artifacts are visible in the magnetic data through dipoles, paired extreme high and low magnetic values. If potential floor features came within close proximity or overlapped these strong dipoles they were not included in the following analysis.

Although this analysis focuses more on the presence of storage pits and their capacity, many other magnetic anomalies represent other important structural components. These magnetic anomalies fall below the 3 nT level used in later analysis, but are still readily visible in the data. As stated in Chapter 1, even though most anomalies that represent archaeological features have values in the ±5 nT range, equipment can also pick up very low readings as well (Kvamme 2006: 209). Four distinct anomalies are visible in House 43, a newly discovered circular structure in the northwest portion of the village (Figure 5). Their location along the periphery of the structure could point to additional storage within this house, but due to their magnetic signature falling below the 3 nT level, they were not included in later analysis. Low
Figure 5. View of low magnetic signatures visible in House 43

magnetic readings could be due to a variety of reasons including a more recent construction or shallow depths.

A degree of error must be assumed in the following analysis due to the ambiguity of magnetic gradiometry imagery. With the variety of pit types illustrated above, it is difficult to determine if the magnetic anomalies represent one type or another. Verification through previous excavations like Ahler’s (2000) can help in eliminating other types of floor features from those that are likely pits. The downfall of doing this is that this may either overestimate or underestimate the actual storage capacity of the village. The upside is that this will likely be the most accurate estimation of population support based on the degree of this magnetic data coverage, encompassing the entire village as compared to past estimates based on subsections of villages.

Values above 3 nT in groups of four or more 0.25-meter square raster pixels guided the identification of the highest potential magnetic anomalies that could represent storage pits or
hearth features. This provided a large sample of the strongest floor features, removing those features that may represent natural disturbances or floor features associated with other domestic activities. Each anomaly was digitized first as a polygon, then as a point. Digitizing possible hearth and pit as polygons gave us the opportunity to examine range in sizes of these floor features, including those that could be interconnected features. It is important to note here that previous analysis on storage pit features, such as Wiewel’s 2017 study on this same data, recognized the possibility of a single magnetic anomaly representing interconnected features. The highest magnetic values of digitized hearth and pit features were recorded as an attribute in their respective feature classes. Although it could translate into higher estimates of possible storage pits present, we digitized separate points at the location of multiple high magnetic peaks within singular anomalies when clear isolated magnetic peaks were visible. This allowed us to identify and include those interconnected features, differentiating them, and allowing them to be included later in quantitative analyses.

Using visual clues was an important initial step in differentiating between central hearths and other floor features. It is clear that central hearths are a common feature observed throughout the Middle Missouri Tradition (see Chapter 3). Their location along the central house axis makes it relatively easy to identify these features. Even inside new circular structures, hearths are typically centrally located as well. Unusual anomalies sometimes made the identification of a central hearth feature difficult. House 65, shown in Figure 6, is an example of a weaker central hearth feature. Here a stronger anomaly overpowers its signature, likely a set of interconnected storage pits. You can easily see how these pits are visibly the more dominant signature within this structure. All central hearths locations identified were digitized based on their central locations within households, as well as their location along the central axis within each structure.
Figure 6. Weaker magnetic central hearth feature within House 65. Arrow pointing toward stronger pit anomaly to right.

A number of interesting anomalies are visible without measuring magnetic field strength or employing statistical analysis. Close alignments of magnetic anomalies that fit our model of storage pits are visible within close proximity of the fortification ditch, as well as surrounding houses. The alignment of magnetic anomalies along the fortification is apparent in two distinct locations. Figure 7 highlights the more prominent examples of these alignments. Along the boundary, 104 magnetic anomalies are within 5 meters of the digitized location of the ditch (Figure 7). Their magnetic strength ranges from 3.46 nT to 31.00 nT, a standard deviation of 3.75. Similar features have been uncovered at other sites, like Double Ditch. Kvamme (2007: 219) illustrates how pits are distributed in a similar fashion interpreting the remote sensing imagery at Double Ditch.
Figure 7. Alignment of anomalies within close proximity to fortification features

The congregation of features along structures is another visible pattern seen through the remote sensing data, a feature that surprised many researchers. Kvamme (2007: 219) notes the location of pits “distributed principally outside houses”. Using a small search distance through the “Selection by Location” tool in ArcMAP, I was able to identify 577 magnetic anomalies that are within 2 meters of delineated structures. For the 91 structures digitized, this is an average of six per house. The pit features surrounding House 101 are a representative example of this (Figure 8). With Buffalo Bird Woman’s (Wilson 1987: 95-96) account stating preferences for storage pit location exterior to houses, as well as those congregated along structures at Huff, it is becoming apparent that the pits outside of structures are just as important as those inside.
Figure 8. Exterior pit features within a 2-meter distance of House 101

Magnetic Signature Variation

The excavation data presented above documented a large degree of size variation between pit features inside and outside of structures. Previous excavation data hinted at functional distinctions between interior and exterior pit features (Ahler and Kvämm 2000). These differences in function and representation can be significant if parallels can be measured through magnetic data and verified through statistical analysis. Our focus here is to investigate this variation on both a small and large-scale, comparing the results of our analysis with previous conclusions. To our benefit, during the 1999 investigation of Huff, Ahler used both magnetic data and coring to investigate a small part of the village (Ahler and Kvämm 2000). This work
provides us with an opportunity to make comparisons in our data, which remains unverified in the field, with that of Ahler’s, which is. By expanding our own investigation to the entire village and its components, we can attempt to determine if the same pattern exists in subterranean features throughout the entire village.

Ahler’s coring survey focused on a 30 meter by 30-meter square area surrounding House 19, House 74, and a portion of House 73, just southeast of the central plaza. When identifying 40 magnetic anomalies around these structures though coring, Ahler (2000: 31) and his team labeled and categorized them using their locations inside and outside of structures. These labels and categorizations are shown in Table 5. Their associated magnetic values, determined through this analysis are also represented. Compared to other features, hearths represent only a small majority of the features documented by Ahler and his crew. Most of the hearths identified were located interior of Houses, within structures 19, 73, and 74. Magnetic signature for these three central hearths measured 7.85 nT up to 10.34 nT. In addition to these central hearths, an auxiliary hearth, identified in House 19, exhibited a slightly lower value of 6.35 nT. Unlike the other hearth features documented, Ahler also identified a single hearth above a pit. This uncommon anomaly is represented by an uncharacteristically low measurement, 2.54 nT (Ahler and Kvamme 2000: 28). Only a single possible exterior hearth was documented, located southwest of House 19. Its magnetic signature was rather low as well, measuring only 3.35 nT. Maximum depths measured for the central hearths extended an average of 76 centimeters deep, with the single auxiliary hearth only measuring 59 centimeters deep (Ahler and Kvamme 2000: 31).

While examining Ahler’s feature interpretations and their corresponding magnetic measurements two unusual anomalies stood apart. These two features cored by Ahler exhibited extremely high magnetic measurements: one exterior and one interior of structures. Coring the
Table 5. Ahler’s analysis combined with the magnetic signature of features cored.

