Location, Location, Location: A Probabilistic Model of Banked Earthwork Placement Within the Central Ohio Landscape During the Early and Middle Woodland Periods.

Dissertation

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

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2010

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Abstract

This research endeavors to explain why Ohio’s prehistoric inhabitants placed their earthworks on the Central Ohio landscape at those specific locations. It constructs a probabilistic model based on the locations of known archaeological sites from the Early and Middle Woodland period. Known locations were compared to a set of randomly placed comparison points using digital GIS landscape coverages, and remote sensing imagery to find areas where unknown earthwork sites were more likely to occur. The sample of nine known earthwork sites and nine randomly placed points were located in an arbitrary area of 3825 km$^2$ in Central Ohio.

For each of the 18 points, landscape and descriptive variables were collected to find a set of traits for each site. The variables were assessed statistically using Monte Carlo analyses and Multiple Components Analyses in SAS to see if differences existed between the two populations. While some of the variables did not have statistical significance, visual appraisal of the data did reveal patterns, for example, viewshed and gateway direction. For other variables, the statistical analyses did find that known archaeological sites were more likely to be found in certain environmental areas compared to the random points.

Of the variables that did have statistical significance, a number of them were then selected, intersected and clipped in the GIS coverages to identify Similar
Environmental Groupings on the Central Ohio landscape. These Similar Environmental Groupings were areas where certain variables co-occurred on the landscape. The GIS identified 69 such Similar Environmental Groupings, with 18 of those of special interest based on the variables tested. These Similar Environmental Groupings were places where Early or Middle Woodland earthwork sites were more likely to be located based on the statistical analyses.

Visual searching of the 69 Similar Environmental Grouping areas was conducted on various remote sensing imagery with the goal of finding vegetation or soil signatures that would indicate a buried archaeological earthwork structure. While no unknown sites were found visually, ground truthing with various geophysics techniques may find such buried evidence. This research has shown how difficult it is to pinpoint archaeological sites as there are so many variables and pragmatic events to consider. Nevertheless, the GIS model presented here is a dynamic one that can be adapted for further research.
Dedication

For all of mine.

And for my Great Aunt Ann, Great Aunt Kit and Great Uncle Bryn, my Granddad, my godfather Peter, my friend Kim, and my little cousin Jasper.
Acknowledgments

As always, a dissertation is not written by one person alone. Many different people and many different agencies had a hand in this work. My sincerest thanks go first to Bill Dancey for taking me on and letting me get on with this work and all the other forensic work I still did; I wish him continued success in his retirement. The other members of my committee also helped me greatly with their comments, especially Paul Scuilli whose statistical knowledge of SAS is unsurpassed. Julie Field kindly and expertly answered all my many GIS questions, helped me set up the model, and gave me computer space on which to do the work. Thanks too to Kevin Nolan who shared his Ohio DEM map data and also helped with GIS questions and Meg Morris who also understood the intricacies of GIS enquiry.

Many other people in outside agencies helped with comments and answers, looking for obscure data, searching through data with me, and providing various documents and disks, often for no recompense – a students’ dream! The Mid-Ohio Regional Planning Commission; the Ohio Department of Natural Resources - Division of Soil and Water Conservation (Mike Angle, Jim Raab, Doug Orr and Neil Martin), and the Division of Geological Survey (Donovan Powers); the Franklin County Engineers (Teel Slike); Ohio Department of Transportation’s Office of Aerial Engineering (Rick Hentz); the USDA NRCS Columbus Office (Bob Parkinson and
Rich Gehring), The Peabody Museum of Archaeology and Ethnology (Susan Haskell and Patricia Kervick); and The Robert S. Peabody Museum of Archaeology, Phillips Academy, Andover (Bonnie K. Sousa) deserve special recognition in that regard.

Martha Otto-Potter of The Ohio Historical Society allowed me access on multiple occasions to the archaeological records and collections that they hold. The other staff members, Bill Pickard and especially Linda Pansing, were also very accommodating and helpful with my research needs. Brent Eberhard of The Ohio Historical Preservation Office allowed me multiple visits to the Ohio Archaeological Inventory, National Register of Historic Places and NADB reports, along with access to their site topographic maps and other site info. He sent me customized database information that was instrumental to the research, plus he made suggestions about research direction during many entertaining conversations.

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One site that I have worked on for the last 6 years is the Holder-Wright site. The family has owned the land since 1820, and the current family members who manage the property, Joan Harless and Kaye Myers, gave me unprecedented access to their family home, land, relatives, friends, records, photos, recollections, collections, ideas, attempts to preserve the land, and social events. They all quickly became
friends. An archaeologist could not wish for a better relationship with landowners who have preservation and research at a premier archaeological site at the top of their agenda despite many attractive opportunities to develop or sell; Josephine would be so proud of her family! Jarrod Burks also collected multiple types of geophysical data from the north field at the site and was generous in his sharing of the results for my research.

My archaeological development would be nothing without the vast input from Ann F. Ramenofsky (University of New Mexico). She gave me incredible opportunities in my first summer as an undergraduate at UNM, so that by the time I applied for graduate school I had four research seasons at Pueblo San Marcos under my belt. She is a wonderful archaeologist, educator and friend. Once in Ohio, I had archaeological opportunities with The Cleveland Museum of Natural History (N’omi Greber), MWAC (Mark Lynott and Rinita Dalan), Mound City (Jennifer Pederson), and Voyageur Media (Tom Law). The Department of Anthropology at OSU gave me wonderful financial support, with a fellowship and multiple teaching opportunities, including running my own forensic field schools. The research in this volume was also supported by a grant from the Alumni Grants for Graduate Research and Scholarship from the OSU Graduate School.

My colleagues, friends, and neighbors also deserve recognition for their support during my long school years, which included multiple surgeries where they stepped up to help me out (many staff at the SHC and OSUH put me back together on multiple occasions and kept me healthy enough to continue school uninterrupted). I would also like to thank my Bricksertation committee. No dissertation would be
complete without at least one huge, distracting project; long term and perhaps ill-advised. I chose to build a large patio out of discarded historic Ohio bricks, which, along with other scavenged brick types, amounted to trying to fit together a finite number of nine different brick sizes and shapes into a coherent pattern. Never do this. It helped me appreciate the effort, time and mental acuity of the Moundbuilders even more. Friends (Jaime, Jen and Scott, Lara, Deb) helped me move 5 tons of gravel for the base, and I moved a few discs trying to level all the bricks. It turned out wonderfully……in the end……

The word processing part of this document was written entirely on Google Documents. It made revisions, backup and access a breeze. I also could not have written this tome without the help of Pandora ® radio – my funky disco/dub/technopop/punk/mod/Spanish guitar station and big band jazz stations got me through – you can’t be unhappy when listening to these types of music!

Finally, nothing would have happened without the love and support of Cindy, who fed me and supported me through the many ‘Dark Days’ of masters, candidacy and multiple draft writings. She was the one who suggested I go back to school 13 years ago; I didn’t want to – WOW; she knows much!
Vita


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  Earthwork Archaeology
  Woodland Period Archaeology
  Geographic Information Systems
  Remote Sensing Imagery Interpretation
  Geophysics Survey Techniques
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Chapter 1: Introduction

"The earth has hid them from the hand of time and they are found after the lapse of ages fresh and perfect, affording matter of much information to the historians, and have become a source of knowledge which they could not otherwise have obtained" (John Clifford, in Boewe 2000:31).

"The antiquity of man in the Ohio Valley is one of the dark and fathomless secrets of the past. Science has endeavored with but faint success to pierce its mystic shadows" (Lee 1892:19).

1.1 Introduction: Brief Overview of Research

This research explores and evaluates the question of whether banked earthworks were placed in the physiographic environment in Central Ohio based on non-random decision-making and specific landscape and environmental criteria selected by the prehistoric builders. That is, did the landscape and the environment influence where people built earthworks in prehistoric times? The subset of nine earthworks in this study comprises banked earthworks that are sometimes associated with mounds. “Banked” in this instance means an earthwork that encloses a lower space using higher earth walls rather than a mound that covers a space completely. These nine sites are located in Franklin and Delaware Counties in Central Ohio, and date to the Early Woodland (Adena culture) (800BC - 0AD) and Middle Woodland (Hopewell culture) (200BC - AD500) periods (Table 1).
This research uses the landscape over a large area to try and explain earthwork placement. To that end, an arbitrary rectangular of Central Ohio comprises the study area (Figure 1). This approach is along the lines of the "siteless survey" idea of Dunnell and Dancey (1983), where an arbitrary area is designated that is not based on specific artifact densities or the common notion of what makes an archaeological site. To enable comparison with areas where no earthworks are found, I constructed a subset of nine randomly placed points within Central Ohio and collected the same landscape information as for the nine known points (Figure 2). To place this research into the broader dialogue about monuments, I also explore and discuss the meaning of a built landscape as it pertains to monuments and compare it to similar research based in Europe.

In an attempt to understand the cultural principles used in earthwork construction I reviewed multiple aerial images dating from 1938 to the present, excavation records from the Ohio Historical Society, and regional and local GIS datasets to understand as many aspects of the known and random sites as possible (Figure 3). A GIS study teases apart the various aspects of the earthworks as separate layers (that can be viewed as composites at will) and allows us to see any consistency in where they are placed in the landscape. By characterizing the earthworks within the environment in Central Ohio, I find common environmental elements that explain their location, and thus establish a suite of environmental traits associated with certain earthworks. After statistical testing between landscape elements from the known and random sites to find which variables are significant, the GIS can help unravel the
various characteristics of the landscape and to search for other similar locations exhibiting those same co-occurring environmental traits or Similar Environmental Groupings. This probabilistic model identified a set of Similar Environmental Groupings in Central Ohio that *may* have earthworks on them. Viewing historic aerial images of those locations may identify any hereto unknown earthworks.

It is posited that the sites where earthworks are located in Central Ohio were deliberately selected because of the significance of features not only at the site, but also within the landscape that surrounded them. It follows then that assessing the environment of the earthworks will show commonalities between them in shared physiographic placement. To make this study more manageable, this research is limited to banked earthworks and does not include Woodland sites containing only mounds or domestic settlements. This is because historically a number of naturally made glacial mounds have been mapped as cultural features (see Mills 1914). Additionally, on remote sensing imagery or geophysical data, mounds are not as easy to discern compared to naturally made landscape elements. Built banked earthworks, however, can be readily visible in remote sensing imagery and ground truthed with various geophysical techniques, such as magnetometry, GPR, and resistivity (Clark 1996; Johnson 2006; Lynott 2001, 2002, 2009).

Populated by increasing numbers of people since the early 1800’s, Central Ohio could be described as a difficult place to try and find presently unknown earthworks. Many areas were surveyed for farm plots, construction, the mining industry and transportation, implying that most of the large earthworks and mounds in the area had
been noted and mapped (e.g. Mills 1914; OAI historical records). Nevertheless, in the late 1970’s a new earthwork was discovered by an amateur viewing aerial photographs (Anderson 1980). In the early 2000’s the Late Woodland Water Plant Site (just south of Columbus) was found to have a large ditch associated with it (visualized by magnetometry). In mid 2007, a new “C” shaped banked earthwork was detected by a gradiometer survey on farmland in Pickaway County, just south of Columbus (33PI917 The Keith Peters Square) (Nolan et al. 2008). And in 2008, a previously unknown circular earthwork was also found in the same area (33PI 1013 Campbell Circle) (Nolan, personal communication). Both sites are on the same land that contains the Reinhardt Village (33P1880); a well known and well visited site. These unexpected finds support the idea that unknown Woodland earthworks are preserved in Central Ohio, and even if they are presently destroyed, then they may be visible on old aerial photography dating prior to the 1950’s development boom.

Though the environment has changed over time since prehistoric people lived in Ohio, the geologic setting, soils, distance to water, and elevations will not have changed significantly in that time and thus can be assessed (Parkinson, 2009). If we cannot answer the question of why the built earthworks are where they are on the landscape then we cannot understand how the various elements of the pre-historic society may have worked together regionally. On a larger scale, we cannot understand why the earthwork phenomena came about and how it flourished. Understanding a new context of the landscape gives Ohio archaeology a platform of knowledge for future research.
Nobody really knows what the Ohio banked and mounded earthworks are for, yet they are at the very heart of what we know, and how we describe and characterize the Early Woodland Adena and Middle Woodland Hopewell cultures in this state. Both Ross County and Licking County in Southern Ohio have large tripartite and octagonal earthworks that have been researched almost exclusively for over two centuries, yet we still know little about what the earthworks were for, why they are there, and about the everyday lives of the people who built them. Central Ohio has really been considered peripheral to those earthworks of Southern Ohio (Greber 2006). I warrant that by understanding some of the marginalized earthworks in Central Ohio we can find out about some of the cultural principles used by the people who built them and explore Central Ohio's role in the state’s prehistory.

1.1.1 The Problem

Archaeologists and the public have long wondered why the prehistoric earthworks are placed where they are on the landscape. Often research is directed at the structure and function of the earthworks as separate entities that are both independent of the landscape they are in, and independent of each other. This research not only treats the landscape and the earthworks as a regional continuum (Bradley 1998:86), but also includes the landscape in the immediate vicinity of the earthworks in the form of a 1km buffer. Such a regional approach befits a community that is dispersed across the landscape but who use the earthworks variously as places for community meetings, ceremonies or burials (Dancey & Pacheco 1997). If, as Madsen states, burial is a
group activity (which could be two people), then a regional approach is indicated (1997:86).

The Woodland period earthworks of the Middle Ohio Valley are undeniably large, have complicated construction techniques, long construction histories and vary greatly in form, design and layout (Atwater 1833; Byers 1987; Clay 1987; Connolly 2004a & b; Lynott 2001, 2002, 2009; Lynott et al. 2005; Mills 1914; Shetrone 2004 [1930]; Squier & Davis 1848), but often involve similar constructions techniques, and artifactual depositions (Greber 2006:95). Across the region some sites resemble each other, (for example, the tripartite geometric works in the southern Scioto Valley area), while others have unique patterns, (for example, Black Run and Indian Fort). In studying the earthworks to find out why they are where they are on the landscape, and by understanding how the environment affected the decisions of the builders who created the earthworks, we can see how the whole environment (not just the site structure, see Robb, 1998) was important to the builders. If all that is Hopewell evolved through a human - land interaction (Pacheco & Dancey 2006), then earthwork placement within certain environments would have been as integral a part of that interaction as catchment choice and natural cycles.

Landscapes with mounds and earthworks on them are a dynamic environment. In fact, Charles et al. (2004) refer to Hopewell mounds not as cemeteries but as "active structures" (Charles et al. 2004:63, also see Knapp and Ashmore 1999) with long term cycles (Bradley 1998; Hutchinson & Aragon 2002; Relph 1989) and a part in social negotiations (Byers 1987; Buikstra & Charles 1999; Carr & Case 2005; Clay 1998;
This dynamic is shown in how site use can vary over time, with earthworks having elements added through time that may change how and why a community uses them. So, for example, there is an indication of independence between earthwork construction and mortuary practices. This is illustrated by some burial mounds having earthworks but not all and some earthworks having burial mounds but not all (Otto 1979). Byers (1987) reports that most earthwork enclosures actually lack burial mounds, and goes on to point out that at a number of sites the burial mounds and earthworks that do co-exist are separated spatially from each other, which implies an independence of activities between these elements. The nine sites in this current research show variation in the presence or absence of mounds. Some have no known mounds (Orange Township and Briggsdale), one or more enclosed mounds (Adler, Columbus Country Club, Dominion, Holder-Wright, Jackson Fort), and one or more enclosed mounds, and a mound incorporated into the earthen embankment (Spruce Run, Worthington Works). Nevertheless, due to a lack of intrasite chronology, and even intraelement chronology, it is not known what order the building at each site occurred.

Generally research shows that earthworks and mounds were accretionally built over long periods of time (Byers 1987; Connolly 2004 a & b; Dancey & Seeman 2005; Dragoo 1963), with use at some sites spanning hundreds of years, for example, the entire Middle Woodland period at Newark (Greber 2003). Such longevity begs answers about site choice and the surrounding environment. Some earthworks do exhibit
similar morphology over space in the Ohio area (Byers 1987); however, this does not necessarily mean that they are also chronological as well (see Greber 2003). This last point is difficult to clarify as similarities and differences in earthworks may be the result of intragenerational differences as much as intergenerational differences. As Greber (2003) points out, the quality of dating in early archaeology, along with obvious resolution problems (no site can be accurately dated below an approximately 100 year standard deviation) make it difficult to pick up intragenerational variation and intergenerational variation of less than five generations (assuming a 20 year generation). Site use, reuse, and disuse, by groups of people practicing different traditions and rituals could further conflate variation and differences until they were perhaps indiscernible, or conversely create variation and differences everywhere. For example, ceremonies could be different not only due to different family or tribal groups, but also because of other reasons, such as season, year, or multi-year cycles, and culturally pragmatic practices. Initially I do not consider site chronology as part of this study, as the nine known sites used in this research have missing or incomplete absolute dating.

Most Woodland research to date has implicitly assumed some type of intentional earthwork placement on the part of the persons who built the earthworks (but see Greber 2006:95). Early archaeological researchers thought that the earthworks were fortifications of some kind (Atwater 1833:18; Lee 1892; Squier & Davis 1848; though see Boewe 2000), that the mounds were for signaling (Lee 1892:25) and that the broken artifacts were evidence of warfare (Moorehead 1908:146). This thinking
was subsequently discarded (where were the weapons and war dead?), but apart from assuming that the placement decisions were for defensive purpose, there was little research into other aspects of earthwork placement on the landscape (Byers 1996, 2004; Dancey & Pacheco 1997). Some research couches the earthworks in a narrow light of structure as function (Romaine 2000) but without including local context. Other research attempts to explain the social implications of the earthworks’ using time and motion data (Bernadini 2004). This current research strives to reduce the burden of assumption when considering earthworks in the landscape by integrating existing research using a GIS to classify and sort the information in a probabilistic model, and viewing existing remote sensing imagery to test for potential new sites. Therefore, I test decisions about where pre-historic builders built the earthworks by using multiple lines of empirical data, to contribute to a clearer and more comprehensive understanding of the Woodland earthwork archaeology of Central Ohio.

This research cannot be based solely on the historically reported or imaged manifestation of the nine Central Ohio earthworks. Historical accounts were written some 4,500 – 1,500 yrs after the monument may have been built, and aerial images are even more recent. In the time since construction natural, biological and cultural processes have changed the earthworks and the landscape. Additionally, to assume earthworks have a finished form, even in the past, let alone accepting them now as finished in their present form, is obviously fraught with many assumptions and misconceptions (Bradley 1998; Chapman 2006). As Clay states, the earthworks we see are not a sum of their parts necessarily for the pre-historic builders. Construction
sequences, element development and modifications all play a part in their appearance now (Clay 2002:173).

Rather than questions about earthwork forms or structure then, the issue becomes -Why is an earthwork (in whatever form it is) located on the landscape at that particular place? That is, based on cultural principles, people are making decisions about building earthworks based on the resources found in their environment. I assume they have certain criteria to meet when considering earthwork placement. While those criteria doubtless evolve non-directionally across time and space, it is parsimonious to assume that some basics remain the same. That is, each subsequent generation is not going to reinvent the wheel each time they need to create a built landscape, and will find ideas in the existing landscape.

This research uses a number of theoretical assumptions. To help guide this research, I borrow some aspects from Human Behavioral Ecology, Evolutionary Archaeology, Gene-Culture Co-evolution (or Dual Inheritance Theory) and Phenomenological approaches. These theories are used as a framework to inform the model generally, rather than to structure the work specifically, and to guide the assumption that landscape choice for earthwork location is non-random. From Human Behavioral Ecology I take Optimal Foraging Theory (specifically Patch Choice) to state that Pre-historic people are choosing specific patches of land to build on based on some intrinsic, perceived value. Gene Culture Co-evolution helps explain variation in earthwork form. Gene Culture Co-evolution discusses the concepts of biases (direct, indirect, and frequency dependent biases). These biases, inherent in how culture is
inherited, would explain the change over time in earthwork forms. It also helps explain the continuation of earthwork building over a long period of time. Boyd and Richerson say “selection ought to favor shortcuts to learning” and they continue that “cultural inheritance is adaptive because it is such a shortcut” (1985:14). The combination of culture, environment, and ecology is also affecting what people build (form) but not where they build (landscape). Evolutionary Archaeology is used to explain the earthworks from the point of view of waste behavior, signaling and bet-hedging, traits that may explain the rise and fall of earthwork building. Finally, Phenomenology is used to explain the experiential nature of the earthworks, which perhaps can give us some insight into their meaning with regards to where they are placed within the landscape.

Using this eclectic mix of theories as an heuristic tool allows this research to relate the decisions and behaviors of past peoples to the environment. The model is also termed probabilistic rather than predictive for good reason. The word predictive indicates a future condition, a prophecy and a foretelling, which suggests I know where the sites are already. On the other hand, a probabilistic model using statistics, a forecasting that can be affected by chance, suggests where the object of choice may tend to be rather than where they are.

This research is based on groups of people in the past making conscious choices about the locations of their earthwork construction sites. Why they may do this is unclear, but reasons may include negotiation with and between groups, a need to dominate the cultural landscape, or a need to satisfy a belief system. I assess
environmental variables at nine existing sites (known sites) and compare them to a randomly placed sample of nine points (random sites). Statistically identifying a set of design rules (sensu Connolly & Sunderhaus 2004), or suite of landscape traits associated with earthwork placement, allows testing for the co-occurrence of those same traits in the Central Ohio area within a Geographic Information System (GIS). The Similar Environmental Groupings are areas where there is a higher probability of finding earthwork sites. Reviewing multiple sources of existing remote sensing imagery did not reveal such sites, but future field research could survey those Similar Environmental Groupings with geophysical prospecting that may detect the buried signatures of unknown earthwork sites.

This original research on the Central Ohio earthworks will add to the intellectual knowledge of Ohio archaeology in seven ways. First, this research contributes to illuminating the neglected banked earthworks of Central Ohio. With much of Central Ohio already under development, or threatened by it, any attempt to find unknown sites needs to be done sooner rather than later. Second, this research coordinated a large body of research materials by collating and synthesizing earlier published and unpublished research, making this disparate information more accessible to a wider audience outside of Columbus, Ohio. Third, this research collated readily available remote sensing data, and visually searched the images for traces of mapped and unmapped earthworks. Remote sensing imagery is now digitally available from many local, state and federal agencies. On a computer screen it is much easier to enlarge a photograph, and manipulate contrast and brightness, to thoroughly search for
vegetation and soil signatures that may indicate a pre-historic site. As historic satellite data becomes cheaper that too can be searched. This option makes it easier to use remote sensing from multiple years to construct a time series for a site or area. All of the imagery considered had not been taken exclusively for archaeological research, but had been taken for a variety of other reasons, e.g. soil conservation, Mid-Ohio Regional Planning Commission (MORPC) etc, thus reviewing existing information for new information. Fourth, data in a GIS environment created various models that attempted to explain the decisions behind why earthworks are placed in the environment in the locations that we find them. These models used environmental data that visualized landscape physiography. Once this probabilistic model has been created using GIS coverages and remote sensing data, it can be added to and updated ad infinitum and used to search for, for example, different site types, different attribute choices of site placement, and different earthwork chronologies. Fifth, this research identified Similar Environmental Groupings that may contain earthworks. Sixth, future geophysics research is possible at these Similar Environmental Groupings, searching them for earthwork signatures. Seventh, there are educational opportunities within the local community of Columbus that will help the general public of Ohio further understand the individuals that lived within the landscape before the modern city developed.

In summary, few archaeologists would deny that the prehistoric earthwork builders used cultural principles in building their earthworks over a 1,500 years of pre-history; cultural principles that we now use to inform a great deal of our understanding
about the builders. This research expected to find some consistent and quantifiable patterns over where on the Central Ohio landscape, banked earthworks were built. Using an inductive approach, from specific sites to a general landscape of Similar Environmental Groupings, and then a deductive analysis, from those Similar Environmental Groupings to specific areas, enables the research to continually reassess the problem. Quantifying the Ohio landscape in a GIS framework allowed a more in-depth understanding of the ancient Ohio people and the relationship they had with their environment. The results do find some statistically significant relationships in what decisions the Native Americans in Ohio may have made about the environment and how it pertained to their construction of the Central Ohio built landscape.

The following sections of this chapter cover Adena and Hopewell burial practices, the built landscape and theoretical issues that guide this research, finally ending with a synthetic discussion of all the subjects covered here, trying to discern how the mound builders made spatial decisions.

1.2 Adena and Hopewell Burial Practices

A discussion of site choice by the people who built and the Central Ohio banked earthworks needs to be couched in context. As banked earthworks are often archaeologically associated with death rituals and burials, this section discusses briefly the burial practices of the Adena and Hopewell people. (Chapter three deals with settlement and subsistence during that time).
1.2.1 Adena

Some antecedents to earthworks and mounds are seen in the Archaic period (for example, Watson Brake is dated at 3,400BC and Poverty Point dated to 1,600BC, both in Louisiana [Milner 2004:48]), but it is during the Early Woodland that both became more prevalent and widespread in the Eastern United States. The Adena began the widespread custom of burying their dead in large, conical mounds (Dragoo 1963; Webb & Snow 1974). The time period that Adena was prevalent was not that extensive; Dancey places the range of dates for the Adena between approximately 500 years B.C. and A.D 200 (Dancey 1996:3). A checklist of traits primarily defined the Adena type. As Greenman (1932) found out during his analysis, the traits that Adena held in common were based on mounds built over burials and little else about their remains was similar. Later Webb & Snow wrote “They held in common very little in the way of burial practices or grave goods” (1974:vii). Apparently there seemed to be more differences than similarities in all that was Adena.

Adena mounds were earthen, with stone, bark or logs used to line burial and cremation areas (Dancey 1996:314-315). Mounds varied markedly from 3 m in diameter and 1 m high, to 46 m wide by 168 m long and 9 m high, continuing multiple or single burials (Dancey 1996:315). The Adena mounds appear to be built using separate basket loads of clay weighing about 30 pounds each and consisting of many different colors (Webb & Snow 1974:41), and were built either over a burial in a house sub floor, a cremation or a log tomb (Webb & Snow 1974:43). Adena mounded burial
complexes are found around the Ohio, Illinois, Southeastern Indiana, Kentucky, West Virginia and Pennsylvania region with the majority of the mounds falling in Ohio.

Banked earthworks are also part of the Adena landscape, though these aspects seem to be independent of mounds. That is, they were not built at the same time as each other. Early Adena did not seem to have sacred circles, moats or other earthworks associated with the simple burial mounds (Dragoo 1976:18), but the occurrence of more extensive earthworks enclosing burial mound becomes more prevalent in the Late Adena (Dragoo 1963:207). Webb and Snow (1945) state that these Adena sacred circles and earthworks are known to arise in groups of two to eight. They suggest this may be to provide a phratry (a subdivision of the group, probably of related clans); which is a private place to meet – a type of a clubhouse for members. There are few circular or earthen enclosures in the Woodland Southeast, (Fort Center in Florida is one exception) with only a few charnel house and mounds located there (Anderson & Mainfort 2002:7).

Certainly, in Adena times, banked earthworks were built some time after the mounds, as if later delineating the sacred space that the mound covered (Clay 1987; Clay 1991). Interestingly, this could either mean independence of the earthworks from mounds or dependence of the earthworks on the mounds, as the spaces that Adena earthworks enclosed were sometimes themselves closed off by building a burial mound in them (Clay 1998), suggesting a change of site function through time. According to Clay (1992), their burial mounds acted as a method of social storage in that the ritual of burying a dead individual brought together different social groups from around the
region in one place. He believes that each mound was used by multiple groups over a period of time, and that the act of gathering together allowed integration and social negotiation between these different groups. Therefore, they had a shared history, both in creating the mounds and also participating in and sharing a similar cultural ideology (Clay 1992:80).

For the most part Adena mounds seem to have had the purpose of housing the dead, whether the dead were enclosed in log tomb, cremated or in a multiple burial sub floor tomb (Webb & Snow 1974:43). In Clay’s view, individual burials were events or single episodes, whereas the earthworks and mounds found with them were accretional, long term processes with no definitive end or finished product in mind at the outset. Thus there was no planning involved for a finished product. The mounds were accreted episodically with two, three or four burials added to the original one and the mound gaining not only in height, but also in area (Webb & Snow 1974:37). As Dancey succinctly states the “. . . Adena consists of a pattern of burial in which the individual is placed in a shallow sealed grave or a log tomb, or is simply laid out on the surface and then covered with earth. Most burials are single, extended inhumations, although cremations and bundle burials are known, as are instances of multiple burials (two to three individuals)” (Dancey 1996:2).

Sometimes these building episodes could be separated by a large enough time period that stratigraphically the building episodes were quite distinct, which suggests pan-generational use by similar groups (Dragoo 1963:164). Artifacts in Adena mounds included leaf points, some mica pieces, engraved tablets, and upright effigy pipes.
The placing of Adena burial sites near water, with engraved stone tablets and destruction of mortuary structures by fire are all analogous to some Native American groups who describe this trio as “purifying” (Korp 1990:65), and some similar effect may have been experienced by the Adena. Korp suggests that water to the east of the earthwork was the most desired orientation when the Adena people chose a site, and perhaps this signifies some ideological affiliation (Korp 1990:51). Long term domestic habitation was not associated with mound sites (though see Potter-Otto 2004), which seemed to function as burial and ritual sites only, with some small, short-term specialist camps for individuals associated with processing and burying the dead. The Adena culture persisted (even in its decline) to overlap with the Hopewell for a number of years (Abrams 2009, although see Seeman and Branch 2006).

1.3.1 Hopewell

The succeeding cultural period to the Adena, the Hopewell, does share many Adena characteristics with its predecessor (Webb & Snow 1974:iix). Dates for the Hopewell culture range from 200 B.C. to A.D. 400 (Dancey 1996:314). The Hopewell also had a propensity to build their hexagonal, circular and rectangular earthworks near water (Anon 1914:410), especially rivers and spring fed streams with some small village clusters nearby (Atwater 1833:151; Boewe 2000:2; Dancey & Pacheco 1997:3; Carskadden & Morton 1997:365; Thomas 1985 [1894]:459, 470). Other traits that define Hopewell are more cremations than inhumations, crematory basins, mica cutouts, platform pipes, long-distance exotics (De Boer 2004), prismatic bladelet
manufacture and copper products, especially ear spools (Webb & Snow 1974). Hopewell traits are recognized over much of the Eastern quarter of the USA from just west of the Mississippi River through parts of Georgia and West Virginia, and from Wisconsin and Michigan to the Gulf of Mexico (Abrams 2009:170 Figure 1). Mounds and earthworks continue to be atypical in the Woodland Southeast (Anderson & Mainfort 2002:9). Commonly termed the Hopewell Interaction Sphere, the area shows much variation around a number of common themes.

Byers (1987) believes that artifacts found in earthworks are as important as the enclosures themselves. Charles et al. (2004) also look at the concept of the mineral deposits used by the Hopewell and conclude that the minerals chosen and used by the Hopewell peoples were important as part of the communication they needed across regionally distinct groups. That implies a certain degree of planning for the earthworks and their contents. Hopewell remains that are chronologically later than Adena suggest some cultural continuity between the Adena and Hopewell people, and for those Hopewell remains that are contemporary with Adena, it suggest a fluidity of cultural information between the Adena and Hopewell (see also Carskadden & Morton 1997).

The Middle Woodland period exhibited a rise in both quantity and variability of earthworks and mounds. Built environments with circles, squares, causeways, mounds and octagons became prevalent throughout this time. The earthworks appear to have had spatial restrictions built into them, with restrictions on access in the form of ditches, banks and segmentation of the earth banks with gateways. These structures could then only be entered in one or two ways, and different segments of the audience
may be kept at different distances and with different viewpoints, e.g. watching from an entrance, or watching from the top of a bank, or being inside the enclosure. Earthworks with gateways were common (Fort Ancient has just under 60 gateways), with those who could enter the internally defined space restricted to specific entrances. Three different types of gateways are apparent at Fort Ancient, which suggest that either it was designed so that different groups of people would or would not have access to the central space, or that different rituals were being held there that required different construction rules. For some of the great gateways at Fort Ancient, this meant walking over the graves of ancestors (Connolly & Sunderhaus 2004). Gateways could function in three ways. First they could restrict the number of people who could physically enter into the earthworks at any one time. Second, they could restrict the view into the earthworks by people outside (people either waiting to get in, who could not get in, or were not allowed in). Three, they would also restrict the view that any audience inside the earthworks may have of the activities occurring outside the earthworks.

Hopewell earthworks do have non-domestic structures in them that are different in form from the dispersed domestic households (Dancey & Pacheco 1997). The dispersed household concept explained by the Vacant Ceremonial Center model of Prufer (1964) holds that domestic households will not be found in or attached to ceremonial sites. These non-domestic structures appear to have acted as charnel houses for the Hopewell people (Greber 1979; Seeman 1979). These charnel houses were large corporate structures, which are made up of square and circular components, resemble round domestic structures according to Smith (1992) (in the same way that
Richard Bradley (1998) thinks the long barrow burials of Neolithic England mirror the ancestral longhouses of Europe. This resemblance between domestic and ceremonial links the two spheres ceremonially, whilst physically keeping the day-to-day aspect of living separate from the ceremonial. Charnel houses are found at seventeen sites in Ohio (Seeman 1979), and appear to have patterning of differentiation of burials that was tripartite in nature (Greber 1979) and thought to mirror divisions in a society that was otherwise egalitarian. At Seip’s tripartite earthworks Greber (1997) concluded that there was too much midden accumulation for it to conform to the Vacant Ceremonial Center model of Prufer (1964), and that people did live long term at the site in a domestic capacity. Conversely, others say these geometric earthworks and corporate burials may have had the purpose of binding together a dispersed population who did not live at the earthworks (Clay 1992; Dancey & Pacheco 1997; Yerkes 2002). Perhaps as groups of people who came together at prescribed times, such as seasons or moon phases, and perhaps in different group types, such as clans, family, sex, age, or totem. Whatever the reason for the earthworks, once nucleated settlements became prevalent at the end of the Middle Woodland period, earthworks ceased to be built or maintained.

Reasons for the 'collapse' of the Hopewell Interaction Sphere are often many and varied too (see the discussion section at the end of this chapter for a more in-depth view). For example, Dragoo cites a change in the economic base of the society as the cause, when the success of the population growth led to localized authorities challenging the elite represented in the burials because that elite “... had become
overbearing and opulent” (Dragoo 1976:19). This type of inference stems from what Ford says is a misinterpretation by archaeologists of exotic goods, that archaeologists see a culture’s lust for non-local materials as indicative of a non-egalitarian society, when tribal people also have a history with trading exotics (1974:402). Certainly non-egalitarian practices could be inferred if public access, or use of, an earthwork or mound is restricted. Earthworks with gateways (a trait of Hopewell) would restrict those who could enter the space within to specific entrances. Dunnell and Greenlee (1999), postulate an evolutionary explanation for the cessation of building large earthen works. They explain that when earthwork building ceased to be a selective advantage the trait would die out (in this case they cite resources becoming more abundant as the climate changed [1999:381]). This is a variation on a theme that Braun postulated in 1986, when he stated that a predictable subsistence, better storage and more diverse plant use would enable earthwork building to cease (1986:123). The Late Woodland period does have just a few earthworks constructed in the Ohio area. These effigy mounds, numbering six according to the OAI database, tend to be in the south of Ohio.

Eastern American mounds had wooden structures in which the dead were laid out, sometimes over long periods of time (Fowler 2003:53; Greber 1979; Seeman 1979). Once the structure was finished with and burnt a new structure would take its place, creating structures that delineated space. In these structures they processed their dead, perhaps over a series of stages and taking years before the remains of the deceased reached a final resting place. Earthworks may themselves be about
remembering where ancestors are buried by simply marking the landscape with a permanent, enduring marker (Williams 2003).

The burial types found in the Woodland time period vary from fleshed, to defleshed, bundle and cremation and may indicate different status, clans, changes in burial over time, or burials stages on a continuum ending at cremation. That we have so many different burial types at Central Ohio sites may just be the cessation of that continuum (see Hutchinson & Aragon 2002:28-30, 42, 43) as family groups died out, or knowledge of a burials' whereabouts was lost and the cycle was unfinished (see also Bradley 1998:92, who uses the term "amalgam of phases"). Hutchinson and Aragon also point out that variation in burial types may have as much to do with the varied status of the dead as it did with the ambitions of the bereaved, who are conducting the burial ritual. Using skeletal morphology, Reichs did find that there were no genetic differences between cremated remains and buried remains in Ohio, suggesting that they were part of the same genetic group. She attributes cremations and burials to different phases of the death ritual (Reichs 1975:136). Additionally, the difference between inhumation and cremations may serve to demarcate the dead in several ways. Some of the dead may need a soul released or to stop them walking among the living (use of burning), some dead may be deified, or need to have their essence 'movable' within the bone (use of burial) (Hutchinson & Aragon 2002:30-31.

At both Adena and Hopewell sites, burial seemed to be a series of events, such as preburial, processing, burial, exhumation, bundling, reburial, or preburial, processing, cremation, and/or reburial. These processes may also occur between a
number of sites, if bone and artifact bundles were taken by kin across a region to a specific sacred area at a later date (see Clay 2002a). This series of burial events then is predicated on biological or fictive kin being available, willing, and able to preside over each event segment that may continue over a number of years within some kind of cycle. Some kind of continuity would be required for a ritual to be passed down the generations. Mills (2003:124), found genetic evidence to group the Hopewell people with the Late Archaic and Adena (Early Woodland) groups, but not with the subsequent Fort Ancient culture. This is also confirmed in the Central Ohio drainage by Johnston (2002:17). Rituals and ceremonials would also be specific to the individual who was dead (and specific to their role in life), which kin were performing the ritual, the location of the remains (which site for which occasion), what part of the cycle was being performed, and future requirements to access the remains, etc. Any interruption to any of these aspects would stop or change the path of the cycle for that dead individual and render differences in the burial record as we find them in an archaeological context (Dancey 2005). Interruptions may be caused by the deaths of any of the keepers of ritual information, disease, warfare, nutritional distress, and climactic extremes.

1.3 The Built Landscape and Theoretical Considerations

This section provides a discussion of the idea of the built landscape, along with the theoretical basis of the discussion concerning environmental choices as part of cultural
behavior. It ends with a short synopsis of research into how much effort went into building earthworks, and thus what inferences can be drawn from such data.

While the specific behaviors that the prehistoric builders engaged in as they created the built landscape cannot be known, it is posited that the earthworks can be used as a proxy for some of those behaviors. This rationale is based on the energy required to produce the large earthworks, their complex arrangements, their distribution over a wide area, and the long time period during the Early and Middle Woodland that they abound (Atwater 1833; Byers 1987; Clay 1987; Connolly 2004a & b; Lynott 2001, 2003, 2009; Mills 1914; Shetrone 2004 [1930]; Squier & Davis 1848; Tainter 1975). Such large labor input, the prehistoric builders’ attention to specific construction components, and the cultural continuity of form implies that people did not simply throw these earthworks onto the landscape in a haphazard fashion. If they had some kind of intent, it should be decipherable. During the Early and Middle Woodland time, groups of people had some cultural continuity in other aspects of their lives so I suspect there would be some continuity in the way the banked earthworks were built too.

The builders would have rules, ways of building that were meaningful to them and the dead they buried (sensu Charles & Buikstra 2002). Much like a language has grammar rules for creating sentences, earthworks builders could also have construction rules (sensu Connolly & Sunderhaus 2004; Leone 1982:743). That language could change over time (e.g., compare the English language used in Beowulf, Chaucer, Shakespeare, and Becket) and so construction styles may change, but with a basic form
that remained similar. Construction rules would also be apparent if related groups built, shared and used more than one earthwork in a region over time. Regionally, group cohesion in the form of a peer polity (Pacheco & Dancey 2006; Greber 2006:95) might shape how earthwork elements were related and the choice of the landscape they were constructed in.

This research uses aspects of Human Behavioral Ecology, Evolutionary Archaeology, Gene-Culture Co-evolution and Phenomenology to guide it. Human Behavioral Ecology considers how individual behaviors work in different environments, when appropriating resources (Dyson-Hudson & Smith 1978), using models such as Optimal Foraging Theory, including patch choice (Kelly 1995). Though the analysis is at the level of the individual, the collective acts of those individuals will have an effect on a population. Those acts have relative benefits to a population compared to other groups. Human Behavioral Ecology uses the currency of calories (or other food specific value), so resources (returns) can be counted based on effort (output). I make inferences about the environments that people are choosing for their earthworks not based on a food resource value, but based on some intrinsic value they had. What that value was or why a place was specifically chosen is difficulty to understand except in broad terms. While that value cannot be calculated in the same way as calories can be, it can quantified in part by the use of a comparative population, or the nine random points I use. Comparing certain traits statistically shows that some patches of land where earthworks are sited are used more non-randomly, that is they are valued more than others.
Evolutionary Archaeology looks at change in frequency of traits through time using a non-directional framework. Proponents see culture as an extended phenotype interacting with the environment, and as such a group’s culture (as well as its biology) is under evolutionary forces (Dunnell 1995). Modified behavior is passed on from generation to generation, leading to variation in the archaeological record. This approach is at odds with a Culture History approach, which relies on types, categories or units of similarity to provide cultural labels. This materialist paradox, of how to explain variation while using fixed types (Dunnell 1995), is a difficult one to overcome. I use the terminology of Adena and Hopewell in this research along with a chronology at a site (if one exists), both of which imply a fixed category, and yet my sample shows variation and spans a long time period. That said, studying the dynamic and variable Central Ohio cultural landscape of earthworks means 'starting' somewhere. If there is a cultural continuity between the Adena and Hopewell people, then whether an earthwork is Adena or Hopewell is irrelevant to start with. In fact by seeking commonalities between the nine earthworks presented here, I am, by definition, implying a cultural link between the people who built them and thus in effect argue against Adena and Hopewell being completely separate cultural entities. Earthworks, as a trait, may have conferred an advantage to those groups building them (or at least neutral or only mildly deleterious), as it did prevail for a number of generations. Once the trait was not a benefit in the Central Ohio region, earthwork building died out and they are not found in the Late Woodland. As Tainter states “organization in any system can only be sustained by energy inputs for without such inputs a system will
evolve toward entropy” (1975:112), which is what he says happened between the Middle and Late Woodland (1975:83).

Gene Culture Coevolution (Boyd & Richerson 1985) views cultural variation as a product of forces. Just as an 'organism' is subjected to natural selection and may respond adaptively creating variation, so through time decision rules would suffer from transmission biases that change those rules and also lead to variation. They apply this view to biology and culture, with each affecting the other and leading to a co-evolution of both. This is similar to the design rules that Connolly and Sunderhaus (2004) found at Fort Ancient. The way Fort Ancient was constructed had rules that changed through time and may be the result of selective forces in the same vein as Gene Culture Coevolution. Cummings (2003) also talks about how building a monument is as much about forgetting certain things and remembering others perhaps as a result of those selective forces. With an underlying structure, variation could be a result of that selection. To that end, I do not think there is a certain gene that people have that makes them build earthworks. Nevertheless, I think genes that influence how we remember or forget (whether those genes are affected by pathology, trauma, and age or just how memories are processed and stored) could be expressed in how the landscape is inscribed with cultural monuments, and thus could be viewed under the Gene Culture Coevolution umbrella. Earthwork building, as an expression of the need to remember in a certain way, would vary over time (both in a presence or absence of earthworks or the variation within earthworks) based on the interaction of biology and culture.
In sociology, Scholte defines Phenomenology as “subjective aspects of human conduct” that “create shared meaning” (Scholte 1976:585). Researchers like Evans-Pritchard and Geertz used some Phenomenology in their cultural anthropology research (Scholte 1976:585). In archaeology, however (specifically European archaeology), Phenomenology did not take root until the late 1980’s and 1990’s with works by Bradley (1998), Hodder (1987), and Tilley (1994). In archaeology this concept was used by the interpretive movement to put the ‘why’ into archaeological research, a why that looked beyond structure and function, and process and change. Phenomenology in archaeology uses scientific principles and statistical analysis to measure aspects of the landscape that have traditionally been ignored, e.g., acoustics, textures, viewscape, design sidedness of monuments, etc. Phenomenology research looks at not only a monument as a whole but also its individual components and (most importantly) its setting in the local landscape and the distant landscape. It is interested in the combined senses of touch, sound, and sight, as opposed to simple size, weight, configuration and direction that archaeological research often follows. Hope (2003) suggests that a visual remembrance is the strongest of the senses, but also does not dismiss sound, smell, taste and touch as evocative elements of the funereal process (Hope 2003:118), and any or all of these may also have been a feature of rituals at the prehistoric monuments in Europe and Central Ohio.

There has been some research recently on both sides of the Atlantic into the built landscape that combines the basic tenets of science with a phenomenological interpretation (Bradley 1998; Hodder & Cessford 2004; Potter 2004; Williams 2003).
Applying the phenomenology of large stone monuments to earthworks and mounds is difficult because the form of the earthworks and mounds has undoubtedly been more damaged over time. In this research, working with mainly diminished or destroyed earthen monuments compared to stone in Europe does, however, limit a totally Phenomenology treatment of Central Ohio (Chapman 2006). Large stone monuments, which abound in the UK and Europe, lend themselves to investigations of sensory perceptions of texture, acoustics, view, etc., while wood and earth, commonly used in earthworks and mounds in Ohio, does not have the same rigidity of shape and imperviousness as stone does.

With relation to the Central Ohio Adena and Hopewell earthworks, a phenomenological approach can be applied to those cultures and the aspects of the monumental works that exist today. In the area, the materials used for building the mounds and earthworks are mainly earth, with some limestone, other rocks mainly sandstone, wood and bark, all items that were readily available and probably evoked a belonging to the landscape. Cultural memory of earthworks and forms on the landscape must also have been involved as both the Adena and Hopewell earthworks continued to be built over many generations. Although the form of an earthwork changed over time due to natural site formation and cultural processes of additions and abandonment, the landscape for each individual site did not change. In fact, the continuity of a site over a long period of time was probably a major part of evoking the past. Seeman and Branch consider the effect that all the Adena mounds in Ohio would have had on the Hopewell peoples in the state (2006:108). They argue that ". . .
Hopewell mound placement decisions were made within a context rich in possibilities for building both spatial continuities and discontinuities with the Adena past as new identities were constructed through ritual practice" (2006:108). This is also a point that Williams makes when discussing monuments in early Anglo-Saxon England (1998). He says "Anglo-Saxon burial mounds created and maintained symbolic relationships with ancient monuments and achieved this through the emulation, alteration and elaboration of more ancient structures prehistoric and Roman structures" (1998:102). To be fair, Anglo-Saxons’ relationships with Roman structures probably have different political implications than the relationships between Adena and Hopewell. Nevertheless, reusing a site in some way, or emulating it in a newly built structure, could be a way for people to retake the past, associate with the past or remake the past in some form or other that was meaningful to them.

1.3.1 Space and Place.

Though this research deals with cultural phenomena, it is essentially spatial. Ingold (1986) uses a geographic concept (now commonly used in Geographic Information Systems analysis), to explain the dimensionality of places. This conceptualizes places (points) as having zero dimension and paths (lines) as possessing one dimension. Such a way of viewing space would apply to hunter-gatherers who “. . . define their territories by the views seen from . . .” the places [points] and paths [lines] (Bradley 2001:95). This is in direct contrast to European agriculturalists who delineate a piece of ground in two dimensions (an enclosed polygon). Therefore, the viewscape
would change from what could be seen from a place to what is seen in a place. Such a bounded place then starts to become an ‘inside’ area, a territory, a tenured scale that needs to be defended (e.g. Tuan 1975:163). Thus the concept of space, of viewscape, of a hunter-gatherer group is transformed from zero or one dimensions into a two dimensional place that is looked in upon as separate to the outside. During this transformative time in the United Kingdom, monument building took on these two different concepts of the land, added myth and cultural historical memories, put them together to produce a highly stylized and symbolic mixed bag, and expressed that as cultural elaboration in a multitude of built landscapes. It would not be beyond comprehension to view mound and earthwork building going through the same process in North America, transforming a space to a place (though not necessarily due to an agricultural transformation as in Europe).

The creation of a built landscape is an important concept. Tuan states “A work of sculptural art or architecture . . . creates place materially as well as in the imagination . . . mere space is transformed into place. The sculpture creates a place, a center of meaning, by creating an apt image of human feeling . . . and draws the surrounding space to itself” (Tuan 1975:161). This is reminiscent of the transcendental movement of the 1800’s, where the concept of space and time are manipulated to transcend reality and move the viewer to a metaphysical plane (Falkenstein 1995; Malpas 2003). Tuan goes on to say that a place encapsulates the past and the present and, in doing so, it shows cultural stability and achievement (Tuan 1975:165), which is somewhat like the social focus of Renfrew (Renfrew 2001:109). Tuan sees a place as
“... a center of meaning constructed by experience” (Tuan 1975:152) and constructed by our senses. Tuans' comments are similar to Blazier et al's idea of the entire Plains landscape as a constructed ideational system (2005:112). As Cooney states "People make their histories and create places in the context of the local conditions of life and society which both enable and constrain the conduct of life" (2000:232).

The aspect of constructed context is most important and seems only recently to have come to the fore in archaeology (Cummings 2003:25-43; Petts 2003:194). The concept of place creates an experience for people (Bradley 1998:17; Cummings 2003:25), a way to recall memories and “reproduce and recreate social knowledge” (Petts 2003:195; see also Sherratt 1990:147-167). This relates itself to Tilley (1994) who states that space changes over time depending on the people creating the space, living in it and experiencing it; the experience is thus symbolic to the people. We have to assume that the places marked by the earthworks of Ohio also encapsulated many different experiences for the prehistoric people, including phenomenological experiences that transcended the rituals and ceremonials performed at these places. Phenomenology in archaeology really tries to create a feeling of ‘being there’; a difficult undertaking, but one that seems to have promise and interest (for example, see Chapman 2006; Williams 2003).

In Europe, local topography seemed to have played an important role in the prominent placement of monuments of all sizes on the landscape (Bradley 2001:80-81; Tuan 1975:157), as well as influencing how people accessed the monument, or the choreography of movement (Bradley 1998:121; Cummings 2003; Tilley 1994).
Cummings states that the form of many types of monuments in western Britain are a direct reflection of the local topography, also with ancestral memory and myth contributing to the construction. She cites a number of authors who suggest that some natural features may have appeared man-made to some groups of people (for example, Tilley 1994). People in these groups then copied those natural features in their own constructions as a way of honoring monuments they thought had been built by their ancestors (Cummings 2003:34-35; Williams, 1998:94). Some also see earthworks as mimicking the natural landscape (Abrams & Freter 2005a:178), as a way of perhaps incorporating that landscape into their lives or rituals. Placement of some of Ohio's earthwork monuments on prime farmland is also different from the placement of European stone cairns in mountainous places like Wales. Modern farming, especially the mechanized farming of the twentieth century, leads to markedly more destruction of earthworks than the stone monuments. The earthworks of Central Ohio may well have been a total sensory experience for the people who built and used them, but modern research is restricted to measuring what remains. This cannot include taste, touch, sound or smell, and even sight (viewshed or inside and outside landscape choreography), which is decided different today compared to the past. These sensory aspects would even have varied over the use life of a site during pre-history.

Williams also alludes to Anglo-Saxon monuments being deliberately placed on the landscape, not only in reference to the local topography, but also as a means to reuse prehistoric and Roman sites (Williams 1998:91; see also Bradley 1998:146; Longden 2003:182). Before the Woodland period in Ohio, Archaic people in
northwestern Ohio and the Red Ochre complex of western Ohio (both in the Late Archaic 3000 BC – 500 BC) are groups who buried their dead in natural kames and eskers that were part of the undulating post-glacial landscape. The Archaic groups may have considered they were using human made landscape elements, or some created space, given the sometimes uniform appearance of kames (perfectly round) and eskers (sorted gravel in a uniform mass). The concept of reuse is the same as Cumming’s concept of copying, when you consider that in Ohio, some of the Archaic groups used existing mounds to bury their dead in after the Middle Woodland. The old sites, though probably softened in appearance and overgrown after years of disuse would be similar to some natural forms and vice versa (Williams 1998:94). Such reuse may have been done for a number of reasons: 1) an existing monument is already a prominent place on the landscape, and easily found, 2) reuse is a way of co-opting an earlier groups dynamic with perhaps new ingredients added, enhancing the current group with some kind of ancestral affiliation to that past dynamic, or as a method of destroying that prior dynamic, and 3) an existing mound is easier to use, compared to either digging and mounding new earth or digging a grave in glacial till (least effort).

European research into the materials used to build monuments has produced some interesting results. Bradley notes that wood was perhaps used as a way to associate its organic structure with the living and that stone had a more inorganic and timeless quality that may have represented the dead (Bradley 2001:83). At many sites in the Old and New Worlds, older wooden structures were burned, mounded and new wooden structures built to create an accretional mound. Multiple uses such as these
help to further imbue an area with memories and meaning. So it seems that although availability of materials does have an effect on the type and construction of large monuments or objects, it is not necessarily the availability of the materials that means a monument is constructed. That is, people are not building large rock structures just because large rocks are available. It should be noted, however, that a lot of monuments are made of wood or earth, which through differential preservation gives us a somewhat skewed view of past cultures. Even surviving stone structures must not be viewed as pristine representations of their original form when considering them (Trigger 1990:120).

1.3.2 Effort or Cost to Build Large Earthworks

This research suggests that earthworks were planned, and cites the large size of the monuments as one reason for that planning. After all, the energy and organization to build a large structure would probably not be a haphazard affair. The careful construction and large areas covered by mounds and earthworks has led a number of researchers to wonder about the energetics of such endeavors. Although it is difficult to estimate the amount of effort a past culture used to build their large burial or public structures, it is possible to come to an approximation of the time taken to build the structure and the size of the workforce needed to complete it. There is also the problem of assigning a specific Protestant Work ethic (sensu Cobb & Nassaney 2002:530) to such endeavors, where words like "effort", "efficiency" and "deadline" have specific connotations that do not take into account the cultural relativity of the
task at hand. On the other hand if efficiency is a measure of fitness, then it could be
applied across cultures. Efficiency in this sense could also be a measure of how well a
message is conveyed rather than a measure in terms of an eight hour work day.

Most mounds in Ohio (more than half) are less than 10 ft in height, the rest are
usually below 17 ft. The exceptions are two mounds that are over 65 feet in height
(Grave Creek and Miamisburg Mound) (Dancey 1996:2), while some earth mounds
have reached around 200 feet in diameter (Webb & Snow 1974:315). In southeastern
Ohio, the Hartman Mound was said to contain over 400,000 ft\(^3\) of earth, or some 1.4
million individual basketfuls (Abrams & Bolland 1999:269). One mound in Illinois is
estimated to be built from 1 million cubic feet of soil, or some 3.5 million individual
basket loads (Struever 1968:309). Some multiple Adena earthworks enclose some 111
acres, with individual enclosures of 1 to 50 acres, and they could contain multiple or
single burials. Hopewell earthworks are even bigger, with multiple enclosures of 20
plus acres each, miles of earthen walls and some construction materials brought in
from 100’s of meters away (Cloud 1967; Squier & Davis 1848). These estimates also
do not take into account natural erosive processes, with soil attrition and site
maintenance requiring extra labor. A nod should also be made to the efforts involved
in forest clearances needed before the earthworks were built, although some evidence
points to earthworks built on areas that were prairie grasslands (Delcourt et al. 1998;

Orton (1893b:37) did some calculations of earthwork building. He estimated
that one man could carry 1/2 bushel or 5/8 cubic ft earth at a time in a basket (weighing
approximately 55 lbs) For a mound that had a circumference of 20 ft around the top, and 100 ft around the base, he estimated that 83,800 loads would be needed. Thus if 100 people carried 20 loads over the course of a 10 hour day, a mound could be built in 42 days according to Orton. Later, Shetrone (2004 [1930]) cites an unnamed archaeologist using a hypothetical mound of 20 ft high and 100 ft diameter for their example of construction time and effort. Based on the numbers from the unnamed source, 50 laborers would take 100 days to build such a mound using 45 lb loads and 20 such loads a day. Shetrone himself (2004 [1930]) has a slightly different view of the efforts to build the earthworks. He weighed basket loads of earth identified as individual loads within the archaeological stratigraphy and found them to be 20-25 lbs. This smaller amount (compared to 45 lb) he ascribed to the low strain that the Native American made basket types could withstand. He cites the same unnamed source as estimating that all the mounds in Ohio would take 1,000 men working 300 days a year about a century to construct. That said, he knew that the large mounds were not built in one episode, with stratigraphic breaks and repair efforts indicating spaced-out episodes of building, and some engineering requirements (retaining walls of limestone slabs and gravels for drainage) that would indicate longer construction times (Shetrone, 2004 [1930]:44, 50-51). Shetrone does caution against the legitimacy of such estimates as they usually do not take into account the weather, that all the workers are 100% efficient for all the hours and days supposed, and that there is little difference ascribed to the effort to collect earth from further away or as the mound gets taller (Shetrone 2004 [1930]:43). For example, at Fort Ancient, Moorehead recognized
materials of various colors and types in one to two peckloads (approximately 17 dry liters) (1908:81), which would suggest a different source for the materials.

Recently, Bernardini (2004), suggests that an itinerant group of laborers wandered the area of Southern Ohio characterized by Hopewellian geometric earthworks and built them all in 350,000 to 500,000 person hours each. That translates to a building episode of about 50 days over 10 years for each site with between 150-400 laborers needed at each. Given a distribution of 2-4 people per 1 km², (Pacheco & Dancey 2006; Greber 1997) that requires a very large area from which to draw labor, some 3000 km². Taking Bernadini's ideas and figures for the 600 known earthworks in Ohio, each 20 year generation would need to build 12 sites (50 building days per year spending 10 years building a site). To complete the 600 sites in 1000 years, they would need to finish one site over one and a half years. Thus, for example, six groups of 200 people each (for a total of 1200 people) would need to be constantly working 50 days in each year, and contemporaneously, to complete 6 earthworks every 10 yrs. The smaller mounds in the Hocking valley could be built in six to nine person days according to Crowell et al., (2005) although to be fair no large geometric Hopewell earthworks have been located in this valley and thus such short estimates cannot really be extrapolated. However, Blazier et al. suggested that 30 people would take 43 days to construct a small circle (2005:108). Milner (2004) who has worked on Watson Brake and Poverty Point, also has some estimates. He suggests that a mound that is 12.2 m in diameter and 3 m tall could be built by 40 people working 5 hours a day in 3.5 days (if they had to retrieve earth from 50 m away) or 5 days (if they had to retrieve
earth from 100 m away). And Pacheco says that to build earthworks would need either a lot of people for a short amount of time (one episode, see Deuel 1952 or Prufer 1964), or a few people over a longer amount of time (a sequence of episodes) (1996:20).

Supposing a group did labor in ways described above, then a number of issues come to mind. The workers would need a support staff to hunt and cook for them, and to make tools or repair them. This would not only increase the group size, but also lead to multiple areas of habitation and work shop debris, which begs the question - would not these relatively large groups of people leave a lot of habitation debris if not in, at least very near the earthworks sites? I agree that the mounds and earthworks described here are large, that is an empirical observation, but Bernadini's methodology completely ignores any contemporaneity between the sites, which negates what chronologies we do have (though very coarse grained [Greber 2003]). If 200-300 years separates some of the geometric sites then Bernadini’s hypothesis fails to hold water. Only if we can garner a fine grained chronology will the order of earthwork or mound construction, both within and between the components, lead to an understanding of the way these monuments were built. This is a view echoed by Abrams (2009:189) and Chapman (2006:520) who both advocate for extensive dating of provenienced items from multiple sites. They do, however, see not only the financial obstacles to such an endeavor, but the ethical ones too regarding Native American claims under the Native American Graves Protection and Repatriation Act of 1990. That said, perhaps using geophysics, along with targeted coring, and the ability to use Accelerated Mass
Spectrometry dating to date microsamples, can satisfy everyone’s ethical and scientific requirements.

1.4 Discussion

This section discusses the concepts of the previous three sections as it relates to monument placement on the Central Ohio landscape. It also addresses monument access as it pertains to restrictions, the variation found in forms (structure), the groups who may have built the earthworks, and the meanings the earthworks may have had (function).

Often discussed among Ohio archaeologists is the concept that Ohio earthworks were placed on the landscape with regard to specific environmental criteria, as is the case for other parts of the country (Immel & Kine, 1984:92; Kohler & Parker 1986; Kvamme 1985). Proximity to caves, springs, large rivers, and elevated areas amongst other things, are suspected, which if those suspicions are warranted suggests a choreographing of experiences for participants. On the British front, Victoria Cummings (2003) covers just such phenomena found at Neolithic monuments there, the concept of viewscape; of what you see when you approach a monument and what you see while you are in the monument. She suggests that monuments were built in such a way as to “choreograph” the experiences of people who visited them, so that the experiences of any number of visitors were all similar (Cummings 2003:26 see also Thomas 1991:51). This choreography extended to the type of view a person would get from the monument. That is, a blocked area would have a restricted view of some
aspects of the outside landscape, whilst drawing the attention to other parts that were highlighted by the structure (the spaces in-between). Other aspects such as a duality and sidedness to structures would all add to this “orchestration” of views both within and without (see also Bradley 1998:96-97). Bradley also has the same opinion about the placement of sites in the landscape, saying “. . . that the form of the monument provides a microcosm of the local landscape” (Bradley 1998:116 & 145) with the monument providing a “metaphor” of the landscape in which it was sited (Bradley 1998;123). So, not only were people involved with the spaces inside the monument area but their experiences, individually and as a group were part of the spaces outside the monument (Bradley 1998:110). That is why he suggests that researchers have to integrate more than one monument in to their research and not view them separately (1998:86) much the same way that Clay sees mounds, villages and earthworks as all being a part of the Adena "ritual landscape" (1998:2)

The nine Central Ohio earthworks in this research include sites with rings and squares of banked earth with one or more breaks in the continuity of the walls, along with mounds placed at various locations inside and outside of the earthworks. European earthworks and henges also had restrictions to access made by the ditches, banks and segmentation of the earth banks. These structures could only be entered in one or two ways, and different segments of the audience may be kept at different distances and with different viewpoints, e.g. watching from an entrance, watching from the top of a bank, and being inside the enclosure (Williams 1998:100). Zipf dubbed the restriction of access, and the fact that people could be made to follow the rules as a
‘Pied-Piper Morality’ whereby “… it extends to the fabrication of marvelous metaphysical and ethical systems that are intended to hallow the status quo and thereby to protect the incumbents of elite positions by making it wicked for the underling to compete or to disobey” (Zipf 1949:478). Large monumental structures with stages and audience areas would additionally give the ritual players another method of impressing the audience with shock and awe performances. Thus the audience is bonded into a cohesive group by common shared emotions, with that emotional memory attached to the monumental structure at hand. Those who do have access are perhaps closer to deities and thus have a higher status to those who do not have access. If earthwork structures and the places they are found act as a way of imbuing a group with an identity and common ideology (which can be made much stronger if the gods or spirits of that society are also deemed as present and living in that construction [Adler & Wilshusen 1990:140; Williams 1998:103]), then restricted access would be even more powerful.

In Ohio, there is a recognized disconnect between domestic habitation sites and earthwork ceremonial areas (Cummings recognizes a similar disconnect in the UK [2003:29]). The Vacant Ceremonial Center model of Prufer (1964), now championed by Dancey and Pacheco (1997, see also Pacheco 1993, 1996) is based on that very concept for the Hopewell period. Dancey and Pacheco (1997, also see Braun 1986), see each earthwork as built and maintained by one community over time. This idea has Hopewell households dispersed around an area with the earthwork as the center of their
focus and their specific identity. Nevertheless, there is room in this model for shared ritual and social movement based on earthwork use by more than one group of people.

Perhaps this presumed disconnect between domestic and ritual areas is just a western view of how a spatial concept was dealt with. Either there was no disconnect in the minds of the people who built these monuments and they always had a mental connection with the ceremonial areas, or there had to be a disconnect between the domestic and ceremonial spheres in order to keep the two worlds separate (Byers 1987). The concept of the monument then is perhaps the important aspect in this case rather than the form of the monument itself, it is the people and ideas that travel rather than monuments (Bradley 1998). Indeed Bradley continues that as “. . . constructions could not travel: it was the concept of that monument which passed from one cultural setting to another” (Bradley 1998:72).

Banked earthwork forms blanket the Midwest landscape (Mills 1914; Squier & Davis 1848), however, though these built environments share similarities they still exhibit variation over both time and through space. There is no debate that the dynamic landscape of the Mid-Ohio Valley built up through time; nevertheless, one of the biggest obstacles in considering how that build up occurred is the lack of a fine chronology. Greber (2003), found that most Ohio earthwork sites could only be, at best, dated to a 100 year window, or some five generations³. Over this amount of time the various elements at a site would undergo cultural as well as the physical site formation processes. The landscape around a site would also change through time depending on how a group used, or did not use, a space. Cultural ideas about a
particular landscape and the site within it, what it meant and the memories it evoked in a person or group would also change.

No two earthworks have the same layout, including mound placements and number of elements, yet many often share similar types of elements and configurations (Squier & Davis 1848; Byers 1996). From her research on similar European monuments Cummings (2003), states that monuments share similarities as they are fragments of past memories (which must consider forgetting and remembering) rather than the whole memory. Such fragmented memories would lead to a general similarity in earthwork building but not an exact replica. Culture, as a learned behavior, suffers imperfect transmissions such as these. Tilley also identifies differences in Welsh monuments as being key, and that it is the placement of those monuments on the landscape that is structured and repetitious not the replicated form (1994). Other sources of variation include cultural and physical boundaries, space, place, dimension, origin myths and oral histories. The latter two would change as they became rounded and honed by different keepers of knowledge. Additionally, as social change occurs (maybe just on a local-leader basis, or perhaps with a regional polity) then more and different meanings would be available to the people who used these earthworks leading to another source of the variation in form that we see over time.

A number of researchers have dealt with the earthworks as if they were corporate works, to be used by different persons or groups of the same community, such as lineages or clans; for example, Buikstra & Charles (1999; see also Riordan 1998:74). These authors specifically look at the Lower Illinois Valley, but their
information may be pertinent to Ohio due to similarities both in environmental variables and cultural artifacts between the two areas. Buikstra and Charles (1999) suggest that mortuary ceremonialism and ancestor worship were two different aspects of Adena and Hopewell society’s that led to variation in earthworks. They believe there is a difference between dividing the living and the dead from each other in mortuary rites and invoking a connection between the living and the dead in an ancestor cult. They claim that different groups within a local community used the earthworks differently, where some mounds served to help negotiate the relative standing of the local community amongst other groups in the area.

Buikstra and Charles see the cyclical changes in burial location, from middens to flood plains to bluff tops from the early Archaic through the Late Woodland as reflecting variation in both subsistence risk and demography. Changes in food availability, population numbers and the different groups living in the area would require different social relations to be negotiated between these groups using the mounds. Longden sees the social relations in the labor group that built and associated with a large structure as important (see also Colloredo-Mansfeld 1994:849; Bleed 1997:98). So if the gods, spirits, or ancestors of a group are associated with, or ‘live’ at, a structure then the idea of sacred place is very strong (Basso 1996). These relations not only mirror the lateral reciprocal relations within a group but also reflect information about vertical relations of authority and obligation (Longden 2003:176, 178). So the abstract meaning of the sacred spaces focuses the needs of the community on the more mundane, but life sustaining domestic needs.
Although Clay finds no evidence for overarching cultural groups, he sees variation in Adena earthworks developing from the need for different negotiations between different groups depending on the context of the person being buried, their role in life, and their kin’s role in the social group (1991). He thinks that different groups used the mounds, as does Yerkes (2002) who believes that building the mounds emerged from the need of groups to reduce their social isolation and to have the ability to exchange mates during rituals. Nevertheless the deprivations of isolation and the need to find mates outside of a family group have always been manifest through time, and one wonders what groups of people did before mounds and earthworks became prevalent to satisfy those needs.

Other researchers view the variation found in Ohio’s earthworks as a product of localized groups sharing both physical space and general ideological concepts about the earth, but keeping their local identity (Pacheco & Dancey 2006; Greber 1991). Group identity creates an integration of economic and social attitudes over a period of time, and thus continued reworking and reinterpretation of a scared place, in the form of additional constructions and updates to old forms, may serve to renegotiate that identity with interacting groups (Clay 1991), "... renegotiate relationships of affinity and obligation" (Seeman & Branch 2006:109) or to reinterpret a worldview (Greber 2003). This may be especially pertinent if those construction updates restrict access and viewing to fewer and fewer people. Restrictions on ceremonial participants or audiences, or both, would serve to individualize groups from each other. As with any structure, object or behavior, interpretations of the meaning associated with them will
change during a person’s lifetime, over generations and indeed between different cultures (Bradley 1998). For example, in Britain, reusing old monumental structures as later settlements was common, perhaps not only because the building and heavy work had already been done, but because the areas were already imbued with the powerful spirits of the ancestors and gods (Bradley 1998).

Seeman (1979; 1995) perceives Hopewell styles and artifacts including earthworks as part of a symbolically based communication system that seeks to convey an invariate, standard or redundant message over a varying population. Different populations with different languages, histories and rituals would then have a common shared symbolism to bind them together for peace, trade and negotiation. The exact meaning for each symbol would remain within each group whilst still being a shared motif. Symbolic communication is also alluded to by Byers (1987; 2004) and Romain (1996). They advocate for supernatural and cosmological communication, with multiple groups having slightly different ways of marking supernatural events depending on their individual culture history and how they physically marked solar, lunar and celestial events. After all there are many ways to mark the land to communicate these same cyclical occurrences, leading to similar earthwork forms but no exact matches.

Researchers such as Greber (also see Van Gilder & Charles 2003; Greber 1979; Pacheco and Dancey 2006; Struever and Houart 1972) all discuss differences in what is called Hopewell based on environment or ecological settings of the various groups. In Greber’s case these differences are manifested in the burial layout imposed at some of
the large geometric sites in South Ohio. These differences she attributes to the roles and status a person had in life, further implying that the roles that are available in a particular society have some environmental basis, e.g. a particular river valley will create specific needs and roles in a group depending on how people want to deal with those needs. She also explored a binary idea in 1997, suspecting internal pairing of funereal and mortuary activity areas and features (see also Byers 1987). She sees site pairs in the geometric earthworks of Paint Creek, North Fork, and the Scioto River, with each river valley sharing similar site components, but with none an exact match (Greber 1979). The differences Greber believes are caused by the singular requirements (adaptations) of living in slightly different environments and based on the character of each valley. She assumes that some aspects of ideology may be shared across groups of people while localization of rituals would account for differences found archaeologically between valleys. Variation within the binary sites themselves may be due to different activities occurring at each of them, perhaps representing different groups, or varying rituals. She also suggests that the tripartite division within the designs of the earthworks (large circle, small circle, square) mirror the same tripartite divisions found in the burial population (see Byers 1987). Where the three segments of the great charnel houses may be representative of the same type of division in the living population.

Greber (1996) firmly believes that the Hopewell landscape was planned and designed, with specific sediments, artifacts, caches, and features having a sacred and ritual importance to the people concerned; confirming the “shared motif” idea of Byers.
Byers (1987), and later Connolly and Sunderhaus (2004), speak of canons of construction and design grammar, suggesting that some sites were planned, if not for a final design then at least in how the component parts were constructed. Greber’s extensive research in the Mid-Ohio Valley found evidence of a planned landscape, and of similar structures that overlap in time (Greber 1979). In response, Clay believes that there was no planning of Adena or Hopewell earthworks. He is against the idea of the “programmatic nature of Adena burial ritual” (Clay 1998:3). He continues that although Hopewell was more articulated across the region, the landscape is still a local product of a regional pattern with pragmatic “happenings” in local histories shaping the earthworks rather than a planned design (Clay 1987; 2002a).

Planning of the large earthworks is also possible using a drawing in the earth or on paperbark, or even a small model, which would give the builders an idea of layout. Nevertheless, after a number of years or generations and with additions, changes to, and erosion of the earthwork forms this overview would soon be incomplete or inaccurate. The view from on the ground then would be the view that people would see and remember. Incomplete knowledge about an earthworks design and layout would affect reproduction of that form. The variation of earthworks in the Midwest could then be explained as “mistakes” in interpretation or execution of design rules from those remembered or copied forms (Byers 1987). This echoes the biases that Boyd and Richerson write about when discussing Cultural Inheritance Theory (1985). It may be that the concept of a copied earthwork design and shape being close enough, as opposed to exactly the same, may be all that a ritual required (Cummings 2003). This,
along with the local history of a group, would influence how they interpreted the design rules, and thus themselves as a group, on and within the landscape.

If local groups of people built and identified with a specific earthwork, then this would argue against regional planning for earthworks, but may still support some kind of local planning over one or more earthwork, for example within a drainage or its tributaries. Local variation between monuments is also found in Neolithic Britain, and there it is explained by Bradley, and Cummings, that people built monuments “. . . as the recreation or continuation of a well supported ancestral tradition” and thus “. . . it was the process and performance of construction, not the precise form of the monument, that was critical” (Cummings 2003; see also Bradley 1998). This could explain differences between monuments across time and space as “new sites may have been quite literally built from the fragmented memories of other places, and . . . . it seems highly unlikely that an exact replica would result” (Cummings 2003:35 emphasis added). Mounds and earthworks as a kind of mnemonic device to remember aspects of the past must leave some portions out too (Williams, 2003:19; Wilson 2010:6). If this were the case in Ohio, then we would expect variation on a theme as opposed to very similar or identical constructions. Indeed in the nine earthworks explored here are not identical in form, although similar motifs, are used at each one, such as the use of circles, gateways and mounds.
1.4.1 Meaning

There are a number of varied generalizations about what monuments may have meant to the cultures that built them, some regarding ethnographic studies. Though involving carving on natural features, the ideas of Peter Jordan could be applied to monuments on the natural landscape, especially if the area of construction has been intentionally chosen. When writing of his research with the Siberian Khanty, a small hunter and gatherer group in Western Siberia near the Arctic Circle, Jordan states:

“The corpus of ethnographic evidence investigated in the monograph has offered new conceptual approaches to the veneration of natural landscape features – that is, that certain ritual locales (islands, water, high ground, rapids) or images (particularly of the bear, but also anthropomorphic dolls) may constitute, in the worldview of particular communities, animate objects. Thus, creating, visiting or venerating (e.g. through recarving) these images may be less about the creation of restricted knowledges (sic), and more about maintaining animate life forces as part of a communicative relationship of obligation and reciprocity with divine powers able to influence the welfare of the community . . . these actions may be conceived as an ongoing dialogue, played out through the seasonal round, so that material culture (e.g. carvings, offerings, feasting residues) at the holy site form only one dimension to a wider relationship” (Jordan 2003:282).

This observation by Jordan suggests that interacting with natural features (landscape) operates on multiple levels (from the individual through to the divine) and at multiple foci (different sites and different temporal cycles) (see Dancey 2005; Pacheco & Dancey 2006).

Hodder (1987), believes monuments were a way of enlarging an important boundary, the liminal area between domestic and wild, to show ever more separation of humans from the wild (Bradley 1998:40-41). Thus there was a cognitive link between
domus- domestic affairs; agrios – the wild; and foris – the threshold or boundary (the monument) between those two that tames the wild. The affect of that association would be the continued building of similar stylized structures that would continue those memories and that separation of domestic from wild. Monuments that are continually changed by subsequent cultures show us how continuity of some cultural aspects is also interspersed with change through time. Every element of these changed structures or objects had a relevance to the culture creating them, a relevance that would change perhaps as time passed and cultural traditions evolved.

Monumental structures are also undoubtedly connected to the supernatural. Supernatural constructs of a society could be said to be looking after the abstract territory of the mind while the monument guards the geographic and tangible space of reality (Axelrod 1984:159). As researchers, we see all the remaining aspects of a monument all together in the same moment; along with the natural changes that passing time has imposed on each element of the construction. So it would be in the past, with the age of the monument impacting the cultural group, and each individual in the audience who attended the monument. This would lead to different concepts and memories of what the monument was to the people involved.

A number of authors speak of monuments in Europe as evoking a memory of a past settlement type, of the past homes of these groups of people (Bradley 1998:18, 36, 150; Bradley 2001:75-76, 87; Cummings 2003:36, 38; Sherratt, 1990:147-167; Williams 1998:91:104). In Europe, people changed gradually from building longhouse, domestic structures to building monumental long barrows and earthworks
as a mirror of that past according to those authors. As Bradley asserts, people living in settlements that contained abandoned houses that naturally decayed into mounds of material would “. . . create an association between the form of the longhouse and the celebration of the dead” (Bradley 1998:46). Bradley puts together the functionalism of Sherratt and the structuralism of Hodder to explain his ideas (Bradley 1998:40-41), (Sherratt thinks that monumentality occurs where settlements are ephemeral and it is the large monumental structures that anchor the cultures’ to the landscape in the absence of large, permanent settlements [Sherratt 1990]). Conversely, monuments may also be about forgetting certain aspects of the past, and revising cultural memories to mythical proportions so that the past is perhaps a composite of memories from various times and places (Cummings 2003:34, 38; Williams 1998:91; Williams 2003:10).

Some anthropologists have designated earthwork building as conspicuous consumption and wasteful behavior. Evolutionist archaeologists see any behavior that takes energy away from reproductive success or resources away from offspring as wasteful (Bradley 2001:72; Dunnell 1999; Neiman 1997:269). Some evolutionary archaeologists also claim that a monumental structure, such as an earthwork, is the extended phenotype of the people that built it. So, the many types and uses of monuments may mirror the complex structures of the human mind and show how phenotypically plastic humans can be. Humans may artificially select some monuments that they believe (for whatever reason) may enhance their fitness more than other designs. Or people who may have more inclusive fitness and build certain
monument forms would mean more offspring who themselves continue building the monuments of their shared culture.

It was Dunnell (along with Aranyosi 1999 and Neiman 1997) who placed earthwork and mound building within a Darwinian evolutionary framework, calling it ‘wasteful advertising’ (Bradley, 2001:72; see also Dunnell 1999:243-250; Dunnell & Greenlee 1999:376-390). From an evolutionary view, Dunnell and Greenlee explain the Hopewell earthworks in relation to subsistence (Dunnell & Greenlee 1999). In an environment that is unpredictable individuals in a cultural group can adapt to that unpredictability. Dunnell and Greenlee predict that the Hopewell lived below the carrying capacity of their environment, and directed the energy away from maximizing their reproductive output towards a waste behavior, in this case the earthworks that the Hopewell people built. In an unpredictable environment a culture that exhibits waste behavior can adapt to that unpredictability in two ways. One, by producing waste behavior in times of higher carrying capacity when the environmental yield is high and thus suppressing their fertility and population growth, or two, comfortably maintaining that smaller population number when the carrying capacity is low and environmental yield is low. Cultures who always seek to maximize their offspring will increase births in the higher yield years, but lose a lot of those individuals to mortality in lower yield years. The cost of producing young who die before maturity will mean that the inclusive fitness of individuals in a cohesive cultural group will be lower than a group who used their energies to produce wasteful behaviors. According to Dunnell and Greenlee, once a more sustainable and predictable economy was established (through
an increase in the carrying capacity of the environment due to environmental change or
cultural acts), the benefit of performing wasteful behaviors disappeared. Once an
adaptation ceases to be a benefit then it may even become a deleterious trait. Dunnell
and Greenlee thus infer that the advent of an increased carrying capacity and more
predictable environment led to the cessation of building the large earthworks of the
Hopewell Culture; in effect the earthwork building trait was selected against (Dunnell
1999:245; Dunnell & Greenlee 1999:378; see also Aranyosi 1999:363).

In a way groups who practiced this so called 'waste behavior' in the form of
earthwork construction would have a selective advantage over those who did not
practice the behavior. In risky subsistence times of reduced carrying capacity those
persons who did not control their reproduction would see mortality rates increase.
Even though persons who suppressed their fitness may be at a disadvantage when
counting births, in the long run the waste group's inclusive fitness would increase,
thereby satisfying the differential reproduction tenet of natural selection. Therefore, it
was not a sustained resource surplus from agriculture as Caldwell advocated that led to
the ability to waste energy by building elaborate monuments and objects (as is often
cited for cultural elaborations), but a lack of surplus due to environmental
fluctuations. This is important, as it would place mound building and other
monumental buildings before a full farming economy is in place, as opposed to
assuming monuments and earthwork building could only occur with a sustained
agricultural economy. Be that as it may, it seems unlikely that Adena and Hopewell
people were consciously doing the costly signaling that Dunnell and Greenlee suggest
(an etic view) and thus ideas of what the mounds and earthworks actually mean to the people (an emic view) is still not addressed, and in reality would be very difficult to do (though see Carr & Case 2005).

Braun (1986), Dancey (1996; 2005), Pacheco (1993), amongst others view the variation in Hopewell material remains as essentially due to natural selective processes too. They suggest that each hamlet represents a reproductive unit that reproduces differentially compared to its neighbors either due to an advantageous adaptation or perhaps random factors (drift). For example, in the Hocking valley, few dispersed habitats are found, and no major geometric earthworks occur either. The small households that are found have few structures and are thought to indicate mobile foragers who are sedentary for certain seasons (Abrams & Freter 2005a&b). They suggest that the Hopewell regional influence never filtered through to the Hocking Valley, perhaps indicating that the Hocking valley cultures did not have to participate in the sacred styles and rituals found over other areas of Ohio. This differential reproduction could lead to variations in burial practices across an area. That is, as the inhabitants of certain hamlets reproduce more than others then the certain styles, artifacts and practices they use will become more prevalent than others by dint of cultural transmission among the greater numbers of people being brought up in these hamlets. The varying population numbers in groups of related people could explain local and regional cultural variation present in the archaeological record and earthwork form.
The concept of topography as a predictor of earthwork location should not only be considered in the context of physical landscape, but can also be applied to the social landscape. That is, where within the social polity of a region does a monument lie? Collins and Chalfant suggest that the building of big mounds can change the psychology of a region (Collins & Chalfant 1993:322), and they use Monks Mound, Illinois (a Mississippian complex) as an example. There, they conclude “. . . that Monks Mound was a purposeful political tool for the manipulation of mass psychology” during the time when the Mississippian culture was fluorescing (Collins & Chalfant 1993:319). Other researchers say that monumental buildings can reaffirm the validity of a political system over a number of generations (Abrams & Bolland 1999:268; Bradley 1998:17; Zipf 1949:483), this may be especially true in the florescent phase of a culture where integration of a larger system is required (Adler & Wilshusen 1990:141). So in these examples large architecture was used to solidify the local population and to perpetuate an ideology.

A number of researchers (Aveni 2004; Hively & Horn 2006; Marshall 1996; but see Marshall 1999; Romain 1996, 2004) believe that the Middle Woodland earthworks are planned as complicated mathematical entities that are all interlinked by alignments to the sun, moon, stars and to each other. They believe some Hopewell earthworks are tied to earth renewal ceremonies based on astronomical observations. Romine states that he has found units of measurement within the geometric earthworks of Ross County and Licking County. The units mean that complicated design can be scaled up from a model (1996:205). He continues that the shapes themselves are not
just by-products of the need to mark lunar, solar or stellar occurrences, but themselves have a meaning. Squares represent the sky, heaven and alignments, whereas round elements represent the earth and water. The extensive math that they all accomplish is certainly persuasive, and may hold water in some cases, but some detractors (Prufer 1996) suggest such theories are untestable even if they do pique the interest of the general public. Research based on astronomy leads to the conclusion that although mortuary ceremonialism seems to be inextricably tied to earthworks and mounds, they perhaps are independent components, or at least started out as independent components. Perhaps burials came first, or alignments came first. Either way, we are back to lacking a fine chronology to answer the question.

1.5 Summary

The theories that explain variation in earthworks are almost as varied as the subject matter itself. It seems that there was not one large pan-regional group representing Adena who were culturally homogeneous or one large pan-regional group representing Hopewell either. There is no clear evidence that Hopewell succeeded Adena in a linear and separate fashion, in fact overlap rather than succession seems favorite. Nonetheless, shared feature types and artifact designs and motifs are apparent across large areas in many sites during the Early and Middle Woodland times, which is why the sites are grouped thus.

Monumental architecture as non-utilitarian objects showed how communities could cooperate in endeavors that seemed outside the abilities of individual humans.
Each episode of building perhaps showed continuity with the previous culture, or a change of perspective. Variability in structure and expression across the landscape was perhaps a metaphor for the different groups involved in the projects, their needs, and the elements of their past that they wanted to remember (Bradley 1998:73, 100; Bradley 2001:78, 89; Petts 2003:193). This is because cultural experiences take time to accrue; it is a process rather than an episode that creates a place in a culture. 

Monuments give a group that builds them a group identity, a visible physical characterization of the group and create memory of their being (Williams 1998:103; Williams 2003:4).

Sacred places within a community area, such as earthworks, are a way of imbuing a group with a separate identity from other groups but who also may share a common ideology with other groups. That is, familial lineages would keep their separate identity from the larger clan group, but still share in a common identity ideology. If public access to such a place is restricted, then those who do have access may have a higher status to those who do not have access. Concerns with naturally sacred places, ancestor associations, family hierarchy's, and clans groups would all affect decisions about mound and earthwork design and placement. Such cultural pragmatism should manifest itself as variation within the archaeological record, which makes finding a set of design rules rather more difficult.

Building large structures can additionally show the beginnings of a new order, something that is a different concept or cosmology to before (Bradley 1998:17, 162; Sherratt 1990:152), Monuments can symbolize the collective dead ancestors as much
as the living (Petts 2003:202; Williams 2003:6), and may have multiple meanings depending on temporal or landscape contexts. As Richard Bradley says, prehistoric monuments “. . . impose an artificial order on the use of space . . . . and they seem to have been constructed according to designs that were the expression of particular ideas about the world” (Bradley 2001:70). The development of mound building in the Later Neolithic in Britain and Ireland supplanted the earlier monument types that mirrored the ancestral longhouses in Europe, and Bradley thinks that “. . . the dominant symbolism of the larger monuments united the dwellings of the living with the landscapes in which they were built” (Bradley 2001:79).

Places and images tied to the landscape not only construct or reflect the worldview of a group, but also maintain a link with the deities and ancestors on a number of different levels and in a number of different dimensions (see Potter 2004:336). Monuments are one of the most enduring of cultural traits, which probably gives us a distorted view of past cultures and how they interacted with the landscape on religious and domestic levels. In Europe, for example, Richard Bradley notes that, ironically, although “they [monuments] played no part in everyday affairs . . . . their prominent place in the prehistoric landscape contrasts sharply with what little is known about settlements and houses . . . ” (Bradley 1998:3) and he continues “. . . the great majority of enclosures seem to have played a specialized role in a landscape in which the other signs of human activity are dispersed and often ephemeral” (Bradley 1998:10). This quote could easily have been written about Ohio. Ohio has the same issues with 1000's of reported and excavated Woodland period mounds and
earthworks, though only 100 or so domestic and habitation sites. This makes it very much more difficult for researchers of any kind to come up with a just one interpretation of what the earthwork structures mean, but that may be good. As this section has argued, varied groups, varied earthworks and varied meanings seem to go hand in hand, leading to the conclusion that there is no one generalization of interpretation.

On both sides of the Atlantic there seems to be a correlation of monument building with early moves towards complexity, and in some cases an agricultural economy of sorts, with a cessation of monument building once a firm subsistence base has been established (see also Trigger 1990:119-132). Sherratt viewed European monuments as an important show of how farming labor was used for mound building as a method of impressing other groups and integrating people into the farming lifestyle (Sherratt 1990). In the Americas such monument building is associated with a move towards more complex societies rather than domesticate farming (Collins & Chalfant 1993:319, 330; Dunnell & Greenlee 1999:384). Indeed, in Ohio it was once thought that the people who built large monuments needed an broad agricultural base before embarking on such extensive construction (Caldwell 1962). The reasoning now, however, is that no such base is needed (Dancey & Pacheco 1997), and certainly paleoethnobotanical studies confirm such reasoning (Wymer 1996). Thus earthwork monuments in Ohio seem to be built in the lead up to social complexity rather than as a result of that complexity, a coevolution of sorts (sensu Rindos 1984).
Overall, the building of the earthwork was not a disorganized affair. The earthworks cover very large areas, are responsive to environmental constraints (they are not exact replicas and tend to follow local topography), and they have specific construction techniques (Greber 2002; Lynott 2001, 2003, 2009). Though the earthworks may not have been based on a blueprint, (that is, a planned operation that envisioned the earthworks as the end collection of elements that we can detect today), they display enough cultural and morphological similarities to suggest some kind of affinal relationship.

It is possible that through time the meaning of burial and of the earthworks changed so that they both became synonymous. In the earthworks described and recorded in historic times we only see the end result of a series of prehistoric cultural processes, processes that undoubtedly changed through time, and additionally many physical, chemical and biological site formation processes and historic transformations. Through time, slight differences in culture would accrue as subsequent generations changed or reinterpreted their rituals and the concepts of their forebears, and as a consequence of cultural drift in a highly interactive region. Diffusion of ideas through trade, migration, and mate exchange would contribute to variation in mounds and earthworks over time and space leading to individual sites with similar overall regional manifestations of styles and designs.
1.6 Approach of the Present Study.

This chapter has discussed and contextualized this research by laying a foundation of information about the problem and existing research. To that end, the four goals of this probabilistic research were:

1. to assess the landscape and environment around nine known archaeological earthwork sites and nine randomly placed comparison points
2. to compare these two subsets statistically
3. to select and intersect certain environmental criteria (within a GIS) that are related to the nine known sites
4. to find signatures of earthwork on historic aerial photography within the areas intersected in the GIS

Chapter one has already introduced and discussed Adena and Hopewell burial practices, the concept of the built landscape and the effort of building that landscape, and finally it concludes with a synthetic discussion. Continuing, Chapter two describes the geology of Ohio, detailing how the regional and local landscape evolved at the locations where the known earthwork sites and comparison points are located. Chapter three lays out the cultural background of Central Ohio, during the Early and Middle Woodland, with information about the settlements and subsistence of the people who built the earthworks. The chapter ends with the history of how archaeology was practiced in Ohio, and discusses how that history has affected archaeological enquiry since. In Chapter four I detail information about the nine sites, including their
descriptions, their environment and the history of excavations. I also detail locational and landscape information for the nine comparison random sites.

Chapter five, on the materials and methods used in this research, reviews remote sensing, studies using GIS, and different types of geophysics as they pertain to the study of earthworks generally and this research specifically. This chapter also lays out the steps of the study at hand and details the statistics used for analyses. Chapter six shows the statistical analyses that compared and contrasted the various aspects of the nine known sites with the nine random sites. Based on the statistics, certain landscape information from digital coverages was selected and intersected in a GIS to identify Similar Environmental Groupings, which were reviewed on remote sensing imagery to identify unknown sites. Chapter seven integrates the results of this work into the regional dialogue about Central Ohio Earthworks and European Pre-Neolithic and Neolithic work in the same vein. Finally, Chapter eight rounds out this work with a concluding remarks and a summary of where this research fits into the dialogue about Central Ohio archaeology.
Chapter 2: The Physiography of the Research Area.

“No one who visits this place can fail to be impressed with the thought that he is viewing the results of a vast amount of labor intelligently performed for a definite purpose; and few can avoid the temptation of endeavoring to interpret this purpose, to fathom the motives which impel men to thus labor, or to frame a theory that will clear away the obscurity impending as a cloud over these mysterious tokens of an unknown people. Many have tried; none has succeeded.” (Edward Orton, Geology of Ohio. 1893 PII:9, talking of Newark Earthworks).

Drift - deposit of mixed clay, gravel, sand and boulders. It is stratified when laid down in beds of sand and gravel as melt water goes through the till; it is unstratified (as till, mostly clay with boulders, "boulders clay") when put down directly by the glacier.

Research on environmental choices associated with a built landscape needs to be couched in the wider context of how that landscape was formed. This chapter sets out the geologic history of the state of Ohio.

2.1 The Region

The research region incorporates an area that is approximately 85 km north to south (between latitude N 40° 30' 00" and N 39° 44' 00") and approximately 55 km east to west (between longitude W 83° 12' 00" and W 82° 49' 00"); for total of 4,675 km2 (Figure 4). The elevation above mean sea level (AMSL) varies over the study area from 200 meters to 433 meters (656 ft to 1,422 ft) (Figure 5). This region incorporates all of Franklin County and Delaware County and, in making the area a uniform
rectangular shape the region also takes in small parts of Fairfield, Knox, Licking, Madison, Marion, Morrow, Pickaway, and Union counties. This rectangular area is used for convenience and neatness (rather than following the county lines exactly) and thus it encroaches between 5 – 8 km into these other counties (Figure 6). The area is in the central lowlands, shaped by multiple glacial episodes in the past that have left little topographic relief on the land (Fenneman 1938:455).