<table>
<thead>
<tr>
<th>Number</th>
<th>Coring Number</th>
<th>Maximum Depth of Artifacts (cmsd)</th>
<th>Inside VS. Outside</th>
<th>Ahler Anomaly Interpretation</th>
<th>Magnetic Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>75</td>
<td>INT</td>
<td>PIT?</td>
<td>3.52</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>75</td>
<td>INT</td>
<td>C. HEARTH</td>
<td>7.85</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>60</td>
<td>EXT</td>
<td>MIDDEN?</td>
<td>7.19</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>69</td>
<td>EXT</td>
<td>PIT?</td>
<td>4.21</td>
</tr>
<tr>
<td>5</td>
<td>E</td>
<td>&gt;112</td>
<td>INT</td>
<td>PIT</td>
<td>2.96</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>105</td>
<td>EXT</td>
<td>PIT</td>
<td>9.95</td>
</tr>
<tr>
<td>7</td>
<td>G</td>
<td>&gt;30</td>
<td>INT</td>
<td>MIDDEN?</td>
<td>18.46</td>
</tr>
<tr>
<td>8</td>
<td>H</td>
<td>74</td>
<td>EXT</td>
<td>PIT</td>
<td>10.23</td>
</tr>
<tr>
<td>9</td>
<td>I</td>
<td>75</td>
<td>EXT</td>
<td>PIT</td>
<td>9.57</td>
</tr>
<tr>
<td>10</td>
<td>J</td>
<td>60</td>
<td>INT</td>
<td>PIT</td>
<td>3.57</td>
</tr>
<tr>
<td>11</td>
<td>K</td>
<td>75</td>
<td>EXT</td>
<td>PIT</td>
<td>10.44</td>
</tr>
<tr>
<td>12</td>
<td>L</td>
<td>108</td>
<td>EXT</td>
<td>PIT</td>
<td>7.02</td>
</tr>
<tr>
<td>13</td>
<td>M</td>
<td>&gt;90</td>
<td>EXT</td>
<td>PIT</td>
<td>7.93</td>
</tr>
<tr>
<td>14</td>
<td>N</td>
<td>&gt;120</td>
<td>EXT</td>
<td>PIT (F501)</td>
<td>UNK</td>
</tr>
<tr>
<td>15</td>
<td>O</td>
<td>&gt;150</td>
<td>EXT</td>
<td>PIT</td>
<td>4.89</td>
</tr>
<tr>
<td>16</td>
<td>P</td>
<td>&gt;73</td>
<td>EXT</td>
<td>PIT</td>
<td>20.41</td>
</tr>
<tr>
<td>17</td>
<td>Q</td>
<td>&gt;120</td>
<td>EXT</td>
<td>PIT</td>
<td>8.13</td>
</tr>
<tr>
<td>18</td>
<td>R</td>
<td>85</td>
<td>EXT</td>
<td>PIT</td>
<td>12.84</td>
</tr>
<tr>
<td>19</td>
<td>S</td>
<td>&gt;120</td>
<td>EXT</td>
<td>PIT</td>
<td>9.70</td>
</tr>
<tr>
<td>20</td>
<td>T</td>
<td>80</td>
<td>EXT</td>
<td>PIT</td>
<td>9.85</td>
</tr>
<tr>
<td>21</td>
<td>U</td>
<td>80</td>
<td>EXT</td>
<td>PIT</td>
<td>6.39</td>
</tr>
<tr>
<td>22</td>
<td>V</td>
<td>75</td>
<td>EXT</td>
<td>PIT</td>
<td>UNK</td>
</tr>
<tr>
<td>23</td>
<td>W</td>
<td>&gt;75</td>
<td>EXT</td>
<td>PIT</td>
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<td>24</td>
<td>X</td>
<td>59</td>
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<td>HEARTH</td>
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</tr>
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<td>28</td>
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<td>29</td>
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<td>&gt;110</td>
<td>EXT</td>
<td>PIT</td>
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<td>30</td>
<td>DD</td>
<td>120</td>
<td>EXT</td>
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<td>68</td>
<td>EXT</td>
<td>PIT</td>
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<td>32</td>
<td>FF</td>
<td>82</td>
<td>EXT</td>
<td>PIT</td>
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<td>33</td>
<td>GG</td>
<td>113</td>
<td>EXT</td>
<td>ENTRY ROOF FALL/PIT</td>
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</tr>
<tr>
<td>34</td>
<td>HH</td>
<td>78</td>
<td>INT</td>
<td>C. HEARTH</td>
<td>10.34</td>
</tr>
<tr>
<td>35</td>
<td>II</td>
<td>45</td>
<td>INT</td>
<td>UNK</td>
<td>4.95</td>
</tr>
<tr>
<td>36</td>
<td>JJ</td>
<td>74</td>
<td>INT</td>
<td>HEARTH ABOVE PIT</td>
<td>2.54</td>
</tr>
<tr>
<td>37</td>
<td>KK</td>
<td>44</td>
<td>INT</td>
<td>UNK</td>
<td>9.81</td>
</tr>
<tr>
<td>38</td>
<td>LL</td>
<td>78</td>
<td>INT</td>
<td>PIT</td>
<td>3.77</td>
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<td>39</td>
<td>MM</td>
<td>38?</td>
<td>INT</td>
<td>UNK</td>
<td>9.47</td>
</tr>
<tr>
<td>40</td>
<td>NN</td>
<td>75</td>
<td>INT</td>
<td>C. HEARTH</td>
<td>8.37</td>
</tr>
</tbody>
</table>
feature labeled G by Ahler and interpreted as midden, measured only 30 centimeters deep due to what he describes an impenetrable layer of bone and rock. When measured, the magnetic signature of this feature reached up to 18.46 nT. Located directly behind house 74, the coring feature labeled P also exhibited many of the same characteristics of feature G. It is interpreted as a pit, its magnetic signature measuring 20.41 nT. The depth recorded as 73 centimeters, but again Ahler could not reach beyond a layer of bone. With such high measurements and depths unable to be determined, it seems plausible that the rock or bone contained within this feature may be producing higher magnetic readings based on reoccurring past use. Wood (1967) documents multiple houses with “calcined granite” inside pit features. Kvamme states that depending on the type of stone (2006: 208), its exposure to firing (2006: 207), or whether it was imported (2006: 220) would all increase the magnetic signature of a feature. This is the result of heating materials beyond the Curie point, approximately 600° C, each time increasing the magnetic field of the material fired (Kvamme 2006: 207).

Table 5 also illustrates that the majority of features Ahler identified were storage pits. It is important to note that the highest two values are not by far the deepest pits documented. One could assume that the deeper the pit, the more contrasting material or refuse it was filled with, therefore the stronger the magnetic signal. Even then, the quantity and complexity of interior features versus exterior ones was noticeable. When examining the specific characteristics of pit features Ahler (2000: 32) found that “the highest frequencies of difficult-to-interpret anomalies occur within the houses.” Given the ability to measure the magnetic value of features cored by Ahler, we now have the benefit of using this data in an attempt find a correlation between feature depth and magnetic strength. From our own examination of the magnetic range of these features, we see that pit features exterior to structures had a far higher and wider range of magnetic
strength than those interior pit features (Table 5). It is important to note that of the 24 exterior pits identified, accurate magnetic measurements could only be obtained for only 21 of them. This also goes for four of the five interior pits as well. Skewed magnetic readings could be a result of past disturbances from excavations, nearby iron dipoles, or conflicting feature function.

In order to determine if a relationship exists between the depth and magnetic values of exterior pits versus interior pits, their values were plotted in two separate graphs, Figures 9 a-b. Utilizing the CORREL function in Microsoft Excel 2013, correlation values were produced to measure this relationship. Only a small correlation was found between exterior pit depths and their corresponding magnetic values. Comparatively, a stronger connection was observed between deeper pits represented by lower magnetic values and shallower pits represented by higher magnetic values amongst pits located interior of structures. This connection parallels Ahler’s conclusion that the function of pit features inside structures were difficult to determine.

Of the 21 exterior pits we measured, their magnetic strength ranged from 3.88 nT to 20.41 nT, averaging 8.56 nT. Interior pits did not exhibit as wide of a magnetic range compared to their exterior counterparts, the lowest measuring 2.96 nT, topping out at 3.77 nT. Pits inside structures only had an average of 3.45 nT. A two sample t-test that assumed unequal variances was performed for both sets of magnetic values measured in Ahler’s cored anomalies. Based on data given in Table 6, the resulting t-value of 6.42, and the critical two-tail values of -2.07 and 2.07, we can reject the null hypothesis. This means that a significant difference in the means exist for both exterior and interior pit features for structures in this area.

Through our analysis of the magnetic gradiometry data, 1,916 potential pit features were identified within Huff’s defensive walls. Of these 1,916 anomalies 419, approximately 22 percent, of them are located within structures. This leaves 1,497 anomalies, approximately 78
Figures 9a and 9b. Comparison of depth and magnetic values of interior and exterior pit features.
Table 6. Two-sample T-test assuming unequal variances of exterior and interior pit magnetic values from Table 5

<table>
<thead>
<tr>
<th></th>
<th>Cored Exterior Pits (nT)</th>
<th>Cored Interior Pits (nT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>8.560952381</td>
<td>3.455</td>
</tr>
<tr>
<td>Variance</td>
<td>12.63190905</td>
<td>0.120566667</td>
</tr>
<tr>
<td>Observations</td>
<td>21</td>
<td>4</td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>df</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>t Stat</td>
<td></td>
<td>6.42443114</td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td></td>
<td>9.15302E-07</td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td></td>
<td>1.717144374</td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td></td>
<td>1.8306E-06</td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td></td>
<td>2.073873068</td>
</tr>
</tbody>
</table>

percent, located along fortification walls, bordering structures, and scattered throughout the village. We cannot assume that all of these anomalies are strictly for food storage or that they were in use at the same time. As mentioned above, clusters of four or more 0.25 meter magnetic signatures above 3 nT factored into our interpretation of these anomalies as potential storage pits or refuse containers. The distribution of the range in magnetic signature strength is shown in the histograms below (Figure 10 a-c). We can see how the majority of the pit features range within lower magnetic levels.