The geological processes that made the Ohio landscape and shaped these counties did so without respect to governmental boundaries, so this area as part of an archaeological research unit is entirely arbitrary. Some of the political boundaries reflect the geology, e.g. Big Darby Creek and the western border of Franklin County and some of the earthworks also are a reflection of the geologic landscape, but the geology was indeed here first.

2.2 Beneath the Surface

The land that is Ohio was made when the original granite base was covered by a salt water sea. This sea lay down carbonate rocks in the form of limestones, dolomites, and sandstones in Silurian and early Devonian times. In later Devonian and Mississippian times fresh water slimes and sands formed sandstones and shales (Stout et al. 1943:98; Wilcoxon et al. 1982). The Devonian limestones are the purest in Ohio, containing corals and crinoids that "...could only have grown in shallow but clear waters of tropical warmth" (Orton 1893 PI:20), with chert layers or nodules (Stout et
The deep sediments were crushed into hard rock stratum and, when uplifted, created a surface for weathering and dissection by water. The surface drainage patterns created valleys and ridges, but not the ones we see today. At least three great glaciers have smoothed and filled three-fifths to two-thirds of the states' land mass. Each glacier profoundly changed the preceding drainage and topography of Ohio, often completely reversing drainage flow directions and depositing drift materials in thick masses. The massive glaciers did not reach to the northeast and southeast parts of Ohio, with large areas where standing water formed when the ice blocked drainages, and where further depositions of shales, coals and sandstones occurred.

According to Forsyth, deposition of the bedrock in Ohio occurred between 500 – 200 million years ago, with most of the glacial and post-glacial deposits coming in the last 25,000 years, during which time the evolution of the current topographic setting occurred (Forsyth 1964: 49, 51); it is on these glacial deposits that archaeological sites are found. Ohio bedrock contains invertebrate fossils that formed in the mud and sand at the bottom of the shallow ocean that covered the state during the early Paleozoic era. In the Devonian period, shale beds were laid down in a north-south band that stretched from Lake Erie to the Ohio River valley (Division of Geologic Survey 2006c&f). Heavy stream erosion of the bedrock over 180 million years during the Mesozoic era and part of the Cenozoic era created many gaps in the depositional record, and also left behind the Teays River system valleys in the central and southern portions of Ohio.
The Teays River system was a mature, low gradient, broad valley stream some 1 - 2 miles wide in the southern area of Ohio (Stout et al. 1943:53) (Figure 7). There may have been earlier large drainages before the Teays River system, but the Teays is the only one whose record remains (Stout et al. 1943:24). A tributary of the Teays River was the Groveport River, which flowed east to west through south-central Franklin County. A number of its tributaries, including Columbus Creek, flowed from Delaware county and drained parts of both counties (Stout et al. 1943:67). The entire Teays River system was more or less filled in by sediment and glacial deposits when the first glacier started to head southwards, blocking the stream that flowed north and then northwest through the state. In unglaciated southeastern Ohio some of the old Teays River valley systems are still apparent. Once the Teays River was blocked, the Columbus River became the major drainage in Ohio, remaining in various incarnations until the evolution of the drainage system that is in place today (Stout et al. 1943).

Today the Scioto, Olentangy Rivers, along with Alum, Big Walnut and Big Darby Creeks run in the basins originally formed by the Columbus River (Stout et al. 1943:83 - 84).

The Pleistocene Epoch glacial periods in Ohio are identified as Pre-Illinoian (over 300,000 years ago; in older books this may be referred to as the Kansan or Pre-Kansan glacier), Illinoian (130,000 to 300,000 years ago), and Wisconsin 14,000 to 24,000 years ago (Division of Geologic Survey 2006a). Little remains of the Pre-Illinoian glacial action, as subsequent glacial periods have mostly erased the aggregation and disaggregation effects of it (Stout et al. 1943:21). The only probable
remaining portions of the Pre-Illinoian glacier in Ohio are in the east in Columbiana and Stark Counties, with more in the northwestern part of Pennsylvania and southwestern New York. The early glaciation produced new streams and drainage systems that cut down some valleys and filled others with drift, and changed the Teays Stage River System for good (Stout et al. 1943:24) (Figure 8). The most stark change was the damming and diversion of the northern reaches of the Teays River, while the headwaters areas to the south remained the same (Stout et al. 1943:25). Ponding occurred that eventually broke through low areas to create changes to the Teays River System that became known as the Deep Stage drainage (Stout et al. 1943:78). Shortly after the new drainage system came into being, a regional uplift occurred that caused the new streams to down cut deeply somewhat abruptly.

The subsequent Illinoian glacier covered some 3/5ths of Ohio, about 22,975 square miles out of Ohio's 41,263 square miles (Figure 9). It deposited drift that leveled the area, and yet more drift (mostly till) was added by the subsequent glacial period. The drift in the central portion of the state is largely derived from parent materials found in the northern areas of Ohio, and made up of mainly limestone and shale (Orton 1893 Pl: 38), while Stout et al. state that the Illinoian drift is of local dolomite and limestone (1943:26). This glacier covered slightly less area than the subsequent Wisconsin glacier, but with an area of 3,247 square miles to the southwest, south, southeast and east central Ohio that was not overlapped and thus remains as an area undisturbed by later glaciation. The drift border in this part of Ohio varies between less than 1 meter and 91 meters (1ft to 300ft), but is usually less than 7.6
meters (25 ft.) It consists of a blue, plastic clay matrix and stony till at the border of the drift, erratics from Canada and a lot of local bedrock (Stout et al. 1943:26).

Generally the Illinoian drift is flat, compacted and "... locally of a sticky gumbo nature." (Stout et al. 1943:27) with few boulders or sand gravel beds. Outwash areas have sand, and the more mature stream areas have sorted gravel and sand deposits.

The changes to drainage in the area covered by the Illinoian glacier were not so acute as the previous glacial extent. Ice blockages led to standing water areas to the south, and new drainage patterns to the east. As the Illinoian glacier covered an area further south that the Pre-Illinoian ice sheets, some remaining portions of the Teays River system were now modified (Stout et al. 1943:27-30). The drift thickness over the state is dependant on a number of variables, such as

"... whether affected by one, two, or three ice sheets, by the unevenness of the floor over which the ice moved, by the trend of the ice flows, by the thickness of the ice, by rate of advance and retreat of the glacier, by the character of the abraded rocks whether hard or soft, by the amount of rock products removed by the glacial waters, by the amount of soils removed since their retreat, etc. In this State the average thickness of glacial drift is between 35 and 40 feet with a minimum of less than a foot to a maximum of over 500 feet." (Stout et al. 1943:39).

Parts of Franklin and Delaware Counties do have thin drift, less than 7.6 meters thick (25 ft.), with little entrenchment of streams, while other parts of those counties have drift 7.6 meters to 23 meters thick (25ft. to 75ft.) (Stout et al. 1943:40).

The last glacial period, the Wisconsin, formed the following physiography within the research area. The ice sheet was thicker than the preceding ice sheet, and
modified the drainages made after the Illinoian glacier. In eastern Ohio the ice sheet did not reach the same extent as the Illinoian glacier, in the central portions of the state the extent of both is about the same, but in the west the Wisconsin ice went 15 - 40 miles past the extent of the Illinoian glacier (Stout et al. 1943:30) (Figure 10). The glacial extent of the Wisconsin ice sheets was over two-thirds of the state, covering 26,463 square miles out of Ohio's 41,263 square miles. In west-central Ohio, the Wisconsin glacial ice came south in the form of multiple lobes that pushed down around the high ground in parts of Logan, Union and Champaign counties. The high ground area, called the Bellefontaine Outlier, is an outcrop of Devonian limestone that bifurcated the glacier into the Miami lobe to the west of it and the Scioto lobe to the east of it.

The Scioto lobe covered all of Franklin County and south on down into Ross County, and as it ebbed and flowed over many seasons it left a terminal moraine at its border with multiple recessional moraines in Franklin and Delaware counties. Stout et al. (1943) describes the area best.

"The bedrock underlying the Scioto lobe is, in the western part, dolomites and limestones of Silurian and Devonian ages; in the central part, shales of Devonian and Mississippian ages; and in the eastern part, shales and sandstone of Mississippian age. With the exception of small areas of Appalachian Plateau along the eastern and along the southeastern borders, it [the area of the Scioto lobe] belongs to the Central Lowland province. The surface was rolling with wide uplands and only locally was marked by prominent hills and ridges. Further leveling and in a more decided way was given to the region by the older Illinoian drift which smoothed the lowland areas to more even plains and modified the hilly portions to a softer to a softer, more gentle relief. The Wisconsin drift in some
areas added further relief by piling up hills, ridges, and knobs of drift. Thus on the Scioto lobe are present the Powell, Broadway, and Mount Victory moraines, the Pickerington, Circleville, Taylor Creek Richwood, Radnor and Leesville eskers and many kames and minor modifications. The drift surface is thus a relatively flat plain with many scattered relief features and with some dissection through stream action." (1943:33).

Also included with the above ground surface were areas of swamp and marsh (Figure 11).

The ground moraine, terminals moraines, drift and till are composed of a tough blue clay with variously sized and fragmented rock pieces (Stout et al. 1943:36). The amount of gravel and sand sorting is dependant on water flowing under, through or out of the glacial material. For example, eskers, or linear hills, formed of well sorted glacial debris at the edges of glaciers, and were created by stream flow under the ice (Stout et al. 1943:37). Kames, or equidimentional hills, are also made by flowing glacial melt water depositing the debris in depressions on the ice, which then gets left on the land surface once the ice completely melts. The silts, sands and gravels, whether sorted or not, along with layers of clay produce many local artesian wells, either on the surface or just below the surface, where bedrock or clay is exposed (Stout et al. 1943:38). The Columbus formation found in western Delaware and western Franklin Counties is one that produces many springs of different sizes (Stout et al. 1943:129). This water may not be potable though as, dependant on its journey under the surface, it may pick up gases and precipitates that render it bitter or "puckery" (Stout et al. 1943:39) e.g. the name Alum Creek, which comes from just such a distinction (although as an astringent alum would help stop bleeding). The Delaware
Limestone formation forms the floor of the Olentangy river, with shale's above it (Stout et al. 1943:273). The city of Columbus itself lies on Ohio shale's.

All the glacial action on the land produced a landscape with little surface relief (Fenneman, 1938), compared to the unglaciated area in the southeast part of the state. Before and between glaciers, drainages flowed north and west cutting down into the bedrock, from 15 meters to 152 meters (50ft. to 500ft.) below the upland plains (Stout et al. 1943:43). Each glacier filled or scoured these valleys, or sorted their contents, but the familiar surface drainage pattern in Central Ohio is generally apparent even in the deep stage drainage patterns in Stout et al. (1943, map facing p. 78), with Big Darby Creek, The Scioto and Olentangy Rivers, and Alum and Big Walnut Creeks shown as the Columbus River (itself a tributary of the Newark River, which replaced the Teays River in the Deep Stage drainage) and its tributaries in similar positions that they are found today.

The research area is an interesting mix of a number of different landscape types formed over these glaciation periods (Figure 12). Glacial action produced glacial till (a heterogeneous mix of clays, silts, sands, pebbles and boulders) over most of Ohio in the form of ground moraine areas (even deposits of till), with end moraine lobes evident (heaped till along the edge of the ice) through west - central Ohio (Forsyth 1964). As the glacier retreated, the rivers and creeks of central Ohio formed below the terminal moraine, and then slowly extended northwards (Stout et al. 1943:97). On melting, the water from the glacier washed out areas of clays and silts to the south,
leaving the coarser material in valleys formed by the outwash action. Multiple episodes of deposition, followed by stream cutting and erosion accompanied each glacial advance and retreat, creating multiple terraces of varying elevations (Forsyth 1964:50). Holes or crevasses on the ice filled with glacial gravel material, which on melting became kames or eskers. Boulders, pushed south by the glaciers, remained behind as the ice melted, and these erratics told the story of their origins in the Canadian Highlands 500 miles to the north (Orton 1893 PI:38). On Waterman Farms, The Ohio State University's agricultural research facility on west campus, Orton (1893 PI:37) reports conglomerates from River St. Mary's in Canada, Marquette iron ore from Wisconsin, and Keweenaw copper from the Upper peninsula of Michigan, along with Potsdam sandstones from the south shores of Lake Superior. Such varied original locations ensured equally varied rock types in the glacial drift, including granite, quartz, and diorite (Orton 1893 PII:46), which, along with locally occurring flints, were utilized by Native peoples for tools. The retreating ice dammed Lake Erie to the north, creating a larger and deeper lake than found today, the depth and beach lines of which oscillated depending on the fluctuations of the ice.

In the west and northwest of Ohio there are places of karst topography. These areas are underlain by limestone and dolomite rocks that are prone to infiltration by water, dissolving mineral salts and causing caves and underground voids. Locally, the Columbus Formation in Franklin and Delaware counties are prone to sinkholes, caves and passages (Stout et al. 1943:129). Such caves are prevalent near known Hopewell sites and are thought to be important to the Hopewell people when making decisions
about where to build their earthworks (Fowke 1902). In the research area, the line of probable karst areas runs in a north-south line through west central Delaware County and central Franklin County (Division of Geologic Survey 2006b). It may be difficult to assess caves as they were in the past due to subsequent floods, cave-ins or seismic events that may have changed or filled in cave areas. The entire study area is relatively tectonically stable, with the last seismic movements (of 3.0 to 3.9 magnitude on the Richter scale) recorded in 1873 at the north end of the lower lobed moraine (Division of Geological Survey 2006e). Nevertheless, it should not be thought that all Ohio is generally tectonically quiet. In Shelby County, just 60 miles to the west of Columbus, between 1875 and 2005, over 50 earthquakes are reported measuring 2.0 to 5.4 in magnitude (one earthquake every 2.6 years). And in the Cleveland area, 120 miles to the north, there were over 70 such episodes between 1836 and 2005, of 2.0 to 5.4 magnitude earthquakes (one earthquake every 2.4 years). This aspect is important to assess when considering how the landscape may have altered over time due to tectonic activity, especially karst areas and drainage patterns.

At the county line in between Franklin and Delaware counties there is a Wisconsin end moraine ridge separating the Central Ohio ground moraine and the Central Ohio Clayey Till Plain in Delaware from the Columbus Lowland relief in Franklin County. The end moraine ridges formed in a lobed fashion when the bedrock highlands in Logan County to the northwest and Highland County to the northeast restricted the flow of the glacial ice. The Scioto and Olentangy rivers both flow from the north to the south, across the Delaware County line into Franklin County. These
rivers cut into the Illinoian ground moraine that underlies the Columbus Wisconsin lowland area. The west part of the study area has the Darby plain, of low relief and hummocky, ground moraine, and the east is separated from the Columbus lowlands by the Berea escarpment that leads to the Galion glaciated low plateau. This Galion region is a transition between the till plains to the north and northwest and the hilly glacial Allegheny plateau further to the east and southeast. The Berea escarpment represents between 160-260 feet of glacial drift material that built up on the underlying bedrock during the end of the last glaciation episode (Division of Geological Survey 2006a&d) (Figure 13).

From the 1800's through to the present, the gravel and clay deposits in Ohio presented many opportunities for mining those resources for construction. Prehistoric mounds, and cultural deposits in natural features such as kames and eskers, were destroyed during Central Ohio's early history for construction materials such as clay, gravel and limestone slabs. For example, in Columbus the very large mound at Mound Street and High Street was removed to straighten out High Street, and in fact some of the clay found within it was made into bricks used the construct the nearby State House (Martin 1964 [1858]:279). Even today crushed stone, sand, gravel and clay are Ohio's leading non-fuel mineral products (National Mining Association, 2000). Early Ohio farmers also smoothed out the landscape by taking down mounds and earthworks and using the materials to fill in borrow pits or natural swales. This destruction of resources for development not only impacts the prehistory of Ohio generally, but also the Woodland mounds and earthworks specifically, further complicating research.
2.3 Soils

The nine known sites in this research are in Franklin and Delaware County, Ohio, while the nine random sites fall in Delaware, Franklin, Madison, Pickaway, Union and Counties. The general soils of these central Ohio counties are somewhat similar based on their shared geologic history, and are some of the most fertile soils in Ohio (Gordon 1969). The underlying sediments in Ohio produced glacial clay deposits in the Pleistocene that cover some three-quarters of the state (Deaver & Aument 1980:3). The glacial movement of the ice produced unstratified till deposits while the outwash action of melt waters created stratified gravel deposits, (Orton 1893 PII:4) both of which contained clay. Clay is made up of various minerals (kaolinite, illite, chlorite, vermiculite, montmorillonite), which are hydrous aluminum silicates and are found when feldspars and micas from metamorphic or igneous rocks are chemically weathered (Lamborn et al. 1938:281). Kaolinite is the majority mineral in underclays (Pennsylvanian age deposits below coal) and illite is the majority in glacial clays. Some of the old valleys in Ohio also contain alluvial clay deposits that vary in composition as the clay originated from different sources before water transportation and deposition. Shales, made up of clay, organic material, and larger particles than found in clay, can be used like clay with careful processing. Clay from glacial and alluvial deposits was the main constituent of Woodland ceramics (Deaver & Aument 1980:3).
At a gross state level, these counties are in the following soil regions: Blount-Pewamo-Glynwood (western Delaware, all of Union except the very south); Miamian-Kokomo-Eldean (all of Franklin except the northeast quadrant); Bennington-Cardington-Centerburg (northeast quadrant of Franklin and eastern Delaware, all of Madison and Pickaway except a small area to the east in Pickaway and the eastern panhandle of Pickaway) (ODNR 2002b; Figure 14). Because of glacial action the soils over the state do not necessarily correspond to the bedrock material, with most of Franklin and Delaware Counties underlain by Devonian system materials (408 - 360 mya) of limestones and shales (ODNR 2002b; Angle 1995:31). As opposed to being made solely from decomposed bedrocks found immediately underneath the area, the various glaciers moved around, broke up, and sorted different deposits from the north depositing them in layers over the state (Orton, 1893 PI:39). Where soil is made from the underlying rock such as dolomite and limestone, it is high in calcium (Gordon 1969). In the Central Ohio area soil deposition by sedimentation due to flooding episodes is thought to be low from the end of the Middle Holocene to the mid Late Holocene (3,000BP to 1,500BP) (Mickleson 2002), except in areas of slope wash or floodplains (Parkinson 2009).

The descriptions of soils today may be difficult to project on to the past, but in a relatively stable landscape such as Ohio, some analogies can be made. Since the last glacial period ended, some 15,000 - 18,000 years ago, "the same basic landforms . . . remain essentially the same . . ." (Parkinson 2009) and there would have been a period of inertia before any soils began to form (Gehring 2009). After chemical and physical
weathering had broken down some of the surface and allowed some plants and roots to congregate the post glacial landscape, soil development would then have accelerated (Gehring 2009). Ohio soils are derived not only from the underlying geology but also the hardwood vegetation prevalent in the state (Gehring 2009). Over the last 3,000 years or so the rate of soil development would be an average of around 1" per 500-1000 years, assuming no major erosion and no alluvial deposits (Parkinson 2009), although it must be noted that this would not be a uniform process either on a regional or a local basis (Gehring 2009). The soils in pre-history would be slightly more acidic, with a thinner A and B horizon (solum), and with a lower clay content in the B horizon. Forest clearance and cultivation, by both prehistoric Native Americans and historic settlers, would affect soils, especially the mixing of the A and E or BE horizons by plowing to produce an Ap horizon. Nevertheless, generally the soils of today would be very similar to those of 3,000 years ago (Gehring 2009; Parkinson 2009). Assuming the same historic geomorphic processes affected the nine random sites in the same way as the nine known sample sites, then statistically apparent differences between the two sites populations should still be valid.

2.4 Landcover

The usual description of vegetation that succeeds a glacier, is one of moving belts of tundra, scrub, conifers and deciduous trees in front of advancing and retreating ice (Sears 1935:37). But Sears suggests that a more accurate description needs to account for ice that is in lobes (rather than in a relatively straight united front), for
glaciers found covering grass and forests, and for trees found growing on edges of glacial areas. He states that not all four successions of vegetation, in the form of belts spatially ranged in the path of a glacier, need be present (1935:38). This means that once a glacier retreats vegetation does not necessarily come back in a strictly linear secession, which will obviously affect the resources found at such a location.

Since the end of glacial times the Eastern Woodlands have included various types of forest with local areas of prairie development (Williams 1962:5, 29 & 34) and marshes, wet prairies, peat bogs and fens (Gordon 1969:26). Prairies would form in areas where the till was shallow, and the shale's and limestone's were close to the surface and restricted drainage (Gordon 1969:65). The hypsithermal interval from 8,000 - 4,000 yrs ago created warmer and drier conditions, leading to an increase in prairie areas and a decrease in spruce and cold species (Gordon 1969). Up to the present day, cold weather species such as conifers and northern hardwoods receded out of the state to the northeast, being replaced by white pine, beech and hemlock, and finally the mixed hardwoods and oak-hickory increasing their coverage (Delcourt & Delcourt 1981; Garrison 1967; Gordon 1969; Sears 1935). Bowman, (1911:41-43), quantifies the amount of rainfall required for forest growth as about the same as for that required for non-irrigation agriculture, about 20" - 40" per annum, the range accounting for different soil types, topography, and seasonal and yearly variations. Generalizations are important, but as Sears (1935:48) and Gordon (1969:81) both point out, climate shifts were not uniform nor did they persist equally in all types of habitats, making site specific (microclimate) paleoethnobotanical studies essential.
Shane et al. (2001), looks at the Late Holocene in two sections that cover the Woodland period. Holocene A (4000 - 2000 C14 BP) and Holocene B (2000 - 200 C14 BP). During Holocene A (4000 - 2000 C14 BP), oak pollen is down relative to the previous period, from 60% to 40% though it is still the majority pollen, while hickory and elm, which have been even with oak, drop to relatively low levels. Ash, sycamore, and beech drop to a very low portion of the pollen count, with just a trace of chestnut. For non-arboreal grasses, ragweed is the majority pollen, while pigweed and legumes show a high relative count. Precipitation is between 92-95 cm, the average temperature in July is +23 to +25C, and the average temperature in January is -1 to -2C.

During Holocene B (2000 - 200 C14 BP), counts of oak pollen rise sharply compared to Holocene A, up from 40% to 65% and still the majority arboreal pollen. Hickory is up moderately from 10% to 30%, while ash, elm, walnut, and sycamore are very low at less than 5% relative counts. Beech remains very low, and chestnut shows barely a trace. Non-arboreal grasses drop low to less than 10%. Precipitation is up 2 cm to 3 cm per annum, and the average July temperature is between +23 and +24C, while the average January temperature is +1 to +2.

Some site specific pollen studies have been done at bogs in the study area. Studies at Davis Bog in Franklin County help track the climate and changes in vegetation that followed (Williams 1962:14). This bog, six miles W of Columbus, consists of some five acres of deposits in the remains of a kettle hole, between the Scioto River and Darby Creek, in undissected uplands (Williams 1962:15).
to Williams (1962), pollen in the bog shows how the climate varied over its life of some 15,000 yrs, with a number of "pulsating" retreats/advances of the glacier from the Powell moraine (Wisconsin) and warming and cooling episodes (31, 32). Further data from Stages Pond, five miles north of Circleville in Pickaway County, yielded more climate information. Based on analysis of multiple cores from that pond Shane et al. (2001), state that the general climate pattern in Ohio was largely settled about 10,000 yrs ago 35-36). There was local variation over the state, and constantly varying conditions generally over that time period, but within the set pattern. Stages Pond is in one of the most ecologically diverse areas, but with the most stable climate, except between 4000 - 2000 C14 BP (Shane et al. 2001:36).

After the hypsithermal ended the subsequent dynamic period as detailed by Shane et al. (2001) may have had a hand in ushering in the start of mound building, and later earthworks, in Ohio. Certainly the Watson Brake earthwork site in Louisiana dates to that period, so building large earthworks was not unknown in Eastern North America. Most of the banked earthworks in Ohio were built during some of the most varying conditions in the state, when resources were in the most danger of fluctuating and not being predictably stable on a generational scale. Building earthworks during an unstable environmental period; may have been a direct way of marking territory, assuaging a god or spirit, creating social coherence, or may show a more indirect change to more enduring building materials or more massive construction type (Braun 1986:123; Buikstra & Charles 1999:212; Carr and Case 2005:42; Clay 1999:18; Hutchinson & Aragon 2002:46; Seeman 1986). Indeed the decline of the Hopewell
earthworks is often associated with a stabilizing of the environment (Anderson 2001; Byers 1987; Dunnell & Greenlee 1999; Seeman & Dancey 2000; Van Gilder & Charles 2003).
Chapter 3: Woodland Settlement and Subsistence in Ohio and Early Archaeology

"If more of us valued food and cheer above hoarded gold, it would be a much merrier world." J.R.R. Tolkien.

This chapter discusses the concept of the Adena and Hopewell cultures in Ohio and reviews their settlement and subsistence patterns. The chapter ends with an overview of the history of archeology in the state of Ohio specifically.

3.1 Cultural types

Neat typologies, although a mainstay for traditional archaeology, give the impression that the region is covered by a uniform cultural concept during specific time periods. I even use the accepted unified cultural tags throughout this research for convenience. Precise cultural time periods are always problematic in archaeology, implying fixed normative behavior by a group of people at that time. For example, the majority of Applegate and Mainfort's 2005 volume deals with the issues associated with Woodland systematics, and how using cultural labels is both useful and problematic. In his paper in the volume, Burks sets out some of the various Woodland taxa that researchers have employed to partition cultural change in Southern Ohio, which includes the current research area (Burks 2005: Table 3.1:41). The dates and definitions are many and varied. Dancey and Seeman's article in the same volume
advocates for a "loose" approach to taxonomy when discussing the Cole Complex (2005:148), yet it seems such an approach could also benefit research the more mainstream cultural areas of Adena and Hopewell. The issues discussed above make using cultural tags for the nine sites in this study difficult to say the least, but also necessary to a certain extent when discussing cultural context.

The names of Adena and Hopewell came from the respective type-site where a suite of cultural traits were first identified. Greber suggests that while the type sites are useful for the areas where they are found, perhaps other spatial names maybe better for other areas outside of Ross County (Greber 2005:39). These names would take into account different drainage's, or differences in the traditions compared to the type sites. This makes sense as any change or variation is, by definition, difficult to pigeonhole into fixed categorizations.

The chronology of the type sites was not at first based on any scientific dating techniques. Chronology is important to any regional exploration of archaeology to tease apart site use and disuse within and between areas. But set chronologies based on culture types are difficult to construct at accretional sites that have multiple built elements and multiple occupations - How many dating samples should you take and from where? What about sites that no longer exist, or are substantially destroyed and where obtaining datable material in context is more or less impossible? Most of the sites in this research no longer exist or have been substantially destroyed. The dates we do have rely on relative methods, others on radiocarbon, yet others on trait lists denoting cultural groups.
Of the nine sites in this study, only one (Dominion) has radiocarbon dates, while the other eight rely on trait lists referenced to the cultural type sites of Adena, Hopewell or Cole. We cannot tell when all aspects of a banked earthwork site were built, or all the times it was used. Sites often have diagnostic artifacts that show long periods, and multiple episodes, of use. For example, in 2004, at Holder-Wright an accepted Hopewell earthwork site (33FR04) we found diagnostic artifacts from the Archaic through to the Late Woodland, though none from Middle Woodland times. This research therefore employs a chronology-less survey because we do not have comparable dating opportunities. This is similar in concept to the “siteless survey” idea of Dunnell and Dancey (1983). They do not delineate a prehistoric site area based on artifact density, instead using an arbitrary boundary line (stream, field edge etc.). When comparing the nine earthwork sites this research similarly uses an arbitrary boundary (a rectangle placed on the Central Ohio landscape) and does not delineate sites using chronology. Thus this research is both siteless and timeless in its approach. Ignoring chronology is not only indicated because of the dating problems described above, but also because elements of earthwork construction are shared across the Early and Middle Woodland periods and are built by culturally and genetically related people. Ideally, research like Leroi-Gourhan's structural work with the cave paintings of France (where “He excluded time, place, ecology and all artifacts other than the paintings . . .” [Leone, 1982:744]) may help find the relationships of earthworks to each other that are timeless. This would take archaeological research out of a narrow, categorically driven mode and into a more fluid interpretation of meaning.
3.2 The Early Woodland Period (1,500BC – 100BC)

Adena as a cultural type was proposed by Mills in 1902 after his excavations at the Adena Mound. This concept was formalized when Greenman devised a list of 59 traits (Greenman 1932), added to later by Webb and Snow and Baby, so that eventually some 240 attributes conferred an Adena identity to a site (Webb & Baby 1957; Webb & Snow 1974; also see Seeman 1992a). Adena (like the later tag of Hopewell coined by Mills in 1904 and given to Middle Woodland groups 100BC – AD500), seemed to have more variation between areas and sites than the similarities that typed them; “They held in common very little in the way of burial practices or grave goods” wrote Webb & Snow of Adena, (1974:vii; see also Carr & Case 2005). Dragoo (1963) saw difficulties with such broad lists, and instead proposed categories. He also identified variation within the Adena temporal span and split the period into Early and Late phases, a concept expanded upon by Clay (1991, 1998), but disputed by Seeman (1986, 1992a).

Adena village areas are often found on hills overlooking river valleys, or on the higher banks overlooking large streams (Abrams 1992:20; Dragoo 1976:18; Webb & Snow 1974:29), and in areas that afford rock shelters (Carskadden & Morton 1997). The domestic sites are not found within mound or earthwork sites, so the domestic and ceremonial spheres appear to be separate. Clay (1991, 1998), concludes that the Adena were an egalitarian, non-nucleated group of people with no long term permanent housing who lived in dispersed, autonomous social groups. They developed some
agricultural practices during the Early Woodland time period (1,500 BC – 500 BC) (Webb & Snow 1974:xi; Watson 1991:19, 23) but mainly practiced hunting and gathering.

Some deposits from rock shelters in the Kentucky area from the Adena time period yield plant remains that show signs of domestication (a genetic change compared to the wild variety) (Cowan 1997). These include; *Helianthus annuus*, (sunflower), *Chenopodium berlandieri*, (goosefoot), *Polygonum erectum*, (erect knotweed), *Phalaris caroliniana*, (maygrass), *Iva annua*, (marsh elder), and *Hordeum pusillum*, (little barley). Watson adds sumpweed and *Cucurbita pepo* (squash) and *Lagenaria siceraria* (gourd) to the list of probable domesticates (Watson 1991:19). In these rock shelters, evidence has been found of corn, squash, pumpkins, gourds, tobacco, as well (Webb & Snow 1974:314), and storage pits dug into the earth floors of the caves have been found with dried shells of pumpkins or squash remains in them (Webb & Baby 1957:37). Gourds may have been used just for the seeds that they produce or for their storage and carrying ability. Textiles are made from plant bast fibers (Webb & Snow 1974:82-105). *Zea mays* (maize) was introduced into the diet during the Late Adena period but it was not a major part of the Adena subsistence base. Burned deer bones in middens from Ohio indicate a diet high in the meat of this animal, (Webb & Snow 1974:40). The deer bones and antlers were used to make tools, and for head-dresses (Dragoo 1963:207, 222). In Ross County, Ohio, deer bones along with small mammals and possibly turkey remains were found in some of the lower
midden deposits (Lovejoy 1975:252), though the turkey was not a domesticated variety.

Although the above cultivars are present at Adena sites, Watson (1991) cites evidence for a significant reliance on acorn and hickory nuts, other terrestrial wild plants and animals, and aquatic plants and animals (Watson 1991:19). Mussels and turtles also had a widespread popularity at Adena sites, and fish probably played a bigger part in Adena subsistence than recovered remains may suggest, doubtless due to differential preservation of the fish bones compared to large mammal bones. Early excavators also placed less emphasis on small bone collection and botanical samples, which was compounded by the less precise recovery methods of early archaeology, e.g. screen resolution, no flotation etc. Anderson (1996) also suggests that in resource rich areas, such as that inhabited by the Adena, there is less evidence of cultivation compared to more marginal areas (Anderson 1996:518). Based on the above evidence, the Adena probably practiced hunting and gathering with horticulture and some incipient agriculture on a seasonal basis (still a relatively low energy budget diet). They may have continually returned to their more permanent villages over a 10-20 years period before perhaps changing site (Clay 1992:80) (moving due to resource depletion, disease, flood, erosion, etc.)

Some of the artifacts found with Adena Burials may be confused with food items. Medicine bags were prevalent in burials during the Adena (Webb & Baby 1957:72-76; Webb & Snow 1974:vxiii) and are reported historically as made using the whole animal (the animals used range from mice to wolves), including the head (skull
removed except anterior portions of both jaws), feet and tail. This bag, when buried with the deceased, would leave palpable archaeological evidence that would more likely pertain to totems or clans rather than to subsistence (Webb & Baby 1957:74), but maybe would be incorrectly considered as part of the diet.

Other information from a site that may detail plant and animal use for food, as opposed to the foods themselves, comes in the form of tools. In Ohio, various flints (Flint Ridge flint from Licking County Ohio and other Ohio flints [Prufer 1975]) were made into blades and scrapers, while stone hoes, hammerstones and grinding stones are also found. The ceramics of this time are few, and pottery is often thick, granular and plain, incised or cord marked (Webb & Snow 1974). This evidence implies not only processing of plant foods, but the cultivation or management of them too. Pottery was considered a way to delineate the Early Woodland from the Late Archaic, and is thought to indicate a more sedentary lifestyle. Nevertheless, this view has fallen out of favor because people in the Late Archaic also used pottery, and not all Early Woodland groups appear to have ceramics (Clay 2002a).

3.3 The Middle Woodland Period (100BC - AD400-500)

The large Hopewell type-site in Ross County also provided a host of traits attributed to earthworks from this time period, which allowed Squier and Davis to think of Hopewell as a unified concept (Squier & Davis 1848) as did Shetrone (2004 [1930]). But as Struever and Houart (1972) pointed out, this site is itself atypical for the time period, a concept echoed by Greber (2003). A host of other researchers agreed
that Hopewell was not a unified concept, that the people who lived and interacted
during this time were regionally distinct, with traded goods that had regional
overarching motifs but were locally produced (Applegate 2008; Carr & Case 2005;
Charles et al. 2004; Clay 2002a; Dancey 2005).

As with Adena, Hopewell earthworks and domestic habitation areas do not
appear to be at the same places, making a coherent view of earthwork use more
difficult to form. To date approximately 100 households have been documented and
investigated (Pacheco & Dancey 2006). Middle Woodland settlements are thought to
be two or three dispersed households or hamlets commonly referred to as the Vacant
Ceremonial Center model (Prufer 1964, 1996, 1997a; Smith 2002 [1992]) or the
Dispersed Sedentary Community model (Dancey and Pacheco 1997; Pacheco 1993,
1996, 1997). Rather than nucleated villages that are year round, these shift every 10-20
years or so due to the agricultural restraints of swidden (Dancey & Pacheco 1997;
bottom hamlets had their roots in the preceding (and in some cases concurrent) Adena
culture (Carskadden and Morton 1997).

The Vacant Ceremonial Center model, first posited by Prufer, holds that
populations did not live at a ceremonial site, but had a habitation site separate from the
ceremonial area, earthwork enclosures and mounds (though see Clay 2002a). Pacheco
tested this Vacant Ceremonial Center model and concluded that the model was well
met with the data that was available at the time (Pacheco 1993, 1996, 1997). Other
types of Hopewell use areas that Pacheco identified were short term activity areas for
seasonal food processing and specialist camps, such as for bladelet making or other manufacturing (Pacheco 1997; see also Smith 2002 [1992]). Some researchers counter that because some of these camps and structures are found next to Hopewell earthworks then the Vacant Ceremonial Center model is negated (Baby & Langlois 1979; Griffin 1996). But Dancey and Pacheco state “. . . current evidence, in our view, points towards Hopewellian communities being made up of single- or multiple-family households scattered across the landscape but concentrated around the centrally located burial and ceremonial precincts. These households were the stable, long-term settlements of people who cultivated indigenously domesticated plants, collected a wide variety of edible plants and nuts, and hunted extensively” (Dancey & Pacheco 1997:3). This view allows for variation in how close settlements or camps are to ceremonial areas without negating it. Chronology undoubtedly plays a part in how settlement patterns relate to earthworks. For example, were settlements or camps contemporary with the earthworks they are closest too? Could domestic areas built near earthworks or burials have been active only when the earthworks were not actively being used? Again the question is one of gaining a fine grained chronology.

Current settlement research in Ohio is no longer as rare as it was in Prufer’s time, although no unequivocal evidence is available to show that Middle Woodland domestic habitats are routinely located at earthwork locales. Nevertheless, exceptions exist. At Fort Ancient, Lazazzera (2004) found a number of substantial habitations in an area inside the earthworks wall that she characterized as long term domestic locales (with intervals of disuse) for inhabitants to live in both during site construction and
while using the earthwork. Some Hopewell earthworks do have non-domestic structures in them that are different in form to the dispersed households cited above, and these structures appear to have acted as charnel houses for the Hopewell people, (Greber 1979; Seeman 1979).

During the Middle Woodland period (100BC- AD 400) people in Ohio were farmers, clearing forests to prepare fields, planting, cultivating, harvesting and storing both domesticate plants and wild plants that were intensively managed (Smith 2002 [1992]). Abandoned swidden areas could still be utilized by the people of Middle Woodland communities as secondary growth products, such as berries, would begin to grow there. Such fallow or unplanted clearings would also attract deer and other forest animals to browse and forage there, making them easily hunted. Farming did not take over as the main mode of subsistence once plants had been domesticated, so the proceeds of domesticated foods seem to have been “... additive to preexisting subsistence patterns...” until the end of the Late Woodland Period (Smith 2002 [1992]). The Hopewell culture utilized goosefoot, sumpweed, squash, erect knotweed, giant ragweed, (all of which have been found at Fort Ancient [McLauchlan 2003], maygrass, little barley and sunflower in its subsistence. Goosefoot is found stored in a large quantity at Ash Cave, OH and dated to around A.D. 230 (Smith 2002 [1992]). By the end of this period, small garden plots change to field cropping areas and maize is added to the subsistence base about A.D. 225 (Smith 2002 [1992]). In Southern Ohio, maize is found in small quantities at the Harness site. As maize did not become a major part of the diet until the Late Prehistoric period, about A.D. 1000, the Harness find
suggests that the earlier use of maize was for ceremonial or ritual use (Smith 2002 [1992]). Other research that supports the importance of wild animals in the Hopewell subsistence has been conducted by Madrigal and Zimmermann Holt (2002). They found that meat was not the primary resource collected, but that the higher calorie bone marrow may have been the most important item for processing, and that there was a heavy reliance on hunting (Madrigal & Zimmermann Holt 2002:755).

As Smith aptly puts it “Almost all of the available evidence regarding Hopewelian farming settlements seems to indicate a largely independent and autonomous status for individual household units, and their consistent dispersal across the Middle Woodland landscape of the prehistoric East” (Smith 2002:240 [1992]). In his 1968 work, Struever attributed a change in the Hopewell subsistence base causing a change in the settlement patterns, precipitated by a population increase. In their 1972 work, Struever and Houart argued that Hopewell sites were part of ranked points in a hierarchy with respect to artifacts, earthworks and resources, although 10 years previously, Caldwell had argued against that view. Caldwell said that cultures who build earthworks must have had an agricultural surplus (from maize farming) to support the risky behavior of building large mounds and earthworks (Caldwell 1962:296) not just the type of social hierarchy associated with cultivation and horticulture. Even so, by 1964 Caldwell had apparently changed his mind and wrote, “Maize and squash were evidently known, but subsistence practices were principally involved with hunting and gathering” (Caldwell 1964:137), although according to Yarnell, James Griffin at the same time had suggested that the Hopewell cultural
system was actually dependant on plant husbandry (Yarnell 1994:11). Fiedel also weighs in with “Hopewell settlements were concentrated on or near river bottomlands, not for floodplain agriculture, but because wild resources were most abundant in those micro-environments” indicating that cultivation or husbandry was secondary to wild resources (Fieldel 1987:236).

3.4 The Late Woodland Period (AD500-AD1000-1200)

Archaeologically, the Late Woodland Period is certainly somewhat less visible than the Middle Woodland as it has no large mounds or earthworks. During the Late Woodland period (A.D. 250 – A.D. 800-1000) populations increased in density, become more sedentary and used more products of horticulture in their diet (Charles 1992), but continued to use natural resources extensively. All the cultivars and domesticates already mentioned (maygrass, chenopod, sumpweed, sunflower, little barley, erect knotweed, tobacco, squash, gourd and maize) are found at Late Woodland sites (Seeman & Dancey 2000). The Water Plant site in Ohio is one that shows nucleation of a population in a multi household village, located on a bluff edge, unlike the floodplain and hinterland sites of the Middle Woodland (Dancey 1992).

There is transformation in settlement patterns over the Middle Woodland to Late Woodland transition, from low visibility, small hamlet settlements associated with earthworks to nucleated settlements away from the earthworks. This change does not seem to be either precipitated by a subsistence change, or cause a subsistence change either (Byers 2004:128). Charles says that during that period, the demographic shifted
from dispersed populations to settled communities along key Midwest waterways due
to more efficient horticultural practices, and better ceramics for processing starchy
seeds (Charles 1992:176). He goes on to state that it was the “. . . increased efficiency
in the horticulture of starchy seeds coupled with improved ceramic technology for
processing the harvest” (Charles 1992:176) that led to nucleation. With populations
during the Late Woodland period (A.D. 250 – A.D. 800-1000) growing denser, more
sedentary and “. . . heavily reliant on horticulture” (Charles 1992:176). The lack of
consensus and conflict that exists in these explanatory types shows how difficult it is to
reach a consensus on changes in past subsistence.

The Late Woodland sites seem to be on naturally defensible areas, and include
cultural enclosures that delineate the space. Settlement data comes from over 30 house
structures in the mid-Ohio Valley that are circular with hearths and storage facilities in
the interior. These villages still did not have full maize agriculture, or even an increase
in food produced by agriculture (Dancey 1992). Furthermore, these villages were not
part of the Hopewellian network. Nucleation may have been due to Hopewell
predation on fields and stored supplies of non-Hopewell groups, caused by climate
stress. This is indirectly indicated by ceramics found in the archaeological record,
which indicate that these had increased in size and were now used for storage as well as
cooking.

Eventually, the nucleated communities out competed (out adapted?) the
Hopewell (Dancey 1996; Seeman & Dancey 2000). Post - Hopewell then was just a
"different" expression of culture compared to Hopewell times according to Seeman &
Dancey (2000:603). Whether this nucleation process happened within the large Hopewell area or developed out of periphery rebellion against perceived Hopewell inequality in the core is open to debate (Seeman & Dancey 2000:602). Although maize farming begins in earnest by the Late Prehistoric period, maize agriculture was not completely widespread throughout the region and some groups did not have much maize in their diets (Dunnell & Greenlee 1999). Cultivation practices do continue, however, and nucleation of year round households occurs relatively suddenly during the period (Dancey, 1992; Seeman and Dancey 2000). The consolidation of garden plots during nucleation would encourage even more agricultural techniques, and by the start of the Late Prehistoric period (A.D. 1000 onwards) we see full agriculture and a maize based farming economy.

3.5 Summary of the Woodland Period

Classic ecosystem and settlement pattern studies like those conducted by Flannery in Mesoamerica (for example Flannery et al. 1967) were just not done to any great extent on the Adena and Hopewell of the Midwest. Stuart Struever is one good exception with work he has completed in the Illinois area (for example Struever 1965 & 1968; Struever, & Houart 1972). In his 1965 work, Struever equates microenvironmental zones with stylistic variation in pottery, and in 1968, he attributes a change in the subsistence base to a change in the settlement patterns caused by a population increase. Again this type of research did not have the additional view of what the mounds and earthworks of these cultures meant to the people who built them.
and what experiences they may have held for them. Although many papers of the day talk about burials mounds as “enclosed within earthworks forming ceremonial centers” (Dragoo 1976:18, emphasis added) nobody really comments about what exactly ceremonial really means; that is, what sort of ceremonies were carried out there, how those related to the wider sphere and what the earthworks meant to the people concerned.

In the Middle and Late Woodland, human activities did change the forest structure in the Eastern woodlands in the form of forest clearances for open land farming (Delcourt 1987; Seeman & Dancey 2000). Land clearances for garden plots and field agriculture would encourage weedy and shade intolerant plants to grow (Delcourt 1987). In an otherwise forested area utilized by prehistoric individuals, the upsurge in weedy crop pollen and seeds in the archaeological record implies such land clearances occurred (Delcourt 1987; McLauchlan 2003; Smith 2002 [1992]). In addition to horticulture, tree clearances would also occur to satisfy the demand for wood, as wood was needed for construction of structures, palisades (Late Woodland), scaffolding for earthwork building, etc.

The cycle of plant use and settlements takes a different path in the Middle Ohio Valley to that of other places in the world (Smith 2002 [1992]). Diverse foodstuffs seem to be consumed throughout the Woodland period, and the seasonal variation that plant resources exhibit in when they seed would influences where Woodland communities chose to live (Gremillion 2002). Though the beginnings of domestication and cultivation are found in the Archaic period, full agriculture, and an economy based
more on grown products than hunted and gathered ones, does not develop until the Late Prehistoric. During the Early Woodland highly mobile hunting and gathering groups start using seasonal growing camps near floodplain growing areas, and over winter in upland areas where shallow storage is used for wild and managed plants (Smith 2002 [1992]). At the start of the Middle Woodland there is a general use of the Eastern Agricultural Complex plants, especially cucurbits. Over the course of the Middle Woodland, people begin to live in semi-permanent dispersed homesteads that have deep storage pits and are sometimes near marsh areas for gardening and cultivating purposes. The majority of their food still comes from hunting and gathering, but a larger and larger percentage is being contributed by cultivated plants, such as at the Fort Ancient site. At the beginning of the Late Woodland nucleation has become the norm and naturally defensible areas with added palisades develop. Management of swidden field plots mean that by the end of the period maize has started to become a staple in the diet.

A change in the subsistence base, perhaps due to climatic upheaval was ruled out by Wymer as a reason for the cultural change, she states there was "no dramatic shift in subsistence that can account for the cultural change that occurred. ."(1989:30). But Loehle (2007:1051) reports a temperature drop around A.D.200 that Abrams thinks ". . . undoubtedly exacerbated risks underlying Hopewellian economic and organizational changes" (2009:175 though see page 186 where Abrams refers to a temperature rise in A.D. 400 as being a possible cause of the Hopewell waning). Anderson also refers to the "1159BC" event at the start of the Early Woodland, and
another event that led to better climate around 450BC at the start of the Middle Woodland as explanations for culture change (2001:164). An event around AD 350, where the climate became cold again, is given by Anderson as a possible trigger for the Hopewell decline.

There are differences in how subsistence strategies in Ohio are defined, and these have implications for settlement size and thus earthwork placement. So although habitations and earthworks appear to be separate, they may both still be placed on the landscape with close regard to each other. For example, seasonal hunters and gatherers (Lepper & Yerkes 1997; Yerkes 2002), mixed hunter and gatherer and farmers (Dancey & Pacheco 1997) or long term farmers (Smith 2002 [1992]) would all have different land use requirements and habitation types, and would be on quite different places on the landscape. Smith states categorically that the Hopewell were farmers in every sense of the word (Smith 2002 [1992]), yet Yerkes (2002) counters that they were hunters and gatherers that only did a little clearing, tilling and cultivating, and were seasonably mobile. To support his hypothesis, Yerkes cites the lack of large, nucleated settlements (the presence of which he states is associated with farming communities and is supported by ethnographic analogy), the lack of large storage areas, the lack of diverse artifacts and lithic tools with varying amounts of reuse, the lack of thick middens, the existence of features similar to Late Archaic foragers, and the lack of year round floral and faunal remains found at Hopewell habitations. Nevertheless, Dancey’s research shows a Middle Woodland settlement scenario balancing the needs of a horticulture and agricultural system, (farming indigenous domesticates and
cultivated plants) with natural resources from hunting and collecting (Dancey & Pacheco 1997:8, 11; see also Wymer 1996; 1997). In Ohio the Murphy site, the McGraw site, Genesee Guard, and (in 2006) Brown’s Bottom are four well-documented examples of such Hopewell settlements.

Throughout the Middle Woodland the number of large geometric earthworks and burial mounds increased, relative to the preceding period, and it was thought that habitations did not increase in size and nucleation did not occur (Dancey 1992; 1997). Recent research, however, has found that away from the core Hopewell places, in the periphery areas such as Central Ohio, nucleation had started as early as the third century (Burks 2004). This new research, if supported by other similar findings, may change the timing of nucleation from after the decline of Hopewell to during its heyday. Such an explanation would perhaps change how researchers explain both the disappearance of Hopewell and nucleation, as each has been used as an explanation for the other.

Archaeologists have tried to explain the Hopewell earthworks in concert with subsistence behavior. Certainly, with regard to the Hopewell culture, the foreign import of maize was thought to be responsible for the upsurge in the earthwork and burial mound complexes found over the key areas of Ohio, Illinois, and Indiana. Caldwell did not believe that large structures could be built in a society that only had a horizontal social hierarchy as opposed to a vertical one and only practiced horticulture instead of agriculture (1964). Nevertheless, later stable carbon isotope analysis of bones from Hopewellian individuals did not find the levels of the C4 photosynthesis pathway
(measured as a ratio of $\text{C}^{12}/\text{C}^{13}$ in bone collagen) expected of people eating a diet high in maize, instead ratio levels indicated a $\text{C}^{3}$ pathway of non-maize plants (Smith 2002 [1992]). The earliest date of approximately A.D. 225 for maize found at the Harness mound in Ohio is obviously too late for maize to have been a major force behind mound and earthwork building and cultural change in the Middle Woodland period (Smith 2002 [1992]).

The discussion about settlement and subsistence underscores the differences in perception and definition of the words associated with subsistence practices. Whether the Hopewell were farmers, horticulturalists, gatherers or cultivators with different levels of hunting supplementing their diet is a matter of definition. The disconnect between domestic and ceremonial sites continues from the Early Woodland through to the end of the Late Woodland period and may be indicative of the need for some kind of ritual difference between domestic and ceremonial spheres (Byers 1987).

3.6 Early North American Archaeology

Early literature about archaeology in the Eastern United States abounds with references to a mysterious, now extinct race of "moundbuilders" (which included the builders of banked earthworks) (Atwater 1833; Boewe 2000; Lee 1892; Squier & Davis 1848). The mound builder concept has been both a blessing and a curse for Ohio archaeology. A blessing in that it gives the public various monikers to refer to as a way to understand the archaeological sites, but a curse as it needlessly conflates variation and implies relationships between sites where perhaps there are none (Seeman 1992).
The concept of the Moundbuilder myth has profound implications on how early archaeology was conducted in Ohio.

3.6.1 The Mound Builder Myth

The mound builder myth may have originated with a colorful character named John Rowzee Peyton. In 1773, after a storm at sea he was captured by the Spanish and, as their prisoner, forcibly marched from the mouth of the Rio Grande to Sante Fe. After incarceration there a careful plot involving stories of wealth, opium drugged guards and lovesick young girls precipitated Peyton’s escape, whereupon he headed north towards St. Louis using an aged compass and a map from 1703. Although his journey was filled with apparently more swash and buckle than an old Errol Flynn movie, Peyton did take time out to excavate a burial mound from which he took bones, shells and some pottery pieces (Blakeslee 1987:788). In writing to his father about the mounds in 1774, Peyton explicitly states that “I am much mistaken if antiquarian research does not show that ages previous to the discovery of America by Columbus, this continent was inhabited by people of an advanced civilization, as compared with the Red Skins of today” (Blakeslee 1987:788). Although this account was not formally published until 1867 by Peyton’s grandson, the contents of the letter were shared around the family friends and colleagues of Peyton’s educated and prominent family. On his arrival back in Virginia (after being wounded in a battle with the British along the way) his stories of escape, archaeology and war would have made him the talk of the town. Blakeslee concedes that Peyton was probably not the direct cause of the
mound builder myth, but it seems possible that he sowed the seed of the idea within educated society. When the idea was popularized by Fitch in 1785 (Blakeslee 1987:791) it became the commonly accepted explanation for all the mounds so prominent across the American landscape.

No university trained or professional archaeologists existed in the USA until the late nineteenth century, when Harvard University offered the first archaeology and anthropology Ph.D. (Meltzer 1985:250), and it was probably this very shortcoming that enabled the Mound builder myth, nodded at by Peyton in 1774 and then started in formal circles by Fitch to perpetuate. The lack of formal education for archaeologists meant that rampant speculation about the origins of the numerous mounds and the extant Indians found all over eastern North America could only become more inaccurate as people tried to out do each other with more ridiculous tales. Such tales between 1785 and 1894 of which people may have built the mounds included - groups of Hindu’s (Atwater, 1833; Boewe 2000:xiii), the Israeli Lost Tribes (Boewe 2000:135), Tartars, Negros, Arabians, Chinese, Indian or Korean people, Nordic and Viking people, Scythians, Toltecs, and Welshmen (Boewe 2000:19; Willey & Sabloff 1974:1-83). Atwater (1833), also suggested that after coming over from India, the people migrated from the north east, to the west and thence to Mexico and Peru, becoming more civilized as they went west, until the civilization peaked with Mayan Architecture.

There was a link between the way archaeology initially thought of the mounds and the way that general society viewed the living Native Americans that inhabited
North America at contact was linked. The thoughts of the day revolved around unilineal evolution with emphasis on progress and development through betterment. Most European settlers in North America wanted to take land off the Native Americans for their own farming and industry needs, but instead of simply forcing the Indians off the land the Europeans went a step further in their justification. They painted the Native America’s as invaders themselves, people who had killed off the original builders of the mounds in a display of primitive barbarity. The original mound builders thus had an air of an heroic past about them, originating in other parts of the world besides North America. This effectively meant the extant Native Americans could have no concept or use for the giant earthwork complexes of the Adena, Hopewell and later Mississippians cultures. Even though De Soto’s party in the 1600’s reported extant Indians building and using mounds, this ethnographic evidence was ignored by later White explorers (Willey & Sabloff 1974:21); another example of ethnocentric behavior against non-whites, this time directed at the Spanish chroniclers. With this blinkered mentality the mound builder myth had fertile grounds in which to grow.

Since the time of the original Spanish invaders, a number of chroniclers and researchers had suggested Native American origins in Asia (via the Bering Strait) and that Indians could be responsible for the mounds. This information was selectively culled from speculative circles of armchair science. The White settlers used mythical stories as a way to control and exterminate the extant Native Americas who inhabited the lands wanted by the pioneers. By alluding to a biblical lost tribe, or a group from one of the great civilizations of the world and suggesting the extant Indians had
destroyed them in a barbarous act of cowardice, the settlers could sell the idea to the
general public and forcibly remove the Indians from the land. All the political and
religious pressure of the day was more about proving extant Indians did not build the
mounds rather than trying to explain what the mounds were and why they were where
they were on the landscape. The stage was set for the indiscriminate recovery of
artifacts to prove Western theories, and by implying a European link, the mounds and
their contents effectively now belonged to the White settlers.

3.6.2 Early Archaeology in Ohio

Ohio was settled in the 1700’s in a series of land tracts that were given or sold
to various entities (Figure 15) before being organized into 88 counties, with the capital
moved from the town of Circleville in Pickaway County, to Columbus in Franklin
County. Antiquarians conducted early excavations of earthworks in Ohio in the first
half of the 1800’s, which took the form of trenching, tunneling or leveling (Dancey
1988:33). They focused on artifacts found at Adena and Hopewell sites (especially
artifacts made from non-local resources) and description of the burials themselves.
These coveted artifacts were for museum collections or to sell to collectors. And
without the rigors of advanced archaeological fieldwork nor anthropological enquiry,
few notes, maps or photos remains from these treasure hunters. There was also an
effort to match artifact burials in the United States to European technology styles and
skeletal remains, thus linking the earthworks and mounds to a European origin. Such a
link would render the mounds separate to Native American origins, justifying not only
the European ownership of the mounds and their priceless contents, but also implying that extant Native American somehow exterminated the European architects of the mounds and stole their cultural heritage; a link they never did find.

In 1848, Squier and Davis published a large volume called *Ancient Monuments of the Mississippi Valley* (Squier & Davis 1848). This book, according to Dancey was a departure from the usual myth and speculation and included objective descriptions of the archaeology, along with methodology, stratigraphy and ethnographic comparison (Dancey 1988:28-30). Squier and Davis explained that, as previous archaeological work was too general and vague, “Minute circumstances are often of the first importance in arriving at correct conclusions”, (Squier & Davis 1848:28). Nevertheless, Squire and Davies still doubted a native American origin for the earthwork builders.

Squier and Davis’ early analytic style laid the basis for the work of Cyrus Thomas, who published a wide ranging work in 1894 (Thomas 1985 [1894]). Thomas took, checked and corrected information from Squier and Davis, added some more excavation research, and provided standardized data recording for archaeology. This enabled Thomas to assess and compare the artifacts and skeletons excavated from the earthworks and mounds. He concluded that nothing about this built environment was of an Old World origin, and that all of cultural remains were consistent with extant Native American cultures, though there was not necessarily a direct ancestral link to the extant Ohio native Americans. In correspondence with the then Ohio State Archaeological and Historic Society dated March 23, 1887, Thomas wrote "There is
also other evidence that the Cherokee were the authors of the typical works of Ohio. . .
" continuing emphatically "The mounds furnish positive evidence that the typical
mound builders of Ohio did not go south and merge into the Chata-Muskeokee (sic)
tribes as Judge Force surmised. They were Cherokee" (Thomas 1887; see also Thomas
1985 [1894]). By 1889, Thomas had suggested ". . . that the ancient works of the State
are due to Indians of several different tribes. . . " with only the least typical ascribed to
the Cherokee (Thomas 1889a:7). The variation found in the geometric works he
suggested was because Native Americans could not necessarily lay out true geometric
works (1889b:15). Though Thomas' assertions of extant groups building the pre-
historic mounds proved untrue, the reasoning about Native American builders
effectively brought the concept of a lost race of Mound Builders to a close (although
see Casey et al. 1979 a & b for a modern perpetuation of the non-Indian mound builder
idea). Shetrone notes that by going from a "superior civilization" to "mere Indians" as
the source of the mounds, many lay people ceased to be enthralled or interested in the
mounds anymore (Shetrone 2004 [1930]:471). Sadly, is seems, once the mystique of
the mounds disappeared the interest of the public in them went the same way.

W. K. Moorehead, a curator for the Ohio Historical Society was no better than a
relic hunter. He swapped spare artifacts he excavated from Ohio earthworks for other
artifacts that other collectors owned in an effort to complete collections with items he
did not have or that were damaged (Moorehead n.d., 1887?). Correspondence between
Moorhead and Fowke of the Bureau of Ethnology show more of an interest in finding
burials and thus the artifacts that often accompanied them rather than understanding
what such items meant. In fact Fowke’s letter shows a good natured jealously of all the mounds that Moorehead was excavating in Ohio and all the artifacts he was finding therein (Moorehead n.d.). Huge numbers of mounds were excavated in a frenzy of relic collecting for the Chicago Worlds Fair of 1893, where Fredrick Putnam was the anthropology administrator in charge of procuring the best and most diverse items from Native American sites amongst other things. Moorehead and Shetrone worked on the Hopewell site in Ross County to stock the exhibition. The information and artifacts were proprietary to the Worlds Fair and thus restrictions on publishing and excavation details further interrupted the flow of scientific and archaeological research. In his defense, Moorehead did begin a drive to map all the prehistoric works of Ohio using a questionnaire sent to all the post masters at offices in each Ohio county. The secretary, A. A. Graham at the then Ohio State Archaeological and Historic Society, apparently approached Cyrus Thomas at the Smithsonian to effect a state map of prehistoric remains by groups. Nevertheless, the finalized map and information did not get published until 1914, when William Mills completed it (Mills 1914). Even so a number of the sites in the current research were either not marked on Mills' map, incorrectly marked on his map, or only had some of the multiple elements marked on Mills' map. Moorehead did agree that Native Americans were the mound builders, but he was still somewhat denigrating of them, comparing their skulls to Negros and all the negative connotations that that term had in the late 1800's, (Moorehead 1892).

Once the concept of Native Americans building earthworks and mounds was established, the focus of archaeological research changed. Gone was the need to find a
cohesive style from a single outside origin, and instead there was a shift to analyzing and comparing the variation that was apparent in the earthworks, (Dancey 1988:34; Meltzer 1985:258; Kardulias, 1989). The variation in earthworks was first addressed by Thomas (1985 [1894]), who noticed regional diversity as opposed to regional unity, with documented spatial differences across the region. This spurred on research to a more regional and comparative footing as researchers like Moorehead, Mills and Shetrone tried to apportion certain earthworks to certain cultural groups.

Between 1902 and 1920, prehistoric and historical cultural groups were categorized as Adena, Hopewell, Fort Ancient, Glacial Kame, Stone Grave, Iroquois and the Algonquian (Dancey 1988:36). Adena, as a cultural group, was eventually identified using a list of traits based finalized by Webb and Snow (1974), and Mills defined the Hopewell culture also with a checklist of traits in 1904. Later in 1939, McKern championed a taxonomic method to document variation in Midwest archaeology using distinct terminology along with exact definitions. McKern considered this methodology a necessity in the Midwest as the Direct Historical Method could not work when no extant groups existed as a direct link to the prehistory of the area (McKern 1939:302). Nevertheless, such strict systematics all but homogenized Ohio archaeology and portrayed variation as a winsome aside.

Between 1929 and 1946, field archaeology in the Midwest slowed, especially in Ohio, and the emphasis changed from excavation and regional views to “. . . the correlation and systematization of all archaeological data accumulated in the past, the minute and comprehensive examination of all the evidence, and the detailed and
extremely careful excavation of prehistoric sites”, as Griffin put it (c.f. Dancey 1988:46; and see for example Griffin’s 60 page chapter in *Man in Northeastern North America*, 1946). Again this work emphasized the minute and functional, which did not look at the world of the people who had built the earthworks, and what the view of the landscape may have been for them. There was no sustained and systematic research into how or why the earthworks and mounds were built or used, what their distribution on the landscape could mean, what experiences and memories they may have been designed to invoke, or how local and regional interactions may have taken place. Archaeological interpretations that were then available made guesses about chronologies and gave explanations that left the reader asking why and how they had come to that specific conclusion (Ford & Willey 1941).

Archaeology on the Adena and Hopewell from the 1990’s onwards tends to have a pluralistic view of the world, using description, history, chronology, function, structure, ecology, settlements patterns, with processual adaptation, and non-biological evolution (e.g. Dunnell 1996; Dancey & Pacheco 1997; Carskadden & Morton 1997). In this modern research, a number of authors attribute that variation to regional cultural groups who had different histories and trajectories based on the area they were in (Dancey & Pacheco, 1997; Clay, 1998; Greber, 1991; Struever & Houart, 1972). Only a few researchers have looked at what the numerous earthwork configurations may have meant outside of their use as burial places e.g. lunar, solar and stellar observatories (Dancey 1996:315), and some research has not been completed at all (phenomenological, physiographic modeling, etc.) Nevertheless, focusing in just one
aspect (e.g. solar alignments) still segments one type of behavior from other behaviors that may well be interrelated. That is, a solar alignment may have as much to do with death, the afterlife, and the ancestors as it may with seasons, subsistence and life cycle feasts. All of these differing views hold valuable information, and much more information can be obtained that is directly applicable to present day research into the Adena and Hopewell.
4.1 Introduction to the Sites

The following section lays out information about each of the known sites and random sites used in this research. For the known sites this information covers site names, county designation numbers, locational aspects, investigators and finds, and for all the 18 sites it includes landscape analysis, with glacial, bedrock, and soils data. Central Ohio has many archaeological sites within it; over 6,100 in the five counties of interest. Of those only a few are earthworks or mounds, and many of those have already been destroyed or severely altered by agricultural practices (see Atwater 1833; Blank 1984). Incomplete, ambiguous and sparse excavation records add to the difficulties of reconstructing histories of sites since razed.

As mentioned, this research focuses on the geometrical sites rather than purely mounds per se, as the geometric sites should be easier to locate than mounds on remotely sensed imagery. Mounds would tend to blend in with the Ohio landscape, and can easily mimic natural landforms or vice versa. Additionally, a small single-burial mound may be dismissed as a natural swale in an archaeological survey, or easily destroyed by farming or development without anyone realizing it is of archaeological import.
Table 2 shows the differences in site counts between Mills' 1914 atlas and the current OAI counts from the SHiPO database. Mill's atlas was the culmination of a concerted work effort over the previous 30 years. The OAI has cards from the card index started in the mid 1950's, but the original card file dates back to the 1930's (Seeman & Branch 2006:111). That became a one page form in 1975, and a multiple page form later on. The OAI office checked the sites on Mills' atlas and a number of them could not be confirmed, either due to development or the lack of evidence. The same problem occurred, when Mill's checked Squier and Davis' maps and locations of 1848. The time span of survey, and the different methods of how sites are designated, have undoubtedly led to these discrepancies. Having said that, although there is not an exact match, Dancey reported that the field checked Atlas was useful “. . . as a controlled sample of certain classes of sites, but . . . virtually worthless as a source of specific locational data” (1984:12). More recently, Seeman and Branch report a Pearson product moment correlation between the Atlas and the OAI data of r = 0.7004 (2006:111). The temporal affiliation from the OAI database is shown in Table 3.

The sample of earthworks used in this research was picked for these reasons:

1. They are known and verified sites.

2. There are records, descriptions, plans, aerial photographs, or artifacts variously available for all of them.

3. These large earthworks have endured, and thus should be representational for the population of large earthworks in Central Ohio.
4. Any information gathered about the placement on the landscape of these types of large earthworks should be applicable to other enduring earthworks - a necessity if they are to be seen on remote sensing imagery or through geophysics survey.

5. The chosen sites span the Early and Middle Woodland temporal phases, so if there is a social memory conditioning the site choice of the people who build them, then that site choice should be recognizable regardless of temporal affiliation.

The known sites are on different drainages within the Central Ohio river system. This system contains six rivers, of which the Scioto River is the largest (Figure 16), and into which the other four drain (Table 4; Figure 17).

4.1.1 Adler FR11

Located in Brown Township on the Plain City USGS quad, little is know about the Adler site (FR 11). Found on the old H.C. Adler farm, the farm is now part of the Prairie Woods Metro Park. The Ohio Historic Society, Ohio Archaeological Inventory cardfile at the State Historic Preservation Office has handwritten notes saying "removed for gravel" (undated) and "no trace remaining" dated 4-21-75 and the initials "BCD" (probably Burt Drennan; both notes are in the same hand and thus probably contemporaneous). No diagram or any detailed description is available, with only a scant description recorded in Rodgers (1892, p.48) and OA&HSQ vol. 1:357.
(Wetmore, 1887) which both quote an entry in The Williams' Brothers History of Franklin and Pickaway County's of 1880 that appears to be from Whittlesey.

"There was also an enclosure, or fort, on the farm of H. C. Adler, Esq., with two circles, enclosing perhaps one-half an acre of ground. Its location was upon the high bank of the creek, [Big Darby Creek, which is the drainage too] toward which was the usual opening found in works of this kind. It was composed of gravel, which has been removed for building and other purposes. Human bones were also found here. It is highly probable that this was a favorite camping ground for the Indians, as stone hatchets, arrow-points, skinning knives, etc., were found here in great numbers by the settlers. Mr. Francis has a number of fine specimens found here" (418).

With so little known about the site, it is difficult to determine what time period it may have spanned, but based on the circular embankment it is thought to be Adena.

The use of the phrase "an enclosure" is assumed to mean a singular entity, with one circle presumably inside the other, although this is not a common form. For a double circle to enclose half an acre, the circle would measure about 166' in diameter. It does not appear on Mills' atlas as a banked earthwork shape, but a mound is shown in the vicinity (just to the southeast), which may be meant to mark this work (Figure 18A). Given the small scale of Mill's work, there are bound to be problems marking the exact position of the numerous earthworks and mounds. Much quarrying has occurred in the area since the 1800's, with aerial photographs from 1986 and 1988 showing extensive stripping on the west bank of the creek and some on the east bank. A house and outbuildings shown on early photographs (Figure 18B) and USGS maps seems to have been removed along with a long gravel driveway; these disappear between 1979 and 1989 according to aerial photographs at Ohio Department of
Transportation. Documents at the Franklin County Recorders office show the land currently belongs to the Metro Park district. After mining rights from 2001 to 2004 expired (the Olen Corp owned them for sand gravel and limestone removal) the area was reclaimed for the Prairie Oaks Park. The site in now part wooded and part prairie.

The closest town to Adler mentioned by Stout et al. is West Jefferson, approximately 3.5 miles to the south (1943: 435). According to Stout et al. (1943) the area had glaciation effects from both the Wisconsin and Illinoian glaciers, leaving drift thicknesses of 80-175ft. The deepest drift is found in Little Darby Creek, itself a remnant of the Groveport River during the Teays stage drainage. The dolomitic bedrock contains water, though it is contaminated with hydrogen sulphide. Overlying the bedrock is till with sand and gravel lenses (ODNR 2000). Major soils associations in the area are Crosby - Kokomo, and the minor soil at the site is SIA, Sleeth silt loam (0-2% slope), somewhat poorly drained (USDA 2009 a&b; Figure 19).

4.1.2 Briggsdale FR 7

Briggsdale (FR 7) is slightly more documented than Adler, but still little is known about this earthwork on the SW Columbus USGS quad in Franklin Township. Briggsdale Works was surveyed in 1840 by Charles Whittlesey, with the map published in 1850 in the Smithsonian Contributions to Knowledge, volume III, article VII p. 10 - 11, Plate III, No.3 (Figure 20A). The direction to the south on the map is noted as to "Harrisville", obviously a mistake as Harrisville is east of Columbus near
Wheeling. Whittlesey also wrote on the map "Three Miles SouthWest of Columbus, Ohio", which places the two earthwork circles on the Harrisburg Pike. Whittlesey's description is minimal "These structures are simply circles, or figures approaching to circles, with occasional irregularities. There is a difference of fifty feet in the diameter of the larger one, and the outline bends each way from the curve of a true circle, a few feet, making short straight portions, not capable of our representation on our scale. The ditches are at present very slight, and not uniform in depth of breadth. From the top of the bank to the bottom of the ditch, the difference in no place exceeds two and a half feet. On all sides, for miles, is a low clayey plane, inclined to be wet, with very slight undulations. This is the only remarkable fact connected to this work. Its ditch being external, and its openings narrow, indicate a work of defense; and if it were known that the ancient inhabitants of the Scioto used palisades, we might safely conclude this to be a place of defense, relying solely on artificial strength. There is no running water in the vicinity" (Whittlesey 1850:10-11). This last point bears expansion, as the Scioto River is 2.2 miles away to the east (the site is the drainage of the Scioto River), but the North Fork of Big Run is only 0.8 mile to the southwest. Whittlesey's description is also reprinted in Lee (1892:48). Presently the area is under medium density housing with some mature trees.

Whittlesey's diagram is troublesome, having no drawn scale but just the writing "scale 400ft to the inch". Other drawings in the same article have a block scale, and when measured the inch is somewhat short by the same amount on all of them, just about 1/32 short or 12 1/2 ft over 400 ft. If that shortfall (hereafter called the
Whittlesey Inch) is applied to the diagram of Briggsdale, the southwest circle measures approximately 620 ft in diameter with no ditch (685 ft with the ditch), not 600 ft using a standard inch, and the northeast circle measures 470 ft in diameter with no ditch (525 ft with the ditch included), not 440 ft using a standard inch. The Whittlesey Inch is obviously a product of the reproduction process used to print the original article, which resulted in a slight reduction in size of the hand-drawn maps⁵.

Wetmore (1887) mentions the earthworks in the "Earthworks of Franklin County, Ohio" by quoting the Williams Brothers (1880). The Williams Brothers supposedly quote the Smithsonian volume, but the description they write is quite different from that of Whittlesey's quoted above. "There were here plainly visible, a few years ago, two almost exactly circular enclosures, one about 800 feet and the other about 500 feet in diameter. These walls were only slight elevations, and measured from the bottom of the ditch (which was in this case exterior) to the top of the embankment, the height was in no place over three feet" (Williams Brothers, 1880). The measurements are quite different to the surveyed results. No record of any finds, excavations or other information is available. Mills (1914) has the site marked with one circle (Figure 20B).

There is an area three miles southwest from Columbus that seems to be the area where the Briggsdale works were located. From the corner of High Street and Broad Street, by the state capital building, the center of this area is exactly three miles in a southwesterly direction matching the description written on the original survey map. It also matches the description on the OIA card, of the site being west of the south end of
Greenlawn Cemetery. There, in the Gibson Park Place and First Searles Addition subdivisions on the Harrisburg Pike there are roads that mimic the circular shapes of one of the two circles that make up Briggsdale, and may relate to the larger southwest circle. To the north, there is a small circular remnant marked out in vegetation, and visible on aerial photos and also in the topography of the USGS maps, that may relate to the northeast circle. This area seems to be a ditch at the present time, but may follow part of the original circle's ditch outline, although it does appear to be too big.

A slightly better alternative, which measures 525 ft in diameter, very close to a measurement for the smaller northern-most circle as conveyed by Whittlesey in the Williams Brother's publication, is partly shown by Wilson Drive and Valley Street. Nevertheless, again the layout does not seem to fit the relative relationships between the two circles and with them and the Harrisburg Pike road (Figure 21A). None of the contemporary measurements of road layouts from these maps or photos fully match the historic sizes and relative spacing, but they are quite close. For example, measuring off Google Earth™ from Searles Avenue to Linnet Drive South is a diameter of 875 ft (Figure 21B), which is closer to the 800 ft stated in the Williams’ Brother's publication. The reason this area is interesting is that it is the only subdivision within quite a large area that is not based on an orthogonal layout, and instead has circular roads. Old aerial photographs of the area, taken in 1938 before the area was developed, show circular marking that could relate to the earthworks (Figure 22). It is quite possible that, when the subdivisions were platted in 1923 and subsequently built upon, the building work followed or partly followed some of the earthworks' topography.
Despite the development, there is still sufficient open space within the area that may reveal portions of these large works using geophysics. The OAI card at SHiPO has a handwritten note (believed to be Burt Drennan) stating that "portions may still exist", though what this assertion is based on is not noted. Like Adler, little is known about Briggsdale, even with the map that exists. Again, it is assumed to be Adena due to the circular enclosures.

Briggsdale is closest to the city of Columbus, at 2 1/2 miles distance, which Stout (1943: 293) characterizes as part of the rolling Mississippi Valley Plain, with the Scioto and Olentangy Rivers and Alum Creek bordering and dividing the area. Though both glaciers worked the area, the drift on the uplands is mostly thin (25 ft thick), but with increasing thicknesses in the valley areas, such as the buried Columbus Creek (Teays Stage) in the eastern part of the city, where thicknesses are 100 - 200 ft. The bedrock is mostly shale (Ohio shale), which bears little to no water, with the western part of the city on the Delaware (shale and limestone) and Columbus (limestone) formations, bearing some brackish water (Stout et al. 1943; Angle 1995). The soils at the site are CsA, Crosby-urban land complex (0-2% slope) for the western part of the south circle, and CsB, Crosby-urban land complex (2-6% slope) for the rest of the site (USDA 2009 a & b; Figure 24).

4.1.3 Columbus Country Club FR 76

Like Adler and Briggsdale before it, Columbus Country Club (FR 76), on the Reynoldsburg USGS quad in Whitehall Twp, is another site that has not been explored
extensively. Located on the 15th tee of the club, this site consists of a low mound of some 55 ft in diameter and 5.6 ft high inside a circular embankment some 110 ft in diameter and 2 - 3 ft high, and an internal 13 ft wide ditch (OHS file). On the OAI card there is mention of a gateway on the southeast of the circle, but the same entry cautions that construction of the tee in 1922 may have produced this artifact. Taylor mentions the site in a 1903 letter, the year the Club was built, saying that the earthwork was already reduced by that date and wooded with large, old trees (Taylor 1903). Martha Otto of OHS surveyed the area in 1973, as a precursor to the National Register of Historic Places nomination (#74001487), which was granted a year later in 1974. The National Register of Historic Places form has much speculation about what may be under the mound based on other mound excavations - a post mold pattern of a house, and anywhere from 1 - 85 burials. A current aerial image from the Franklin County Auditors office, with overlaid topographic contours, shows a rounded, higher area in the vicinity of the 15th tee, with a diameter of 110 ft, that is grassed with mature trees to the southwest and east (Figure 25A), and a site with a measurement line of 155 ft is shown on a Google Earth image (Figure 25B). At this site, the 1938 aerial does not clearly show the site (Figure 26A). The site, in the Big Walnut River drainage also appears on Mill's Atlas (1914) although marked a little north of its actual position (Figure 26B). Little is known about the CCC site. More could be learned, as except from its use as a tee area, it has not been developed or farmed. Nevertheless, Peet does say that by 1903 the mound is in a "reduced state". Based on the circular embankment enclosing a mound it is assumed to be Adena in origin.
CCC is nearest to the town of Reynoldsburg, and Stout et al. (1943:299) describes the area as moderately dissected Mississippi Valley Plain on the top portions of the Ohio Shale formation, and shaped by both the Wisconsin and Illinoian glaciers leaving < 25ft drift thicknesses. The soil is BfB, Bennington urban land complex (2-6% slopes) (USDA 2009 a&b; Figure 27).

4.1.4 Dominion Land Company FR 12

Situated in Clinton Township and on the Northwest Columbus 7.5' quad, FR12, is one of the more referenced sites in this study (Baby 1971; Baby & Goslin 1953:79-80; Carr 1988; Clay 2002a; Cramer 1989 who did her detailed masters thesis on the ceramics from the site; Deaver and Aument 1980; Hays 1995:52; Keener & Nye 2007; Lee 1892:47; Mills 1914; Otto 1979:14; Phagan 1977b; Wetmore 1888:3527. It still evokes local interest, 55 yrs after its destruction (Ravinia 2004). Presently, the area is under housing and mature trees.

Called Overbrook Ravine Earthwork, Fort Reserve, Indian Springs, Cook Works or the Dominion Land Company site, it was excavated as a salvage project in 1953. This hastily planned excavation came about when a city council plan to save the area as a park, with development and a road around the earthworks, was completely reversed in a vote three weeks later with no explanation8. The area had been platted in 1910 to preserve the earthworks (Figure 28A). The new plat, entered in October 1953 (Figure 28B), shows the new arrangement that resulted in the road destroying the area and necessitating the salvage operation of summer 1953 (Anon 1953). The city had
proposed to buy the area, and this was supported by the Kiwanis Club, 95 local businesses and professional men in the area. The new plan instead allowed a road to cut right through the large circular earthworks (Figure 29A & B and 38). In the 1938 aerial the site does not show up very convincingly (Figure 30A).

The earthworks were 400 ft in diameter enclosing 2.9 acres, with embankments 17 ft wide and 2 ft high and an inside ditch also 17 ft wide and some 2 ft deep. Within this earthwork area was two mounds. The south mound (Mound 1) was some 2 ft high but destroyed by early preparations for subdivision development before 1953. The mound had been bulldozed from east to west with the earth pushed over the south edge of the ravine along with earth from portions of the south embankment (Anon 1953). There was a much bigger, intact north mound (Mound 2) 60 ft in diameter and 6 ft high. Wetmore (1888:352), refers to the works on H. C Cook's farm as "situated on high ground, at the junction of two branches of a run [Adena Brook] that empties into the Olentangy [river]". He recalls the mounds being conical and about 10 ft high when he had visited the then forested area as a boy (about 50 yrs previously); the reduction in size coming with cultivation and plowing down. A unattributed hand written note on the OAI card says "west portion of embankment remains", and an unattributed hand drawn diagram on the reverse of the OAI card shows the road cutting through the earthwork, with a long, curved area of remaining earthwork delineated on the east bank of Adena Brook. Both items may have been done by Stan W. Baker who handwrote the OAI form, as some of the handwriting is similar. The site is marked on Mills (1914), but the mound is placed slightly to the north of its actual position (Figure 30B).
The salvage operation began in May 1953 as a joint effort by OHS and OSU (Baby 1971), and initially supposed to be concluded in 2 weeks, it actually lasted from May 11 through September 24 that year (with a four week break). There is no site report as such; just field notes (Anon 1953). The field notes are somewhat confusing. They suggest two trenches were cut to the south and southeast of the house pattern, but nothing on the site maps show any excavations at those places. Instead there is one exploratory trench mapped to the south and west of the south mound, Mound 2 where there was no house found. There is also a reference to a second house pattern, though this seems to be in error. Feature numbers are also confusing, with feature numbers reused for the pits, within each mound, and the postmolds as a whole also given a feature number. Accessioned artifacts are at OHS (OHC # 3336/1-116), but with the confused field notes and no analysis much of the synthesized information and diagrams come from Cramer's thesis (1989).

No previous excavation had been recorded, but Baby found evidence of old potholing; a not unexpected occurrence at Ohio mound sites. The excavation was conducted in and around both mounds Figure 31A & B), two exploratory east west trenches to the west of Mound 1, and a north south trench through the southern part of the embankment (Figure 31). Under Mound 1's remains, Baby found a 2 ft by 4 ft burned clay area with a raised edge. He found an un-paired post mold structure pattern beneath Mound 2, variously described as 10 ft long (OAI form), 20 ft long (Anon 1953), or 40 ft (Baby 1971; Baby and Goslin 1953), made up of 47 postmolds (though the numbering on the original map goes up to 64 including some internal
support posts) (Figure 32A & B). In the house pattern was found a 2.5 ft diameter hearth and 3 ft by 2 ft burial area with skeletal remains covered with pieces of limestone. Three human long bones were found in a postmold (#9) (Figure 33A).

Baby found nine large ovate pit features (12 ft to 21 ft long, 3 ft to 6 ft wide, and an average of 3 ft deep), with seven grouped to the north of Mound 2 and two southeast of what was left of Mound 1. Hundreds of granite tempered pot sherds were found in the pits, the house and the mound, some of which were refitted into six large, barrel shaped vessels with everted rims. One vessel was 25" wide and 40" tall. Three of these large pots were found in Feature VI (one of the pits to the north of Mound 2), and may have been 'kill pots' broken at the time of burial, rather than broken items thrown away with trash. Cramer analyzed the very thick ceramics in 1989, and designated them Dominion Thick as they were different from Fayette Thick, in both thicknesses (thicker) and with a flying triangle incised rim and neck. Around the site were also found 12 Adena and Cresap points, and nine late archaic points, that may have been an intentional or accidental inclusion. A clay tube pipe was found in Feature III under Mound 2, and in one of the ovate pits (FVIII), with five found in total. The accession records are problematic too as Cramer found quite a lot of the excavated items (about 500 sherds and the floral remains) were unaccessioned. Cramer’s analysis showed:

1. The nine pits ranged from 3.8 - 5.9 ft wide, 10.9 - 18.65 ft long, 1.4 - 2.7 ft deep, all elliptical.
2. most ceramics from ditch features (FIII = 94; FVIII = 59; FV = 52).
3. the pots were made using slabs not coiled

4. they were between 1.5 - 2.5 cm thick

5. the style of the artifacts suggest Adena (Dating by Carr (1988) and Carr and Haas (1996) has a range of calibrated dates from 781 BC to 169 BC.)

6. 99% of the flint was local (only 1 bladelet was found)

7. the burials were only found in Mound 2 fill, as fragments in surface fill, or in the ditch fill

8. there were at least five infants, sub adults and adults represented - a later Native American Grave Protection and Repatriation Act accession survey shows at least eight individuals represented.

Cramer concludes that this was not classic Adena, with only crude ceremonial items and thus is an early Adena mortuary camp, not a domestic habitation site (1989). Hays, however, suggests that the site was not a burial site per se, but had another function (1995:377). He bases this on the lack of formal burials, as there was only one formal burial (in Mound 1, a child under limestone slabs) and the rest of the remains were found in the general fill (the total number of skeletons listed by OHS is 11, although this does not necessarily equate to the actual number of individuals. A later National Register of Historic Places survey shows at least eight individuals represented). He surmises that a primary burial processing area was located somewhere else, and that the mainly infant, child and sub adult burials found at Dominion is in itself meaningful. Otto (1979) sees Dominion representing the antecedents to Hopewell in Ohio. This could hold true if Hopewell either grew out of
Adena, which has historically been the conventional wisdom, or if Hopewell were perhaps somewhat contemporaneous to Adena, with a degree of overlap. Baby maintained that the house was an early phase of Adena that pre-dated the classic Adena paired postmold pattern (Baby, 1971:194).

A few other sites have been identified with Dominion Thick pottery at them (see Keener & Nye 2007 for a summary). Compared to the previously described sites, a lot is known about Dominion. It is designated Adena due to the circular nature of the earthworks and the thick pottery found at the site. With the possibility of some of the embankments still existing in gardens there it may be possible to do some geophysics in the future.

Dominion is closest to the center of the city of Columbus, at 5 miles distance, and within the Olentangy River drainage. Stout et al. (1943:293) characterizes the area as part of the rolling Mississippi Valley Plain, with the Scioto and Olentangy Rivers and Alum Creek bordering and dividing the area. Though both glaciers worked the area, the drift on the uplands is mostly thin (25 ft thick), but with increasing thicknesses in the valley areas, such as the buried Columbus Creek (Teays Stage) in the eastern part of the city, where thicknesses are 100 - 200 ft. The bedrock is mostly shale (Ohio shale), which bears little to no water, with the western part of the city on the Delaware (shale and limestone) and Columbus (limestone) formations, bearing some brackish water (Stout et al. 1943; Angle 1995). The soils are BfB, Bennington-urban land complex (2-6% slope) in the eastern half of the circle, and CbB, Cardington-urban
land complex (2-6% slope) in the western half of the circle (USDA 2009 a&b; Figure 33B).

4.1.5 Holder-Wright FR 4

Located in Perry Township, Ohio, just outside of the I 270 outer belt, Holder-Wright (FR4) is a large earthwork with multiple elements 1/3 of a mile east of the Scioto River. It is the most northerly Hopewell site in Ohio, making it a particularly interesting place. FR4 is the most documented of the sites in this study (Baby 1961; Case & Carr 2008:389-390, [though with errors in their data]; Converse 2006:20; Fowke 1902:221; Hooper 1920:5; Immel & Kime 1984; Keller 1956; Lee 1892:47; Morgan 1980:28; Morgan 1999:84;reichs 1975:22-23 [though with errors]; Sauer 2006; Shetrone 1924:341-358, 1925; Thomas 1891:171; Thomas 1894:449-51; Wetmore 1888), and one that still garners local interest (Kidder 1988:19-21; Mayhood 2007; Miller 1988). Even though the Holder-Wright earthworks have been the object of all these citations, surveys and excavations over the last 120 years, the published information consists mostly of short summaries.

The site, on the northwest Columbus 7.5° quad map, and within the Scioto River drainage, is on the National Register of Historic Places under # 74001496. It is alternatively called the Wright Group Works, Wright-Holder earthworks, Wright-Holder Mound Group and is sometimes linked to Krumm Mound. Krumm Mound actually refers to a mound some 500 ft to the west of the rest of the Holder-Wright earthworks, and which may be a separate site; Krumm Mound is actually designated
a different county number, FR1 whereas Holder-Wright is FR4. Mills maps the site using three earthwork symbols and a mound representing Krumm mound (Figure 34A). Most of the site is under cultivation by a farmer from Grove City. However, the cost of farming small tracts of land so far from Grove City may mean the farmer could stop cultivation in the next couple of years. The area is currently farmed as no till.

The elements of FR4, (according to Thomas 1894) comprise a 120 ft diameter northeastern circle (10 ft wide and 2 ft high) with an inside ditch (15 ft wide and 2 ft deep) and an 12 ft wide opening to the north east (Figure 34B). The "C" shaped enclosure is 287 ft east to west (north wall) and 220 ft north to south (east wall) at its greatest extent. It was not a regular shape, and this amount reduces to 262 ft east to west (south wall) and 212 ft north to south (west wall). The irregular shape is probably an artifact of natural and cultural site transformation processes, rather than an irregularity produced by the builders. This enclosure was originally reported to have three mounds in it. It had a 15 ft wide gateway to the north east and an inside ditch. The ditch varied in both width and depth (16 ft to 30 ft wide and 2 to 4 ft deep), as did the walls (25 to 35 ft wide and 3 ft high). The last element is another circle, 180 ft in diameter with a 22 ft wide opening to the north - north east, walls 18 ft wide and 2 ft high, and an inside ditch 22ft wide and up to 3 ft deep. This last circle contained a mound 40 ft in diameter, although no trace of that mound remained by 1972 (McCollough, 1972). This circle is still quite apparent (as of 2009), as it was incorporated into the farmhouse lawn and farming in that area was stopped in the
1950's. Current family members remember standing water in the ditch of the circle as late as the 1940's.

Most of the land is owned by Joan Harless and Kaye Myers, both daughters of the late Josephine Holder, although the southwest circle is partly on land to the west that is owned by Tom McDowell. Krumm mound is also on McDowell’s land. For the purposes of this description the area owned by Harless/Myers will be referred to as the north field (the site of all the FR4 earthworks and mounds) and the area south of Billingsley Ditch will be referred to as the south field. Dublin City Council is in talks with the family to buy the Holder tract for some kind of interpretive park or area. This will protect the earthwork area from future development, which has been the family's intent since they first built the original farmhouse in 1810 and started farming the property. The negotiations are in tentative stages, probably as a result of budget issues due to the 2009 economic downturn.

First mentioned by Thomas in 1894, the north field of FR4 was excavated in part in 1887 (probably by Fowke who worked as a regular field assistant for OHS out of New Madison, OH at that time). Thomas makes mention of a stone covered mound in the "C" shaped enclosure (Mound A 4 ft high by 35 ft diameter) that contained "skeletons of a very large size" (Thomas 1894:450). A second mound in the enclosure (Mound B 8 ft diameter) had already been opened and destroyed according to Thomas, and a third mound (Mound C 1 ft high and 24 ft diameter) was ascertained in a 1961 excavation to have been misconstrued as cultural, and no trace was found during trenching and test squares in the area (Baby 1961).
In the summer of 1922, Shetrone excavated the north field of the Holder-Wright site (Shetrone 1924). He looked at the three units, on an elevated terrace above the Scioto, which fell mostly on the Holder land. In 1922, the earthworks were still comparatively bold according to Shetrone. He removed the rest of the stone covered mound mentioned by Thomas (Mound A, now 28 ft by 20 ft by 34" high) and found a level floor, a structure of clean, clayey loam (later disputed by Baby, [1961]), with a thin charred layer. On the clay structure he found 11 randomly placed burials that had not been cremated, but were not articulated either, being crushed bone in piles (Figure 35A). There were no artifacts, and the area was covered with limestone slabs up to 3 ft in length that formed an arch over the mound, which were then covered with earth. Within the "C" enclosure, but not in a mound, he found one other burial that had been cremated, had no artifacts, and was within a limestone basin with limestone on top. He moved on to the large circle partly under the farmhouse and partly on McDowell's land, which had a large mound in it. The first time the mound area was plowed in 1914 by Mr. Wright (the current owners' grandfather), he unearthed four graves. The north east circle was quite apparent in the 1920's, still collecting water in the ditch area (Figure 35B). By 1938, the site was more degraded, but still apparent in the aerial imagery (Figure 36).

Shetrone took out the entire mound and found the four burials first found in 1914, two cremations and two inhumations, and a third inhumation. The bones were found with a number of artifacts, including an ocean shell, flint knives, ear spools, plain platform pipe, slate gorget, mica, and beaver teeth. As was the penchant of the
day, the items were mostly given to various named people, the museum or the family.

At OHS there are just three groups of items accessioned under #298 from Shetrone's dig:

- 289/1 cremains from the stone lined and covered grave in the "C" enclosure, but not in a mound (not found at OHS);
- 289/2 eight flake knives from the mound by the farm;
- 289/3 a shouldered flint spear point found with the reburied bones in a stone crypt (it is unclear if this is from the mound by the farm or Krumm)\(^\text{12}\).

Shetrone also excavated Krumm Mound, which is worth mentioning here. He found six reburials, with a Minimum Number of Individuals of at least three people, along with a flint stemmed spear point. He characterized the burials as "careless", and though they were also covered in limestone flagstones, he concluded that the builders of the Krumm Mound were not of the same cultural group as the builders of the Wright Group. He likened the Krumm builders to the groups who buried their dead in the gravel deposits of the Scioto, the Glacial Kame. He concluded that Holder-Wright was built by an outlying colony or band of Hopewell who also may have built Worthington Works. He saw it as an intermediate burial form between Hopewell proper (cremations) and Adena (inhumations), with the fragmented skeletal fragments substituting for cremains at this time.