In order to determine if significant differences exist in the means of the magnetic data, interior versus exterior magnetic values, the same two sample t-test was employed as used in comparing Ahler’s data. The results, shown in Table 7, illustrate that our t value of 1.02 falls in-between the critical two tail value of -1.96 and 1.96. This means that we are unable to reject our null hypothesis, that no significant difference exists between the means measured for exterior pits versus interior ones.
Figures 10 a through c. Histograms illustrating the range in magnetic values measured in possible pit features in a) the entire village, b) exterior of structures, and c) interior of structures.
Table 7. Two-sample T-test assuming unequal variances of all exterior and interior pit magnetic values within the site

<table>
<thead>
<tr>
<th></th>
<th>Exterior Pits (nT)</th>
<th>Interior Pits (nT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>7.084702739</td>
<td>6.843102625</td>
</tr>
<tr>
<td>Variance</td>
<td>11.36217613</td>
<td>19.92702432</td>
</tr>
<tr>
<td>Observations</td>
<td>1497</td>
<td>419</td>
</tr>
<tr>
<td>Hypothesized Mean Diff</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>df</td>
<td>558</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>1.028798454</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.152010065</td>
<td></td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td>1.647588963</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.304020131</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>1.964224446</td>
<td></td>
</tr>
</tbody>
</table>

Having conducted the same test using our data set and Ahler’s coring data, we can clearly see that differing results were produced. Although it appears perplexing, there could be various reasons for this inconsistency. One reason could be attributed to differences in societal or familial roles and how those relate to households features. This would support the large differences in the means found in Ahler’s data. Wiewel (2017) supports this notion, based on his analysis of house size in relation to proximity to the central plaza. Historical research also supports this, as stated above in Buffalo Bird Woman’s (1987) account. Another reason could be attributed to the sample sizes used in the tests. Using such a small sample to represent interior pit features, in the test involving Ahler’s data, may have skewed the data to highlight a larger difference than actually exists. Until we are able to conduct a study similar to Ahler’s, we will not be able to fully understand the variation found in the mean differences in his data set versus those found in ours.

Utilizing the variety of data at hand allows us the opportunity to employ a range of analysis, as shown above. The results appear to parallel what we have seen through previous work like excavations, but the road doesn’t end there. How these potential pit features are
represented amongst other key features, like structures, communicates other important cultural attributes. In the following chapter structural features will be analyzed in a similar fashion compared to pit features. It is only through the additional analysis employed in chapters 4 and 5 that we really begin to see this relationship have significant cultural implications.
CHAPTER 3 - STRUCTURES

Early accounts by explorers were the first written descriptions of Middle Missouri village composition and house form. Many of these accounts detailed spatial dimensions of these structures, along with illustrating the life that surrounded them. Starting in the early 20th century, excavations looked more in depth at house construction, further refining specific details that historical accounts lacked. Unfortunately, even though excavations produce an extraordinary amount of valuable information, they are limited by space, time, and funding. This can prohibit our understanding of relationships that can exist between various village features. Remote sensing has aided archaeological investigations in attempting to better understand the village as a whole, a valuable supplement to past excavations. Huff village is a model of success in this regard. A variety of archaeological methodologies provide us the opportunity to look at Middle Missouri sites with a wider lens. The next stage in Middle Missouri site interpretation begins with utilizing multiple technology data sets, extracting patterns from them, and finding the unique relationships present. Data that can be utilized here includes past excavation data, historical documentation, and remote sensing technologies.

In order to understand village composition, as a whole, along with the relationships between features present, we must first address the evolution of work completed at Huff. In doing this we will be able to present the physical manifestations of house forms excavated and their specific structural characteristics that currently place Huff within the Middle Missouri taxonomy. It is also important to compare Huff with other sites in the Middle Missouri Tradition, as well as the Coalescent Tradition. This is done in order to outline associated similarities and differences of house features. Looking specifically at the structures themselves, we can measure consistencies and deviations in size and shape, using simple quantitative measurements.
**Historical Documentation**

Plains cultures were one of the many Native groups encountered by European explorers in 18th – 19th century descriptions, which included paintings by eye-witness artists like George Catlin and Karl Bodmer. Their descriptions of the environment and specific landmarks aid historians and academics when defining routes traveled. More importantly, some detailed their interactions with these groups documenting ceremonial and economic lifeways. Although there are differing interpretations, as well as missing pieces of information, these accounts still provide a great deal of knowledge about Plains cultures. Elizabeth A. Fenn (2014: 56) has compiled a valuable collection of sources that document Mandan culture. In her book *Encounters at the Heart of the World: A History of Mandan People*, she describes circular house forms and depicts important external and internal architectural features.

Others have also compiled information like this. Roper and Pauls (2005) looked more specifically at the historical documentation of earthlodges, describing Pierre Gaultier De Varennes, the Sieur De La Vèrendrye’s first account. There he describes the orderliness of house interiors (Roper and Pauls 2005: 2-3). Other details gleaned from illustrations account for construction processes and cultural preferences in regards to the quantity of materials used (Roper and Pauls 2005: 7). In reference to Mandan earthlodge descriptions, Roper and Pauls (2005: 4-5) list at least five sources that range from early 20th century accounts to the 1970’s. Even though some of these early accounts have attributable biases, they are still valuable in helping us to visualize structure and feature functions, without which we can only hypothesize.

**Middle Missouri and Initial Coalescent Structure Development**

Although there were slight fluctuations in size and distribution over time, the overall
shape of structures, attributed to specific Middle Missouri variants is constant. Slight fluctuations can be seen when examining Middle Missouri and Coalescent villages, including temporal and geographic variations. Changes like these delineate social transformations and represent the dynamic environments that Plains groups were immersed in. Overall, three main house forms constitute Plains structures: circular, long-rectangular, and square shapes.

Differing hypothesis surround the origin of Initial Middle Missouri cultures, some arguing they were a direct outgrowth of Late Woodland groups, like the Great Oasis phase (Ahler 2007, Tiffany 2007, Winham and Calabrese 1998). If this is true, a significant transformation occurred when IMMV cultures choose a sedentary lifestyle and focused on horticulture practices, not completely abandoning their hunting regime. These groups built “long-rectangular houses often fortified by dry moats and palisades” (Wood 1967:19). Tiffany (2007) attributes horticulture as “a prime mover in the nucleation process that led to the formation of compact, fortified IMMV villages from dispersed Great Oasis hamlets” (2007: 7). Wood (1967: 20) also details other specific house features including southeast and southwest orientations of covered entryways.

Geographically there were differences in IMMV structures themselves and their organization. Clear distinctions have been made in Middle Missouri taxonomy, separating IMMV groups into eastern and western divisions. Larger villages were located at locales farther north and west (Tiffany 2007:11), with the Sommers site representing a site with an increase in the number of structures and population (Johnson 2007: 12). While analyzing Menoken, Ahler (2007: 24) provides some of the structural attributes specific to western IMMV groups including a “two-post lintel at the entrance with a ‘king-post’ at the rear, a main hearth on the centerline, and the interior entry ramp that sets off alcoves in the front of the house. Alex (1973) describes
the structures excavated at the Mitchell site during 1971, while at the same time investigating contents of the cache pits located there. While the illustrations depicting House 3 are somewhat limiting, the illustration of House 4 allows us to examine the architectural features present (1973: 152). House 4 has posts of similar diameter along all four walls, red ochre painted floors, a central hearth, and an entryway ramp (Alex 1973: 152). From visual inspection of the illustration provided by Alex, House 4 appears to be missing a king post and a distinct two-post lintel. Although there is not mention of these in this report, further investigation into earlier excavations might reveal the truth. The Mitchell site, located along the James River, is representative of smaller IMMV eastern cultures. Apart from differences in the organizational structures of the village itself, structures were relatively the same size from Great Oasis to eastern IMMV (Tiffany 2007: 11). This could mean that continued single structure familial living arrangements followed from Great Oasis cultures into eastern IMMV groups.

Extended Middle Missouri house forms do not exhibit significant departures from IMMV peoples. The changes observed involve the size and number of structures present. Just as with IMMV groups, EMMV origins are disputed as they temporally overlap with the end of the IMMV. Tiffany (2007:4) believes that the development of EMMV groups was independent from IMMV progression. Others side with the development of the EMMV directly from IMMV groups (Windham and Calabrese 1998). Overall, we see EMMV communities located farther north along the Missouri River, occupying terraces and utilizing Knife River Flint resources (Ahler 2007: 29).

Just as in IMMV villages, differences in EMMV communities are based on their temporal occupations and geographic locations. Villages were larger and more compacted in western areas, some exhibiting multifaceted fortification systems (Windham and Calabrese 1998: 287).
Smaller structures were present further south along the Missouri River, similar in size to western IMMV structures (Windham and Calabrese 1998: 288). The basic composition of western IMMV structures is similar to houses constructed in EMMV communities. Structures retained their long-rectangular shapes and a semi-subterranean floors. They also continued to exhibit a two-post lintel near the entryway, a “king-post”, and central hearths. Some features departed slightly from IMMV structures. EMMV houses exhibited an elongated entryway that protruded from the structure, typically oriented toward the southwest (Winham and Calabrese 1998: 288-290).

Located mainly in the Knife, Heart, and Cannonball regions on both the east and west banks of the Missouri River, the number of sites that represent the Terminal Middle Missouri variant are limited. Two sites that represent the TMMV are Huff Village and Shermer (Johnson 2007: 41). Although there are not a significant number of sites representing this variant, their differences from Middle Missouri and Initial Coalescent sites are significant. A critical amount of information remains to be discovered with this ostensibly transitional phase in prehistoric plains culture.

Terminal variant sites in the Middle Missouri taxonomy are represented by a complex combination of constructed features. The multifaceted fortification systems that surround sites like Helb, Huff, and Shermer represent shifting social tensions at that time (Kay 2007; Mitchell 2007). These systems utilized ditches, bastions and palisades to protect the large compacted congregation of structures. A more patterned and organized placement of structures surrounded a central plaza that was typically free of any habitation activities. Large long-rectangular structures continued to be the house form of choice, but the overall occupations of these villages tended to be shorter in length (Mitchell 2013: 70-71). Clear increases in structure size are evident
(Winham and Calabrese 1998: 288), but key internal components like they king post and hearth features remained the same.

Coalescent occupation of the Great Plains extends from 1300 into the post-contact period (Johnson 1998). Sites belonging to this tradition cover a wide swath of the Plains geographic area, a southern border of Kansas along the Republican River to the upper parts of the Missouri river, north of the Knife River (Johnson 1998: 310). Initial Coalescent groups occupied the area contemporaneously with Middle Missouri groups, but were mainly concentrated in the Big Bend region in central South Dakota (Johnson 1998: 313; 2007: 120). Extended Coalescent groups are contemporaneous with Extended and Terminal Middle Missouri groups, dating from the 15th century to the mid-17th century (Johnson 2007: 59-61).

Initial Coalescent sites are very different in many key aspects from their Middle Missouri neighbors. The most notable difference is their house form, groups occupying circular houses with entrances facing toward the river, or along a parallel axis (Johnson 1998: 313). A smaller number of houses were present in their villages. Johnson (1998: 313) illustrates only “an average of 1.4 houses per acre.” The circular house form was not the only form utilized, as square house forms were present at other Initial Coalescent sites (Johnson 1998: 313). Village organization was often randomly distributed, as evidenced at sites like Whistling Elk (Kvamme and Bales 2005: 170). Even though the above illuminates stark deviations in house forms at Huff from their Plains neighbors, similarities exists represented by levels of defense present. Most Initial Coalescent sites have fortification features similar to those seen at MMT sites, including bastions, ditch and palisade features.

Architectural composition of these circular and square house forms have many similarities. Both house types were documented by Albert C. Spaulding (1956) at the Arzberger
site. House 2 was a circular house that had four equally spaced central posts providing the main structural support (Spaulding 1956: 18). Its entrance was delineated by a series of posts projecting to the southeast. A series of smaller posts were found to be associated with the square central posts. Spaulding (1956: 18) eluded to their function as braces. House 3, also excavated by Spaulding (1956: 26), represented more of a rounded square shape. It still exhibited four central support posts, like the circular house, but had an increase of smaller posts surrounding them. Other similarities included the projecting entrance facing toward the southeast (Spaulding 1956: 25). In terms of internal components, floor features were mainly composed of cylindrical, basin, and bell-shaped pits, as illustrated in Chapter 2.

**Structure Representations through Excavation**

Excavation details like those above help to provide the specific details about structure forms, internal structural components, and the changes between them in regards to geographic area and temporal ranges. The wide variety of data produced from Huff’s previous excavations is valuable in lending clues concerning the interpretation of structural features we see reflected in the remote sensing data. This includes Will and Hecker’s (1944) early excavations through the first intensive geophysical survey work by Kvamme. Deviations and parallels from their conclusions, when compared to the interpretations made here, will allow new and old questions to be answered.

During Thad C. Hecker’s (1944) investigation at Huff, his focus remained entirely on House 5, gleaning many structural details that would later be confirmed as common in most structures present (Wood 1967). He observed the common long-rectangular shape of the structures: the floor sloping down toward the center of its footprint, and a southwest projecting
entryway. Structural details, interpreted and illustrated by Wood (1967), include the presence of a large end post, central hearth, and a large center post offset toward the rear of the house. In order to confirm many of the details provided by Hecker, Wood uncovered these same structural details in House 5. Overall, Wood (1967: 42) concluded that House 5 “Closely conforms to floor patterns of the rest of the long-rectangular houses.” Not completely square in design this house may have been truncated for reasons related more to space limitations, not cultural affiliation.

James H. Howard’s (1962) excavation of House 1 and 2, House 2 representing the ceremonial lodge, was the next significant excavation that occurred at Huff. Although House 1 is a typical long-rectangular shape there are many interesting interior details of note. First, the centerline posts deviated from the typically larger and deeply buried center posts found in other rectangular houses. Wood (1967: 32) notes this discrepancy, finding it unusual since the supporting load would have needed larger diameter and deeply positioned posts. Second, the absence of a central hearth also deviates from the basic floor plan seen throughout the Middle Missouri tradition. Even though several auxiliary hearths are present, the absence of this key feature could be important if it stands alone or if this is something seen in other structures.

Excavations conducted on House 2 were no doubt significant due to the sheer size of the structure, but also due to its prominent placement directly adjacent to the plaza. Apart from this there appears to be the same floor feature components as seen in other rectangular structures including a central hearth, auxiliary hearths, bell-shaped storage pits, basin-shaped pits, and a cylindrical pit. Its architectural components appear to follow the same trend with the presence of a larger center and rear support post, along with lintel posts at the entryway. Wood (1967: 36) notes additional pits excavated during the remapping of this house as well as several stone
concentrations which he postulates could represent former sweat lodge locations. Both Houses 1 and 2 exhibited southwest projecting entryways.

Excavations conducted by Raymond Wood still remain the most significant study completed at Huff to date. His excavation of nine houses along with other village locations both solidified the dominance of the long-rectangular house form at Huff and documented new features. All structures excavated were located along the river’s edge of the village, an area within 100 feet of the Missouri river (Wood 1967: 28). House forms excavated included seven long-rectangular structures (Houses 3, 4, 6, 7 8, 9, 10, 11, and 12), a single square structure (House 12), and another ambiguous structure (House 9) whose shape was inconclusive (Wood 1967). Those with definite shapes all exhibited entryway features. Their floors were similar to that excavated in House 5 by Will and Hecker (1944), gently sloping down toward the center. Entryways faced toward the southwest, but their lengths and widths varied significantly (Wood 1967: 32). A ramp was constructed along this length from the subterranean floor to the outside ground surface. All of these structures exhibited the typical large mid-line and end posts with two large entryway support posts. Central hearths were present in all of the structures, typically offset toward the front of the house.

The excavation of a square-shaped, or what Wood (1967: 51) terms a “sub-rectangular” structure, certainly contrasts with the majority of structures excavated by Wood. He is correct in terming it sub-rectangular as it is slightly longer along its entryway axis, and its corners are slightly rounded. Similar to the surrounding long-rectangular structures, House 12 also features a slightly depressed floor, a central hearth, and a southwest projecting entryway. Instead of two entryway posts and two large supporting posts, four posts of equal size were used to support the structure. These supports are situated along the cardinal directions (Wood 1967: 51). A likeness
can be observed between House 12 and the features in the square structure present at the Coalescent site Arzberger. This includes comparable spacing of the four center posts, approximately four and a half meters. Bracing posts, like those excavated by Spaulding in House 3 at Arzberger, appear to be absence in House 12 at Huff.

Shrouded in mystery, the shape of House 9 and its specific dimensions remain unclear. In general its location was identifiable by Wood as a depression, like many of the other structures. Floor features were similarly perplexing, key pieces of information that would confirm its house shape missing. This includes wall postholes or even large support post holes. Only a single large posthole was documented by Wood but its location doesn’t follow a pattern shown in other houses. The only conclusion provided by Wood (1967: 49) is that House 9 represents a different house form, separate from the dominant choice of long-rectangular structures. Even though the information concerning this particular structure is limited, the amount of data recovered from Wood’s entire excavation is significant. Wood (1967) recognized and documented many of the unique characteristics of Huff that helped set it apart from other traditions. He was more accurate than he realized at that time.