In 1961, Baby undertook a field school at Holder-Wright. Nothing was published from that dig, and when I first went to OHS in 2004 all they had were 22 pages of typewritten field notes. On returning in 2007 I found all the student
Notebooks from the dig. Most field school student notebooks are marginal at best, but
one student had very detailed notes, with diagrams and drawings, and the only
description of where the main datum was in relation to the still-standing farm garage.
Thank you Margery Shafer (Shafer 1961). The excavation in 1961 was remarkable by
today's standards, with 2,900 ft² of earth removed, mostly in a north-south trench 300
ft long and 5 ft wide through the "C" enclosure (Figures 37A & B; 38A). Nine
postmolds were described, but only one of them is described as flat-bottomed, the rest
are described as either tapered or due to a rodent, or not described at all. In a 1972
letter on file at OHS, Martha Otto tells a Mrs. Loveland that the postmolds were from a
screen that protected flint workers from the wind (Otto 1972). The postmolds in
question run four in a northeast-southwest line, with two more making the corner of a
screen towards the northwest; they are quite widely spaced, between 2-6 ft apart. No
mention was made of whether more flint flakes were found in their vicinity or not.
Accession records at OHS show a number of diagnostic artifacts - scraper, flake knife,
slate celt, leaf point, side notch point, bifurcated point, and thin pottery fragments. The
OHS accession records for The Native American Graves Protection and Repatriation
Act list 66 human identifications, mostly inhumations, with a few partly cremated
remains (the number of 66 does not necessarily equate to Minimum Number of
Individuals). Figure 38B shows the site in 1964, with the signature of the enclosure
quite intact and no evidence of the large excavation just three years earlier.

The next archaeological work carried out at Holder-Wright come in 2004, when
Angel and Dancey conducted a surface survey of the two fields on the property - the
north field (east of the farmhouse) and the field south of Billingsley Ditch (Notes on file at the Dept of Anthropology, OSU). A small area in the east field was also surveyed with a gradiometer in an effort to relocate the northeastern circle and the gateway of the "C" enclosure. The northeastern circle was not relocated (subsequent research suggests we started the survey a few feet too far west), but the gateway was relocated (Figure 39).

The surface collection, completed by Dancey's field methods class students over a few days, is detailed in Sauer (2006:Figures 31 & 32). Her basic findings suggest that both the north and south fields had a lot of knapping activity in them over a long period of time. Of the 11 complete points recovered, most were Late Archaic, with three dating from the Late Woodland/Late Prehistoric periods. No points were recovered from the Middle Woodland times. There was no spatial patterning evident in either field to suggest work areas, but Sauer concludes that the south field was used more for late stage reduction and retouch, while the north field where the earthworks are located was used more for primary reduction. This was a surprising finding in the field with the banked earthworks. Although Ohio’s Flint Ridge flint was found in 2004, some non-local flints were also found. However, it was not known whether the flints had been brought in, traded in or were available near to the site due to glacial action that had moved them across the landscape.

Further magnetometry investigations occurred in early 2008, when Jarrod Burks, assisted by Angel, wanted to cover the entire north field. We covered the entire "C" shaped enclosure in twenty-six 20 x 20 m squares (Figure 40A), and found the
underground signature still quite apparent, though the ditch signature was quite strong
the embankment signature was not. Burks was retained by the family in late 2009 to
complete magnetometry, Ground Penetrating Radar and resistivity data collection for
the three elements on their property. Early results from the resistivity are encouraging,
with the southwest circle clearly visible, and parts of the northeast circle quite apparent
(Figure 40B). Interestingly, none of the geophysics located Baby's trenching of 1961.
Figure 41A has the original Thomas map overlaid onto a Google Earth™ image.
When compared to Figure 40A & B it shows how the magnetometry has picked up the
ditch area, but little of the embankment outline. It also shows how the embankments
have widened since the original map was made, probably due to agriculture at the site.

Time constraints and farming needs precluded finishing the entire field. We would like
to survey in the area near the post mold pattern that Baby found to the south of the "C"
enclosure and see if there are any magnetic features associated with the area that may
bear fruit if excavated.

Even with the large and relatively intact nature of Holder-Wright, the remote
sensing imagery of the site is often of mixed quality when it comes to visualizing the
components. In early May 2009, I attended the site with R. Joe Brandon to do some
kite photography. Brandon flew a kite up to about 500 ft with a small digital camera
slung underneath it at about 350 ft above the ground. The field had been under corn
the previous season, and with no till the surface of the field was covered in stubble and
organic detritus. No surface manifestation was apparent from the ground, but from the
kite the "C" enclosure is very apparent (Figures 41B & 42). More conventional remote
sensing can also show the site quite well. Sometimes the site is very visible (Figure 43A & B), other times it is barely visible (Figure 44A), and other times it is virtually invisible (Figure 44B).

Part of the threat to Holder-Wright comes from Dublin City Council's need to complete the Emerald Parkway extension. Cardinal Health came to the area with their national operations with the understanding that the extension would be completed. Early 2008 saw surveying work on the south field by Burgess and Niple in preparation for the work. I was told of this by the family and so went to the south field to conduct a magnetometry survey. The south field is about 7.5 acres, and an irregular shape, looking like an opened envelope with the triangular flap at the top. I set my main datum in the top of that flap area, just off the plowed area, behind a medium sized granite erratic. Using a Total Station I tied my grid into Burks 2008 grid from the north field and my datum from 2004. I placed two additional datums off field at the very south of the south field. This was precautionary as I knew the farmer would be working the field before planting and I could not leave my grid stakes out between collection days as they could damage his tractor tires. Data collection at that point was near the south of the field, and so it was easier to reset my grid using tapes from these two south datums, than from the one northerly one by the granite rock. I collected twenty 20 x 20m squares (about 25% of the entire field area) over 4 days, downloading and visualizing the data in field. The results show some interesting anomalies (Figure 45) that have no visual component in any aerials of the site since 1938, and do not seem to relate to farming activities. Excavation across the linear anomaly, and of some
of the other discrete anomalies may expose cultural material related to the earthworks. Based on the lithic analysis by Sauer (2006), the material may be contemporaneous with the earthworks, or may pre- or post-date it.

The land is cut to the south of the earthwork by a clear water stream, previously called Wright's Run and now called Billingsley Ditch or Billingsley Creek, that runs down a limestone lined stream bed to a series of cascading waterfalls (on the McDowell land) before it joins the Scioto River. As soon as you cross the property line between the Holders and MacDowell’s property the gorge drops down quite steeply as you make your way to the Scioto River, and becomes quite deep, incised in the limestone at some 30-50 ft, before flattening out to join the Scioto River. The karst digital coverage from ODNR does not document the karst areas described above, although the limestone bedrock in the area outcrops along the Olentangy and Scioto River. In the gorge area are caves of varying sizes and at various elevations up the side of it, big enough for one or two people to fit inside. One of these caves, in the bank above the stream, is a 3 ft wide hole going straight down. According to Joan Harless (the current landowner), it came out further down the stream bed, underneath the stream. As the stream does sometimes run dry in the summer months, it was feasible for youngsters to crawl through it and exit in the then dry stream bed. She also recalled a Boy Scout troop had 'excavated' the cave for some geology project, and thus the size of it now was artificially larger than it had been previously. Talking recently to a family cousin, Jim Thompson, it appears that the cave system actually may run past the stream and up underneath the north field owned by McDowell. A caving
friend of his, who was small enough to get through the tunnel, reported finding artifacts in that area in 2009. Mr. Thompson was also given artifacts from a cavern underneath the stream by some researchers from OHS and OSU who went to the caves in the mid 1990's, though no one at OHS has any record of that visit. He went into one of the caverns under the stream (after crawling through a tunnel on his stomach). Unfortunately once there he did not have a chance to look around properly as, when they shone their torches around, the cavern was full of hibernating snakes and they beat a hasty retreat! Further talks with these individuals are planned.

In 1964, Potter and Baby reported on some dog skeletons recovered from caves in the vicinity of the Holder-Wright site. It is possible the bones came from the same cave area described by Harless as the dimensions and location fit Potter and Baby's depiction of their Cave Number 1, which is 300 ft from the site. (see also Converse 2006:20 - he characterizes the 300 ft distance as "considerable"). The cave's contents were "exhumed" by a group looking for reptile remains (this may be the same as the geology project mentioned earlier). It yielded 25 partial dog skeletons and some human remains, including a skull. The human remains were not examined as part of the study, but Baby identified the skull as morphologically and metrically that of a Hopewell person. In a puzzling conclusion they concluded that the dogs were typical Hopewell dog skeletons, even though they statistically resembled the smaller Archaic shell-heap dogs of Kentucky and Alabama. The linkage to the Holder-Wright site is thus based purely on the burial "type" of the dog bones. The bones were fragmented, unburned and with limestone on top and below the bones, very similar to the burials
that Shetrone had found at Holder-Wright in 1922. Given the action of the water and the boy scouts, the limestone bedding or covering may well have been incidental. Also, bearing in mind the multi-component nature of Holder-Wright, the dogs may well be of an earlier or later period.

Holder-Wright is an interesting site for a number of reasons. Not only is it the northern most Hopewell site found to date, but it is also relatively unscathed compared to other earthwork sites in Central Ohio; the burials found there are a mix of cremains, inhumations and crushed bones; some of the burials are in stone graves; the family is very interested in, and cooperative with, research at the site; little of the research work done at the site has been published. Because the site contains such variety, it is an important place to protect. Keller (1956), concludes that the stone mounds at Holder-Wright and Krumm are representative of a general burial tradition of the Woodland period, possibly with a different function to purely earthen structures. He continues that they developed due to low population density and isolation of that population, so that the trait is due to convergence, not diffusion (the theory of the day). The stone mounds also occur mostly in high, physiographically isolated areas comparatively.

Stout et al. (1943:294) wrote about the city of Dublin, which is less that 1 mile from Holder-Wright. He said the village was on the Mississippi Valley Plain, shaped by the Wisconsin and Illinoian glaciers leaving less than 25 ft of drift. Compared to the east side of the county, Dublin is located on rock from the top of the Columbus limestone formation, with sulphurous water. The soils at Holder-Wright are BoB, Blount silt loam (2-6% slope) in the northeast circle and most of the "C" enclosure and
GwB, Glynwood silt loam (2-6% slope) in the southwest corner of the "C" enclosure and the entire southwest circle. Krumm mound would fall on GwC2, Glynwood silt loam (6-12% slope) (USDA a&b 2009; Figure 46). Schmidt, (1993) states that when the 98 ft well on the property was drilled the depth to bedrock was 10 ft.

4.1.6 Jackson Fort FR 49

Jackson Fort, FR 49 in Mifflin Twp Franklin County (on the USGS NE Columbus quad) is another site on the National Register of Historic Places, #74001493. Mentioned in three sentences by Wetmore (1888:353-4), "There is an "Ancient Fort" on the farm of R. Jackson. His house is built on it. It is about one mile west of Alum Creek."\(^{13}\) and also by Cyrus Thomas "Fort on R. Jackson's land." (1891:172), the amount of information known about this site is equally brief. The site is a 252 ft diameter circle, enclosing 1.14 acres, with embankments some 1 1/2 to 2 ft high (though the National Register of Historic Places write up says 2 - 3 ft high) and a mound in the center (National Register of Historic Places form; OAI cardfile).

Termed a 'fort' in the parlance of the day, Jackson Fort is not now thought of as a fort or a defensive work. No excavations have ever been done at the site, and when the mound was leveled to build R. Jackson's house in 1890, (which still remains) no artifacts were reported. This may be due to a number of reasons - there were no artifacts in the mound; artifacts were found but not reported for whatever reason; broken or damaged items were not considered artifacts and were thus not reported; excavation techniques precluded finding or preserving anything. The Westerville
Road, Route 3 cuts through the southeast section of the embankment, and the driveway to the house cuts through the south wall, but apparently the rest of the embankment area is intact, the 1973 National Register of Historic Places form stating "The remaining enclosure is in excellent condition". Having said this, a map produced for this research by the Franklin County Engineers Department does not show an obvious circular topographic relief at the right diameter (Figures 47A & B). An aerial photograph from 1938 shows the area under trees with little of the outline particularly noticeable (Figure 48A). A visual inspection around the area revealed some probable embankment remains of maybe 12"-18" high to the north of the house, amid some mature trees. Though the mound is substantially gone (or at least under the house), a geophysics survey would probably show any remaining aspects, especially in the absence of farming or cultivation. The site seems to be marked on Mills (1914), though slightly misplaced to the south (Figure 48B).

Jackson Fort is closest of the sites research to the city of Columbus, at 5 1/2 miles distance in the Alum Creek drainage. Stout et al. (1943:293) characterizes the area as part of the rolling Mississippi Valley Plain, with the Scioto and Olentangy Rivers and Alum Creek bordering and dividing the area. Both glaciers worked the area leaving a thin drift on the uplands (25 ft thick), but with increasing thicknesses in the valley areas, such as the buried Columbus Creek (Teays Stage) in the eastern part of the city, where thicknesses increase to 100 - 200 ft. The bedrock under Jackson Fort is mostly shale (Ohio shale), which bears little to no water (Stout et al. 1943; Angle 1995), and on top is till with sand and gravel lenses (ODNR, 2000). The major soil
associations in the area are Bennington - Pewamo, and the minor soil at the site is the somewhat poorly drained BeB, Bennington silt loam (2-6% slope) (USDA 2009 a&b; Figure 49).

4.1.7 Orange Township Works DL 2

This site, Highbank Park Works (not to be confused with High Bank Works in Ross County), is also known as Orange Township Works, DL 2, and was added to the National Register of Historic Places in 1975, under #74001466. The earthworks are in the Olentangy River drainage and appear on the Powell 7.5° quad map. Orange Township Works, so named for the township it is located in, was surveyed in 1836 by Whittlesey whose drawing appeared in Squier and Davis' 1848 publication (Squier & Davis 1848:Plate XIV No. 2; Whittlesey 1851 [Figure 50A]). Squier and Davis considered it a defensive work. Presently located in the 1,159 acre Highbank Metro Park, it truly is an enormous earthwork measuring approximately 785 ft by 635 ft at the largest extent (approximately 1500 ft total wall length) when measured from the Whittlesey drawing, with banks three feet high (OIA form; Squier & Davis 1848:36) and an exterior ditch of 3 ft deep (Otto 1966; Otto mentions the site as 750 ft north to south and 600 ft east to west). The park gets between 800,000 and 1 million visitors a year, often being the most visited Columbus metro park in the 15 park system. The 2.4 mile Overlook Trail in the park passes through the earthwork embankment, the whole of which is heavily wooded with mature trees, and leads to an interpretive plaque and overlook deck on the cliffs 100 ft above the Olentangy River. While walking through
the earthworks to the overlook the banks are easily visible and still in reasonable condition.

When the area is under trees the embankment is not visible from the air, as the aerial from 1938 shows in Figure 50B. But with a different coverage taken at a different time of the year (winter) part of the embankment appears visible (Figure 51). Lidar data also shows the east and north parts of the embankment quite well (Figure 52). Interestingly the map from Whittlesey does not match up with the landforms on Google Earth, or the probable embankment, very closely (Figure 53A).

Passing mentions of the earthworks are in Howe (1847), Fowke (1902), Rodgers (1892 with a slightly changed version of Whittlesey's map, Figure 53B), Lytle (1908) and Phagan (1977a and 1977c), with a more in-depth overview provided by Baby and Potter (1965) and Otto (1966, 1968). It is listed in The Earthworks of Franklin County in error (Wetmore 1887:192), and also in the Delaware County section (Wetmore 1887:193), with a correction written later (Wetmore 1888:349). Mills shows it using a circular icon in his 1914 atlas (Figure 54).

It was surveyed in 1951 by OHS, with some flint chips accessioned, and a handwritten note on the OAI card refers to the 1951 survey:

"May 21, 1951 Site reexamined by Baby, Thomas, Tucker and Bennett; in wooded part of 75 acre tract of Highbank Park (___[unreadable] metropolitan park). Work intact except for two small excavation pits and fallen tree's on east and north portions of wall. Exterior ditch ranged from 3-7' feet in depth the greatest depth on
east side. Two flint (grey flint) chips found in ____ (sic) segment of north wall; 3 pieces of chert found along edge of bluff."

In the summer of 1952, one of the embankments and a nearby area had four trenches put in over 27 field days, and one trench put in within the enclosed area (OHS accession number 3192/1-85) (Baby 1952). The trenches equaled some 2,400 ft 2 of excavated area. The field notes, and two maps, are somewhat sparse, but the high points from the field notes are:

1. The wall was built on top of a thin organic layer (grass?) (sic)
2. Trench 4 had loading of red clay apparent, which was different from the yellow clay subsoil from which the external ditch had been dug (Figures 55A &B).
3. 478 flakes or blocks of chert and flint were found, along with some grit ceramics (Deaver & Aument, 1980), some burnt earth and FCR.
4. only a few projectile points were found, including three side notched (can be Archaic or Woodland), and a leaf base (Adena).

What is more remarkable is what is not found according to the field notes. There was very little charcoal, no plant or wood remains, no animal or human bones, and no features at all - no pits, postmolds, hearths etc.

Martha Otto analyzed ceramics from the Orange Township works and concluded that they were constructed during the Late Woodland, by Native Americans of the Cole Complex (Otto 1966; though see Dancey & Seeman 2005). Baby and Otto argue that based on the utilitarian ceramics found at Orange, the Cole Horizon was
distinct from Hopewell. They explain that by the end of the Hopewell period people were living a simpler life with little of the overt ceremonialism seen during Hopewell times (Baby & Otto 1965; Otto 1966). Dancey and Seeman, however, argue that the Orange Township works show evident signs of a Middle Woodland affiliation based on the "discontinuous embankment" and the bi-colored strata (yellow over red) that the 1952 fieldwork exposed (140) (see also Lynott 2006 and Moorehead 1892), although they use it to argue for "periodic enlargement" of the embankment rather than as a specific design element as Lynott does at Hopeton. In 1972, Hutchins surveyed and photographed the area, (probably in preparation for the National Register of Historic Places report that he was interviewed for). Finally, in the early 2000’s an Ohio State University student, Melissa Neil, produced a topographic map of the site using a Total Station™.

The nearest geological location that Stout mentions is based on the city of Powell, (1943:276). Stout states that the area was shaped by both the Wisconsin and Illinoian glaciers, leaving a thin (< 25 ft) drift over the area. A Teays stage drainage valley links Worthington to Powell, having fill of some 190 ft. The town is on the basal portions of the Ohio shale with Devonian limestone below, all yielding briny and sulphur water. The soils are GwC2 Glynwood silt loam (6-12% eroded) for the eastern portion and LbF, Latham Brecksville Complex (25-75% slopes) in the western portion (USDA 2009 a&b; Figure 56). It should be noted that the LbF soil description includes the 100 ft sheer drop from the earthwork down the incised banks of the Olentangy River.
Spruce Run (DL 22) is located on the Sunbury 7.5° quad map. It is on a peninsula between Big Walnut Creek (the site’s drainage) and Spruce Run in Genoa Township, on the east bank of Hoover Reservoir. The area was owned by the Cochran and Dennis families. It was platted in 1969 when they divided it for development, and in 1973 the site was added to the National Register of Historic Places under #73001431. Currently the area is under low density housing and some mature trees.

This is a large site area, with two mounds, two circular earthworks and an earthen causeway to Spruce Run. This site was extensively excavated by John T. Short in 1879, the details being published by James Griffin in 1947, and the maps and artifacts are at the Peabody Museum of American Archaeology and Ethnology at Harvard University under accession number 79-85. The maps and illustrations still exist (Figures 57 & 58), as do some of the artifacts, but no photographs are on file (Haskell 2009). As was the penchant in those days in archaeology, the mounds were the focus of excavation. This information in this section is taken from Shorts' account. The large site was on a tongue of land 100 ft above Big Walnut Creek (to the west) and Spruce Run (to the east) where Spruce Run meets Big Walnut. Figures 59 and 60 show the area before the reservoir was created and the area around the site flooded, the images are from 1938 and 1951 respectively. Neither images show any remains of the sites, although geophysics may find portions of the area. On the National Register of Historic places form the northern mound is reported to be reasonably intact. The area
today still affords an impressive view of the confluence of the two water courses, with the promontory still rising sharply out of Hoover reservoir.

Mounds A, in the northern enclosure, was between 68 ft and 75 ft in diameter, some 12 ft high, and covered in 12 in. by 3 in. thick pieces of sandstone. This sandstone had come from one of the ravines, and had been removed for cellar walls before Short excavated. During the excavation another layer of stones were found within the mound, about 3 ft off the mound floor, and basket loads of mottled earth were apparent in its construction. The floor of the mound contained a circular bed of ashes, 8 ft in diameter and 6 in. thick, with large, incised, sandstone tempered pot sherds, burned bone, and shapes of burned bones apparent. Short surmised that this area was an alter with a body sacrificed on a layer of wood and then burned. On the west aspect of this mound was a crescent shaped platform 25 ft wide at its middle, which had been potholed with nothing found. The nearly perfectly circular enclosure around Mound A was 570 ft in circumference, or 182 ft in diameter, and with walls some 3 ft high that had been plowed down from 10 ft high. The inside ditch was some 27 ft wide and 7 ft deep, and there was a 20 ft wide gateway to the east leading to a 400 ft long graded way that lead to Spruce Run at an angle of 30 ft. Just north of the gateway was a second mound reportedly 10 ft in diameter, 4 ft high and made out of the side of the embankment. The 1973 National Register of Historic Places inventory form however states that the size in 1972 was 33 ft diameter and 3.2 ft high. The amount of soil that could be spread out from the mound based on the reduction in height from 4 ft to 3.2 ft would not account for the increase in the mound diameter
from 10 ft to 33 ft. The National Register of Historic Places form suggests Short was incorrect in his measurements, though the 1979 OAI form says that back-dirt from the original excavations may have caused this enlargement and that the original measurements may be more accurate. In this second mound Short found nothing of import even though a 6 ft shaft was sunk through it, Short noting only charcoal, burnt clay and calcined animal bones in his account.

Three hundred yards to the southwest Short described another circular enclosure of 300 ft in diameter, with embankments of 2 ft high. Nothing more is described. Even though Short states "The plan is also correct" that does not appear to be the case given the measurements he cites. If this map is measured, then the relative distances between the Mound A and the southern circle are wrong. It is not possible for the circle to be 300ft in diameter and the distance between the Mound A in the northern circle and the southern circle to be 300 yds. So either the map is wrong, the written distances are wrong, or some of both.

I overlaid Short's map onto a Google Earth™ image to look at the relative positions of the sketch to the extant topography\(^\text{16}\). Again I found that when the south circle was the right size, as measured with the Google Earth tools, the relative positions of Mound A and the south circle were wrong, only 640 ft or 231 yds not 300 yards (Figure 61A). When the image was enlarged so that the distance between Mound A and the south circle was set to 300 yds, then the south circle measured far too big, over 500 ft diameter instead of 300 feet (Figure 61A). The graded way on Shorts map is also described as "probably" 400 ft long, yet his map shows it only as about 150 ft long to
Spruce Run if you assume the south circle is the same scale. So although the map of Shorts is all we have to illustrate this large site, it is probably incorrect.

Griffin's discussion of Short's report focuses on the ceramics and the importance at the time of the Adena designation for Spruce Run. If correct it would be the first Adena site found in Delaware County, the first Adena site with a graded way and the first Adena site with incised pottery in Ohio. Mills (1914) shows two circles and two mounds, but not really in the right place, even given the small scale of the map (Figure 62).

Stout et al. (1943:301) portrayed the area closest to Spruce Run, Westerville at 3 miles away, as on the Mississippi Valley Plain, which both the Wisconsin and Illinoian glaciers shaped leaving the Westerville Moraine between 40-60 ft thick. Columbus Creek, from the old Teays drainage, is a rock floored drainage with fill some 30-40 ft deep. The bedrock is the top of Ohio Shale formation with brine or sulphur water. The soils are BeA, Bennington silt loam (0-2% slope) for the north circle and the eastern half of the south circle, Beb, Bennington silt loam (2-6% slope) for the western half of the circle and AmF, Amanda silt loam (25-50% slope) for the graded way (ODNR 2009 a & b; Figure 63).

4.1.9 Worthington/Jeffers Mound FR 3

The site of FR 3, in the Olentangy River drainage of Perry Township, is variously called Worthington Works, Plesenton Works, Smith Group, Smith Works, Vining Mound, H.P Jeffers mound and finally Jeffers Memorial Mound. In Perry
Township, and on the northwest Columbus 7.5° topographic quad map, the site was added to the National Register of Historic Places in 1974 under #74001499. This site comprises a square enclosure, two circular enclosures and two mounds on a 60 ft bluff about the Olentangy River, and is one of the more referenced sites here (Addington 1976; Boewe 2000:114, 125; Baby 1971; CMJ 1866; Fowke 1902:217-8; Hooper 1920:5; Kime 1978; Rodgers 1892:46, 54; Peet 1903:265; Shetrone 1924:352; Squier & Davis 1848:Plate XXIX No. 3; Thomas 1889a:193; Thomas 1891:170, 172; Wetmore 1888:349; Yerkes 1985). The area is currently under housing and mature trees.

The area that FR3 is in was a part of the Scioto Land Company's 38 tracts of land, and William Vining purchased 203 acres of that land in 1894 (Worthington Historical Society, n.d.). The last owner of the land containing the earthworks, H. P. Jeffers, platted the area for development in 1967 leaving 1.7 acres of the lands as a reserve to protect Jeffers Mound (Figure 64). On his death, Jeffers left the area in trust to his beneficiaries, who decided to sell the reserve area with the mound to the Worthington Historical Society in September 1974 for $1. The deed of gift restricted cutting live trees and building or development, and encouraged walks and signage about the Indian Mound. This deed is in effect until December 31st, 2074, rather than in perpetuity (Franklin County Recorders). In the OAI records the site is currently designated as unknown Woodland, which means the site could be from the Early, Middle or Late Woodland periods. Earthworks of this geometric style are also usually
associated with the Middle Woodland Period, as are bladelets, of which one is listed in the OAI database.

The square enclosure (630 ft by 550 ft and with no ditch) encompassed eight acres, and contained one mound (192 ft diameter and 20 ft high) within its south wall and a smaller mound (60 ft diameter and very low) near the center of the enclosure. To the southwest, 125 ft distance, was another circular enclosure of 120 ft diameter with an inside ditch and a gateway facing back towards the square. To the northwest, at 500 ft distance and across a small ravine, was a third enclosure of 140 ft diameter, whose embankment was broken up by three gateways (Squier & Davis, 1848 p. 82-4; Figure 65A). Whittlesey in Squier and Davis reports that the square is within 5° of the cardinal directions. Both the mounds are reported as being in the center of the enclosure or south wall respectively, but the 1825 Whittlesey map published by Squier and Davis, (Figure 65A), the map in Fowke (captioned as being from Squier and Davis but obviously not an exact copy; Figure 65B), and the map in Rodgers (1892) (Figure 66) do not show that tendency. When the Fowke diagram is overlaid and scaled on the 1938 aerial, the vegetation signature does match up quite well (Figure 67A). Figure 67B shows that same diagram overlaid onto the modern subdivision showing how the roads have cut through many areas of both circles and the embankments of the square. Figures 68A & B; 69A & B; & 70A show how the mound has changed in the intervening years. The site is marked on Mills (1914) as a square, two circles and a mound (Figure 70B).
The known excavation history of the large site starts in 1866. Then William McK. Heath of Worthington obtained a rare permit from Mr. Vining and dug a narrow tunnel into the east side of the center mound, along with a vertical shaft to the center (these scars are still apparent and reported on the National Register of Historic Places nomination form). He found the mound "... composed of rich alluvial soil, apparently skimmed from the surface of the adjacent fields ...", more than one fine ash bed, charcoal, two burials extended nearly east-west "... surrounded on all sides by multitudinous layers and coverings of wood, now decayed." and some ceramics (CMJ, 1866:2; Figure 71). The size of the mound in 1866 was reported as "... about 480 feet in circumference, 160 feet in diameter, and 35 feet high ..." No artifacts exist at OHS from this dig, and in that era artifacts were often either kept by the excavator or given to the family rather than being curated at a museum or historical society (OHS began in 1885). There is some suggestion that Baby may have at least surveyed the site in 1961, but no records exist of this effort if it did occur (OHS, site file). Baby does talk about Worthington in his 1971 article comparing house types across time, suggesting that the nearby Phillips Mound site (FR63) may "... represent the dwellings of the persons who maintained the earthworks" at Worthington (196). Addington, (1976:31), states that sections of the embankment about 2 ft high are in the gardens at Plesenton Drive, and based on the 1938 aerials (Figure 72) it is probably portions of the north embankment that he is referring to.

In 1978-9 and again in 1985, OHS and OSU undertook some extensive excavations around Jeffers Mound. In 1978, 5 meters from the mounds south edge a
large postmold pattern was found, with one feature within the pattern and two without. The 177 postmold house found in 1978 contained 900 flint artifacts including bladelets and cores, and the 1979 trench to the north and east yielded 3,866 artifacts, but did not find any further postmold patterns. Baby speaking to the Columbus Evening Dispatch in 1978, thought the 47 ft by 25 ft structure was a "sloppily" built house, yet no mention is made of midden, hearth or pit features that would usually be associated with a habitation area.

In 1985, a field school run by Richard Yerkes of OSU's anthropology department excavated 13 units - four to the west of the 1978 house pattern, seven just to the west of the 1979 trench and two units a few meters to the north of the mound. The field school used magnetometry in the enclosure area to the north of the mound that led to 64 m² of excavations. (Yerkes 1985:8) Compacted midden area was found in four small pit features located in the units to the west of the house pattern. Milling stones, bladelets, flakes, grooved hammerstones, and five projectile points were also found, the latter dated stylistically from the Middle Archaic to the Late Woodland, with Hopewell represented. Yerkes, (1985: opposite page 2 Figure 2:bottom), draws a map with earthwork embankments areas marked in the gardens of the north part of Plesenton Drive, most likely the gardens of house numbers 6516, 6500, and 6490. Yerkes concluded that the evidence pointed to episodic, short term occupations across the time periods mentioned above, in the manner of the "Vacant Ceremonial Center" model of Prufer (Prufer 1964). The area in the enclosure seemed to have been kept 'clean', which led Yerkes to suggest the area was used ceremonially rather than for
everyday, domestic use. In 1924, Shetrone had suggested that the people who built the Worthington earthworks were an outpost from the large geometric earthworks of the South (presumably Ross County) or Newark, and that Holder-Wright (FR1 and 4) was itself an outpost of Worthington. Yerkes, while not making that close a connection, certainly considers them within the same time frame (Yerkes 1985:15). 

Worthington Works are closest to the town of Worthington, characterized by Stout et al. (1943:301-2) as on the Mississippi Valley Plain that both the Wisconsin and Illinoian glaciers covered, leaving thin (< 25ft) drift. The old Columbus Creek (Teays stage) is found in the southwestern part of the town, with silts and sand and gravel fill. The bedrock is the early portion of the Devonian Ohio shale, with the Delaware formation below. Most water in the area is sulphurous or briny. The soils of the north embankment and most of the east embankment of the square are on HeC2, Hennepin and Miamian (18-25% slopes, eroded), as is the north circle. The rest of the square enclosure and the south circle are on CfB, Celina urban land complex (2-6% slope) (USDA 2009a & b; Figure 73).

4.2 Discussion of Known Sites

The nine sites discussed in the preceding section are an interesting collection of circles, squares and rectangles, with and without ditches, with and without mounds, excavated and unexcavated, and built over five drainages. Figure 74 illustrates the relative sizes of the geometric components of each site by drainage. Each site with multiple components has those components designated based on size, e.g. HWa is the
large "C" shaped enclosure, HWb is the smaller southwest circle and HWc is the smallest component - the northeast circle (Table 5). These simple designations based on size are used throughout this research to differentiate the different geometric components during analyses. The acreage enclosed varies quite considerably between sites, from 0.21 acres to nearly 13.5 acres (Figure 75). Where the site has more than one component that encloses space, the numbers for area enclosed have been totaled. Where a site is known to have a mound or mounds, the diameter of those mounds are shown in Figure 76. Jeffers mound, at the Worthington site, is by far the biggest compared to the others. This is partly a function not only of the initial size of the mound, but also because it has been fervently protected from much excavation, plowing or removal compared to the other mounds. Taken as a whole, Figure 77 shows the sites ranked based on complexity based on number of elements (rank 1 being highest). It should be noted that there are many ways to rank a site, for example Orange township is ranked the lowest (1/2 circle) but the length of walls is over 1300 ft and the wall have a number of gateways. Other sites have multiple walled areas that are not as long but include mounds and multiple areas that have been built.

4.3 Random Points Descriptions

For a comparison population, nine points were randomly placed on the Central Ohio landscape within the GIS. First, a column and row grid was placed over the area in the GIS. Second, each square was identified by a unique, sequential number. Third, using a random number generator, nine numbers were randomly picked from the set of
sequential numbers. Fourth, in the GIS the nine points were placed at the corner of the
grid squares that corresponded to the randomly picked number (see Chapter 5 for a
detailed explanation of these steps). The nine random points in this study, R0 - R8, fall
within the central Ohio area but are less clustered than the nine known sites. This
section describes the landscapes and soils of each of these nine random sites (Figure 5).

Random 0 is 0.2 miles from Magnetic Springs, just over the west Delaware
border in Union County in the Scioto River drainage. Stout et al. (1943:614 - 5)
describes Magnetic Springs, as on the Mississippi valley Plain, which both glaciers
shaped leaving 40 ft deep drift. The bedrock of dolomite produces sulphur and other
mineral waters, which in Magnetic Springs led to the health resorts founded there. The
area is a flat, farmed plain around Bokes Creek. The soils at the site are Pw, Pewamo
silty clay loam (USDA 2009 a&b).

Random 1 is 2.2 miles south of the town of Prospect in Delaware County, also
on a flat, farmed plain that is an old terraced floodplain of the nearby Scioto River
(Stout, 1943:444). Shaped by both the Wisconsin and Illinoian glaciers, the drift varies
from 10-50ft over a dolomitic bedrock. Water at depth is sulphurous. The soils are
PwA, Pewamo silty clay loam (USDA 2009 a & b).

Random 2 is 1.1 miles south of the town of Delaware in the county of the same
name, very close to the Olentangy River. Again, as with most of Central Ohio, both
glaciers shaped the area, leaving < 25ft of drift. The river is quite cut down at this
point, with a bed of Delaware limestone, and bluffs of Olentangy Shale and then Ohio
Shale. The rock water is good, with sulphur water encountered at depth and in some
springs, e.g. at Ohio Wesleyan University (Stout, et al. 1943:273). The soils are UdB, udorthents, clayey-urban land complex, undulating (USDA 2009 a&b).

Random 3 is on the upland area between Big Run and Alum Creek, on farmland 3.25 miles from Kilbourne in Delaware County. Stout et al. (1943:274) characterize the Kilbourne area as glaciated by the Wisconsin and Illinoian glaciers, with drift thicknesses of 20 - 40 ft. The area is on the mid portion of the Ohio shale with little or no water in it. Below the shale the water contains salt and hydrogen sulphide. The soils are BoB, Blount silt loam (USDA 2009 a&b).

Random 4 is in Franklin County, on farmland 4.5 miles north of Dublin in the Big Darby Creek drainage. Stout et al. (1943:294) wrote that Dublin village was on the Mississippi Valley Plain, shaped by the Wisconsin and Illinoian glaciers leaving less than 25 ft of drift. Compared to the east side of the county, Dublin is located on rock from the top of the Columbus limestone formation, with sulphurous water. The soil in the area is Ko, Kokomo silty, clay loam (USDA 2009 a & b).

Random 5 is on the floodplain of the Scioto River, 3.75 miles from Ashville in Pickaway County. Stout et al. (1943:516) describe Ashville as on the glaciated plain, shaped by both glaciers, and with a thick layer of drift. The area is on the mid portion of the Ohio Shale formation with limestone underneath and with little usable water. Soils at Random 5 are Gn, Genesee silt loam, occasionally flooded (USDA 2009 a&b).

Random 6 point is 3.3 miles from Bexley in Franklin County on a terrace above Alum Creek. Stout et al. (1943:292 - 3) describe Bexley as on the Mississippi Valley Plain smoothed by both glaciers, and with fill of 100 - 200 ft. The town is on the old
Teays stage Columbus Creek, with Ohio Shale on top of limestones and dolomites yielding sulphur or brine water. The soils here are BeB, Bennington silt loam (USDA 2009 a&b).

Random 7 point is 3.4 miles from Rome in Franklin County adjacent to Big Run Park. Stout et al. (1943:300) describe the area as on the glaciated and smooth area of the Mississippi Valley Plain shaped by both glaciers. The drift thickness is some 130 - 170 ft, and the bedrock is the Columbus formation limestone, which gives good water from the lower portions but sulphur water at depth. Soils at this site are CfB, Celina-Urban land complex (USDA 2009 a&b).

Finally Random 8 is in Madison County a few miles west from the border with Franklin County in the Big Darby Creek drainage. The closest town to Random 8 mentioned by Stout et al. is West Jefferson, approximately 3.35 miles away (1943:435). According to Stout et al. (1943) the area had glaciation effects from both the Wisconsin and Illinoian glaciers, leaving drift thicknesses of 80-175ft. The deepest drift is found in Little Darby Creek, itself a remnant of the Groveport River during the Teays stage drainage. The dolomitic beds contain water, though it is contaminated with hydrogen sulphide. Soils here are CsA, Crosby-Lewisburg silt loam (USDA 2009 a&b).

4.4 Discussion of Existing Pre-Historic Sites

No regional analysis would be complete without assessing the rest of the prehistoric sites near to the nine known and nine random sites in the study. The split of
known sites and random sites within counties is shown in Table 6 and Figure 2. This information was gleaned from the State Historic Preservation Office 7.5' topographic maps that are marked up with all the reported known sites (those that are assigned an OAI number) and also notes about finds reported by the public that may not have a OAI number assigned to them yet (sensitive areas, areas that collectors frequent or isolated finds noted in the topographic map margins). Earthwork sites are not known to have habitation areas in or near them so any habitation areas used by people who might also be using the earthworks would not be in the immediate vicinity of that earthwork. To that end, an arbitrary buffer of one mile (1.6 km) radius was used around the nine earthwork sites as a means to find any nearby known sites that may be related to the earthworks. This one mile radius buffer was also used around the nine random sites as a comparison group. No known archaeological sites actually occur at these nine random points according to the OAI 7.5' quad maps of known sites housed at SHiPO.

Although one mile is a relatively short distance in a regional comparison, the number of known sites that litter the Central Ohio landscape make it difficult to extend the buffer radius out without encompassing hundreds more sites, and thus complicating the scope of this research. Ohio has more than 44,000 inventoried sites (both historic and pre-historic). The pre-historic counts are 2,363 in Franklin County, 2,240 in Delaware County, 937 in Pickaway County, 374 in Union County, and 193 in Madison County. Table 7 shows the results of this buffer, with the known sites clearly being closer to other known sites (total 131) than the random sites (total 70). The nine
known sites are also more likely to each be closer to other Woodland affiliated sites than the random sites. The data in Table 7, however, belie this fact as the data is somewhat skewed by R5, which has eight Woodland affiliated sites near it (most associated with the newly discovered Campbell's Circle (PI 1013) and Peters Square (PI 917). If this outlier is taken out, the percentage of Woodland affiliated sites near the nine random sites drops from 16% to 4%. Nevertheless, attributing a Woodland affiliation to a site is in and of itself problematic as the OAI database contains incomplete data.

Any contemporaneity between the nine earthwork sites and any nearby sites is based on dating from diagnostic artifacts or features, e.g. bladelets for Middle Woodland, found at those nearby sites. Many of the OAI forms make these affiliations based on one or two artifacts and the experience of the person submitting the form. Some forms mention bladelets without suggesting a Middle Woodland designation (e.g. Worthington), and others list a Woodland affiliation without explaining the rationale for that connection, e.g. no diagnostic artifacts or features. Nevertheless, in many cases the nearby sites assessed here have an unassigned temporal period making it difficult to determine the relatedness of these nearby sites to the earthworks. If a nearby site is given the same temporal period as an earthwork site the exact affiliation to the earthwork site is difficult to establish, even if radiocarbon dates exist (which is rarely).
Chapter 5: Materials and Methods

This chapter explains the materials and methods used in the research. It introduces regional analysis methods, the steps involved in this research, how the GIS was constructed and finally what statistics were used. The first section details remote sensing generally, its use in archaeology, and how it is used in the current research.

5.1 Remote Sensing

Lillesand and Kiefer define remote sensing as "... the science and art of obtaining information about an object, area or phenomenon through the analysis of data by a device that is not in contact with the object, area or phenomena under investigation" (Lillesand & Kiefer 2000:1). In archaeology this would include any kind of non-invasive technique that images buried natural or cultural features without disturbing them physically. Images from kites and model-planes are low altitude remote sensing methods, aerial photography is considered a mid altitude approach, and satellite imagery is a high altitude operation. The size of the area these three procedures can image, and thus the scale, will depend on the altitude and focal length of the lens at the time of image acquisition.

Some geophysical methods are also considered remote sensing by archaeologists as, for the most part, they are also non-invasive, and while some instruments do touch the ground, they do not necessarily touch the archaeological...
remains or prehistoric surface in question (Johnson 2006). These non-invasive methods include metal detectors, magnetometry, gradiometry, conductivity, magnetic susceptibility and GPR. Though perhaps not technically remote sensing based on Lillesand and Kiefer's definition, there are some minimally invasive techniques that researchers also use, which include resistivity (pressing a number of electrodes a few centimeters into the ground) and down-hole magnetic susceptibility (inserting a 2 m pole into a 2.5 cm bore-hole). I mention geophysics as the natural extension to this research, which would be to investigate the Similar Environmental Groupings identified in the results with one or more of the geophysical techniques listed above. Although the Similar Environmental Groupings were visually assessed using remote sensing imagery, multiple lines of geophysics inquiry would complete ground truthing (Bevan 1998; Burks & Waters 2003; Clay 2001 & 2002b; Dalan 1995; Dalan & Banerjee 1998; Dalan & Bevan 2002; David 1995; Gaffney et al. 1991; Heimmer & DeVore 1999; Kvamme 2001; Linington 1963; McKee 2005; Sommers 2002 a & b; Vaughan 1986; Weymouth 1986; Wynn 1986 a & b).

The objective of using remote sensing in this current research is to locate unknown earthworks using a soil or vegetation signature. Any anthropogenic activity on the landscape can cause changes in the soil, and can affect vegetation growth, sometimes for many thousands of years (Angel 2001; Avery & Berlin 1982; McDonald & Eliot 1987; Scollar 1990; Sever 2000; Wilson 1982). Ditches will show as darker soil marks as they are filled with organic materials, either directly by humans or just by aggregation of organic matter over the ensuing years. As lower elevation areas, ditches
will also tend to be moister than any embankment area. Embankments will be more compacted, possibly with gravel areas, and more likely to be composed of a clay based soil compared to a more organic soil material. They will also be at a higher elevation, even after many years of plowing. Any mound will also have a higher elevation, compacted clay soils, possible gravel or sand layers, and possibly limestone slabs used for a pavement or in a burial.

Based on the above descriptions, ditches, embankments and mounds will have different vegetation or soils signatures that can be seen on remote sensing imagery. More organic soils will promote growth, and be relatively moister, while clay, compacted areas, gravel or sand layers, and any stone areas will retard both moisture content and vegetation growth in certain seasons. On imagery then, differences in soils colors may result, or differences on height and vegetation color may be visible. What can be seen, however, will depend on when the remote imagery is taken, and this can vary by time of day, time of year, whether it is cloudy or sunny, the rainfall and drainage patterns, the crop type, the soil type, the size of the earthwork, and its topographic relief if any.

Despite the relative ease of using most of the techniques mentioned above, few archaeologists use either ground imaging or geophysics in their archaeological research in North America compared to Europe (Clark 1996; Johnson 2006). The contents of Johnson's 2006 book came about because he recognized the bias between the two continents in the use of remote sensing methods and geophysical techniques.
Some of the bias lies in the different type of archaeological remains that are being sought in each continent. In Europe, Neolithic sites tend to be fairly large and found near the surface. The remains are often constructed of stone, along with various metal components, both of which are visually compelling when using either remote sensing or geophysics. Conversely, prehistoric North American archaeological remains tend to be more similar to Pre-Neolithic Europe, a time period in which geophysics is also a rarely used method, for the very same reasons "... the traces left behind are far less structured and much more difficult to detect using remote sensing techniques" (Johnson 2006:3). For example, an historic kiln area may have a magnetic gradiometer reading of some 600 NanoTesla’s (nT) in relation to the undisturbed soil matrix, while a Hopewell earthwork may have a reading of only a few nT difference to the surrounding soil, and probably under 20nT at the most. To that end, in Britain especially, geophysics is utilized as a site discovery technique rather than as a means to explore a site once the site is identified, as is more the case in North American Pre-History (Johnson 2006:10).

In 1981, Baker and Gumerman wrote about the use of remote sensing data in Ohio and the Midwest. Their main point was that most researchers do not use the right techniques, or get discouraged when geophysics or remote sensing imagery do not show what the researcher thinks should be there. The issues discussed above are part of the reason (low background contrast), as are using incorrect survey methods (data gathering transects too widely spaced), incorrect instrument choice for the terrain or soil type, perceived instrument cost, and perceived instrument complexity (Johnson &
Haley 2006:33-45). Some researchers maybe did use remote sensing imagery or geophysics some decades ago, and found that it did not work for their particular needs at the time. They may not realize how much improved the instruments are in ease of use and cost, or that remote sensing imagery taken during a different season may more clearly show a vegetation or soil signature of buried components.

Archaeologists use remote sensing imagery mainly in the form of historic aerial photography to create a time series image sequence for a site (see for example Reeves 1936). Older historic satellite imagery has too little radiometric, geometric, temporal and spectral resolution to be useful for time series studies. For example, Landsat - 5 had only 30 meter multispectral resolution in 1984, which even for large earthworks sites is still too coarse. By 1990, SPOT - 2 had 10 m panchromatic resolution, and KVR-1000 had 2 m panchromatic resolution, but it is only since the early 2000's that sub-10 m resolution, along with multiple bandwidths, became the norm rather than the exception.

Imagery is now regularly captured at sub meter resolution (e.g. Geo-Eye-1's panchromatic data is 0.40 meter, and even its color data has a resolution of just over 1.5 meters too). Images created from LiDAR data offer a fine-grained alternative. The data in Ohio are available from OGRIP (Ohio Geographically Referenced Information Program), but the computer programs required to visualize the data are quite expensive and require training. Another aspect of LiDAR is that it requires that an archaeological site to still have some ground. If a site does not have that topographic relief, that is the site is completely plowed down, then LiDAR will not work. Nevertheless, geophysics
(GPR, magnetometry, resistivity/conductivity) can still show up any underground signature of the site even if surface topography is absent. Remote sensing and geophysical technology allows relatively quick survey and mapping of underground features and allows for the detection of any old excavation areas (including pot-hunting and looting attempts) and of undisturbed deposits that could prove interesting for limited and focused excavation in the future.