In 1999, Ahler and Kvamme (2000) conducted the first large scale remote sensing survey of Huff. Using three survey methodologies they laid the foundation for the larger survey conducted in 2009. Their magnetic gradiometry survey focused on 0.71 hectares, the largest area in the Great Plains subjected to a remote sensing survey at the time. An electrical resistance survey covered 0.16 acres, and a resistivity tomography survey spanned 0.04 acres (Ahler and Kvamme 2000). All of these areas focused on the southern part of the village, a portion of the plaza and adjacent houses to the south (House 19). It didn’t take long to realize that the magnetic gradiometry survey stood out amongst the other technologies, well suited to identify the
numerous magnetic anomalies present. Their interpretation of the data led to many significant conclusions. This included the presence of magnetic signatures the length of house entryways and others congregated on the periphery of structures. More importantly, they confirmed that houses that were not earth covered due to the clarity of interior house features in the data (Ahler and Kvamme 2000). These same determinations are supported by the most recent data set, showing the same characteristics detailed below.

**Geophysical Representations**

The most recent work and the data set utilized here is the product of the work completed by Kvamme et al. (2009). Their survey utilized the efficiency and success of magnetic gradiometry in Plains environments to capture subsurface features present throughout the entire village. By also completing a topographic survey they were finally able to address many long standing questions. This data confirmed house locations in association with their depressions observed on the surface. Included in their initial analysis of the topographic data was the utilization of a DEM to produce hillshade images. By creating a slope gradient through the hillshade function in a GIS one can emphasize house footprints, employing shading to highlight their depressions (Kvamme et al 2009: 10). Other initial benefits gained from their analysis include the accurate mapping of the fortification system, the location and extent of previous excavations, and the correction of subtle deviations in house location compared to those illustrated by previous researchers. Although this investigation did not employ complex analysis, it did provide future researchers with a chance to push our knowledge about Huff even further.

Even with the newest data Huff does not disappoint, revealing additional possibilities for analysis. Initial review of the DEM revealed the presence of additional houses not previously
documented (Kvamme et al 2009). It also provided complete coverage of the entire village, allowing simple statistics to be compiled and other patterns to be measured. These patterns can be as simple as quantifying the size range in structure types present. Comparing similarities and deviations between the types and sizes of structures could also answer some long pending questions about multiple occupations of the village, integration of Plains groups, or other simple things like population estimates.

Both the digital elevation model (DEM) and the magnetic gradiometry data set were used together to delineate the presence of houses, identify their shapes, and confirm the locations of other floor features and disturbances. For example, two centimeter contour lines created in ArcMAP from the DEM allowed identification and enhancement of subtle deviations in slope. Manipulations in the magnetic data also helped to define the outlines of structures. Subtle magnetic contrasts observed along structures walls, have the ability to be enhanced using a lower nanotesla range. Figure 11 illustrates this process, identifying an anomaly observed along the northwest wall of House 93. From this manipulation this wall could be interpreted as a line of structure posts that are blending together or an excavated wall of the subterranean structure floor.

![Figure 11. View of the northwest wall of House 93 with a low magnetic gradiometry signature](image)
Upon initial review of the DEM and the magnetic data, Kvamme et al. (2009) observed the presence of additional houses, including a circular house form not previously documented. From previous excavations and the new magnetic data, it is clear that the long-rectangular house is the dominant form present, composing 81 percent of houses (n = 94). A total of 20 circular houses were also delineated, composing 17 percent of the structures at Huff. The shape of House 9 remains indeterminate and House 12 still represents the single square-like structure present. Houses destroyed by the mechanical excavation, those excavated by Will and Hecker, Howard, and Wood, were not included in the following analysis. A level of error must be acknowledged due to the number of structures whose features and sizes were difficult to interpret. Many times neither data set provided a concrete house definition, sometimes disturbances, and other times crowded magnetic anomalies, made an outline difficult to determine.

Previous analyses employed by Kvamme and Bales (2005: 173) involved measuring 11 structures defined by previous remote sensing survey completed over a portion of the village. Of these 11 houses, the smallest measured 118.4 m² with the largest measuring 193.1 m². Average size equaled 153.7 m² and the standard deviation of the structures measured 22.3 (Kvamme and Bales 2005: 173). In order to summarize the entire range of sizes the same analysis was employed, but with a few caveats. Sizes of 92 structures were analyzed, with House 2 (the ceremonial lodge) and those structures located in the systematically plowed area adjacent to the river’s edge excluded. Minimum, maximum, average and standard deviation values were determined for 72 long-rectangular structures and 20 circular structures. Table 8 illustrates the resulting range of values in sizes measured for the 92 structures delineated. We are able to see that circular houses are far smaller in number and area compared to long-rectangular structures. From the standard deviations we can see that circular structures also do not vary in size as much
Table 8. Range in structure area values for 92 houses.

<table>
<thead>
<tr>
<th>Structure Form</th>
<th>n</th>
<th>Min (m²)</th>
<th>Max (m²)</th>
<th>Mean (m²)</th>
<th>s.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>92</td>
<td>50.9</td>
<td>265.4</td>
<td>126.1</td>
<td>28.5</td>
</tr>
<tr>
<td>Circular</td>
<td>20</td>
<td>50.9</td>
<td>121.6</td>
<td>81.7</td>
<td>17.0</td>
</tr>
<tr>
<td>Rectangular</td>
<td>72</td>
<td>81.3</td>
<td>265.4</td>
<td>138.4</td>
<td>33.3</td>
</tr>
</tbody>
</table>

as rectangular ones do. Compared to the size analysis completed by Kvamme and Bales (2005), we see a larger size variation in the long-rectangular structures than previously calculated.

Characteristic of many long-rectangular structures are their sloped entryways. Both visible in the DEM and the magnetometry data, they helped in my efforts to delineate house outlines and determine a centerline axis for many of the long-rectangular houses. Figure 12 illustrates how these entrances are illuminated through the magnetometry data. In what can be alluded to as storage pits, magnetic anomalies are consistently visible along the center axis of many structures protruding out more than a meter. Documented in the physical record are the consistent directions entryways are oriented, including the single square-like structures excavated by Wood (1967: 52). This southwest orientation away from the river has been documented in a variety of Middle Missouri structures, although it is unknown whether its exact purpose was defensive, spiritual or practical.

Initial Coalescent (IC) structures differ significantly from Middle Missouri long-rectangular structures not only in their shape, but their entrances as well. In regards to their orientation, Johnson (1998: 313) states that many IC structures have entryways that face toward the Missouri River or parallel it. He then discusses how variable they become in the Extended Coalescent period, facing east, southeast, southwest, or toward major waterways (Johnson 1998: 318). Having both long-rectangular structures at Huff alongside circular structures, it appears that they do not share the same entryway orientation.
If we were to follow the same line of evidence, that magnetic anomalies lie beneath a protruding entryway, then some of the circular houses appear to have both the topographic and magnetic evidence that point toward this. Figure 13 shows an alignment of two semi-isolated magnetic anomalies on the edge of House 44 that appear to be less sloped than the other edges of the structure. Other possible entryways for circular structures could be found through the process of elimination. This could include possible entryway locations blocked by other encroaching features or structures, as well as superimposed structures that appear to be connected to one another. Both the DEM and the magnetic imagery illustrate this connection. In terms of entrances, it is unlikely to be located along the northern, western and southern steeply sloped sides of the houses, but more along the eastern edge where a lower degree of slope is exhibited. Figure 13 shows this lower degree of slope along the eastern edge of the structures. Unfortunately only future ground-truthing will be able to confirm this entryway location.
Figure 13. View of possible circular house entrance location.

The organization of Huff prior to the more recent analysis was considered orderly, with rows of rectangular houses surrounding the central plaza. New house forms appear to deviate from that order, clustered in different places around the village. Although the largest concentration of circular houses appear to be located more or less along the southeastern periphery of the village, they do not all line the edges. These circular structures seem to be intermixed with long-rectangular structures in no apparent manner. Structures located to the north and west are also intermixed in with long-rectangular structures along the periphery. Visually, they too do not follow the order of parallel placement, which seems to be only represented by the long-rectangular structures. There could be multiple reasons for their placement in these locations, some practical and others representing unknown cultural practices. Practical reasoning for their placement could be attributed to the timeline in which the groups
converged with the population already present at Huff. This would make spatial restrictions one of the prominent causes for the location of circular structures near the periphery of the village. Another theory involves the proximity to the central plaza, prominent families or individuals therein occupying those spaces (Swenson 2007: 256, Wiewel 2017: 105, Wood 1967: 15). The quantitative analysis employed in the following chapter will be able to measure whether or not these structures are indeed patterned, clustered, or randomly organized.

**Unusual Structural Anomalies**

From the beginning it was clear that Huff village was unique in many ways. Even with the extensive excavations that have occurred, the recent remote sensing data made it clear that there are still aspects of Huff that remain a mystery. The discovery of new circular house forms brought forth a myriad of new questions. There appear to be obvious differences in their placement and construction that contrast starkly with the dominant long-rectangular house type. One of these differences was the discovery of two superimposed circular structures in the southeast portion of the village. Houses 66 and 67 appear to be two circular structures that in the magnetic gradiometry data appear very close in proximity. Using the DEM we could see that their distinct depressions were separate, but that they were indeed connected. Figure 14 illustrates how this is reflected in both the DEM and the magnetic gradiometry data. Whether or not these circular structures had separate entrances or were an extension of a single structure with one entrance remains a mystery. Multi-room or superimposed structures were unusual in MMT sites that were not occupied at a later date, but they did occur at Coalescent sites. The possibility also exists that these two structures were indeed constructed during Huff’s tenure, but built at different times during occupation.
Another instance of unusual structural features relates to two possible structure locations. Figure 15 depicts two possible structures along the southwest fortification wall. Neither the magnetic gradiometry data nor the DEM provides us with a clear signature of a structural outline at this location. What these datasets do provide is evidence of other features that are typically associated with a structure, roughly shaping what could be two circular houses. Possible central hearth locations are visible in what could be a house center, along with clustered magnetic anomalies along their perimeter. The clustering of perimeter storage pit features is evident around a majority of the other structures present. Unfortunately, field verification through partial or complete excavation would be the only way to confirm this theory. It is possible that this
Figure 15. Two possible circular structure locations along the southwest fortification wall. Inconclusive structural outline could be attributed to a late date of construction, close to when Huff was abandoned.

Our last unusual anomaly, visible in both data sets, remains uninterpretable. Typically central plazas are devoid of all features, but some Mandan sites had a center cedar post associated with Okipa ceremonial activities. Wood (1967: 24) investigated a possible cedar post location within the plaza, but failed to locate any evidence of one. Although no features were revealed in the plaza center, an unusual anomaly is visible on the southern corner near structures 52 and 53. What is clearly a circular depression in the DEM, visible in Figure 16, is not as clear in the magnetic gradiometry data. Unlike the possible structure locations mentioned above, there appears to be no indicators like a central hearth and storage pit features there. It is possible that
Figure 16. View of unusual central plaza anomaly in the magnetic gradiometry and DEM data.

Initial construction of a structure was started, but shortly abandoned due to the culturally important nature of the plaza area. Another hypothesis that is plausible is the use of the dirt from this area as fill for other construction needs, making it a borrow pit. Even though anomalies like these aren’t clear, their presence continues to provide future research opportunities and allow us to piece together Huff’s past.

In evaluating and summarizing the data presented in this chapter there are clear trends that Huff follows and others that further separate it from Middle Missouri and Coalescent representations. Excavation data already provided significant data for long-rectangular structures, including internal feature organization and architectural composition. With a large portion of long-rectangular structures excavated it is fair to assume that the majority of long-
rectangular structures seen in the magnetic data and DEM data are similar in their basic internal components as well. This also includes entryway orientation. Comparing these long-rectangular structures on a broader scale we can see how using these structures align Huff closer with IMMV and EMMV sites. It is the circular and singular square-like structures that are more difficult to attach to Coalescent or Central Plains taxonomies. We can definitely say that based on their shape alone that they share similarities with these groups, but unfortunately without excavation documentation we do not have much more than the visual interpretations of their internal components made through the remotely sensed data.

Even though there are large similarities there are important deviations to acknowledge. Neither Middle Missouri nor Initial Coalescent cultures exhibit such an intermingling of structure shapes, at least at sites discovered and investigated to date. Newly discovered circular structures deviate from the southwest entryway orientation, but determining their orientation remains a mystery based on inconclusive evidence from the remote sensing data. Although the square-like structure is the only one of its kind that we know of at Huff, it aligns with the surrounding long-rectangular structures. Looking on a smaller scale we can see variation in the sizes of these structure types, the largest variation associated with long-rectangular structures. So even though its previous key descriptor was systematic distribution there appears to be as much of a range in size as there is in shape. The following chapter will investigate whether this systematic distribution exists, a long-held conclusion that has strong ties with the Middle Missouri tradition.
CHAPTER 4 – DISTRIBUTION AND QUANTATIVE ANALYSIS

With new structures revealed in the remote sensing imagery, a more complete analysis concerning the distribution of structures can now be employed. The distribution of structural features has long tied Huff to the Middle Missouri Tradition, Coalescent Tradition villages reflecting a drastically different organization. Since studies regarding distribution analysis have been employed in the past, the results can be compared and utilized to identify parallels. Due to the significance placed on distribution patterns of structural features, the same types of analysis were utilized to measure the degree of distribution of pit features as well. This could communicate and confirm a significant relationship between structures presents and the pit features scattered amongst them,

Distribution Analysis

From the structure summary statistics illustrated in Chapter 3, we learned that a majority of the structures at Huff are of the long-rectangular style. Past visual inspection has spurred on the long-held conclusion that a patterned organization of these structures exists. Previous analysis measuring the patterned nature of structures has been employed before, but with limited data available (Kvamme and Bales 2005). Using point pattern analysis to measure the placement of structures in a portion of Huff, as well as two other sites, Kvamme and Bales (2005: 168) found that the 11 structures analyzed were indeed organized systematically. This was based off of the resulting variance-mean ratio which indicates whether points are clustered, randomly, or systematically distributed. With the entire village now visible and new structures documented, will reanalysis yield the same conclusion?
Furthering the efforts lined out by Kvamme and Bales (2005), the same analysis was employed using a majority of the structures visible in the remote sensing imagery. To begin this process, a center point had to be delineated for each of the structures as the point pattern analysis cannot be employed on polygon features. Central hearths are typically placed within a central location within circular and long-rectangular features. These central hearth locations were used to represent as indicators of structure presence of both structure types. Only those structures within the previously excavated 100 foot area adjacent to the river were excluded. The remaining 92 should provide a representative sample of the organizational structure of Huff.

Using the Terrset program, three separate square quadrat sizes, a 32-meter, 24-meter, and 16-meter, were used to quantify the distribution of storage pits and calculate the VMR within them, all of which lie close to “ideal” quadrat sizes in VMR analyses (Boots and Getis 1988: 24). An identical range of quadrat sizes used in the analysis of the storage pits. Although Kvamme and Bales (2005: 168) employed their analysis using a 20 meter by 20 meter square quadrat area, this analysis uses a range of sizes for two purposes. First, our results can be compared to the earlier storage pit results that used the same range of quadrat sizes. Second, the range of quadrat sizes and the range of resulting VMRs could communicate different conclusions if they vary widely. Table 9 illustrates the results from the point pattern analysis. Only with the smallest quadrat size do we see a VMR associated with systematic distribution. Once the quadrat size was increased we see a more clustered distribution of structures. When we extended the quadrat size further it produced results associated with spatially random patterning.

**Table 9. Terrset point pattern analysis of house distribution**

<table>
<thead>
<tr>
<th>Quadrat Size (m²)</th>
<th>Mean</th>
<th>VMR</th>
<th>Significance Level</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 meters</td>
<td>0.58</td>
<td>0.68</td>
<td>&lt;0.01</td>
<td>Systematic</td>
</tr>
<tr>
<td>24 meters</td>
<td>2.59</td>
<td>1.46</td>
<td>&lt;0.01</td>
<td>Clustered</td>
</tr>
<tr>
<td>32 meters</td>
<td>1.97</td>
<td>1.02</td>
<td>Not Significant</td>
<td>Random</td>
</tr>
</tbody>
</table>
From the identification of potential storage pit features in chapter 2, we have the benefit of employing the same distribution analysis to the other most prominent feature at Huff, pits. The sheer number of potential pit features, regardless of their location inside of structures or outside of them, is impressive. Applying this type of analysis to the distribution of possible storage pits enables us to determine if floor features follow a similar distribution as the structures, or if they deviate, clustered as visual analysis suggests. Table 10 shows the variance mean ratios and their associated distribution. All point toward significant clustering.

Table 10. Terrset point pattern analysis of pit distribution

<table>
<thead>
<tr>
<th>Quadrat Size</th>
<th>Mean</th>
<th>VMR</th>
<th>Significance Level</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 meters</td>
<td>11</td>
<td>3.9</td>
<td>&lt;0.001</td>
<td>Clustered</td>
</tr>
<tr>
<td>24 meters</td>
<td>25</td>
<td>6.2</td>
<td>&lt;0.001</td>
<td>Clustered</td>
</tr>
<tr>
<td>32 meters</td>
<td>39</td>
<td>10.3</td>
<td>&lt;0.001</td>
<td>Clustered</td>
</tr>
</tbody>
</table>

Quantitative Analysis

Unfortunately, analyzing the distribution within the Terrset program is limited due to its employment of a single quadrat size. Utilizing the R statistical package (version 3.2.2) we are able to see the distribution of storage pits in a variety of spatial scales. The K statistic of the Ripley’s K function gives us the ability to use numerous spatial scales to determine if points exhibit clustering. This was achieved through the R statistical package, version 3.2.2, as well as the “maptools”, “sp”, and “spatstat” packages. Employing this same analysis in R allows us to see if the same conclusions reached using point pattern analysis are reflected in R as well.