Many data sites that offer LiDAR, orthoimagery and satellite data are aimed at GIS professionals, which makes the data difficult to use for a non-professional. Much of this imagery was taken in the last 15 years, which is not very useful for investigating an archaeological site developed before the 1990's. For example, six out of the nine known sites in this research were developed in the 1960’s or before. Additionally, out of the three remaining sites one is completely forested and two have been substantially damaged making even historical imagery of little use. Recent data are useful to monitor non-developed sites, however, and as a means to search for new sites (Fowler 2002; Masini & Lasaponara 2006) in undeveloped areas. Cost concerns for buying recent high resolution imagery (whether aerial or satellite) could also be prohibitive, especially if tasking is considered or multiple spectral bands from hyperspectral sensors at multiple archaeological sites are required.

Nevertheless, Byers (1987) considers the view that people would have of a monument, and compares that to the view that historic researchers have of an earthwork. He cautions about using the information from remote sensing to review how geometrically perfect an earthworks is, as the people building them would not have had
that direct overhead view (sensu Cooney 2000's "experiential" versus "birds eye view"). Climbing a large tree may have been the highest aspect they could have seen the earthwork from. Some idea, in the form of received knowledge, may have been from the words of a shaman who, whilst in a transformative state, “flew” over the area and described his vision to others, but this would hardly be a first hand view. That said, seeing the surface of the earth as a plan view, which orthographically corrected aerial and satellite imagery can give us, is a very tried and tested way to find anthropogenically made patterns.

5.2 The Research

This section details regional analysis methods as they pertain to this study, the steps in this research, information about the GIS basemap used, and the statistics employed.

The study area consists of an arbitrary area of Central Ohio 85 km x 45 km, which encompasses all of Franklin County and Delaware County, and parts of the surrounding counties, namely Fairfield, Knox, Licking, Madison, Marion, Pickaway, and Union (Figure 4 - 6). For ease this area will be referred to in the text as Central Ohio. Nine known earthworks were compared to nine randomly placed points to ascertain if differences existed between the two populations. Most archaeological enquiry in Ohio has focused on the larger and more complex earthworks and mound groups in Ross County in southern Ohio and south Licking County in east-central Ohio (Dancey 1988). The earthworks clusters found in these two locales cover many acres,
have multiple, repetitive elements and mirror each other in those elements. They additionally yielded rich artifacts during the excavations of the 1800’s and early 1900’s (Fowke 1902; Greenman 1932; Mills 1899, 1902, 1904, 1906, 1907, 1909, 1914, 1916, 1922; Moorhead 1892; Shetrone 1924, 1925, 2005 [1930]; Thomas 1985 [1894]). On the other hand, Central Ohio, though also containing a cluster of earthworks, is not accorded the same interest (Griffin 1947; Shetrone 1924; Dancey, 1988). It does not have the same number, complexity or size of earthworks available for study as the counties of Ross and Licking and many Central Ohio earthworks have been destroyed by development.

Part of this deficit of information is due to the assumed peripheral nature of the Central Ohio earthworks on the edges of the glacial till plains and away from the earthwork heartland of Ross County (see Greber 2006:103 who refers to a "fringe area"). This is both a product of the antiquarian history of archaeology, where excavating only the big and artifactually rich areas was undertaken, as well as the fact that the current area under study is physically on the periphery of earthworks in Ohio. If we accept the northern earthworks in Ohio as part of the Early Woodland and Middle Woodland Hopewell Interaction Sphere, and contemporaneous to the Ross County earthworks, then it follows that the Franklin County and Delaware County sites that are included in this study are within that cultural story and an equal part of it. To come to that conclusion it does not even matter how one interprets that Interaction Sphere, whether by artifacts, earthwork and mound construction, trade, as an overall frosting [Struever& Houart 1972] or an underlying principle [Caldwell 1964]).
As stated, the earthworks in Franklin and Delaware counties could be considered outliers to the Ross County earthwork complexes and on the margins of the Ohio earthwork building area. Outliers in any continuum are, by definition, variants that are more rare and do not fit the majority criteria, although they are accepted as part of the group. It is in outliers, however, that interesting and novel data can be found. For example, what if unique sites such as Stonehenge, Carnac or the Great Pyramids had been dismissed as merely outliers that did not fit the patterns of architecture for their time periods? Nevertheless, these sites are viewed as very important when trying to explain the histories of the countries they are found in. The outliers that are represented by the Franklin County and Delaware County earthwork clusters are maybe not quite as unusual as the sites mentioned above, but they are dismissed as having perhaps too much variation when compared to Ross County and Licking County tripartite earthwork structures.

5.3 Regional Analysis Methods.

Common methods for regional analysis of archaeological sites based on landscape form, spatial distribution, inter and intrasite distances, structure, form and function, probabilistic and predictive models, and those using GIS and remote sensing are not new or unknown (Allen 1990; Angel 2001; Baker & Gumerman 1981; Barnes 2003; Bauer et al. 2004; Brandt et al. 1992; Byerly et al. 2005; Campana & Piro, 2009; Crumley & Marquette 1990; Custer et al. 1986; Eddy et al 1996; Fowler, 2002; Green 1990; Gumerman & Lyons 1971; Hicks et al. 2008; Hirsch 1995; Hudak et al.
Looking for patterns in data is a basic necessity for an archaeologist trying to make general inferences about past behavior. Identifying commonalities in constructions between a small sample of sites would then enable a probabilistic model that could be used to identify areas that are more likely to contain sites than not. Nevertheless, any unique sites, by definition, will not have a recognizable pattern of attributes that matches other sites. Thus a unique site may be missed while trying to produce a set of common construction rules for a sample of sites (for example, see Altschul 1990). On the other hand, taking commonalities from a number of sites and pooling them can create a composite site that cannot exist in actuality. For example, when compiling a list of the 15 most common landscape characteristics found at a group of sites, it would be unusual for any one site to exhibit all 15 characteristics. Subsequently, if those 15 common characteristics were selected from a set of GIS coverages as places to find potential sites, no sites would probably be found and none of the original sites would be predicted. Additionally, specific paleo environmental
information from the period of site construction may be scarce at some sites. The lack of information, plus any unknown cultural and pragmatic components to site choice, all conspire to make such models difficult to produce (though see Hudak et al. 1995). That said, a dynamic model that can adapt to more information from more sites will have the ability to find either "red flag" sites (Altschul 1990) or common patterns (Hudak et al. 1995).

No studies like the current research have been done within a digital GIS environment on the earthworks in Central Ohio. In addition, despite a surplus of field research few of the large Central Ohio earthwork sites have published field data. This field research is often difficult to access, some of it being in the form of Ohio Archaeological Inventory forms, colloquial publications (local newsletters, non-academic sources), unpublished theses and dissertations, and unpublished field notes, student notes and field maps. As this research treats the landscape form as a continuum, and implies a connection between sites based on landscape choices, the notion of "site" based on a circumscribed area is somewhat difficult to use. The idea of a "siteless" survey, championed by Dunnell and Dancey (1983), thus makes sense in this instance for this kind of research. If the act of burial is considered a group activity (which seems sensible), and the population is dispersed, then a regional approach is justified, and single 'sites' would not be representative that dispersed population (Madsen 1997:86). Thomas also contends that if monuments form traditions with shared construction features, then the meaning of any given structure is conditional on other sites (1991:33 emphasis added).
This research uses varied data. First, there is a fair amount of existing research by early excavators, cultural resource management projects (CRM Ohio Archaeological Inventory forms), M.A. and Ph.D. researchers for specific sites within the region of interest and for the region in general. Second, remote sensing imagery of the area is available from many local, state and federal agencies, either directly in the form of downloadable images from the web or by ordering through the mail. This imagery, whether already in digital form (more recent) or in analogue form (dating back to the 1930’s), is sometimes free or reasonably priced. Third, GIS coverages of the state are available from various agencies, mainly various divisions in the Ohio Department of Natural Resources that are downloadable on demand. Not all data used in this study is available as a GIS layer, nevertheless, that data was still considered in analysis.

Data that can be used in a GIS is often freely available for instant download off the web. Some agencies, such as the USDA’s Natural Resources Conservation Service (NRCS), take orders for specific data and, after processing, will make it available for download via ftp within a specific timeframe. Still other agencies (some divisions within ODNR and SHiPO), require a proposal or letter of recommendation for any research, but this can often mean they will provide the digital information for free if it is for education or research purposes. The platform for GIS, ArcGIS, can be run on any computer or laptop, with large files saved on external hard drives if necessary. Using a GIS to process existing data produces novel new data dependant on the queries of the operator. The search criteria used here found Similar Environmental Groupings,
resulting from classification of the nine earthwork locations in this research. After new Similar Environmental Groupings were distinguished by the GIS search as potential locations of unknown and unmapped earthworks then review of aerial photography can be done to determine the presence or absence of an earthwork. Even though the aerial images did not reveal any visual earthwork signatures, earthworks could still exist at the new Similar Environmental Groupings. If the model is accurate in being able to determine potential locations of unknown earthworks, then future research with geophysics, if the site is accessible, could detect a recognizable signature of those earthworks under the surface.

5.4 GIS Basemap

Knowing where you are in space is essential, whether completing a regional archaeological analyses of site placement or excavating discrete units at an archaeological site. GIS is an excellent tool to utilize for either of these endeavors in archaeology, as it can import disparate data for storage and retrieval, and it can be used to analyze, manipulate, and generate data that can be visualized in a map or report form (DeMers 2003; Farley *et al.* 1990; Knoerl 1995; Mazroas & Zack 1990 Savage 1990 a & b Stine & Lantner 1990). But in and of itself it does not have any inherent spatial information attached to the map when a new map application is opened. This necessitates using coverages and layers with spatial information attached to them, and subsequent layers added to that map are related to the spatial information of the initial coverage the basemap selected. Nevertheless, there are many different versions of
locational information, such as UTM, and Lat/Long, which may also have different datums related to them, e.g. NAD 1927, NAD 1983. Spatial information related to coverages can vary widely across and even within agencies producing such data. Getting spatial information in the GIS to relate in a meaningful way to other spatial information is extremely important when assessing co-occurring vertical information, which is the basis of this study. For example, I chose the wrong projection for a coverage I was using to create a map and the coverage moved 6 miles to the east compared to the same coverage I had used to create a different map. The question then becomes, which placement is correct - the original coverage or the coverage shifted to the east? By using the metadata attached to the coverage and the unique geomorphology of the Central Ohio area I was able to ascertain that the original placement was indeed correct, and I was able to reset the projection to move the coverage 6 miles back to the west.

Within the above caveats, the basis for any good GIS research is using an accurate base map on which all other data is overlain, thereby matching datums and coordinates uniformly (Burrough & McDonnel 1998). ArcGIS 9.3 is very easy to use in that respect, as re-projecting data to match a base map is done either automatically through prompts or through a tool within the ArcToolbox. Having said that, there were occasions when I added some Ohio county data to a map project and it would project automatically into the wrong place, such as what would be Canada. Careful viewing of metadata, re-projection to match the base map, or manual movement of the coverage can solve this problem. Nevertheless, this works only if the operator is already
intimately aware of the geomorphic structure of the region they are working in, and can spot errors before they become entrenched and perhaps untraceable.

The 10 meter DEM basemap used here (Figure 78) came from Ohio's EPA office, though it was constructed by the USGS for the Department of Emergency and Remedial Response (EPA 2004). This map, according to the metadata, is "meant to be used for detailed elevation analysis" and has a Root Mean Square (RMS) of 6.35 ft with a vertical accuracy of 12.45 feet at 95% confidence. The projection was NAD 1983 SP Ohio South Fips 3402 ft. For location reference, digital mosaicked topographic maps for the area were also used, along with county and township coverages. Other data used in this GIS are detailed in Table 8. The DEM was for the whole state of Ohio, so a central portion that covered the whole of Franklin and Delaware counties and overlapped into the surrounding counties by varying amounts was clipped out. The new clip extent, hereby referred to as the DEM clip, was used in other GIS operations to clip Central Ohio out of other GIS data layers that often also covered the whole of Ohio.

To facilitate a comparison sample for this research, nine points were randomly placed onto the GIS landscape in the DEM clip (Figure 79). To accomplish this, a data-frame grid was constructed over the DEM clip area, in the form of a reference grid (Figure 80). To cover the area the columns (east to west) were set to 14 (A-N) while the rows (north to south) were set to 22 (1-22), giving a grid 14 x 22, or 308 squares. Each grid square was an arbitrary 3,889 acres, and approximately 3951 m east - west and 3,984 north - south. Using a random number generator at Graphpad.com
I picked a subset of one number from the population of 308 in nine groups. This method always gave each of the 308 squares an equal chance of being picked each of the nine times. The nine numbers generated were correlated with a letter and number designation to match the GIS grid (Table 9). For example, the random number 10 would correspond to a GIS grid square of J1, or a random number of 29 would correspond to a grid square of A3. At the approximate southeast corner of each square that correlated with the generated random number, a point was manually placed on a GIS layer. As this was arbitrary, no attempt was made to be absolutely exact in this placement. The Feature Identification number (FID) automatically produced by the GIS was used as the identifying number for the rest of the research with the prefix "Random" or "R".

This analyses treats the archaeological site as the dependant variable and the non-archaeological characteristics, such as landscape, soils etc. as the independent variables. Assuming there are "common locational tendencies" (Hudak et al. 1995) to be found within the earthworks featured in this research, then viewing various historic remote sensing images should establish a simple presence or absence visual test of that assumption. Of course, "the importance of social and political factors in the spatial location of settlements cannot be ignored" (Hudak et al. 1995), but these factors are difficult, if not impossible to quantify or assess.

This study viewed imagery from different agencies, taken at different times of the year, over different years and at different resolutions. The local ODOT houses many photographs commissioned by other local agencies. They have digitized these
aerials for easy visualization, and on request they will scan, print and burn a CD for any negatives in their collections for a small fee. The earliest photographs of central Ohio that were of use were from 1938. The original negatives are housed at the National Archives in Maryland, but FCEO also has not only large positives and large prints of the photographs (2 ft by 3 ft), they also have copies of the original negatives. By chance, in September 2009, FCEO commissioned ODOT to scan the copy negatives, thereby adding the images (with a mosaic map) to ODOT's inventory, making access much easier and cheaper than approaching a National Archives vendor in Maryland.

5.5 Statistics

The research presented here uses just 18 samples in two populations. At each of the nine known sites and nine random points, information was gathered from the GIS layers and from other available data. Information was collected on point elevation, elevation change within 1 km, slope classes within 1 km, soil types (major soil associations in the area and specific minor soil information), glacial aquifer type, hydrogeologic setting, distance and direction to water and karst areas, ‘gateway’ (break in an earthen embankment) direction, and viewshed.

Univariate statistics were run first using Monte Carlo tests for a number of different attributes. Any tests that produced a p value below p < 0.05 were earmarked to be included in a multivariate Multiple Correspondence Analysis (MCA).
As is the case with most archaeology, the samples in this research were small - just 18 sites within two populations - which are difficult to statistically analyze. For the numerical data I used a two-tailed Monte Carlo test (except where noted) with 999 iterations as standard, and for the nominal data I used an MCA. The choice of variables was anything that I could measure or categorize, and that would have been similar to pre-historic times. Some of the variables also had to be available in digital GIS coverages so that the GIS aspect could be completed.

The Monte Carlo Test is a stochastic t-test that can be used on a small sample, and makes minimal assumptions about how the data are distributed (Gotelli & Ellison 2004). This test is well suited to the type of research being conducted (see Kvamme 1999:170-171). The Monte Carlo analysis randomly sorts and shuffles observed data into groups to simulate datasets, and then compares the absolute difference of means. There is no assumption that the data are normally distributed. A drawback of the test is that, being random, the resulting p-value is not fixed, but can vary slightly each time the test is conducted.

The three assumptions for a Monte Carlo Test are (Gotelli & Ellison 2004:115):

1. the collected data are random, independent samples
2. the test statistic will describe the pattern of interest
3. the randomization creates an appropriate null distribution for the question

MCA is a method of ordination, where the sites are the objects of interest and the environmental attributes were the variables being analyzed (Manly 1994). The
analysis seeks to clarify relationships, in this case between the known sites and the unknown sites based on the environmental attributes (Manly 1994:15).

Using SAS 9.2 (2008), it was hoped to run a MCA on the data, but that requires a table of one less variable than the number of the population in question - so a population of 18 samples needed 17 variables. Just analyzing the number of soils, 19 variables were generated (some of the known sites had more than one soil type associated with the large area covered by the earthworks), without adding any other data about geology, etc. Attempts to conflate and recode the soil data to accommodate the statistics requirements were not successful. For example, soils are designated as a specific kind because of their attributes - if they were similar, they would be named the same. I analyzed pH, drainage, and color to try and differentiate the soils in a more general way, but this showed very few differences between them. Conflating types by removing the slope designation only reduced the number of soils to 15. For example, CsA and CsB are both a Crosby soil, with the 'A' representing slopes of 0-2% and 'B' designating the soil as 2-6%. Conflating variables, continuous or discrete, also runs the risk of losing variability within the data in the first place (see Kvamme 1999:169). Though the very nature of a probabilistic model seeks to find an homogeneous site type in effect, the data going into the statistical analysis should contain all the variation so that the statistics can pick out any similarities.

As stated, a number of landscape elements were identified for each of the 18 sites, which will be referred to as types in the following discussion. Each type had a number of different variables associated with it, e.g., the type Glacial Aquifer could
have the variables of ground moraine, thin upland, complex, end moraine, alluvial and buried valley associated with it. The types multiplied with the variables produced 59 attributes. In an attempt to group or conflate similar attributes, a MCA was run comparing two attributes at a time to ascertain if the two populations, when compared randomly, would group into their respective populations. If they did group then the sites could be said to be different to the randomly placed points, indicating some kind of choice regarding the two attributes tested. All the attributes were run against each other except the minor soils as they numbered 19 variables, which was two more than the program should run with. Running seven types, and the variables associated with them, against each other produced 21 results. The 18 sites were run as a supplemental column so that they would not influence the variables. Using the supplementary column coordinates the sites were hand plotted. No distinct groupings of the sites were apparent in any of the plots, so the column coordinates were plotted to see if the variables grouped in any way. Groupings varied over the 21 tests and 42 plots (Table 10), but neither the known sites versus the random points, nor the variables compared to each other, were ever very clear as clustering in separate populations. Separate tests were proposed to investigate the individual variables and tease apart any differences between the known sites and the random comparison group.

After the Monte Carlo tests for the numerical data, an MCA was set up and all the statistically significant variables with their types were added to the program to see if the individual significances held, once the variables were grouped. Variables with data in the form of numbers were grouped into types, e.g., the range of elevation was
coded into Hi for over 15 meters (50 ft) and Lo for under 15 meters (50 ft). Various combinations of data were compared (Table 11).

5.6 Steps of the Research

The steps involved in this research (Figure 3) were:

1. Choose a subset of sites from the known earthworks in Central Ohio.
2. Gather information from OAI forms and maps, published and unpublished data.
3. View historic remote sensing imagery of the subset of sites to provide a time series of them.
4. Obtain a DEM coverage of the area as the base map for all of the GIS analyses.
5. Add the nine known sites as a point data layer on the GIS and nine random points as a point data layer on the GIS for a comparison group.
6. Find GIS layers of the central Ohio landscape
7. Research the nine known sites at SHiPO in the OAI and the site plot maps, and the nine random points, including finding out what sites occur within 1 mile of them all.
8. Characterize the landscape of the nine known and nine random sites using maps, GIS coverages and other available information, such as online soils data.
9. Perform statistical analyses on the landscape characterizations in #8 to uncover any statistical differences between where the known sites and where the random sites were located on the Central Ohio landscape.
10. Select and intersect the statistically important environmental variables within the
GIS; that is, where do the statistically important landscape characteristics, Similar Environmental Groupings, co-occur in Central Ohio?

11. Research the OAI for any known sites that are at or very close to the Similar Environmental Groupings that the GIS highlighted.

12. Revisit the historic remote sensing imagery to evaluate the landscape for previously unknown sites in the Similar Environmental Groupings highlighted by the GIS.
Chapter 6: Results and Analyses

"Whole Sort Of General Mish Mash (WSOGMM). The technical term for the sum total of all the parallel universes, which aren't parallel, and furthermore are not, strictly speaking, universes either. This is easiest if you don't try to realize that until a little later, after you've realized that everything you've realized up to that moment is not true. The reason they are not universes is that any given universe is not a thing as such, but rather just a way of looking at the WSOGMM. The reason they are not parallel is the same reason the sea is not parallel. You can slice the WSOGMM any way you like and you will generally come up with something that someone will call home. Please feel free to blither now." Douglas Adams.

This chapter details the results of the statistical analyses and subsequent GIS analysis in this probabilistic model based on the nine known and nine random sites in Central Ohio.

6.1 Results and Analyses

This research quantified elements of the landscape found at known archaeological sites. It asked the question - Which environmental aspects were important to the pre-historic builders? Did they have 'rules' about where they built their sites based on distance to water, or caves, or other landscape criteria? To answer these types of questions details for the nine known sites and nine random sites were collected and compared statistically to find out if any meaningful differences existed between the two populations. Data on a number of different criteria were collected and tested. Within a GIS those statistically significant aspects could be selected and
intersected, essentially finding a stack of traits that co-occurred in the form of Similar Environmental Grouping's. The Similar Environmental Grouping's were treated as areas of interest that had a higher probability of containing unknown archaeological sites based on the propensity of earthworks to be in similar areas. To that end, those Similar Environmental Grouping's were searched by visually reviewing multiple years of satellite remotely sensed imagery for evidence of vegetation or soil signatures indicating some kind of earthwork remains.

Tables 12 and 13 show an overview of the known sites compared to the random sites when 15 variables, within certain criteria, are considered. Between them the known sites share 103 instances of being associated with those criteria where the random sites share only 53 instances. The bold boxes indicate the variables used in the GIS analysis. Not all the most prevalent variables could be used in the GIS model. This was true if they lacked GIS coverages, or when selected in the GIS, were so widely found in the research area that including them would not have advanced the search for Similar Environmental Grouping's by narrowing down possibilities.

6.1.1 Elevation and slope

A number of different measurements were used for elevation comparisons. Initially, point elevations were generated from the DEM for the 18 sites (Table 14). For the known sites, which actually cover an area, a point approximately in the center of the site was used as the site elevation. As the random sites were only a point to begin with, this point was taken as the point elevation. When compared using a Monte
Carlo two-tailed test, the results of $p \leq 0.489$ were not significant (Appendix D). To further explore possible differences between the two populations of sites and known sites, a 1 km radius buffer was placed around the point data for all the 18 sites in the GIS. Each buffer's attribute table contained elevation information about the range of elevation in that buffer. For example, at Adler the elevation range was 868 ft to 925 ft AMSL, a range of 57 ft (Table 14). Figures 81 - 83 show the ranges of all the 18 sites. When those ranges were compared across the two populations, there was a statistically significant finding, with $p \leq 0.005$. This suggests that within 1 km radius of the known sites, there is more variation in elevation than within 1 km of the randomly placed points. Investigations into slope at the two sets of sites had similar results; when slope was measured as a point at each site, there was no statistical significance. However, when slope was measured generally within the 1 km radius buffer, some statistical significance was found.

Slope at each of the 18 points was derived from the DEM, but when these numbers were compared in the Monte Carlo test, there was no significance at all as $p \leq 0.961$. The DEM was reclassified into 14 slope classes (0-13 in the attribute table) (using the default of the Jenks Natural Breaks) (Table 14). Reclassification made the subsequent clipping procedure easier, as well as making the slope class analysis more straightforward. This raster was clipped using a 1 km radius buffer around each of the 18 points. Within each 1 km radius buffer around each point it was noted how many slope classes were found out of the 14 possible classes, identified in the coverage attribute table as 0-13 (Table 14). These total slope class numbers were then used in a
one-tailed Monte Carlo to compare the two populations, with a significant outcome of \( p \leq 0.013 \). This supports the preceding elevation data, implying that within 1 km of the site there is more slope variation at the known sites compared to within a 1 km radius at the random sites.

The known sites were not on the highest points they could have been in the near vicinity, which suggests that the highest place was not the key and a lower elevation may have been important. The higher places, or "overlooks" (Hively & Horn 2006:316), may have been used to help predict actual lunar, solar or stellar events some amount of time (weeks, days, hours) ahead of the actual moment to allow people to be prepared for them. This kind of notice would be essential for the alignments that happen only rarely, such as the once a year solstice, or the 18.6 year lunar cycle, or those alignments which were considered extremely important by the people. Seeman and Branch also find that "... mound locations tend to be framed by adjacent hills rather than being on them" (2006:117), which again implies the choreography that Cummings (2003) and Tilley (1994) discussed\(^\text{18}\).

6.1.2. Soil Types.

Soil information in Ohio can be roughly split into two categories 1) Soil Survey Geographic Database (SSURGO) detailed surveys by county at a scale of 1:15840 and 2) State Soils Geographic Database (STATSCCO) more regionally based information at a scale of 1:250,000. From the STATSCCO data the very general soil maps for a county or the state soil regions are generated (Figure 14). Three soil associations can then be
drawn for each site or point: Statewide associations (ODNR 2002b), county wide associations (USDA [NRCS] 2009a), and a specific single named soil (USDA [NRCS] 2009b). Visual information about specific soils at a point can be generated at the Web Soil Survey site (USDA [NRCS] 2009b) National Cooperative Soil Survey (NCSS), which allows an area of interest to be selected and provides a graphic report about the specific soils that appear there. Information by county is available from Soil Data Mart (USDA [NRCS] 2009a), with a choice of what information is included in a report. For this analyses, the parameters of acreage and proportionate extent of the soils that are found at each site was chosen for each of the counties that the 18 points fell into - namely Delaware, Franklin, Madison, Pickaway, and Union. ODNR also has county GIS coverages of soils available for FTP download on request, and copies of the paper County Soil Survey reports (ODNR 1980 a&b; 1981; 2001; 2002a).

As mentioned previously, the soils found at each of the 18 sites were quite different and could not be conflated based on similarities. One way to differentiate among them was to compare percentages of each type of soil by county (Table 15 & 16). Starting at the county level, the major associations are published in the county level soil survey, with a percentage count of how much of the county has that particular soil association (ODNR 1980 a&b; 1981; 2001; 2002a). For example, the site of Briggsdale falls on a Crosby - Kokomo association, with Crosby as 60% of the soils in that area, Kokomo as 20%, and 'other' soil types equaling 20%. That Crosby-Kokomo soil association at the county level is 24% of Franklin County (see Appendix C for descriptions; Figure 84). Interestingly, when Figure 84 is compared to Figure 77 it can
be seen that the sites that fall on the rarer soils (as a percentage) tend to be ranked as
more complex in construction based on the number of elements (circles, mounds,
geometric shapes etc.).

Those associations at the county level for the nine known sites and the nine
random sites were compared using a two-tailed Monte Carlo at 999 iterations. One
site, Holder-Wright, was on two major and quite different associations, both Crosby -
Kokomo and Glynwood - Blount. To take into account the two associations at Holder-
Wright the test was completed twice, once with the figures for Crosby - Kokomo and
once with the figures for Glynwood - Blount. The outcome when using the figures for
Crosby - Kokomo was \( p \leq 0.027 \) and when using the figures for Glynwood - Blount
was \( p \leq 0.037 \); both significant at the 0.05 level. This suggests that some degree of
choice about soils types is being made by the builders when they site their earthworks.
Bob Parkinson, a USDA soil scientist, reported in 1978 that "... the chance for finding
artifacts on well drained or sloping land is about 10 times greater than for finding them
on poorly drained or depressional land, with the stronger correlation to slope"
(Parkinson 1978). Although the current research did not find slope or drainage
correlations, the potential for such correlations is certainly feasible.

At the site level, each specific soil type was visually identified from the Web
Soil Survey 2.1 site (USDA 2009b), then a report about acreage and proportionate
extent was generated at the Soil Data Mart (USDA 2009a) to find out the percentage of
that particular type of minor soil in a specific county. Where a known site had more
than one soil type, as was the case for five sites, all percentages for each soil found
there were recorded. This problem did not occur at the random sites as they were a one
dimensional point as opposed to a site, which had a spatial extent associated with it
(Table 17). A two tailed Monte Carlo program was used and run twice to
accommodate more than one soil type occurring at a known site. For the first program
run the percentages of all the soils occurring at a known site based on county wide
numbers were added and averaged and run against the random site numbers. For the
second program run only the soil with the smallest percentage was used from a known
site and run against the same random site numbers. For the averaged soil percentages
program, $p \leq 0.022$, and for the smallest percentage program, $p \leq 0.004$; both were
significant at the 0.05 confidence level. This result also suggests some kind of choice
about soils and where earthworks are built when compared to the soils found at the
nine random sites.

Another aspect of soils investigated was the elevation range each specific soil
type was found in (Table 17). This information is available at the Web Soil Survey
under the map description report request option. The report details different aspects of
a minor soil series, for example, Amanda silt loam (found at the graded way at Spruce
Run), or Pewamo silty clay loam (found at Random point 0). County specific
information includes setting, properties, other soil components and elevation range
where the soil is found, e.g., Bennington silt loam in Delaware County is found
between 800 and 1200 feet, a range of 400 ft. Using the range figure for the minor
soils series at each of the 18 points, a one tailed Monte Carlo test was run. As before,
the test was run twice to take into account some of the known sites that had more than
one soil type. In the first test, the highest elevation range of any soil found at a site was used, and in the second program the lowest elevation range of any soils was used. When the highest elevation range was used, the outcome was $p < 0.556$, which is not significant. When the lowest range of a soil was used, the outcome was $p < 0.015$, which is significant at the 0.05 level. Figure 85 shows how the majority of the known sites tend to cluster on soils found at slightly lower ranges, while the random points are more likely to be spread across all ranges. This further supports the notion that, where earthworks are found, a specific soil or the elevation range of that soil is a matter of choice made by the prehistoric builders, rather than a simply random act by them.

Soils were a difficult variable to discern in this research. As described, the difficulty of conflating the 19 soils varieties found at the 18 sites, whilst at the same time not homogenizing the sample proved quite challenging statistically. Additionally, using soil descriptions from soils that had been chemically and scientifically analyzed would not be information that Native peoples would have had. They would be more likely to use folk categories, or other criteria that meant something to them. I did try and use colors of soils, which is one criteria that earthworks seem to have in their construction (Charles at al. 2004; Dancey & Seeman 2005; Greber 1996:153; Lynott 2006; Moorehead 1892; Thomas 1985 [1894]:448), but as the colored soil is obviously brought in from outside the immediate area of the site, then soils from a buffer zone would have to be taken into account too. Such an undertaking was outside of the scope of this study, considering the number of soil types that would exist in a 250 m diameter buffer area for example, but would certainly be of use in future research.
Approaching the soil problem using different criteria (elevation range of soil type and percentage of the county that had the soil type), however, proved rewarding statistically. The results show that the relative rarity of the soil compared to other soils seems to be an aspect of site choice (some of the choice may be based on the elevation range a soil is found in, though elevation could in fact be an aspect of viewshed requirements and the soil is thus a coincidence).

6.1.3 Water and Springs

Distance and direction to major and minor water courses were assessed for each of the 18 sites. This was completed using a distance measured in meters (Table 18; Figures 86 - 87; data about gateways are included in most of these figures for the reader to compare, but they are dealt with in a later section) and direction based on a 16 point compass (Figures 88 - 91) and a 360 degree compass (Tables 19 & 20). Using the distance tool on ArcGIS and the topographic 7.5' quad maps digital coverages the distance was measured to the closest major river and the closest minor water. For the most part the minor water was a ditch or creek that may run seasonally in the present, with an unknown drainage pattern in the past. Based on this portion of Central Ohio being a mature landscape (Gehring 2009; Parkinson 2009), I am assuming that the distances to both major and minor waters have not changed appreciably, even with meandering and flood episodes, and if they have, it would be in a fashion that would affect the known and random points equally randomly.
The distances were run using a one-tailed Monte Carlo program with 999 iterations to compare the two populations. Neither were significant, with the distance to major water result of $p < 0.243$, and the distance to minor water result as $p < 0.128$. Direction to water was compared using a 360 degree compass reading and a one-tailed Monte Carlo test. These tests also came out as not statistically significant, with direction to major water results of $p < 0.435$ and direction to minor water resulting in $p < 0.221$. Figures 89 and 91 show that the direction to major and minor water does not cluster visually anymore than the random points, though certainly direction to major water from the known sites tends to be east or west.

None of the statistics for direction or distance to major and minor water sources were statistically significant. Ohio, compared to New Mexico, for example, is covered with water sources, big and small. It would be difficult to randomly place a point on the Central Ohio area used in this research and not be near water of some description. In fact some of my random points, namely R0, R2, R5 and R6 all fall within 250 meters of major water sources, some on banks overlooking water, by chance. In such a mature landscape as Ohio is, and with so much water on it, the sample of known and unknown sites needs to be increased to see if there are differences with a bigger population.

Some researchers report that prehistoric sites are found more often close to springs (Atwater 1833:151; Boewe 2000:2; Dancey & Pacheco 1997:3; Carskadden & Morton 1997:365; Thomas 1985 [1894]:459, 470). To test this assumption I tried to find an analogue or digital coverage of springs in Ohio. Unfortunately, no such data
exists. ODNR (Division of Water) gave me two documents. One is a one page word document entitled "A Partial Listing of Springs in Ohio" that listed 102 springs in the state by region (Radvansky 1971). For the Central Ohio region the document states "Springs are concentrated in Adams and Delaware counties. Generally, they are of chalybeate and sulphur nature." The second document, an Excel (TM) spreadsheet with the same title as the 1971 document, lists 103 locations with springs (ODNR 2008). The total number of springs is ambiguous, however, with some entries just stating "numerous". One location in Warren County has 50 springs listed, but many have no total number listed at all (though the assumption is that at least one existed at each location). Franklin County has one spring listed (OSU campus at Mirror Lake); Delaware lists 14, Madison and Pickaway have zero and Union has two.

The location of springs with regard to earthworks was also part of this research. Unfortunately there were a number of problems associated with collecting and analyzing this data. Based on information from ONDR, the records about springs in the research area are probably incomplete. Even if we had data about the location of springs, spring flow would be sensitive to seismic action (see Chapter 2) and changes in water table levels.

Based on the discussion above, the spring data was not used for a variety of reasons: 1) there was no good locational information for any of the springs to produce a digital layer for use in the GIS; 2) the data seem to be rather too sparse, and quite possible incomplete. For example, at Holder-Wright the ditch that runs through the site (Billingsley Ditch) runs absolutely clear, except in rain. That suggests it may be spring
fed, yet no spring is listed in the vicinity of Holder-Wright in either data sources; and 3) of all the variables used in this research, springs also seem to be the one that may be most prone to being different today when compared to pre-historic times. With river dams, multiple wells and other changes to drainage patterns, the water table will have changed probably quite dramatically since the Woodland times. Over the last 3,000 years it would be safe to say that seismic action in the area (see Chapter 2) and anthropogenic action relating to irrigation for farming and water needs for settlement would have changed water table levels. If the water table has lowered, then water pressure that enables artesian springs to flow would be reduced, which perhaps means that a spring would not flow presently. As and when new data is developed about springs, it may be useful in future analysis. Again, given the available data this makes it difficult to know if future research will be able to use spring information.

6.1.4 Caves

Writers have long suspected that earthworks were placed near to caves (Potter & Baby 1964; Shetrone 2004 [1930]). One of the ODNR digital coverages contained spatial data about known and probable karst areas in the whole of Ohio (ODNR 1999). The central rectangular portion of karst data was clipped out using the DEM clip (Figure 91). To test the assumption about cave proximity, distances and direction were measured from an ODNR GIS coverage to each of the 18 sites (Table 21 and Figure 93). These two populations of distance measurements were then compared
using a Monte Carlo test. The distances were compared and the two populations exhibited a p-value of p<0.273, which is not significant.

Direction to the cave areas was then considered. The digital coverage, available from ODNR, shows known and suspected karst areas based on geology. Measured using a 360' compass heading, degree numbers were generated for the 18 sites (Table 21). Again, using a Monte Carlo test, they were compared between the two populations. This time the p-value was p<0.354, and again it was not significant. These results suggest that with the current sample, there is no statistical significance with regard to site placement in the vicinity of caves or karst topography. When the sites are plotted on a compass diagram (Figure 94), however, there does seem to be some directionality to the nine known sites compared to the nine random ones. Six of the nine sites are clustered in the area between west and north-northwest, compared to only two of the random sites. There were no matches of any of the 18 sites in direction to karst to any of the solar and lunar alignments considered in this study (see the gateway section).

I had hoped that information about sites being close to caves would bear fruit, statistically speaking. However, I think that the information and data about caves is probably incomplete, based on my reported experiences at the Holder-Wright site. In this case, a bigger sample may not help discern this, if the data about caves is incomplete. Caves, being underground or hidden in rock formation, would by definition be difficult to search for on remote sensing imagery and may only be accessible by on-site reconnaissance. That said, there may be problems with gaining
permission to search areas near known sites (which may also have been destroyed). In this case it is difficult to see how cave data will be any better or useful in the near future.

6.1.5 Gateways.

The direction of gateways (breaks in the earthen walls) within the earthwork embankments at the known sites was measured using a compass and recording on a 0 - 360 degree scale. The random sites obviously did not have any gateways or cultural remains associated with them, so to allow comparison gateway directions were arbitrarily assigned to the random points. This was accomplished by using a random number generator at GraphPad.com (GraphPad 2005) and picking one subject from a group of a possible 360 and repeating that task nine times (Table 20; Figure 95). This enabled each number between 1 and 360 to be available each time a number was picked, rather than picking nine numbers in one group, with no repeats.

Some of the nine known sites had multiple gateways associated with multiple earthwork elements, and one had an unknown gateway direction (Jackson Fort). To compensate for the lack of gateway data on Jackson Fort, the gateway data for Random Point 5 was arbitrarily removed from the comparison population before running a Monte Carlo test. To fully test the different iterations, the test was run four times using these rules.

1. When more than one element had a gateway at a site, the gateway of the biggest element was used
2. When an element had more than one gateway, the numbers were run in size order.

3. Once the biggest element had been used, the second biggest element with a gateway was used.

4. The gateway of the smallest element was used last.

The results were not statistically significant at all for:

1. \( p \leq 0.40 \)
2. \( p \leq 0.65 \)
3. \( p \leq 0.93 \)
4. \( p \leq 0.755 \)

Gateways exist at many sites and are obviously an important element of construction. Though there was no statistical significance, there are some interesting inferences to be drawn from the gateway data in the same vein as the directionality of the karst topography. The data from the nine known sites show a tendency to have gateways facing either the nearest major water source, or one of the 14 lunar and solar alignments (including equinox) considered here (Table 22) (see Romain 1996, 2000, 2004). Table 23 shows that the gateways for the known sites tend to be more aligned with the direction to major water or major solar and lunar events than the random sites (though see Marshall 1999). As this aspect was not the major focus of this research, no attempt has been made to find other solar, lunar or stellar alignments, nor to correct the compass degrees of the solar and lunar events to correspond with the slight differences in the alignments that would be found in the Woodland time period. When
considering direction to major and minor water, and the direction the gateways faced for the sites (Figure 96) no apparent patterning is discernible. In looking at gateway placement and directionality the larger concept of the entire earthwork construction may have to be addressed.

6.1.6 Viewshed

If site choice for earthworks is non-random, then are differences between the two populations (known sites and random sites) apparent regarding viewshed? I define viewshed as an area that is visible from a fixed point based on the elevation of the observer and the elevation of the land. In this case I measure the number of pixels that are visible from each of the 18 sites based on elevation. Intervisibility is important when investigating the choreography of a site, the elevation where a site is, and the landscape the site is on.

Viewshed analysis is not new, but certainly much easier to accomplish within a GIS environment (Kvamme n.d; 1985, 1989, 1999). What can be seen and what cannot be seen from a place have been identified in a previous section as being important, perhaps as part of a sites choreography and experience for the persons using it (Cummings 2003). Nevertheless, there are many aspects of viewshed that are problematic - how close or tall were nearby trees; were different areas away from the sites used as lookouts rather than the site itself; if sites were not contemporaneous then how useful is viewshed analysis; were platforms built, or trees climbed when trying to view the surrounding areas; how did refraction based on air density change the view; if
topography was not the key, perhaps views of other sites, or signals like smoke, were important; was seeing out or being seen more important? Were trees used as a means of delimiting either space or the experience of view at a site? (see Riordan 1998:77) As none of the above were known for either the known sites or the ransoms, a general and relative comparison was made using the basic formula from Cole (1913) of:

\[ 7x = 4y^2 \]

where \( x \) is the height of the observer in feet and \( y \) is the distance to the horizon in miles. Deriving from that is

\[ y = \sqrt{\frac{7x}{4}} \]

From this it is possible to ascertain that a 2.1 meter tall (6 ft) person can see 5.23 km (3.25 miles) on a flat plain before the curvature of the earth becomes too great and the continuum of view is reduced. The height of 6 ft was chosen as a purely arbitrary number for the height of a Native person. As this formula takes no account of trees (both in the view and as a climbing opportunity), atmospheric light refraction, lookout platforms, the use of smoke, fire, or sound, the topography of the land as in what the people may have wanted to see (although the GIS does take elevation into account), the viewers eyesight, the viewers disposition (prone, standing, kneeling) or other variables that could affect viewshed, I doubled and rounded the distance to 11.27 km (7 miles) to create a generous buffer zone for analysis.

This operation used the clip DEM extent raster with a seven mile buffer zone around each point for most of the points. It was done differently for Adler, and random
points 0, 1, 4, 5, and 8, as a seven mile buffer took the viewshed analysis outside of the clip DEM extent for those six sites. That is, those 6 points were quite close to the edges of the clip DEM extent causing the 11.27 km buffer circle to overlap the edge of the clip DEM extent into null space. To ameliorate that problem for those sites, I clipped a 7 mile buffer out of the original state DEM (that the clipped DEM extent had been taken from). Figure 97 shows just Adler to illustrate this. I could then do the viewshed analysis on that clipped buffer area to make sure all points were treated the same and had exactly the same area associated with them. A viewshed analysis was then conducted on each of the 18 clipped DEM seven mile buffers. As the height and position of the viewer was unknown, the default of one unit (in this case 1 foot) was kept over all the 18 sites.

The resulting pixel counts were noted from the attribute tables; no attempt was made to convert the pixel counts into acreage for the purposes of comparison as the relative counts served to compare the two populations just as well (Figure 98). Using a two-tailed Monte Carlo the raw pixel counts were compared with a result of p < 0.762, which was not significant. However, though the statistical significance is lacking, Figures 99 & 100 show that the distribution of the data for the known sites is different when visually compared to the random sites. The sites of Columbus Country Club, Dominion, Holder Wright, Orange, Spruce Run and Worthington all seem to have a suppressed viewshed. It can be seen from Figure 81 that they were not built on the highest point available within the area. It is possible that total viewshed was not as important for the builders as other attributes, such as soils. Alternatively the choice of
site may have been about what *could not* be seen from the sites rather than what *could* be seen, akin to the choreography of experience with views into and out of monuments that Cummings (2003) suggests.

The directionality of the viewsheds for the known sites also bears some analysis. Figure 100 shows the viewsheds of the nine random sites. The seven mile radius circular buffer is clearly implied in the viewsheds of Random 0, 6, 7 and 8, yet no such circular artifact is seen in the viewsheds of the known sites (Figure 99). The viewsheds of the known sites seem to have a more organized quality about them. For example, Holder-Wright has a very clear view of the western skies, but has a very limited view of the eastern horizon, where all the sites' gateways point. All but Briggsdale have a definite directionality within their viewsheds, with very defined angles and edges associated with what can be seen.

These defined angles may have been based on views of solar, lunar or stellar events, views towards other sites, or a combination of both. Conversely some of these alignments at the known sites may not exactly correspond with lunar, solar or stellar events for good reason. For example, if a group of people needed to travel to another site for a ceremony or event that was based on a solar alignment they would need *advance* knowledge of that event. Holder-Wright is 38 miles as the crow flies from Newark. A group that lived near Holder-Wright may need four or five days to travel to Newark, depending on who was going (old, young), what they had to take (recovered bones to bundle and rebury, offerings etc.) and their mode of transport (walking, waterways) necessitating a few days warning to prepare for such a trip. Alignments at
Holder-Wright may thus be slightly 'incorrect' compared to actual solar, lunar or stellar alignments (even taking into account differences in those alignments during the Woodland period compared to today) to enable that advance planning and to arrive at a different site in time for an event.

Directionality of viewshed may also be determined by where the people who used the earthworks lived. The view they had whilst travelling towards the earthworks, and whether they could see the earthworks or the event being celebrated (the moonrise or the sunset) may have been part of the locational qualities of the site. A site used for more than one event in a year could also have different viewshed requirements, with each event or each group of people requiring different viewing experiences.

Tilley suggests in his 1994 book that movement across a landscape is as important as leaving or arriving a place and that the whole experience is choreographed (see also Cummings 1994; Williams 1998). He found that one landmark marks another landmark, and which landmark you can see is dependent on your distance from them; so locating and getting to the monument is done by reading the topography in the right way, in the right order and at the right scale. Looking at monuments in the Welsh landscape Tilley shows that once there the viewshed is also carefully constructed, and that the invisibility and visibility of other monuments and the natural surroundings makes a distinct duality.

The Eastern Woodlands in Ohio have a somewhat different topography than Wales as it pertains to topographic relief, but trees could serve the same purpose as rock formations. Riordan identifies three types of Middle Woodland enclosure types:
1) clear - no trees inside or outside the site, a lot of work up front and a lot of maintenance, 2) open - some clearing, lines of sight, gateways, medium amount of work upfront and medium amounts of maintenance and 3) closed - all the trees left, little work upfront and little maintenance (Riordan 1998:1977). However, clearings within wooded areas would also attract certain wildlife and plants that may offset the cost of the clearing based on Riordan's types. Trees would also be needed for building materials and fuel. For example, at Fort Ancient, McLauchlan says the area was deforested up to 200 meters away (2003:558) (although see Wymer who says that earthworks were built in wooded areas in the core Hopewell area [1996:47]). Trees may have been part of constructing the choreography of a place, with the obvious natural, solid and imposing barrier they provide, both physically and visually. Whether trees feature in the cultural landscape would also depend on the view the people in a culture had of trees, or perhaps certain species of trees. Trees could be seen as a nuisance, as harboring ill spirits or harboring good spirits amongst other things. Pragmatically, while clearing trees by girding, burning, etc. removes them from the surface, digging earthwork ditches or soil borrow pits through tree roots, old or not, is extremely hard work.