Using the R program we are able to see how hearths, representative of structures, were analyzed against 99 simulations of complete spatial randomness (CSR; Figure 17). If the data are random then the black line would remain in the gray highlighted area and close to the red dashed line, the expected CSR. What we see is very similar to our point pattern analysis results. Only at
low spatial scales, between 6 and 14 meters, is significant dispersion measured, meaning uniformity in the distribution. It was only at the lowest quadrat size in our point pattern analysis, 16 meters squared, that we observed systematic distribution as well. If you look at the path of the black line, we see that when the spatial scale increases the distribution becomes random. The data exhibit slight, but insignificant, clustering at larger spatial scales. Going one step further, the data were analyzed using the maximum absolute deviation test, or MAD. This test is also computed in R, but is based on 499 simulated distributions, instead of 99, and gives an overall significance test. The resulting MAD value produced equaled 770.88 with a P-value of 0.16. These values indicate that overall the data do not appear very different from randomness, although at the limited small spatial scales (about 8-13 m radius) significant uniformity is clear.

Figure 17. Illustrates the distribution of central hearths (91) with uniformity only at low radiuses, while randomness is observed at much larger scales.
The results from both the point pattern analysis and the analysis employed within R could be attributed to the number of structure types, or the spatial restrictions imposed upon the occupants. As the spatial scales are increased and the distribution becomes more clustered, this could be a result of the placement of circular structures. Since the majority of structures represented are of the long-rectangular type, this sample represents the systematic distribution at those low spatial scales. Apart from the obvious shape and size differences, the deviation in the location of circular structures could be pushing the distribution farther away from the systematic placement that long-rectangular structures appear to follow. Spatial restrictions might have limited the location options to particular places within the village.

Again, the same type of analysis employed to determine structure distribution was employed using the location data of pit features throughout the village. The distribution of n = 1916 storage pits was analyzed against 99 simulated distributions of complete spatial randomness (CSR). Figure 18 shows the deviation of the distribution (solid line) away from the expected envelope under CSR. Significant clustering is observed in the distribution of storage pits at all scales. Another test to test for clustering was utilized in R, called the maximum deviation test, which tests for the largest deviation seen in Figure 18. Using 499 simulated distributions resulted in a maximum absolute deviation (MAD) of 1296.1 and a p-value of 0.002, which also points to highly significant clustering.

Through the quantitative analysis above, we can see that the potential pit features present at Huff exhibit a clustered pattern, which is not surprising because visible they tend to cluster around houses and along fortification ditches. Previous population estimates at Huff and other Middle Missouri sites have largely relied on calculations based on floor size, not storage capacity. Although it is previous knowledge that the number of potential storage features is high,
Figure 18. Illustrates significant clustering of storage pits using Ripley’s K function in R. The black line is the observed value of K at spatial scales ranging from a radius of 0 – 50 m which falls outside the “envelope” generated by random data, pointing to clustering.

there have been no concrete estimates made with the most recent data set of the entire village. We know from the previous excavation data and historical documentation outlined in this analysis that a majority of storage pits were restricted to the exterior of structures. Using our totals for potential exterior storage pits (n=1497), it is now possible to list a range of potential capacity of corn storage. Comparing this to population estimates based on house size may lend to the surpluses documented in historical accounts. No matter how many potential storage pits are present the amount of people that could potentially live within such a compacted area remains limited. Factoring in occupation range, this likely surplus of corn could have solidified Huff as an economically viable player in mid-15th century Plains economic trade.
CHAPTER 5 - SUBSISTENCE OR SURPLUS

From the analysis outlined in Chapters 2 and 3 our focus has involved only principal features utilized by occupants: food storage and structure types. Both features are reflected clearly in the magnetometry data, food storage types dominating the subterranean landscape, while semi-subterranean houses with surface and subsurface reflections. Distribution and quantitative analysis have allowed us to quantify their patterns and enabled us to find unique characteristics about both features. In the end, by translating this data into capacity estimates we can help to narrow down the range of previous population estimates. Compared to past estimates based on house size (Wedel 1979), recent estimates using partial remote sensing data have pointed toward an extreme amount of surplus (Ahler and Kvamme 2000). The question remains, what do these surplus counts signify, and how do they translate into Huff’s representation within the Terminal Middle Missouri variant.

In past investigations researchers have used historical data, house size, and quantity of houses present to determine how many people likely occupied MMT sites. Wedel’s (1979) methodology is utilized by many, estimating populations based on floor size. However, it should be noted that his analysis involved prehistoric Central Plains groups. Based on internal spatial divisions of structures, he estimated a household area of 5 m² per person or eight persons per household (Wedel 1979: 94). Tiffany (2007: 11) utilized this method as well to determine Initial Middle Missouri site populations. Using historical data provides similar counts per household. Using David Thompson’s personal accounts of Hidatsa communities, Mitchell (2013: 63) estimates 8 to 10 people per household, but increases this number to 10 to 12 people for EMMV sites based on their increased house and village sizes (Mitchell 2013: 64).
Population estimates based on calculations of caloric support and the capacity of food storage has also been previously approached. Michael Scullin (2007: 93) examined farming yields to determine populations at the Price site. This was done in conjunction with his own attempts to replicate this number using native farming practices. His calculations included an average storage pit volume of 858 liters that could store 25 bushels of corn, totaling one acre of output needed for a single family of nine for a year (Scullin 2007). If we want to use a simpler means of calculating population using the same method, Munson’s (2004) one pit per acre cultivated to support 9 people per year, we would have an extreme population estimate of over 10,000 people for the total amount of exterior pits at Huff. This inflated number is unrealistic and provides the basis for why we should employ more than one method of calculating population capacity.

Historical documents like Gilbert L. Wilson’s (1987) Buffalo Bird Woman’s Garden are referenced in similar studies. They can be beneficial in terms of outlining potential storage pit contents, but the lack specific details necessary to achieve an accurate pit capacity estimate. Wilson outlines the specific steps taken during corn processing. For example, he references 55 ears of corn tied to a single string. Typically, these were the largest and best ears; smaller ears were left loose and shelled. When the pit was filled there were initially 30 strings, each string folded in half, spread around the circumference of the pit. Accounts document that two levels of 30 strings were stacked around the edge of the pit, the void in the center then filled with dried squash and topped with loose corn. Key information needed to use this method of calculating pit capacity includes how many levels of strings it took to fill the pit completely. We also know that other foods like squash were also stored amongst the corn, but their quantity is also missing in this estimate.
Both Scullin’s (2007) and Wilson’s (1987) methods for estimating capacity appear to exponentially inflate the total storage capacity of Huff. Even if you interpret exterior anomalies, \( n = 1497 \), as potential storage pits and assume they were all in use at the same time, that would total well over 250,000 bushels of corn for the entire village. Even half that number would be an extreme amount if we translated this into possible people present. Alternatively, this quantity could have been a surplus for economic purposes. During the historic period, the Mandan recognized the importance of trade and the demand by nomadic groups for necessary carbohydrates like corn. Therefore, corn surpluses were planned to accommodate future economic transactions. Not only were foodstuffs and clothing traded, like dried meats and hides, other items became valuable when commerce occurred later with European groups. Items such as guns, knives, glass beads, and metal pots were very valuable. The population at Huff could have made similar preparations for future economic transactions.

With the number of discrepancies and rough calculations in using the methodology above you can see the benefit of using other capacity calculations. Although not completely dissimilar, past investigations have taken a portion of this methodology and used just the volume of pits to examining storage capacity. During their 2000 investigation at Huff, Ahler and Kvamme (2000) estimated that there could be a total of 2,046 storage pits present. This estimation was based on the results of the survey completed from a portion of the site. Using their average volume of a storage pit, \( 1.2 \, \text{m}^3 \), and our count of 1,497 pits, this would equal a total volume of \( 1,796 \, \text{m}^3 \) for the village. Their estimated 28 to 29 bushels per pit would equal 43,384 total bushels. With only 78 percent of Huff’s magnetic anomalies digitized, due to the large swath of disturbance along the river’s edge, it is possible that a total of 55,620 bushels were present, using these calculations.
Michael Scullin (2007) also used volume to estimate the capacity of pits at the Price site. A volume of $0.85 \text{m}^3$ resulted from the average pit depth and base diameter measured there (Scullin 2007: 87). Using this estimated volume for the 1,497 pits at Huff equals $1,272 \text{m}^3$. His bushel per pit count is slightly lower as well, totaling 25 bushels (Scullin 2007: 93). This would make our estimated storage pit capacity equal a total of 31,800 bushels of corn per pit.