6.2 Nominal variables

To compare nominal variables for any relationships between sites versus the random non-sites, a multiple components chi-squared analysis SAS program was used.
Only a few variables were initially randomly paired up to ascertain any statistical significance before a larger number were compared.

The first two variables compared were hydrogeologic setting and glacial lithology (Angle 1995; Angel 2004; Angle & Barrett 2005; Angle et al. 2005; Sugar 1990) (Appendix D). The 18 sites, denoted by "1" (known site) and "0" (random point), were run as a supplemental column so that the 1's and 0's would not influence the outcome of the test. At a 95% CI $X^2 = 103.010$ with 81df, with the outcome of $X^2 = 169.174$, this test gave $p < 0.0001$.

The next comparison was the two variables of hydrogeologic setting (Angle 1995; Angle 2004; Angle & Barrett 2005; Angle et al. 2005; Sugar 1990) and soil drainage (USDA [NRCS] 2009 b) using the same program (Appendix D). At a 95% CI $X^2 = 124.342$ with 100df, with the outcome of $X^2 = 191.109$, this test gave $p < 0.0001$.

Lastly the site specific soil type was compared to the topographic place that that soil type was formed and located (USDA [NRCS] 2009 a&b) (Appendix D). At a 95% CI $X^2 = 124.34$ with 100 df, with the outcome of $X^2 = 239.143$ this test also gave $p < 0.0001$.

Having assessed a number of different paired variables and found them statistically significant, the analysis continued by placing more variables into the Multiple Correspondence Analysis program. This program was run using eight variables - elevation range of the soil type, soil type, where soils are found, the elevation range within 1 km of the sites, the percentage of a major soil association by
county, lithology, the hydrogeologic setting, and soil drainage type. Variables with numbers were coded as shown in Table 11.

At a 95% CI the critical value is $X^2 = 1034.23$ at 961 df, with the outcome of $X^2 = 1068.67$ this test gave a significant $p < 0.007$ (Appendix D). Thus when these eight environmental variables are considered together, the two populations of known and random sites continue to have significant statistical differences discernible between them. It can been seen, however, by bundling eight variables together compared to just two variables in the previous MCA, that the p-value has increased. Adding more variables to another MCA may still give a $p < 0.05$ though. That said, the test does show that the environment found at the known sites tends to be statistically significantly different to the environment that occurs at the random points. While no causation is claimed, this result highly suggests that the variables at known sites tend to vary together compared to the comparison set of random sites.

One final Monte Carlo SAS program was run on the data from Tables 12 and 13. These tables identified whether 15 separate environmental types were present or absent at each of the 18 sites. The totals in the right hand columns for the two populations of known sites and random sites were statistically compared. The result of $p < 0.0001$ clearly shows that the suite of 15 traits are more likely to occur at an archaeological earthwork site rather than at a point randomly placed on the landscape. Table 24 summarizes all the statistical results from the above section. Tables 25 - 27 summarize the data used in the above analyses and also in the GIS analyses covered in the following section.
6.3 GIS Analyses

For the GIS section of the analysis, the method was to select and intersect some of the variables that were statistically significant. This can be accomplished in the GIS by selecting a chosen variable in the digital layer's attribute table and then creating a new layer from that selection. It can be done for any number of different variables to produce a number of different layers or selections. These layers, of only the selected elements can then be intersected in the GIS to produce a new digital layer of just those intersections. Any places of intersection would show where the chosen variables co-occurred in space, in this case as designated Similar Environmental Grouping's.

Not all the variables that were statistically significant could be used to good effect as, depending on the variables used, some of the selections would produce new intersect layers that were too broad to be used. For example, selecting just the minor soils that were less than 5% by county highlighted vast swaths of the Central Ohio area on the DEM clip, meaning that using that variable as part of an intersection to find a Similar Environmental Grouping was not very useful. Conversely, some selections when intersected would produce no Similar Environmental Grouping's at all, meaning those chosen variables just did not all co-occur in the research area. For example, intersecting any areas where minor soils were < 5%, the elevation range was 800-1200 (for specific minor soils formation where the soils at six known sites and only two random sites are found), the lithology was 'till', and the hydrogeologic setting was 'buried valley,' produced no areas where they co-occurred in space.
The aim was to generate an intersected selection that produced a manageable number of Similar Environmental Grouping's that could then be visually searched on remote sensing imagery. In a GIS it is very easy to pick variables and intersect them at will and in various iterations. After some experimental analyses using the set of statistically significant variables the decision was made to initially use the co-occurrence of just three variables to produce Similar Environmental Grouping's. The three variables were 1) aquifer setting, or the landform created, in this case, by glacial action. 2) hydrogeologic setting, or the base landform (geologic structure) that the aquifer was on. And 3) lithology, or the matrix (fill) that was on top of the hydrogeologic setting and which the aquifer setting landform was composed of. Using the coverage from the ODNR Division of Water Ground Water Pollution Potential (GWPP) (Angle 1995; Angel 2004; Angle & Barrett 2005; Angle et al. 2005; Sugar 1990) coverage and the ODNR glacial coverage (ODNR 2000), the following three variables were selected from the attribute table:

1. areas in the attribute table of the Glacial coverage of lithology of T, or Till (ODNR 2000)
2. areas in the attribute table of the GWPP coverage under DRASTIC CODE (hydrogeologic setting) of 7D, or buried valley (Angle 1995; Angle 2004; Angle & Barrett 2005; Angle et al. 2005; Sugar 1990).
3. areas in the attribute table of the GWPP coverage under glacial aquifer of thin uplands, ground and end moraine, and complex (Angle 1995; Angel 2004; Angle & Barrett 2005; Angle et al. 2005; Sugar 1990) (Figure 101).
These variables were selected by clicking on the relevant row in the attribute table of each coverage, for each of the five counties, and saving that selection as a new layer. The five resulting new layers were then merged into a new coverage and clipped to the DEM clip extent that only covered the clipped five county area. This process was done separately for each of the three variables. Once each of the three variables had been selected, merged and clipped in the five county area, the three resulting layers were intersected to produce one new layer that showed only the areas where those three variables, (Till, Buried Valley, and the three aquifer types) co-occurred in the clipped DEM area (Figure 102).

This new intersected coverage identified 69 Similar Environmental Grouping's that co-occurred in Franklin County (#0-68 as identified in the GIS FID), with a combined area of 1582.83 acres. Manual update of the area field was completed using the 'calculate geometry' option as this does not automatically occur in ArcGIS (Table 28). Figure 103 shows the distribution of the Similar Environmental Grouping's based on acreage, with a distribution between approximately 150 acres and 0.21 acres, and an average of around 23 acres. These sizes fit in quite well with the spatial extent of earthwork sites within the Central Ohio area.

To ascertain if another variable would significantly change the number of Similar Environmental Grouping's, a fourth statistically significant aspect was added. This was the number of slope classes within a 1 km radius diameter buffer circle of the site. Seven of the known sites had more than 11 slope classes within that circle, while only 1 of the random sites had this aspect. So first a layer had to be made that
identified only the slope classes of interest; those that represented the higher slope values, or 15.83° and above. First, the DEM clip extent was reclassified into 14 slope classes coverages to produce a new layer. Then in the Spatial Analyst menu, the Focal Statistics function was selected, followed by the choice of the Range Data type. The point of the exercise was to find all the areas within the DEM clip extent that had slope classes 11 – 13 (15.83-38.83°) represented within a 1 km circular buffer.

The Range Data statistical function was set up so that a moving kernel would move across the reclassified DEM coverage. The kernel size was set to 1 km to match the buffer zone that had been set up around all the 18 points by using a diameter of 50 cells (each cell was 20.3 m² to give a diameter of 1015 meters). This produced a new layer showing areas where the slope classes 11 – 13 occurred. This is identified in the attribute table as classes 0-13, where 0 meant the slope was 0.00 – 0.45° in the 1km kernel at that point, to 13 where the slope was 24.51 – 38.82° at that point (Figure 104). It was then a simple manipulation to manually select classes 11-13 in the attribute table (actual slope classes 12-14) (Figure 105) and reclassify them to create a new layer just out of those chosen classes. The slope data in the new layer was reclassified from 0-10.99 as '0', and the data for the selected slope classes 11-13 as '1'. The new layer with the data from the selected slope classes of 1 was set to the color of choice for visualization while rest of the area that had been reclassified as '0' data was set to no color (Figure 106).

This new slope selection layer was then intersected with the previous intersection layer that contained the other three variables. The four intersected
variables now produced 18 new Similar Environmental Grouping's that were spatially intersected with some of the previous 69 Similar Environmental Grouping's (Table 29). The original 69 Similar Environmental Grouping's were given automatic ID numbers of 0-68 in the FID (feature identification) field of the layers attribute table. The new 18 Similar Environmental Grouping's also got automatic FID's of 0-17. To avoid confusion between the old set of Similar Environmental Grouping's and the new Similar Environmental Grouping's, I manually added a new field to the attribute table and designated my own FID numbers, from 100-117, to the 18 new Similar Environmental Grouping's and manually updated the area field using the 'calculate geometry' (Table 30). The new FID numbers were used for labeling, reference, and analyses of those 18 Similar Environmental Grouping's (Figures 107 - 109).

The model employed in this research claimed that certain environments were preferable to build earthworks on, and thus there should be differences between the environments where known sites were located compared to a set of randomly placed sites. To that end, all the Similar Environmental Grouping's detailed above should be similar to where pre-historic sites tend to be located and thus those Similar Environmental Grouping's may contain visually locatable known or unknown sites.

To test this model, the Similar Environmental Grouping's needed to be searched on a number of different imaging media for evidence of archaeological sites. In an easy to use mapbook from Franklin County Engineers I marked up the Similar Environmental Grouping's using a highlighter pen. This made all the searches I had to do much easier to negotiate. First, I searched the Similar Environmental Grouping's at
SHiPO on the 7.5' quad maps of known sites that they hold, and found a total of 28 known sites within the Similar Environmental Grouping's areas (Table 31). Seven further known sites were found adjacent to the Similar Environmental Grouping's. Of these 35 sites only four had an Early or Middle Woodland affiliation, and only one site was designated as a mound (Table 32).

The 69 Similar Environmental Grouping's identified by the GIS intersects were then searched on images from:

- Google Earth imagery (accessed October 2009, in the form of aerial photographs dating from various years starting in 1988, and composites from Digital Globe from the years 2002-4; 2006-7 and SPOT from 2009).
  
  o searched visually on a computer screen

- USDA APFO DOQQ's from 1994.
  
  o searched visually on a computer screen

- DOT aerial photographs from the years 1946-8, 1950 and 1956.
  
  o searched visually on a computer screen

- USDA APFO aerials from 1938.
  
  o searched visually on 32" x 20" black and white prints

If a Similar Environmental Grouping was found to be fully developed and built on at any point, then further visual analysis of the site was not undertaken. The reasoning was that any soil or vegetation signature created by an archaeological site, and that may show up on remote sensing imagery, would be too disturbed after development.
I located the Similar Environmental Grouping's on the highlighted topographic map and then located that same area on the aerial imagery. I looked within the Similar Environmental Grouping's areas as well as in the general vicinity of the Similar Environmental Grouping for evidence of any earthwork signatures. The searching was mainly completed using a computer screen and zooming in or out as required and also by manually manipulating the contrast and brightness to highlight any subtle signatures. The 1938 aerials were not available digitally at the time of the analysis, so they were visually searched using a magnifying glass on the large prints held by FCEO. Any images that showed any kind of vegetation or soil signatures that seemed out of place were saved digitally, or requested digitally and in print form. Figures 110 - 129 show the results of this search.

When viewed on multiple imagery resources, none of the 69 Similar Environmental Grouping's showed any soil or vegetation signatures that strongly suggested buried archaeological sites, this even included the 18 highlighted using the fourth variable. Nevertheless, some of them showed some interesting surface manifestations that may bear further investigation using geophysics, although the markings seen in many could possibly be drainage or historic manifestations. Images that seemed visually interesting were Similar Environmental Grouping 26 in Figure 119, Similar Environmental Grouping 32 in Figure 120, and Similar Environmental Grouping 52 in Figures 126 & 127; all have the more interesting signatures. It should also be noted that even a known site can show no surface manifestations of the buried aspect of it in remote sensing imagery. Holder-Wright, for example, is sometimes not
at all visually apparent, as in Figure 44B, and at other times it is extremely visible, as in Figure 43A and B.
Chapter 7: Discussion and Summary

"We apologise for the inconvenience" (Douglas Adams)

7.1 Discussion

The previous six chapters discussed a number of aspects concerning Central Ohio archaeology. Chapter 1 started with a brief overview of the research at hand, along with a discussion of Adena and Hopewell burial practices, the theory of a built landscape, and a discussion of European research as compared to Central Ohio. Chapter 2 conveyed information about how the landscape of Ohio was formed, and Chapter 3 reviewed Woodland settlement and subsistence information, as well as detailing how early archaeological exploration affected what we know about the pre-history of Central Ohio. Chapter 4 explored the nine known archaeological sites used in this research and how they were compared to nine random points. Chapter 5 showed how the research was performed, with the results specified in Chapter 6. In this chapter, Chapter 7, I discuss the results detailed in Chapter 6 and try to explain why temporally, spatially and morphologically diverse earthworks in the sample appear to have statistically significant underlying similarities.

In this research I have tried to understand some of the behavior of pre-historic earthwork builders and why they placed their earthworks in Central Ohio where they did. I compared nine known sites with nine randomly chosen points, and statistically
tested whether the environmental variables found at each site were chance occurrences or a more pervasive choice by the builders. For all of the sites I used data-mining of existing excavation or historical records, and existing remote sensing imagery and digital GIS coverages.

I treat the earthworks as ritual artifacts in and of themselves (as a cultural landscape), I consider them within the landscape rather than as separate from it, and I consider them as a group. I addressed the following three questions: 1) What general effect does the physiography of landscape have on the decision-making by Native peoples associated with the building of earthworks on the landscape in Central Ohio? 2) If there is an effect, is there a specific suite of landscape variables being chosen? And 3) Is some kind of patterning discernible across time and space with regard to the placement of earthworks on the landscape?

Due to incomplete $^{14}$C dating for the nine known sites I used an ahistorical comparison that did not compare Hopewell to Adena but treated them as part of the same cultural continuum. Even should a $^{14}$C date exist for a site, just one date for a spatially large area would not be that helpful. There is also disagreement not only in how chronologies are constructed, but also where they may be relevant. For example, Prufer argued that some of the geometric earthworks in Ross County, such as Tremper and Mound City, were contemporary to Adena, but that Newark was a Late Hopewell site (1977:51).

A regional approach was used in this landscape research on nine temporally and morphologically varied sites because earthworks and mounds cannot be divorced from
The results detailed here should be no surprise. Knapp and Ashmore write that you cannot separate the landscape of subsistence and settlement (domestic) from that of the ritual and ceremonial landscape (1999:5-6). It follows that if settlements are non-
randomly placed, then by default the earthworks and mounds that are used by the inhabitants must also be non-randomly placed. There may have been a degree of location choice specifically for the earthwork sites, but realistically it was probably a choice constrained by habitation requirements primarily concerning settlement and subsistence resources, and based on where temporally earlier sites were located (Seeman 1992:32). Hicks et al. researched location of settlements and mounds in the Hocking Valley. They found that although the mound locations were not the premier concern of the indigenous people (the settlements were, and thus were non-randomly placed) the mounds "... were clustered with the habitation sites, and other satellite sites signifying the development of "homestead" areas" (Hicks et al. 2008:44, 60). This clustering of settlements and ceremonial sites was evident from the Late Archaic through the Woodland time periods. Seeman made a similar observation in 1979, stating that during the Late Adena in Ohio (about 150 BC) settlement sites were concentrated in choice environmental areas (Seeman 1992:31a see also Seeman 1992b).

Having discerned some choices for earthwork placement, however, does not provide a formula for finding them. In fact, this research showed that I could not find unknown earthworks using a probabilistic model. While statistically speaking there may be tendencies as to where sites are located it is far from formulaic. I would suggest that the problem may be one of scale. The nature of landscape data and the GIS coverages derived from that data are not based on a human inspecting every square centimeter of the land. They cannot be, nor am I suggesting that they should be.
Certainly ground-truthing of various aspects of the data is done by the agencies involved. Nevertheless, the data from such tests and aerial photography analysis is extrapolated over much larger areas by necessity.

Ultimately this research can not precisely predict where earthworks should be. Instead it suggests, through probability, where earthworks *may tend* to be in a nested landscape. No one can search an entire landscape in person, or search historical images for vegetation signatures, thus this model as least narrows down the probability to specific areas. But this is no substitute for fieldwork. For research such as this we need smaller scale data, we need to go out and do our own site work, to get the data, and to actually *be there* on the ground. But many sites are completely destroyed and much of Central Ohio is developed; so how can we gather data for those areas? Well, in some cases we may be forced to use the best proxy data available to us; the extrapolated data collected by the agencies with experts in those areas. For this type of research then, the quality and scale of the data must be decided on a case by case basis.

While we have gained some insight into earthwork placement, the exact nature of what the earthworks were for is difficult to discern. Were they used and built by single groups or multiple groups (the "polities" of Dancey & Pacheco 1997 and Greber 2006; Mills 2003; Seeman 1992a), were they for one ritual or more than one (Madsen 1997), were the landscapes they were in the main reason for their existence (Abrams & Freter 2005 a & b; the "world renewal" of Byers 1987; Greber 2006; Romain 1996)? Possibly they were for specific event cycles (Bradley 1998), or for negotiations between living groups (the "hinges" of Clay 1998:18), perhaps for negotiations
between the living (descendants) and the dead (ancestors) (Buikstra & Charles 1999; Greber 2003; Hutchinson & Aragon 2002:46; Parker Pearson 2001), maybe they were built by roving artisans (Bernardini 2004), or were they a liminal area that acted to segregate nature and culture (Carr & Case 2005; Cobb & Nassaney 2002:531; Hodder 1987; Hutchinson & Aragon 2002:34)? Each of these aspects deserves discussion and can be roughly grouped under social negotiations and cause of variation.

7.1.1 Social Negotiations

The idea of negotiation (within or between groups, between humans and nature, or between humans and deities) is one that often surfaces when discussing earthworks and their meaning (Buikstra & Charles 1999; Carr & Case 2005; Clay 1998; Cobb & Nassaney 2002; Dancey & Pacheco 1997; Greber 2003; Greber 2006; Hutchinson & Aragon 2002; Parker-Pearson 2001). Negotiations could be to prevent conflict, as a way for a number of people to cooperate, no matter whether they are different families or different groups (sensu Carr & Case 2005:42). For example, Byers’ describes the Hopewell culture as an unstable system. That system needed a structure that would allow continual negotiations about roles, with the earthwork as the physical structure that enabled that social structure to continue (Byers 1987:170, 186). As Greber suggests, events at earthworks may have had different sponsors, actors, and audiences, requiring cooperation between these different entities. Such negotiation and interactions within and between different groups of people would lead to variation in earthwork forms too (although she uses this concept to support her idea that earthworks
were planned forms from the start, rather than any variation resulting from long term, unplanned, accretional episodes based on continued negotiations).

Sharing building duties, maintenance, use time, land, and possibly rituals and ancestors or deities would obviously need cooperation on a number of physical and social levels. Additions or changes to an accretional earthwork would require agreement between all users to maintain the sacredness of an area for all; somewhat like a building permit and code process if you will. The need to negotiate and cooperate becomes obvious if, as Knapp and Ashmore suggest, ethical lessons are fixed to natural features in a nested landscape where ancestral spirits are at specific locales, (1999:16). Non-compliance between groups could lead to the destruction (by neglect or desecration) of the very essence (a scared space, ancestral spirits, memories, history, bones, deities, the earth) of an ethnic group. If the dead are a resource, whether in the form of spirits or physical remains (sensu Parker Pearson 2001:136-137; Wilson 2010), then that resource is powerful, functional and worth protecting. By extension, the earthwork where the dead (including memories of the dead) are housed is also worth protecting. In groups with little overt evidence of hierarchy in everyday life, such as the Hopewell, limiting access to such resources may be a way for some people to negotiate and construct a hierarchy that is acceptable in an otherwise egalitarian social structure (see Byers 1987; Greber 1979).

Part of the argument that earthworks were for social negotiations may also pertain to the placement of domestic habitations near or in earthwork locales. That there were structures at earthworks is not contested, but what those structures represent
is the issue. Both Greber (1979) and Seeman (1979) suggest that some structures were charnel houses where the dead were housed and processed. Byers contends that the structures were burial houses that represented the social structure of the society, while the earthworks represented the belief structure (1987:183). Nevertheless, some researchers say that charnel houses and burial processing areas aside, some structures found in earthwork and mound locales are for full time, year round habitations (Greber 1996; Greber 1997; Griffin 1967; Griffin 1996; Lepper & Yerkes 1997). Greber states that if earthworks are used for astronomical events then they have to be inhabited all year round (1997:218). Additionally, Greber (1997) and Griffin (1996) point to the domestic artifacts found within the earth used to construct earthworks. Parts of earthworks were sometimes constructed by people scraping the surrounding surface to produce a volume of earth instead of digging a ditch, borrow pit, or importing building earth from the near vicinity. Greber and Griffin say that only if people lived in and around the earthworks could that kind of habitation debris be caused in the first place. Year round habitations are also espoused by Lepper and Yerkes at Fort Ancient and Newark (1997:177, 188), and Lepper cites eight authors who write about habitations at the earthworks of Fort Hill, Newark, Fort Ancient, Seip and Hopeton (1996).

Habitations in or near to earthworks is not something all researchers agree upon. However, Prufer's Vacant Ceremonial Center model (1964) and later Dancey and Pacheco's Dispersed Sedentary Community model (1997) both support the notion that earthworks did not have year round habitations located in or near them. And at Fort Ancient, Connolly contends that the habitational remains within the walls were
from a habitation that was removed before the parallel walls were built in the north-east part of the site, the walls being contemporaneous with the geometric sites in the Scioto valley (1997; 2004a:44).

A number of arguments spring to mind about the assertions concerning habitations at earthworks. 1) Most importantly, are the deposits contemporaneous (see Seeman 1979:42)? For example, at Holder-Wright I found evidence of multiple temporal components in and around the earthwork, dating from the Archaic to the Late Prehistoric. Sites often have such multiple temporal components to them, so it would be no surprise to sometimes have habitations debris in an area; 2) Additionally, the Vacant and Dispersed models do not mean habitationally 'sterile'. There is room in both of these models for habitation debris from builders/maintenance camps and camps for ritual participants and proponents; and 3) As a matter of semantics, how close or far away does a habitation area have to be located to be considered associated with the earthwork structure, assuming that some degree of contemporaneity can be established? Contemporaneity and context of the habitation debris clearly have to be considered to argue for on-site, year round habitation at earthworks. Habitations are not known at the nine sites discussed here, but certainly more data mining of OAI records may find associated contemporaneous areas within a short distance.

7.1.2 Variation

Variation in earthworks is another aspect that is often referred to when analyzing earthworks. No two earthworks are exactly the same, or even very similar.
Dancey writes about regional variation in earthworks caused by different resource stresses (1992), and that variation could be the result of selective forces working on certain elements (traits). Pacheco also explains regional variation caused by dispersed communities having their own earthworks, but with overarching peer polities tying the region together (Pacheco 1996). The concept of a "mosaic of lineages" in different drainage's is suggested by Abrams (2009:169); an idea that Prufer also wrote about when he suggested that each lineage had its own monument (1977:73).

Having shared symbols (artifacts, earthworks) gives a selective advantage to those who produce and recognize those symbols (Braun 1986:122). This trait would only remain while it conveyed an advantage (or at least was neutral or less than mildly deleterious) and was a benefit in that particular environment at that time. Dancey explains the demise of the Hopewell culture as the result of another trait out-competing Hopewell - that of aggregation (Dancey 1996:399). When aggregation of settlements was selected for, labor that had been spent on earthwork building was redistributed instead to the production of resources. In the more peripheral areas, including Central Ohio, communities do seem to produce nucleated villages at the same time the earthworks cease to be built, (Dancey 1992:26). Continuing the evolutionary theme, Charles writes that variation in mounds is due to drift that manifests itself in regional diachronic change (1992:187).

I have previously discussed the concept that earthworks were objects. If we accept earthworks as at least objects, in the same way we would other archaeological artifacts or features, then it follows that those objects would have a use, a meaning, and
rules of construction. Those rules may allow for variation in earthworks, in the same way that Adena and Hopewell motifs are similar yet varied, with rules that would include placement properties. Greber found that it was not just an object, but the placement of that object that was significant (1996:166-167), and I would argue that this placement applies to where earthworks are built in the landscape. She continues that the variation of the objects found within earthworks is itself caused by the variation in the earthwork form - so different earthworks equal different deposits (Greber 1997:221). Thomas goes a stage further by asserting that earthworks are not just objects, like artifacts or features, but have more meaning. He explains that the transformation of space that the earthwork ‘objects’ are able to achieve makes them therefore more than simple objects within a cultural group (1991:30). If, as previously stated, the dead can be a resource, I believe that traits within the landscape can also be a resource. Just as a particular clay, flint or wood could be chosen by Prehistoric persons, so could a suite of landscape traits, especially if a transformative space was desired. However, as no two landscape areas are exactly the same so no two earthworks built on them would be the same either; thus variation in earthwork form would result.

Continuing the discussion about earthwork variation, and the concept of earthworks as objects intrinsically related to the builders' worldview, it follows that cultures would have different symbols and ways of expressing that world view (Greber 1996). For example, Spielman regards the earthworks themselves as the ritual craft, not just for a ritual, and as an integral part of all the paraphernalia associated with
rituals (1998). In much the same vein, Bernardini set forth an argument for artisan groups who went around Hopewell core areas in Ohio building earthworks as a specialist activity (2004). Such a group, in Spielman’s argument, would be under the control of a ritual specialist who controlled the means of production of the earthwork (1998) – yet another cause of variation.

Alternately, Cowan argues that similar artifacts (objects) differ in their meaning depending on context and use (Cowan 1996). For example, a trait (a gateway perhaps) may appear at more than one site but may be used in a different context and in a different layout at each individual site (Aument 1990:10). This concept, if applied to earthworks could mean that one earthwork could be used for multiple events and that a different message is sent depending on the situation. Madsen suggests an object can represent more than one event (Madsen 1997:90) and Cobb and Nassaney use a similar idea stating that one earthwork can have different meanings to different groups (Cobb & Nassaney 2002:532). Though the general concept of earthwork building may be selected for, the use of different landforms and space, different ritual user groups, and different craftspeople may lead to similarity in earthwork form without exact copies. This last point is supported by this research, as patterns were found in placement rather than earthwork element form, layout, or function, suggesting a basic choice of environmental setting was at work.

So variation in earthwork form may be due to different cycles, who used the site, and how they used it. Different ritual cycles would need different structures to measure them, e.g. stars, seasons, lunar and solar aspects, cultural cycles, etc. Different
stages of the death cycle process would lead to variation in burials as bodies were left in different stages of the unfinished cycle (Hutchinson & Aragon 2002:44). Hutchinson and Aragon continue that the timing of the stages may have to vary depending on the economy at the time, and who could afford (in resources) to have the ritual feast (2002:46). They state that an elaborate burial may be as much about the status of the living as it is about the dead. I would also add that periods of resource surplus may lead to more elaborate burials compared to periods of resource deficit, when burials may have to be scaled back. But a lack of a fine grained chronology may hamper efforts to test such an idea.

Mounds, and by extension earthworks stand as dynamic records of the interaction of people, and not just as static monuments to the dead (sensu Clay 1998:3). A mortuary ritual makes death, a somewhat destabilizing event, into a stabilizing event, giving the event a transcendency (Hays 1995:383). Chapman compares the Ohio Hopewell with Neolithic Western Europe (2006). He argues "... that monuments are palimpsests of construction and structural remodeling over time ("life histories") and that they embody the materialization of social practices through social labor. The individual acts of construction are not additions based on some predetermined plan but draw on, sustain, or change the commemorative symbolism" (2006:519). He goes on to say that "... monument forms do not necessarily "evolve" in sequences but overlap and may be contemporary with each other ..." (also see Burks 2004:192-193).
Though there is a temporal separation between earthworks throughout the Early and Middle Woodland, the concept of “an earthwork” does have a continuity over time (Hutchinson & Aragon 2002:35). For example, individual sites exhibit evidence of being "active sites" (Charles et al. 2004:63), that is they are not just cemeteries, not just a place to put the dead, but they are used as active parts of the culture. This active landscape shows a community the "ways of living", with the landscape representing roles, ethics and sacred locales to the builders (Knapp & Ashmore 1999:8, 16). That would mean that abandoned earthworks could still be part of a cultural landscape and still have meaning for a group even if that group did not build it, or no longer used or maintained that earthwork (Knapp & Ashmore 1999:18). This last point may partly explain why we find later temporal artifacts and occupations at known Early and Middle Woodland sites.

In the UK, Williams recognizes similar regional and temporal problems discussed here "These spatial relationships are not always clear and well defined, partly because different communities were relating to monuments in different ways, but also because attitudes were not static but changed over time" (1998:99, see also Hays 1995:383). In the same vein, Cummings writes that even the memories of the dead are not fixed, but alter through time (Cummings 2001:26). Congruently, Relph writes that the landscape is a text that shows the consequences of individual actions in the forms left in the landscape (Relph 1989:152, 158). Thomas, however, says that how a space (or text) is read is conditional; so earthworks as symbols are arbitrary, which allows multiple readings and a lack of fixity concerning meaning (1991:52). I would add that
such memories and alterations may depend on how recently a person died, or was buried. For example, I can only have memories of people I have known. Anyone related to me who died before I could know them, while still my ancestor, creates a different concept of memory for me. In fact, to describe it even as memory may be misleading in this instance. Perhaps the phrase "representational memory" may be a better descriptor.

Memory could also affect the different concepts of time that people have. Cobb and Nassaney refer to earthworks as having three 'times' - earthworks simultaneously evoke the ancestor and past, they reproduce the present via ritual, and they point to the future as landmarks on the landscape (2002:534). Seeman has another type of time within the concept of flexible or rigid (Seeman 1979), where individual ceremonies would be flexible and semi-annual ceremonies would be more rigid in nature. Bradley talks about the concept of monument time (public and ritual) versus everyday time (private and mundane) (1998:88, 90), though these concepts of time can run together. To that I would add the phrases "near time" (closer to, knew, known, memories, remembered) versus "far time" (farther away, oral history, unknown, representational, forgotten).

"Representational memory" would also be a factor in cultural practice as it relates to oral history and how 'to be' in a specific culture, or local tradition. Similar earthwork forms but with variations on a theme found between the nine known sites in this research suggest a set of shared social practices but with a distinct tradition locally (Hays 1995:394). Cummings (2003) contends that building monuments is akin to a
bodily performance that creates and conveys social memory by inscribing it on the landscape (34, 38). If that performance is based on the concept of "representational memory" rather than direct memory, then variation in placement, form and content of monuments will result. Concepts of memory may also explain why different burial types are found at different sites (Hays 1995).

Many sites in Central Ohio have multiple temporal components to them. There is a lot of cultural overlap between Adena and Hopewell, only 12 traits separate them, and only one of those is 100% Adena (Aument 1990:47-8). It is becoming more apparent that in some parts of Ohio, Late Adena is really quite contemporary with Hopewell. Even though some researchers believe there is no temporal overlap between Adena and Hopewell in the Central Scioto area (Carr & Haas 1996; Seeman and Branch 2006, though see Abrams 2009), some of those same researchers argue for an Adena landscape that would significantly influence how the Hopewell landscape would be built (Seeman & Branch 2006:108). Prufer, for example, says that late Adena survived in the hinterlands of the Hopewell Interaction Sphere after the Hopewell people came in from the west (1977:56, 62).

I think there is cultural overlap, whether learned directly or indirectly by the influence of the already built landscape that the Hopewell found themselves in. Indeed, skeletal studies support an in-place origin for Hopewell people in the Central Scioto River drainage (see Johnston 2002:17), although this is highly variable between regions (Abrams 2009:174). Seeman and Branch do concede that in Ross County "... the Hopewell distribution [of mounds] is in part the continuation of a pattern of
concentrated ritual efforts that were already under way in the locality" (2006:113).
Whether by reusing they sought to enhance their own past by association (veneration),
co-opt the Adena past (emulation), with a Hopewell twist (alteration and elaboration),
or erase that Adena past through that reuse (destruction) or a combination is unknown.
Which of these pertains to Central Ohio is open to debate, and it may be that different
sites and different groups sort to do any or all of these at some point. This may be akin
to Williams’ question about Anglo-Saxon burials in England that "By burying the dead
in, or close to, ancient monuments, could the Anglo-Saxons have been constructing
social identities, myths of origin and relations to the distant past?" (Williams, 1998:91,
101).

Besides time, another issue with explaining earthworks is context. Many early
archaeologists were interested in portable things, not ritual context, with a mound or
earthwork treated as the unit of analysis not the components of it (Aument 1990:49).
Knapp and Ashmore state that a built landscape exists due to people’s perceptions,
contexts and experiences of their memories, identities, and social orders (Knapp &
Ashmore 1999:1). Seeman and Branch write about the concept of this cultural
landscape saying "Native American Woodland societies inhabiting the American
Midwest two thousand years ago also lived in worlds of their own creation. They
actively constructed these worlds, not only interpreting the landscape in ways that were
meaningful to them, but also adding to it a variety of buildings, monuments, pathways,
fields, and public places" (2006:106). The "scale of action - in real terms,
relationships to region, to community, and to household . . ." is also an issue (Seeman
& Branch 2006:107), and dependant on the lens through which those relationships are viewed.

7.1.3 Observations about this Research

This current study is essentially stating that similar materials (Woodland earthworks) in similar contexts (Similar Environmental Grouping's) equals similar behavior (placement rules), within the regional context. Several observations can be deduced from the research results and discussion presented previously.

For the most part:

The Adena and Hopewell earthwork sites in this study varied in form, layout and size, yet tend to share the same Similar Environmental Grouping's compared to a random set of sites. Nevertheless, I am not implying that the whole earthwork form or all the elements of the earthwork were planned in advance before execution, or even built as one coherent whole. As discussed above, variation between different earthworks could be based on: usage by different groups, from different locales, for different rituals, within different time cycles. Certain elements (gateways, layout, form, elements) may be constructed and located, based on certain ritual requirements or representational forms (sensu Romain 1996).

That said it follows then that:

The earthwork placement was based on a suite of environmental traits that co-occurred, or Similar Environmental Grouping's, not just one trait, although this suite could vary in the number of variables it contained and the types of variables
represented. The landscape inside and outside of an earthwork, perhaps for quite some
distance (physically and visually), was an important part of why the earthwork was
placed there.

The soil type chosen tended to be rarer when measured as a percentage by
county (a county being used as an arbitrary unit). A number of sites (five out of the
nine) had two soil types associated with the sites. It may well be that the presence of
two soils, as in the case of Holder-Wright, may be a factor in placing earthworks at
specific locations. Choreography of experience based on a phenomenological point of
view was apparent based on elevation ranges and soil types. It should be noted that
variables with no statistical significance may still be important based on a visual
assessment of them in GIS map form. For example, gateways direction, and distance
and direction to major water did not show any statistical significance at the specified
significance level, but in map form appeared to exhibit clustering to certain directions.
This also seemed apparent in the viewscape illustrations specifically too, where the
viewscape had a suppressed direction to it (Figure 99), which is visually compelling.

As Tilley (1994) suggests looking for patterns within and between earthworks and
mounds is important, but perhaps we do need to look for patterns in the topography or
the locales too.

The use of a random set of points as a comparison added a robustness to this
work. But the essential comparison was hard to achieve. There are so many variables
to consider, and I have only considered a few of those aspects, those that seem stable
enough to project back into the past. Undoubtedly the prehistoric people who lived in
Ohio had many reasons for their choices. They may even have had a ranked hierarchy of a set of traits, with grammar rules on how and why they chose a specific suite of traits for a specific earthwork. I had previously argued that cultural labels do not work well for research, in the same view it could be argued that a static suite of variables (a landscape label) also does not work well.

7.1.4 Observations about Further Research

This research does not pretend to have opened the door on landscape research in Central Ohio. Indeed, it is more likely that it has barely put the key in the lock of that door. With the availability of a myriad of GIS coverages, databases, remotely sensed imagery and computer programs that can handle large amounts of data, the potential for future research is almost limitless; an archaeologist with such an embarrassment of riches could be like a kid in a candy store to mix metaphors. Nevertheless, some Ohio based archaeology has found some interesting results from regional, GIS based data. For example, in Southern Ohio Seeman and Branch find: 1) mound building decreases from the Early to Middle Woodland, 2) a more clustered concentration of Hopewell compared to a dispersed Adena (this also happens in the Hocking Valley, see Abrams 2009:175), 3) bigger mounds tend to be Adena and are built in bigger valleys’ with rich resources, and 4) " . . . there was little difference in the size of the groups cooperating in . . . " the construction of the Hopewell and early Adena mounds (Seeman & Branch 2006:113). Although this current research did not answer the same kinds of questions that Seeman and Branch did, it would be interesting to
expand the current Central Ohio GIS to accommodate the same kinds of data for a
direct comparison to Seeman and Branch's work.

The following then is just a small list of suggestions for future research.
1) It would be very easy to add and assess more sites in the GIS, both known ones and
random ones. The random sites can perhaps be added in multiple groupings so that one
grouping of known sites can be compared against multiple groupings of random points
in different populations. 2) More landscape attributes can be added, and different ones
intersected to produce different sets of Similar Environmental Grouping's. 3) The
physical area of research can be changed to accommodate almost any other arbitrary
area depending on the scale of inquiry whether based on state, county, or township. 4)
Sites could be assessed based on radiocarbon dates versus those that have a trait based
chronology to further explore the issues with categorizations currently used in
Woodland period research in the Eastern Woodlands. 5) Different types of sites could
be assessed as compared to earthworks, such as settlements, short term seasonal camps
and episodic sites. 6) Perhaps analyzing soil types within 250 meters of the sites would
show that choices of soil types and colors were also an important factor in site
placement. 7) Fieldwork at known sites to assess landscape traits firsthand. 8)
Comparing the variance around the mean for the two populations and using statistics
for parametric data (more powerful than a Monte Carlo analysis). 9) As a simple
extension of this research, the question of whether earthwork structure varies based on
the landscapes they are found in could be tackled. Is patterning discernible when
looking at structural components of Central Ohio earthworks? That is, are circular
earthworks found within certain landscape types, or ditch and bank geometric
earthworks found with another set of criteria? This may help answer questions about
exactly what cultural differences existed between time periods with regard to
earthworks. Using sites to explore "ancestral ties, world renewal, and personal
connections to animal spirit helpers" would also be feasible, as would using sites that
were permanent or transitory depending on the needs of the group using them (Seeman

7.1.5 Limitations of the Study

This research has covered a great deal of material from various sources, and has
found some interesting tendencies. Nevertheless, it does have some limitations.
Six limitations of this study include:
1) A small sample size; the curse of archaeological research. There are two ways to
improve the sample size problem. The easiest way is to pick another nine random
points and re-compare the two populations again to see if the statistically significant
results hold. A more involved, but ultimately better way, would be to add more
earthworks to the nine known sites group (along with increasing the number of random
points to match or exceed the number), and place them within the same boxed Central
Ohio region used here. The beauty of the GIS model in this research is that it can be
added to or changed as desired - sites can be added or taken away, the area of interest
can be changed, the types of sites can be changed perhaps to villages or camps instead
of earthworks, and more or different variables can be used to find Similar
Environmental Grouping's. A bigger sample size would also allow more robust statistical comparisons to be made, which can only improve the results. 2) Inability to visit many of the sites to do fieldwork, and the incomplete excavation records that seem to blight many Central Ohio sites. Nevertheless, crying over spilt milk is not helpful. And as Riordan believes, we can still understand an awful lot from what we have - "Even if we cannot predict with complete accuracy their prehistoric conditions, an awareness of the implications of their potential settings may bring us closer to the vanished world we seek" (1998:76 but see page 77). 3) Lack of multiple geophysical investigation at the Similar Environmental Grouping's identified in this research. It would be very useful to attend a sample of the Similar Environmental Grouping's (which would depend on the owner's permission) and collect geophysical data on them. The Similar Environmental Grouping's that have interesting visual surface signatures (Figures 110 – 139) would seem to be the obvious choice to investigate first. Nevertheless, it would be interesting to go to some of the other Similar Environmental Grouping's as well to see if sub-surface signatures exist even though the remote sensing imagery did not show any visual manifestations. I would choose magnetometry initially as it is relatively quick and easy to produce data over large areas and is good at detecting the kinds of prehistoric remains that this study seeks. Depending on the findings from magnetometry I could then collect some resistivity data or GPR data, or both. The data from these instruments, along with survey, surface collection, test pits and perhaps targeted excavation would really exhaust the investigation of the Similar Environmental Grouping's and hopefully validate this model on-the-ground. 4) The
issue of spatial autocorrelation (Jones 2010:2; Kvamme 1985:236). This is a concept where while statistics require independence of variables, geography does not have that independence as traits are linked across the landscape. For example, certain landforms are more likely to occur together than not, such as caves and bedrock outcrops or marsh areas and lakes. Thus if a variable such as elevation is considered, and known sites are more likely to be up high than random sites, the question becomes, why are they up high? Jones (2010:2) uses this example to ask - Are they up high for defense or because of marsh areas in the vicinity making that area the only dry ground, year round? 5) The use of points and not polygons for the randomly placed sites. It may be worth creating randomly sized and shaped polygons (within certain criteria) to randomly place on the landscape instead of just a point. That way, the landscape within the area of the random sites can be taken into account, along with the same variations of soils and landforms that many of the known sites enjoy within their polygon spaces. 6) The use of a more tightly constrained region. The differences that are apparent statistically may be due to the random sites falling too far away from the cluster of known earthworks. It would be interesting to see what would happen if the area was constrained more to the southern half of Delaware county and the top three-quarters of Franklin County, which would match the area of the nine known sites more closely.
7.2 Summary

Being considered a marginal area should not stop Central Ohio from being important to the overall archaeology of Ohio. Though the earthworks in Central Ohio have been considered an addendum to the Ross County clusters (Greber 1996), perhaps they should be considered a part of those same clusters. Certainly, the earthworks in Central Ohio are outliers, not only regionally by representing the northern most area in Ohio where earthworks are found, but also due to the relatively smaller sized earthworks found here, and the increased variation in the earthwork forms and layout. The central area enjoys, however, the same longevity (500 BC – AD 500) as Ross County, which makes it contemporaneous to Ross County rather than an afterthought to a fading earthwork building tradition. Additionally, the prehistoric persons in Central Ohio participated fully in what is termed the Hopewell Interaction Sphere (Caldwell 1964). This is based on the artifacts found in the earthworks, and in how some of the earthwork elements were constructed, making the research area part of the total archaeological story of Ohio, not merely an postscript to it.

In short, the Central Ohio area deserves attention; this becomes especially critical given that the urban setting the earthworks now find themselves in encroaches more and more every day; their future protection is at stake. For example, at present, the family that owns the Holder-Wright site is in negotiations with Dublin City to save the area as an interpretive park to highlight the mound builders of old. This rich part of Central Ohio’s archaeology needs to be studied with a modern approach to the landscape, using remote sensing imagery and geophysical exploration to bring it up to
the level of knowledge afforded the other areas of archaeological import in Ohio.

Modern land use patterns have already robbed us of many of the earthworks settings in Ohio and that makes it imperative to encourage research on the Central Ohio earthwork clusters.

I believe that the results in this research support the theoretical assumption that people choose to build their earthworks in specific places. The interaction of biology and culture, of how memories are made, used, recalled and forgotten are all played out in how monumental earthworks are inscribed onto and into the landscape during the Woodland period. Some environmental traits are being valued more than others (a version of patch choice) when it comes to earthwork location. And although the form of the earthworks changes through time between the Adena and Hopewell periods (on a gross level it changes from mounds and circles to more geometric shapes), landscape choice remains somewhat constant according to the sample in the current research. This result shows that the choice of specific traits (identified as Similar Environmental Grouping's) was adaptive in nature and stable through time. Once the adaptive nature of the choice ceased to be a benefit in the Central Ohio environment for whatever reason, the earthworks cease to be built. If, as Mills suggests, there is no genetic continuity between the Hopewell and Fort Ancient cultural groups (2003:124), then the trait of building earthworks (as a meme) may simply have had no cultural means of replication any longer or have been outcompeted as a trait (Dancey 1996).

Settlement archaeology has argued for years that domestic sites have been neglected in favor of the stunning earthworks and their contents, and so some
researchers had left the earthworks alone to do such research. Interestingly, this

current research has shown me that although the earthworks are big and pretty and
remarkable in their own right, it may be the more mundane domestic habitats that are
actually driving where the earthworks are located. So, a slightly different reason to
continue research on domestic habitations, but a valid one nevertheless. That said it
seems that this current earthwork research needs to be done alongside that of settlement
study. That makes sense - the very argument most archaeologists make is that
earthworks and domestic settlements are not divorced from each other even though
they may be spatially separated (Cummings 2003:29; Hays 1995), so why should
research be divided that way?

Talking of Anglo-Saxon England, Williams writes "... ancient monuments
may have been important fields of social action and ritual discourse. They played a
part in the construction and negotiation of social and ethnic identities within and
between early Anglo-Saxon communities. Thus it may be argued that relationships
between the living, the dead and ancient monuments were central to the social, political
and religious lives of early Anglo-Saxon people" (1998:103) This suggests that the
cultural landscape must be made up of research covering both ritual and domestic
landsapes, as linked entities (see Chapman 2006:520). That said, some kind of
circumscription of subject matter must take place just to make research manageable,
but perhaps more integration of research from many researchers, or one researcher over
many years will help solve this issue. With the massive amounts of information that a
GIS can now hold and manipulate in ever unique ways this integration is really, more than ever, within our grasp.

As Carr and Case (2005) suggested, a 'thick' explanation of past behavior may be possible. Ethnographic analogy suggests that groups often name stream inlets (see O’Shea & Milner 2002:208), that may map their past (memory), their religion (why and how they believe what they do) and the physical map of how to move across that particular landscape (sensu the 'language rules' of Tilley 1994 and the 'stalking with stories' of Basso 1996). While we cannot necessarily test these kinds of data when researching the Central Ohio landscape, finding testable alternates, such as landforms, is possible.