Comparedly, Susan Vehik (2007) and Adam Wiewel (2017) took a slightly different approach to determine the volume of a storage pit. Using the formula for a frustum cone allowed for more accurate measurements in regards to pit capacity, Vehik illustrating that most storage pits are not perfect cones but curved in a bell-like shape (2007: 205). Using this formula, with the average measurements of bell-shaped storage pits recorded during past excavations at Huff, we can estimate a volume of $0.95 \text{m}^3$ for each storage pit (Wood 1967). Estimated volume in the 1,497 possible exterior pits equals a total volume of $1,422 \text{m}^3$. The estimated number of bushels per pit is 27, the average of estimated used by Kvamme and Ahler and Scullin above. Using the total volume of $1,422 \text{m}^3$ and 27 bushels per pit, the total capacity would equal 38,397 bushels. If the disturbed portion of the village is accounted for, 22 percent, then the estimated amount could extend upwards of 49,223 bushels.

Having two previous investigations concerning Huff’s storage pit capacity (Ahler and Kvamme 2000, Wiewel 2017) allows us the opportunity to compare our results. Wiewel (2017: 108) estimated a larger capacity of 55,038 bushels, which is comparably lower than Ahler and Kvamme’s (2000: 34) estimate of 69,500 possible bushes. Although these estimates appear to be pointedly different from one another, including ours outlined above, each of the approaches was slightly different. Wiewel (2017) included pits internal and external pits in his total capacity estimate of $1,939.6 \text{m}^3$. Alternatively, Ahler and Kvamme (2000) only had partial data when they
estimated 2,455 m$^3$ of storage capacity. Our lower estimate of 1,422 m$^3$ falls short of both of these previous calculations. The reasoning behind this involved calculating capacity using only possible external pit magnetic anomalies. Previous excavation and historical data illustrate that external pits were primarily used for storage purposes. Utilizing only external pits was intentional in order to prevent inflating storage pit capacity estimates until further research can be conducted comparing internal and external storage pit contents at Huff Village.

In each of the examples we see that an extreme surplus of corn that could have been stored at Huff at a single time. This is important especially when comparing these large estimates to a projected population if using Mitchell’s methodology (2013: 64). If we were to apply Mitchell’s estimate of 10 to 12 people for the 116 structures present at Huff Village we would see a population range of 1,160 to 1,392 people. With its short occupation it seems probable that a majority of the pits constructed were used continuously. Although Wiewel (2017: 109) accurately remind us of the likelihood of pit construction failures, he also acknowledges the length of use extending beyond a few short years. Having such complex fortification features present can translate into a certain degree of preparation taken to provide protection to the residents at Huff. Could they have taken the same sort of preparation measures to ensure that a proper amount of reserves were in place as well? Comparing even the lowest of corn capacity estimates, the food simply outweighs the people it could possibly feed. These reserves could have translated to valuable social economic or nutritional survival in dire situations such as tribal conflict or environmental degradation.
CHAPTER 6 - CONCLUSIONS

In the past archaeologists have relied heavily on data from excavations to answer questions about prehistoric lifeways. Here the approach used is far from traditional, but has allowed us to come to important new conclusions. Even though these methodologies are far from new or ground breaking, using GIS with remote sensing followed by statistical analysis, I have been able to bring a level of clarity to long standing discussions about the past of Huff Village. Discussions revived here involve both the internal and external forces that shaped the past of people who lived there. The following is a summary of findings using these methodologies, some keeping with historical research and others deviating in new directions.

For over 50 years taxonomic descriptions demarked Huff as the end of the Middle Missouri tradition, a climactic period reached before representations of the variant disappeared. Huff and Shermer have long stood alone as the singular representations of the Terminal variant, their unique characteristics not aligning it completely with the Extended Variant of the MMT. Coalescent groups contrasted distinctly from the Middle Missouri tradition in many ways such as their dominant circular house form and village composition. The presence of new circular house forms pushes Huff into a new category. Now with this analysis we see attributes from both Extended and Coalescent sites at Huff, mainly represented through structure types present. With the data at hand and the results of the analysis it appears more appropriate to attribute Huff as an important stage in a transition, instead of the end of the Terminal Variant completely associated with the Middle Missouri Tradition.

Transitional attributes likely infiltrated Huff after the initial settlement was constructed. This is represented by the location and the patterning of the circular structures discovered. Not only are they restricted to the periphery, but they are also placed in a way that deviates from the
row patterned placement that influences a majority of the long-rectangular structures. From our point pattern analysis, we know that a clustered or systematic distribution exists amongst structures. This may have been influenced by the conflicting placement of circular houses compared to the placement of long-rectangular ones. Perhaps, the initial intent was to expand the population at Huff into those areas where circular structures were found. With the mounting pressures of surrounding social conflicts, external groups may have abandoned their own homelands to seek additional aid and protection. Alternatives seem unlikely, such as circular houses developing internally by Huff’s founding occupants. Development of transitional house forms would have been more apparent if this was the case. The short tenure at Huff supports the acceptance of outside groups in lieu of internal development.

When outside groups were accepted, it is unknown whether any integration of traditions occurred. Peripheral locations of circular structures could either be a function of location or spatial availability. Their locations could have had cultural implications as well. From the magnetometry imagery it is clear that the central plaza continued to be kept free of any major ground disturbing activities. What remains unclear is whether the placement of circular houses was intentional, purposefully keeping these structures farther from this sacred space. Wiewel (2017: 105) quantifies the association between house size and proximity to the central plaza using Pearson’s $r$, finding that larger structures do indeed be in closer proximity to the plaza than those farther away (Wiewel 2017: 105). Societal roles could have played a part in the occupation of these structures in relation to the central plaza, but further investigations would have to occur in order to bolster this conclusion.
Past versus Present

With the data presented before us, three main comparisons can be made between past and present knowledge. The largest comparison concerns structure types. Prior to this relatively recent survey, an overwhelming majority of the structures documented were of the long-rectangular type. Even though a four-post square structure was excavated by Wood (1967), it was the dominant long-rectangular structure type that firmly tied it to the Middle Missouri Tradition. Upon the discovery of circular structures we have been able to investigate further into how they compare physically to other village features. More importantly, we are aware now of other processes occurring during this time. Past work throughout Great Plains prehistoric sites have made clear the intense economic environment surrounding Huff. An argument for power in numbers can be made due to the sheer size of the original population, as well as the fortitude of their already established defenses.

Storage pits provide us with another significant comparison. Research conducted at Huff Village, prior to recent work within in the last decade, had never before calculated possible populations based on caloric support. Capacity extents were made based on the number and size of structures present. New structures discovered obviously increased the number of possible inhabitants, but also raised questions about their individual capacity as well. Internal organization of long-rectangular structures might have differed in comparison to circular ones. As illustrated in the previous chapter, using the number and quantity of storage pits to estimate population capacity far exceeds any realistic population estimated. Even though having a larger population in place might be considered the most appealing attribute to external groups, having such a large food storage system in place may have overruled this element. Food as a valuable commodity probably played an important role in the economic status at Huff village. With
surplus and people it could have meant a better chance of survival in such trying times.
Fortifications represent the effort made to protect inhabitants and could have been there to
protect valuable resources like food reserves as well.

Using both structures and extent of capacity to compare past versus present knowledge at Huff, we can see how Huff’s past is starting to come into focus. What remains a mystery is the fact that the occupation remains limited to a couple of decades. Physically, we can observe that all of the factors were there: protection, food, and people. So the largest question remains. Why was Huff abandoned? Looking at the relationship between circular and long-rectangular houses, the placement of structures built by adopted outside groups, we can see a possibility that expansion of original occupants was planned. We also can say with some degree of certainty that the food being produced was sufficient enough to support the original population well beyond its expectations. Were changes like population integration and additional food production so significant to warrant abandonment after such a short time? Is it possible that stronger external forces were at play, such as large environmental changes or dwindling local resources occurring at a quicker rate than estimated?

If we can take away anything from this analysis it is that our work is not complete. Additional research using these data can help lead us in the right direction. Continued work should begin by specifically examining circular and long-rectangular structure pit features. Similarities and differences in content, and measurable differences in composition (i.e. depths and volume), could communicate familial or societal roles. Studies determining the lifecycle exterior storage pits could also help in our understanding of the short occupation range indicated. Lastly, finding answers to the questions of where these external groups originated, should be pursued by examining the internal and external components of circular structures. This might
lend to the information regarding the events that occurred during this period in Great Plains prehistory.

Following these leads could help in our understanding of Huff’s founding and fall. It could also aid in determining if it is relatable to any other sites. Although our overall understanding of prehistoric Great Plains cultural interaction remains somewhat ambiguous, investigating Huff’s complexity can help further our knowledge about these relationships. All the research conducted at Huff Village is invaluable in this sense, its continuing complexity always enabling us to better shape and see what life was like back then.
REFERENCES CITED