These monuments stand as enigmatic demonstrations of the organizational prowess of past groups of people, and because of their intensive and extensive constructions we know that the structures must have been fundamentally important to them. Some researchers regard them as intentionality statements about the world and the place the builders had in that world (Byers 1987; Romain 1996, 2004), while others see no design or plan applied to the end result at all (Clay 1991). Some argue that earthworks are the remains of social and political processes (Van Gilder & Charles 2003:121, 127) that can be read like a text (Thomas 1991; Relph 1989), as an invariate and redundant message (Seeman 1979, 1995) or perhaps with a conditional message (Thomas 1991). While Central Ohio archaeologists now know more about both large earthwork monuments and settlements than they did even 50 years ago, it is still difficult to integrate the somewhat less visible record of domestic settlement life with
that of the earthwork sites. How did people move between these two facets of their lives, and what connections did habitation sites have to earthworks or other ceremonial places? These are questions that only further research can try and answer. As Seeman states, Hopewell was an interregional and multidimensional community (as was Adena before it) that needed a similarly complex communication system, of which the earthworks are just one aspect (1995:134). If this research has piqued your interest in such research then this dissertation has been worth it.

A last word should perhaps go to a respected researcher in the field of art, interpretation, meaning and science. At a lecture at The Ohio State University in May 2004, Margaret Conkey related a story that should at least make us stop and consider the ‘other’. Conkey, herself a proponent of science and interpretation amongst other paradigms, tells of a fellow researcher who worked on the rock art of extinct cultures in South Africa. Part of that research took this researcher to Australia to meet extant Aborigines who still live in their own landscape with multiple rock art sites. The researcher was asking question after question about the meaning of rock art to the Aborigines – was it to mark a path, or remember an ancestor, was it of supernatural beings or scared places, was it depicting origin myths or representations of objects, deities or visions, did it convey news, or the culture’s history? Despite the number of questions the researcher asked, and all the possible answers to them, the Aborigine replied only once; “yes” was all he said.
End Notes

Chapter 1

Note 1 page 8
Moorehead suggested that the Hopewell would not destroy their own possessions and it was the Fort Ancient people that attacked them and did so [1908:146]).

Note 2 page 9
Byers does look at the morphology and similarities between earthworks but as divorced from the landscape.

Note 3 page 44
Dating techniques have to be used with care however. Large pieces of charcoal may give dates that illustrate the 'old wood' problem, where the charcoal submitted for dating come from the heart wood of the tree, which may be hundreds of years old, and not the growth rings closest that represent the 'cut' date. Many now destroyed earthworks do not have dates associated with them and some earthworks were dated before calibrated dates became the norm. Nevertheless, calibration methods also change over time making dates seem to move about fluidly. Miniaturization of the sample size required for an AMS date means a small piece of nutshell, food residue within the matrix of a ceramic, and micro charcoal from an ash layer can provide dates with a sigma of ± 15/25 yrs (Puseman et al. 2009). Thus testing or retesting old excavation samples may fill in or revise some dates. Coring for small samples across
an entire earthwork is also feasible and would provide construction and use periods. Such inter and intra-site chronologies would add another layer for use in a GIS in the future.

Note 4 page 55

There is also a distinction between the two models of waste behavior and bet-hedging. Waste behavior is designated as the need to signal high quality and maximize offspring in the present, whereas the bet-hedging model would benefit other generations; that is, inclusive fitness (Aranyosi 1999:361). It should also be noted that Aranyosi considers Dunnell’s waste hypothesis as a specific form of the bet-hedging model (Aranyosi 1999:373). Although, as Aranyosi states in Bradley’s book (as does Neiman 1997) wasteful advertising is also smart advertising in the sense that the sender and the receiver gain a benefit from the advertisement. The question that this assertion bids then is, how could waste behavior ever be selected for as an adaptive behavior and as a behavior that contributed to reproductive success (Dunnell 1999:245; Hamilton 1999:347), and if it did contribute to the reproductive success of an individual or a group is it then not a wasteful behavior but in fact a useful behavior?

Chapter 4

Briggsdale

Note 5 page 120

A new 2007 facsimile of the whole Whittlesey article is published by Gustav's Library, and has the block scale reproduced to the correct size.
The Harrisburg Pike has not changed direction or moved from its present position to account for the lack of fit between the current road and Whittlesey's diagram. Teel Slike (records manager, Franklin County Engineers Office) said "Harrisburg Pike was established in 1823 and in reviewing our Franklin County Maps of 1840, 1856, 1872, 1883 and 1895 and up there appears to be very little discernible change in the path of the road between Mound Street and Eakin Road that shows on any of our maps." (email communication, Jan 22, 2009).

According to OHS (Anon, 2009), Volume 1 was actually published in both 1887 (pages 1-302) and 1888 (pages 302 - 404).

Bill Pickard, an archaeologist with OHS and longtime Columbus resident said the reason the council reversed its vote was that the residents of the new subdivision did not want visitors coming into their neighborhood to visit the park and Indian remains. (Pickard 2007 personal communication).

This publication also gets the date of Wetmore's publication wrong too, incorrectly stating it was 1882 not 1888.
Holder-Wright

Note 10 page 130
Gerard Fowke was also known as Charles M. Smith and Kentucky Q. Smith (Smith 1985:17).

Note 11 page 130
The current owners, Joan Harless and Kaye Myers prefer the name Holder-Wright for the site; they are the daughters of Josephine Holder (upon the death of the elder Mrs. Holder [June 1, 1911- September 14, 2007] her two daughters inherited the farm land in trust. Talks are currently being conducted between Dublin City Council and the family to arrange sale of the land to Dublin for use as an interpretive park that will preserve the archaeology).

Note 12 page 134
The family has some artifacts from their own collecting and a few from Shetrone's dig. A larger number of items from Shetrone’s dig were given to a family member for safekeeping, but all have been lost in the ensuing years.

Jackson Fort

Note 13 page 142
It is actually 2/3 mile from Alum Creek.

Orange Township

Note 14 page 144
The Highbanks metro park also includes two other prehistoric sites, Mumma Mound and Orchard Mound (DL15 and DL18 respectively), between 3/4 and 1 1/2 miles away from the earthworks, but they are not included in this sample.
Spruce Run

Note 15 page 148

The accession records for 79-85 at Harvard show only:

1. 79-85-10/20388 Fragments of 3 vessels. Peninsula between Big Walnut Creek and Spruce Run Spruce Run Earthworks; State site # 33DL22 Mound A, ash heap

2. 79-85-10/20389 Charcoal, shells, and burnt bone. Peninsula between Big Walnut Creek and Spruce Run Spruce Run Earthworks; State site # 33DL22 Mound C

3. 79-85-10/20390 Ashes, charcoal, and clay. One mile south of Galena Phillips Mound Mound

4. 79-85-10/20391.0 Fragmentary human remains of 2 adults of unknown sex. near Galena; 3 miles south of Galena Stone Mound Vault 4’ below original ground surface Middle Woodland Period (Haskell, 2009 personal email).

Note 16 page 150

The accuracy of Google is not known per se and in fact they have a disclaimer about accuracy standards. In order to test this though I found areas with known distances in both counties - for the Delaware coverages I used a football pitch just south of Sunbury at Big Walnut Middle School and for the Franklin County coverages I used a football field to the south of the OSU stadium (the stadium did not have clear yard markings in it). The Delaware coverages had worse resolution compared to Franklin, and no line markings could be seen, so I measured between the goal posts at an altitude of 122 m. Doing this three times, without looking at the real time distance, I
got measurements of 119.66 yds, 119.98 yds, and 119.66 yards for a distance that should be 120 yds. In Franklin County, the resolution was alot clearer, and thus I was able to measure between two yard markings. At an altitude of 36m, I measured three time with the results 9.92 yds, 10.04 yards and 10.00 yds. These two tests show that in terms of the large sites that I am working with, measurements taken with the Google tools are quite accurate, and certainly not 10's or 100's of feet off. The measurements of Shorts maps overlaid onto Google earth show errors of a much bigger magnitude than my tests, and thus the veracity of the contents of his sketch seem to be a real issue.

Worthington

Note 17 page 156

In a note within the OHS file on FR 3 are some numbers that suggest radiocarbon dates, "1860 ±85, 1360 ±, and 895 ±110", but there is a "? Jeffers" that makes the information less than certain.

Chapter 6

Note 18 page 188

I am not implying a rare lunar, stellar or solar event was more important to the people who built the earthworks than more ubiquitous events, as the importance of any event, episode or occurrence is relative and would be culturally driven by the history and proclivities of the individuals or group.

Note 19 page 190

Parkinson only looked at projectile points that were recognizable as such, and did not note flakes, debitage, or temporal affiliations.
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Thomas, C.

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Thomas, C.

Thomas, J.


Tilley, C.

Trigger, B. G.

Tuan, Y. F.

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USDA (NRCS)

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Wynn, J.

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Yerkes, R.
Yerkes, R.

Zubrow, E.

Zubrow, E.

Zipf, G. K.,
Appendix A: Tables
<table>
<thead>
<tr>
<th>County number, all preceded by the number 33 for Ohio.</th>
<th>Abbreviations used in this research.</th>
<th>Site Names. All alternates shown.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL02 (DL18(^1), DL15(^1))</td>
<td>OR</td>
<td>Orange Township, Highbanks Park Works, (Orchard Mound, Mumma Md)</td>
</tr>
<tr>
<td>DL22</td>
<td>SP</td>
<td>Spruce Run</td>
</tr>
<tr>
<td>FR04/01(^1)</td>
<td>HW</td>
<td>Holder-Wright, Wright Group Works, Wright-Holder, (Krumm Mound)</td>
</tr>
<tr>
<td>FR07</td>
<td>BR</td>
<td>Briggsdale Works</td>
</tr>
<tr>
<td>FR11</td>
<td>AD</td>
<td>Adler</td>
</tr>
<tr>
<td>FR12</td>
<td>DOM</td>
<td>Dominion Land Company, Cook Works, Indian Springs, Fort Reserve, Overbrook Ravine Earthworks</td>
</tr>
<tr>
<td>FR49</td>
<td>JF</td>
<td>Jackson Fort</td>
</tr>
<tr>
<td>FR76</td>
<td>CCC</td>
<td>Columbus Country Club</td>
</tr>
</tbody>
</table>

1. Not considered in this research.

Table 1: All the known sites in this research, with all names associated with them and their assigned county numbers.
<table>
<thead>
<tr>
<th>County</th>
<th>Mills’ mound count</th>
<th>Mills’ earthwork count</th>
<th>OAI database mound count</th>
<th>OAI database earthwork count</th>
<th>OAI database all prehistoric sites count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delaware</td>
<td>61</td>
<td>6</td>
<td>17</td>
<td>3</td>
<td>2,240</td>
</tr>
<tr>
<td>Franklin</td>
<td>132</td>
<td>28</td>
<td>57</td>
<td>7^2</td>
<td>2,363</td>
</tr>
<tr>
<td>Madison</td>
<td>12</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>193</td>
</tr>
<tr>
<td>Pickaway</td>
<td>173</td>
<td>33</td>
<td>31</td>
<td>11</td>
<td>937</td>
</tr>
<tr>
<td>Union</td>
<td>11</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>374</td>
</tr>
<tr>
<td>Five county totals</td>
<td>389</td>
<td>67</td>
<td>109</td>
<td>23</td>
<td>6,107</td>
</tr>
<tr>
<td>State of Ohio totals</td>
<td>3,513</td>
<td>587</td>
<td>1,882</td>
<td>218</td>
<td>~ 44,000</td>
</tr>
</tbody>
</table>

Table 2: Comparison of mound and geometric earthwork counts between Mill’s 1914 atlas of archaeological sites in Ohio and the current (as of January 19, 2010) Ohio Archaeological Inventory Database.

1 A handwritten and undated list in the Franklin County folder at The Ohio Historical Society lists 107 mounds, 24 circular earthworks and 1 crescent for the county divided in 18 townships. Martha Otto did not recognize the handwriting when shown the document in 2006.

2 Out of the nine site in this study, only six are designated in the OAI database as being geometric earthworks, while three (Spruce Run, Orange Township Works and Columbus Country Club) are not, even though they clearly have geometric elements. To that end the count of Delaware County has been increased by 2, and the count of Franklin County has been increased by 1. SHiPO was informed January 5th, 2010 of the discrepancy.
<table>
<thead>
<tr>
<th>Common Site Name</th>
<th>OIA temporal period affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adler</td>
<td>Early Woodland</td>
</tr>
<tr>
<td>Briggsdale</td>
<td>Early Woodland</td>
</tr>
<tr>
<td>Columbus Country Club</td>
<td>Early Woodland</td>
</tr>
<tr>
<td>Dominion Land Company</td>
<td>Early Woodland</td>
</tr>
<tr>
<td>Holder-Wright</td>
<td>Early, Middle and Late Woodland</td>
</tr>
<tr>
<td>Jackson Fort</td>
<td>Early and Middle Woodland (although the NRHP lists Adena)</td>
</tr>
<tr>
<td>Orange Township Works</td>
<td>Unknown Woodland</td>
</tr>
<tr>
<td>Spruce Run</td>
<td>Early and Middle Woodland</td>
</tr>
<tr>
<td>Worthington Works</td>
<td>Middle Woodland</td>
</tr>
</tbody>
</table>

Table 3. Temporal affiliation of the nine known sites.
Table 4: Details of the five main river drainages in the Central Ohio area (Childress, 2001).

<table>
<thead>
<tr>
<th>River</th>
<th>Drains into</th>
<th>County at mouth</th>
<th>Length miles</th>
<th>Elevation AMSL at source ft</th>
<th>Elevation AMSL at mouth ft</th>
<th>Square miles drained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Darby</td>
<td>Scioto</td>
<td>Pickaway</td>
<td>78.7</td>
<td>1170</td>
<td>643</td>
<td>555</td>
</tr>
<tr>
<td>Scioto</td>
<td>Ohio</td>
<td>Scioto</td>
<td>230.8</td>
<td>1010</td>
<td>481</td>
<td>6,517</td>
</tr>
<tr>
<td>Olentangy</td>
<td>Scioto</td>
<td>Franklin</td>
<td>88.5</td>
<td>1189</td>
<td>702</td>
<td>543</td>
</tr>
<tr>
<td>Alum Creek</td>
<td>Big Walnut</td>
<td>Pickaway</td>
<td>55.8</td>
<td>1120</td>
<td>715</td>
<td>199</td>
</tr>
<tr>
<td>Big Walnut</td>
<td>Scioto</td>
<td>Pickaway</td>
<td>74.2</td>
<td>1165</td>
<td>667</td>
<td>557</td>
</tr>
<tr>
<td>Sites with multiple geometric components</td>
<td>Designation used in this research based on size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-----------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Briggsdale west circle</td>
<td>BR\textsuperscript{a}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Briggsdale east circle</td>
<td>BR\textsuperscript{b}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holder Wright “C” shaped enclosure</td>
<td>HW\textsuperscript{a}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holder Wright southwest circle</td>
<td>HW\textsuperscript{b}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holder Wright northeast circle</td>
<td>HW\textsuperscript{c}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spruce Run south circle</td>
<td>SP\textsuperscript{a}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spruce Run north circle</td>
<td>SP\textsuperscript{b}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worthington square</td>
<td>WO\textsuperscript{a}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worthington north tripartite circle</td>
<td>WO\textsuperscript{b}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worthington south circle</td>
<td>WO\textsuperscript{c}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5: The designations used in this research to identify sites with multiple geometric components. The letters are appended based on size, with the biggest components given an “a” and the smaller ones having subsequent alphabetical letters added.
<table>
<thead>
<tr>
<th>County</th>
<th>Sites found there</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delaware</td>
<td>Orange, Spruce, R1, R2, R3</td>
</tr>
<tr>
<td>Franklin</td>
<td>Adler, Briggsdale, CCC, Dominion, Holder-Wright, Jackson Fort, R4, R6, R7</td>
</tr>
<tr>
<td>Madison</td>
<td>R8</td>
</tr>
<tr>
<td>Pickaway</td>
<td>R5</td>
</tr>
<tr>
<td>Union</td>
<td>R0</td>
</tr>
</tbody>
</table>

Table 6: How the 18 sites are related to the Central Ohio counties.
<table>
<thead>
<tr>
<th>Site ID</th>
<th>Number of archaeological sites within 1 mile/1.6Km.</th>
<th>Number of sites with OAI Early or Middle Woodland affiliation.</th>
<th>% of sites with an Early or Middle Woodland affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adler</td>
<td>8</td>
<td>1</td>
<td>12.5</td>
</tr>
<tr>
<td>Briggsdale</td>
<td>2</td>
<td>1?</td>
<td>50</td>
</tr>
<tr>
<td>CCC</td>
<td>2</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>Dominion</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Holder-Wright</td>
<td>52</td>
<td>5</td>
<td>9.6</td>
</tr>
<tr>
<td>Jackson Fort</td>
<td>5</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Orange</td>
<td>27</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Spruce</td>
<td>20</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Worthington</td>
<td>15</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>131</td>
<td>16</td>
<td>12%</td>
</tr>
<tr>
<td>R0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R1</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R2</td>
<td>20</td>
<td>1?</td>
<td>0.5</td>
</tr>
<tr>
<td>R3</td>
<td>18</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>R4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R5</td>
<td>23</td>
<td>8</td>
<td>35</td>
</tr>
<tr>
<td>R6</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R7</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>R8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>11</td>
<td>16%</td>
</tr>
</tbody>
</table>

Table 7: This lists the total number of sites within a 1 mile/1.6km radius of the 18 sites in this research, along with any known affiliation to the Woodland period. (Due to the nature of OAI forms these affiliations may be incomplete.)
<table>
<thead>
<tr>
<th>Data</th>
<th>Attributes used</th>
<th>Source of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ohio Digital Elevation Model</td>
<td>Elevation, slope, spatial base map</td>
<td>Ohio EPA/USGS Division of Emergency and Remedial Response</td>
</tr>
<tr>
<td>Topographic maps</td>
<td>Landform and spatial location</td>
<td>USDA/NRCS National Cartographic Geospatial Center, DRG file</td>
</tr>
<tr>
<td>Ohio Counties</td>
<td>County boundaries</td>
<td>USGS Earth Science Information Center, DLG vector file</td>
</tr>
<tr>
<td>Townships in Central Ohio</td>
<td>Township boundaries</td>
<td>ODNR/USGS/CFM, DLG</td>
</tr>
<tr>
<td>Site information</td>
<td>Location</td>
<td>State Historic Preservation Office site database, Ohio Historic Society.</td>
</tr>
<tr>
<td>Soils</td>
<td>Major and minor soil types</td>
<td>Soil Data Mart and Web Soils Survey, USDA SCS NRCS</td>
</tr>
<tr>
<td>Streams</td>
<td>Distance and direction to major and minor water</td>
<td>USGS Seamless data site</td>
</tr>
<tr>
<td>Glacial</td>
<td>Location of Karst areas; lithology and aquifer setting at all sites</td>
<td>ODNR, Division of Geologic Survey</td>
</tr>
<tr>
<td>Ground Water Pollution Potential DRASTIC(^1) data</td>
<td>Hydrogeologic setting at all sites</td>
<td>ODNR, Division of Water</td>
</tr>
</tbody>
</table>

\(^1\) DRASTIC is an acronym made up from some of the data within the coverage and report - depth to water, net recharge, aquifer media, soil media, topography, impact of the vadose zone media, hydraulic conductivity (Angle 1995:5). Only data from the hydrogeologic attribute was used.

Table 8: Origin of data used in this research.
<table>
<thead>
<tr>
<th>Randomly generated number</th>
<th>Corresponding Square</th>
<th>GIS FID</th>
<th>References used in the text</th>
</tr>
</thead>
<tbody>
<tr>
<td>58</td>
<td>B5</td>
<td>0</td>
<td>R0</td>
</tr>
<tr>
<td>32</td>
<td>D3</td>
<td>1</td>
<td>R1</td>
</tr>
<tr>
<td>90</td>
<td>F7</td>
<td>2</td>
<td>R2</td>
</tr>
<tr>
<td>92</td>
<td>H7</td>
<td>3</td>
<td>R3</td>
</tr>
<tr>
<td>157</td>
<td>C12</td>
<td>4</td>
<td>R4</td>
</tr>
<tr>
<td>301</td>
<td>G22</td>
<td>5</td>
<td>R5</td>
</tr>
<tr>
<td>233</td>
<td>I17</td>
<td>6</td>
<td>R6</td>
</tr>
<tr>
<td>228</td>
<td>E17</td>
<td>7</td>
<td>R7</td>
</tr>
<tr>
<td>197</td>
<td>A15</td>
<td>8</td>
<td>R8</td>
</tr>
</tbody>
</table>

Table 9: How the nine random points used a as comparison population were generated.
<table>
<thead>
<tr>
<th></th>
<th>Glacial aquifer setting</th>
<th>Soil minor(^1)</th>
<th>Elevation range</th>
<th>Hydrologic setting</th>
<th>Slope range from soil coverage</th>
<th>Bedrock from ODNR</th>
<th>Glacial Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soil major</strong></td>
<td>-All cluster</td>
<td>n/a</td>
<td>-6 sites cluster with 1 random. -4 randoms cluster</td>
<td>-No clustering</td>
<td>-2 sites cluster with 1 random</td>
<td>-6 sites cluster with 1 random</td>
<td>-3 sites cluster</td>
</tr>
<tr>
<td><strong>Glacial aquifer</strong></td>
<td></td>
<td>n/a</td>
<td>-4 sites cluster with 2 randoms</td>
<td>-No clustering</td>
<td>-3 sites cluster</td>
<td>-3 sites cluster</td>
<td>-All cluster</td>
</tr>
<tr>
<td><strong>Soil minor(^1)</strong></td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Elevation range</strong></td>
<td></td>
<td></td>
<td>-4 randoms cluster</td>
<td>-4 sites cluster</td>
<td>-4 randoms cluster</td>
<td>-4 sites cluster with 1 random</td>
<td>-4 randoms cluster</td>
</tr>
<tr>
<td><strong>Hydrologic setting</strong></td>
<td></td>
<td></td>
<td>-4 randoms cluster</td>
<td>-2 sites cluster -remaining 16 sites and randoms cluster</td>
<td>-6 sites cluster with 2 randoms.</td>
<td>-6 sites cluster with 3 randoms</td>
<td>5 randoms cluster</td>
</tr>
<tr>
<td><strong>Slope range</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-4 randoms cluster</td>
<td>-4 randoms cluster</td>
<td>-4 randoms cluster</td>
</tr>
<tr>
<td><strong>Bedrock</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-4 randoms cluster</td>
<td>-4 randoms cluster</td>
</tr>
</tbody>
</table>

\(^1\) Minor soils were not considered as they could not be reduced to 17 variables as required by the analysis type.

Table 10: Clusters from the initial MCA for the sites compared to the random points.
<table>
<thead>
<tr>
<th>Codes for hydrogeologic setting</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS</td>
<td>Alluvium over sedimentary rock</td>
</tr>
<tr>
<td>BV</td>
<td>Buried valley</td>
</tr>
<tr>
<td>GTLS</td>
<td>Glacial till over limestone</td>
</tr>
<tr>
<td>GTSH</td>
<td>Glacial till over shale</td>
</tr>
<tr>
<td>MOR</td>
<td>Moraine</td>
</tr>
<tr>
<td>OWLS</td>
<td>Outwash over limestone</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Codes for glacial lithology</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSG</td>
<td>Fines with sand and gravel</td>
</tr>
<tr>
<td>T</td>
<td>Till</td>
</tr>
<tr>
<td>TSG</td>
<td>Till with sand and gravel</td>
</tr>
<tr>
<td>SGF</td>
<td>Sand and gravel with fines</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Codes soil drainage</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>MWD</td>
<td>Moderately well drained</td>
</tr>
<tr>
<td>SPD</td>
<td>Somewhat poorly drained</td>
</tr>
<tr>
<td>VPD</td>
<td>Very poorly drained</td>
</tr>
<tr>
<td>WD</td>
<td>Well drained</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Codes for soil type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL</td>
<td>Clay loam</td>
</tr>
<tr>
<td>SL</td>
<td>Silt loam</td>
</tr>
<tr>
<td>SLL</td>
<td>Silt loam and loam</td>
</tr>
<tr>
<td>SCL</td>
<td>Silt clay loam</td>
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<table>
<thead>
<tr>
<th>Codes for soil setting</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP</td>
<td>Flood plain</td>
</tr>
<tr>
<td>MOR</td>
<td>Moraine</td>
</tr>
<tr>
<td>OTMUF</td>
<td>Outwash/till plains/moraine/uplands/floodplain</td>
</tr>
<tr>
<td>TMU</td>
<td>Till plains/moraine/uplands</td>
</tr>
<tr>
<td>TMO</td>
<td>Till plains/moraine</td>
</tr>
<tr>
<td>TP</td>
<td>Till plains</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Codes for soil elevation range</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>&lt;600 ft</td>
</tr>
<tr>
<td>H</td>
<td>&gt;600 ft</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>Codes for elevation range within 1 km</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>LO</td>
<td>&lt; 50 ft</td>
</tr>
<tr>
<td>HI</td>
<td>&gt; 50 ft</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Codes for major soil percentage by county</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMJS</td>
<td>&lt; 20%</td>
</tr>
<tr>
<td>HMJS</td>
<td>&gt; 20%</td>
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</table>

Table 11: Codes used in the MCA program.
<table>
<thead>
<tr>
<th>Site name</th>
<th>Elevation of minor silty loam soils ≤ 600ft</th>
<th>Soil formed on moraine</th>
<th>Minor soil &lt;5% of county</th>
<th>Major soil &lt;20% of county</th>
<th>Somewhat poorly drained soil</th>
<th>Buried valley hydrogeologic setting &gt; 50 ft elevation range within 1km</th>
<th>Till lithology</th>
<th>Aquifer setting moraine upland complex</th>
<th>Karst &lt;10 km</th>
<th>Major water &lt;1000 meters</th>
<th>Minor water &lt;325 meters</th>
<th>Slope classes within 1 km ≥11</th>
<th>Bennington soils, minor and major</th>
<th>Ttls</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD</td>
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<td>✓</td>
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<td>✓</td>
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<tr>
<td>CCC</td>
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<td>8</td>
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</table>

Table 12: Summary of the variables considered in this research for the known sites. The bold columns indicate the variables used in the GIS analysis that produced the Similar Environmental Grouping’s for visual searching on remote sensing imagery.
<table>
<thead>
<tr>
<th>Site name</th>
<th>Elevation of minor soils ≤ 600ft</th>
<th>Silty loam soil</th>
<th>Soil formed on moraine</th>
<th>Minor soil &lt;5% of county</th>
<th>Major soil &lt;20% of county</th>
<th>Some-what poorly drained soil</th>
<th>Buried valley hydro-geologic setting</th>
<th>&gt; 50 ft elevation range within 1km</th>
<th>Till lithology</th>
<th>Aquifer setting - moraine upland complex</th>
<th>Karst &lt;10 km</th>
<th>Major water &lt;1000 meters</th>
<th>Minor water &lt;325 meters</th>
<th>Slope classes within 1 km ≥ 11</th>
<th>Bennington soils, minor and major</th>
<th>Tls</th>
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</thead>
<tbody>
<tr>
<td>R0</td>
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<td>52</td>
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</table>

Table 13: Summary of the variables considered in this research for the random points. The bold columns indicate the variables used in the GIS analysis that produced the Similar Environmental Grouping’s for visual searching on remote sensing imagery.
<table>
<thead>
<tr>
<th>SITE</th>
<th>Point elevation</th>
<th>Degrees slope at site</th>
<th>High within 0.6 miles</th>
<th>Low within 0.6 miles</th>
<th>Elevation range within 0.6 miles</th>
<th>Number of slope classes within 0.6 miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adler</td>
<td>901</td>
<td>3.05</td>
<td>925</td>
<td>868</td>
<td>57</td>
<td>11</td>
</tr>
<tr>
<td>Briggsdale</td>
<td>744</td>
<td>0.31</td>
<td>770</td>
<td>706</td>
<td>64</td>
<td>7</td>
</tr>
<tr>
<td>CCC</td>
<td>769</td>
<td>1.11</td>
<td>823</td>
<td>752</td>
<td>71</td>
<td>13</td>
</tr>
<tr>
<td>Dominion</td>
<td>870</td>
<td>0</td>
<td>881</td>
<td>774</td>
<td>107</td>
<td>12</td>
</tr>
<tr>
<td>Holder-Wright</td>
<td>867</td>
<td>0.98</td>
<td>905</td>
<td>761</td>
<td>107</td>
<td>12</td>
</tr>
<tr>
<td>Jackson Fort</td>
<td>830</td>
<td>2.41</td>
<td>876</td>
<td>769</td>
<td>144</td>
<td>12</td>
</tr>
<tr>
<td>Orange</td>
<td>921</td>
<td>1.8</td>
<td>961</td>
<td>758</td>
<td>203</td>
<td>14</td>
</tr>
<tr>
<td>Spruce Run</td>
<td>917</td>
<td>5.54</td>
<td>962</td>
<td>853</td>
<td>109</td>
<td>12</td>
</tr>
<tr>
<td>Worthington</td>
<td>747</td>
<td>1.54</td>
<td>851</td>
<td>745</td>
<td>106</td>
<td>13</td>
</tr>
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<td>R0</td>
<td>932</td>
<td>1.27</td>
<td>946</td>
<td>919</td>
<td>27</td>
<td>6</td>
</tr>
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<td>R1</td>
<td>919</td>
<td>0.98</td>
<td>936</td>
<td>910</td>
<td>26</td>
<td>5</td>
</tr>
<tr>
<td>R2</td>
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<td>9.86</td>
<td>924</td>
<td>837</td>
<td>87</td>
<td>12</td>
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<td>R3</td>
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<td>0.98</td>
<td>949</td>
<td>889</td>
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<td>704</td>
<td>656</td>
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<tr>
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<td>792</td>
<td>731</td>
<td>61</td>
<td>10</td>
</tr>
<tr>
<td>R7</td>
<td>829</td>
<td>1.27</td>
<td>884</td>
<td>778</td>
<td>96</td>
<td>10</td>
</tr>
<tr>
<td>R8</td>
<td>949</td>
<td>0.31</td>
<td>967</td>
<td>935</td>
<td>32</td>
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</table>

<table>
<thead>
<tr>
<th>Reclassification of slope class number GIS FID</th>
<th>Renumbered</th>
<th>Slope equivalent in degrees</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>2</td>
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</tr>
<tr>
<td>2</td>
<td>3</td>
<td>1.52-2.74</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>2.74-4.11</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>4.11-5.63</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>5.63-7.15</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>7.15-8.67</td>
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<tr>
<td>7</td>
<td>8</td>
<td>8.67-10.20</td>
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<tr>
<td>8</td>
<td>9</td>
<td>10.20-11.87</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>11.87-13.70</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>13.70-15.83</td>
</tr>
<tr>
<td>11</td>
<td>12</td>
<td>15.83-18.87</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
<td>18.78-24.51</td>
</tr>
<tr>
<td>13</td>
<td>14</td>
<td>24.51-38.82</td>
</tr>
</tbody>
</table>

Table 14: Table detailing the slope and elevation at each site, and the reclassification used in the GIS.
<table>
<thead>
<tr>
<th>Site name</th>
<th>County</th>
<th>Major Soil Association (ODNR 1980a&amp;b; 1981; 2001; 2002)</th>
<th>Percentage of major soils in county</th>
<th>Specific site soils (USDA 2009a&amp;b)</th>
<th>Percentage of minor soils in county</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adler</td>
<td>Franklin</td>
<td>Crosby Kokomo</td>
<td>24%</td>
<td>SIA</td>
<td>0.3%</td>
</tr>
<tr>
<td>Briggsdale</td>
<td>Franklin</td>
<td>Crosby Kokomo</td>
<td>24</td>
<td>CsA and CsB</td>
<td>3.8</td>
</tr>
<tr>
<td>CCC</td>
<td>Franklin</td>
<td>Bennington Pewamo</td>
<td>29</td>
<td>BfB</td>
<td>3.7</td>
</tr>
<tr>
<td>Dominion</td>
<td>Franklin</td>
<td>Cardington Alexander Bennington</td>
<td>3</td>
<td>BfB (E half) and CbB (W half)</td>
<td>1.4</td>
</tr>
<tr>
<td>Holder-Wright</td>
<td>Franklin</td>
<td>Crosby Kokomo and Glynwood Blount</td>
<td>2</td>
<td>BoB (NE circle, most of “C”) and GwB (SW corner of “C”, and SW circle). GwC2 (Krumm).</td>
<td>0.4</td>
</tr>
<tr>
<td>Jackson Fort</td>
<td>Franklin</td>
<td>Bennington Pewamo</td>
<td>29</td>
<td>BeB</td>
<td>5.1</td>
</tr>
<tr>
<td>Orange</td>
<td>Delaware</td>
<td>Bennington Cardington Pewamo</td>
<td>13</td>
<td>GwC2 (E) and LbF (W)</td>
<td>0.3</td>
</tr>
<tr>
<td>Spruce</td>
<td>Delaware</td>
<td>Bennington Pewamo Centerburg</td>
<td>7</td>
<td>BeA (N circle and E of S circle) BeB (W of S circle), AmF (graded way).</td>
<td>0.2</td>
</tr>
<tr>
<td>Worthington</td>
<td>Franklin</td>
<td>Miamian Celina</td>
<td>15</td>
<td>HeE2 (E and N embankment of square, and S of N circle). Rest of square, rest of north circle and S circle in CiB/CeB.</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Table 15: Soils at the nine known sites with the percentages by county used in the statistics analyses.
<table>
<thead>
<tr>
<th>Site name</th>
<th>County</th>
<th>Major Soil Association (ODNR 1980a&amp;b; 1981; 2001; 2002)</th>
<th>Percentage of major soils in county</th>
<th>Specific site soils (USDA 2009a&amp;b)</th>
<th>Percentage of minor soils in county</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random 0</td>
<td>Union</td>
<td>Blount Wetzel Pewamo</td>
<td>47</td>
<td>Pm</td>
<td>9%</td>
</tr>
<tr>
<td>Random 1</td>
<td>Delaware</td>
<td>Blount Pewamo Glynwood</td>
<td>31</td>
<td>PwA</td>
<td>21.4</td>
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<td>Glynwood Blount Pewamo</td>
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<td>UdB</td>
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</tr>
<tr>
<td>Random 3</td>
<td>Delaware</td>
<td>Blount Pewamo Glynwood</td>
<td>31</td>
<td>BoB</td>
<td>15</td>
</tr>
<tr>
<td>Random 4</td>
<td>Franklin</td>
<td>Kokomo Crosby Lewisburg</td>
<td>10</td>
<td>Ko</td>
<td>10.8</td>
</tr>
<tr>
<td>Random 5</td>
<td>Pickaway</td>
<td>Eldean Genesse Warsaw</td>
<td>18</td>
<td>Gn</td>
<td>2.9</td>
</tr>
<tr>
<td>Random 6</td>
<td>Franklin</td>
<td>Bennington Pewamo</td>
<td>29</td>
<td>BeB</td>
<td>5.1</td>
</tr>
<tr>
<td>Random 7</td>
<td>Franklin</td>
<td>Crosby Kokomo</td>
<td>24</td>
<td>CfB</td>
<td>1.6</td>
</tr>
<tr>
<td>Random 8</td>
<td>Madison</td>
<td>Crosby Kokomo Lewisburg</td>
<td>53</td>
<td>CsA</td>
<td>14.6</td>
</tr>
</tbody>
</table>

Table 16: Soils at the nine random comparison sites with the percentages by county used in the statistics analyses.
<table>
<thead>
<tr>
<th>Site</th>
<th>Soils designation code</th>
<th>Soil name and slope association</th>
<th>Soils elevations</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD</td>
<td>SIA</td>
<td>Sleeth silt loam 0-2%</td>
<td>400-1000</td>
<td>600</td>
</tr>
<tr>
<td>BR</td>
<td>CsA</td>
<td>Crosby urban land complex 0-2%</td>
<td>600-1200</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>CsB</td>
<td>Crosby urban land complex 2-6%</td>
<td>600-1200</td>
<td>600</td>
</tr>
<tr>
<td>CCC</td>
<td>BfB</td>
<td>Bennington Urban land complex 2-6%</td>
<td>800-1200</td>
<td>400</td>
</tr>
<tr>
<td>DOM</td>
<td>BfB (east half)</td>
<td>Bennington Urban land complex 2-6%</td>
<td>800-1200</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>CbB (west half)</td>
<td>Cardington Urban land complex 2-6%</td>
<td>800-1200</td>
<td>400</td>
</tr>
<tr>
<td>HW</td>
<td>BoB (northeast circle, most of “C” enclosure)</td>
<td>Blount silt loam 2-6%</td>
<td>580-1530</td>
<td>950</td>
</tr>
<tr>
<td></td>
<td>GwB (southwest corner of “C”, southwest circle)</td>
<td>Glynwood silt loam 2-6%</td>
<td>800-1000</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>GwC2 (Krumm)</td>
<td>Glynwood silt loam 6-12% eroded</td>
<td>800-1000</td>
<td>200</td>
</tr>
<tr>
<td>JF</td>
<td>BeB</td>
<td>Bennington silt loam 2-6%</td>
<td>800-1200</td>
<td>400</td>
</tr>
<tr>
<td>OR</td>
<td>GwC2 (east)</td>
<td>Glynwood silt loam 6-12%</td>
<td>800-1000</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>LbF (west)</td>
<td>Latham-Brecksville complex 25-70%</td>
<td>700-1100</td>
<td>400</td>
</tr>
<tr>
<td>SP</td>
<td>BeA (north circle &amp; east of S circle)</td>
<td>Bennington silt loam 0-2%</td>
<td>800-1200</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>BeB (west of S circle)</td>
<td>Bennington silt loam 2-4%</td>
<td>800-1200</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>AmF (graded way)</td>
<td>Amanda silt loam 25-50%</td>
<td>900-1200</td>
<td>300</td>
</tr>
<tr>
<td>WO</td>
<td>HeE2 (east &amp; north embankment of square, &amp; south of north circle)</td>
<td>Hennepin and Miamian loams 18-25%, eroded</td>
<td>400-1530</td>
<td>1130</td>
</tr>
<tr>
<td></td>
<td>CFB rest of square, circle &amp; south circle</td>
<td>Celina Urban land complex 2-6%</td>
<td>860-1100</td>
<td>240</td>
</tr>
<tr>
<td></td>
<td>CFB rest of north circle</td>
<td>Celine Silt loam 2-6%</td>
<td>860-1100</td>
<td>240</td>
</tr>
<tr>
<td>R0</td>
<td>Pm</td>
<td>Pewamo silt loam</td>
<td>600-1400</td>
<td>800</td>
</tr>
<tr>
<td>R1</td>
<td>PwA</td>
<td>Pewamo silt clay loam 0-1%</td>
<td>600-1400</td>
<td>800</td>
</tr>
<tr>
<td>R2</td>
<td>UdB</td>
<td>Udorthents, clayey urban land complex, undulating</td>
<td>340-1530</td>
<td>1190</td>
</tr>
<tr>
<td>R3</td>
<td>BoB</td>
<td>Blount silt loam 2-4%</td>
<td>600-1500</td>
<td>900</td>
</tr>
<tr>
<td>R4</td>
<td>Ko</td>
<td>Kokomo silt clay loam</td>
<td>600-1000</td>
<td>400</td>
</tr>
<tr>
<td>R5</td>
<td>Gn</td>
<td>Genesee silt loam, occasionally flooded</td>
<td>340-1000</td>
<td>660</td>
</tr>
<tr>
<td>R6</td>
<td>BeB</td>
<td>Bennington silt loam 2-6%</td>
<td>800-1200</td>
<td>400</td>
</tr>
<tr>
<td>R7</td>
<td>CFB</td>
<td>Celina Urban land complex 2-6%</td>
<td>860-1100</td>
<td>240</td>
</tr>
<tr>
<td>R8</td>
<td>CsA</td>
<td>Crosby-Lewisburg 0-2%</td>
<td>600-1200</td>
<td>600</td>
</tr>
</tbody>
</table>

Table 17: Minor soils at each site with descriptions and elevation range where the soil is found.
<table>
<thead>
<tr>
<th>Site</th>
<th>Distance to major water in meters</th>
<th>Distance to minor water in meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adler</td>
<td>80</td>
<td>382</td>
</tr>
<tr>
<td>Briggsdale</td>
<td>3450</td>
<td>1192</td>
</tr>
<tr>
<td>CCC</td>
<td>455</td>
<td>400</td>
</tr>
<tr>
<td>Dominion</td>
<td>2231</td>
<td>80</td>
</tr>
<tr>
<td>Holder-Wright</td>
<td>532</td>
<td>112</td>
</tr>
<tr>
<td>Jackson Fort</td>
<td>1164</td>
<td>257</td>
</tr>
<tr>
<td>Orange</td>
<td>173</td>
<td>200</td>
</tr>
<tr>
<td>Spruce</td>
<td>173</td>
<td>133</td>
</tr>
<tr>
<td>Worthington</td>
<td>274</td>
<td>145</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>948</strong></td>
<td><strong>322</strong></td>
</tr>
<tr>
<td>R0</td>
<td>144</td>
<td>150</td>
</tr>
<tr>
<td>R1</td>
<td>2190</td>
<td>300</td>
</tr>
<tr>
<td>R2</td>
<td>238</td>
<td>39</td>
</tr>
<tr>
<td>R3</td>
<td>1333</td>
<td>400</td>
</tr>
<tr>
<td>R4</td>
<td>4110</td>
<td>680</td>
</tr>
<tr>
<td>R5</td>
<td>55</td>
<td>500</td>
</tr>
<tr>
<td>R6</td>
<td>157</td>
<td>842</td>
</tr>
<tr>
<td>R7</td>
<td>7930</td>
<td>280</td>
</tr>
<tr>
<td>R8</td>
<td>3008</td>
<td>420</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>2129</strong></td>
<td><strong>401</strong></td>
</tr>
</tbody>
</table>

Table 18: Distances to major and minor water for each of the 18 sites.
<table>
<thead>
<tr>
<th>Site</th>
<th>Direction gateway faces</th>
<th>Compass Degrees</th>
<th>Direction to major water</th>
<th>Compass Degrees</th>
<th>Direction to minor water</th>
<th>Compass Degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adler</td>
<td>W</td>
<td>270</td>
<td>W Big Darby Creek</td>
<td>270</td>
<td>NNE Burkett Ditch</td>
<td>22</td>
</tr>
<tr>
<td>Briggsdale&lt;sup&gt;a&lt;/sup&gt;</td>
<td>SSW</td>
<td>197</td>
<td>ENE Scioto River</td>
<td>67</td>
<td>SW Scioto Big Run</td>
<td>225</td>
</tr>
<tr>
<td>Briggsdale&lt;sup&gt;b&lt;/sup&gt;</td>
<td>NW</td>
<td>322</td>
<td>ENE Scioto River</td>
<td>67</td>
<td>SW Scioto Big Run</td>
<td>225</td>
</tr>
<tr>
<td>Columbus Country Club</td>
<td>E?</td>
<td>90</td>
<td>E Big Walnut</td>
<td>90</td>
<td>SSE No name</td>
<td>157</td>
</tr>
<tr>
<td>Dominion</td>
<td>NW</td>
<td>310</td>
<td>WSW Olentangy River</td>
<td>247</td>
<td>SW Adena Book</td>
<td>225</td>
</tr>
<tr>
<td>Holder - Wright&lt;sup&gt;a&lt;/sup&gt;</td>
<td>E</td>
<td>80</td>
<td>W Scioto River</td>
<td>270</td>
<td>SE Billingsley Ditch</td>
<td>135</td>
</tr>
<tr>
<td>Holder – Wright&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ENE</td>
<td>60</td>
<td>W Scioto River</td>
<td>270</td>
<td>SSE Billingsley Ditch</td>
<td>112</td>
</tr>
<tr>
<td>Holder – Wright&lt;sup&gt;c&lt;/sup&gt;</td>
<td>E</td>
<td>90</td>
<td>W Scioto River</td>
<td>270</td>
<td>E Billingsley Ditch</td>
<td>90</td>
</tr>
<tr>
<td>Jackson Fort</td>
<td>?</td>
<td>?</td>
<td>E Alum Creek</td>
<td>90</td>
<td>SW No name</td>
<td>225</td>
</tr>
<tr>
<td>Orange Township</td>
<td>N, E, ENE</td>
<td>0, 70, 105</td>
<td>W Olentangy River</td>
<td>270</td>
<td>SE &amp; NNE No name</td>
<td>135, 230</td>
</tr>
<tr>
<td>Spruce Run&lt;sup&gt;b&lt;/sup&gt;</td>
<td>E</td>
<td>80</td>
<td>W Big Walnut Creek</td>
<td>270</td>
<td>E No name</td>
<td>90</td>
</tr>
<tr>
<td>Worthington&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NE, SW</td>
<td>45, 220</td>
<td>E Olentangy River</td>
<td>90</td>
<td>NNW No name</td>
<td>337</td>
</tr>
<tr>
<td>Worthington&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ESE, SSW, NNW</td>
<td>110, 205, 335</td>
<td>E Olentangy River</td>
<td>90</td>
<td>NNW No name</td>
<td>337</td>
</tr>
<tr>
<td>Worthington&lt;sup&gt;c&lt;/sup&gt;</td>
<td>NE</td>
<td>55</td>
<td>E Olentangy River</td>
<td>90</td>
<td>NNW No name</td>
<td>337</td>
</tr>
</tbody>
</table>

Table 19: Details of the direction of gateways, and major and minor water for each known site.
<table>
<thead>
<tr>
<th>Site</th>
<th>Direction ‘gateway’ faces</th>
<th>Compass degrees</th>
<th>Direction to Major water</th>
<th>Compass Degrees</th>
<th>Direction to minor water</th>
<th>Compass Degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0</td>
<td>E</td>
<td>82</td>
<td>NE</td>
<td>45</td>
<td>ENE</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bokes Creek</td>
<td></td>
<td>Bokes Creek</td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>NW</td>
<td>328</td>
<td>W</td>
<td>270</td>
<td>S</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Scioto River</td>
<td></td>
<td>Kebler Run</td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td>SSE</td>
<td>148</td>
<td>E</td>
<td>90</td>
<td>S</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Olentangy River</td>
<td></td>
<td>No name</td>
<td></td>
</tr>
<tr>
<td>R3</td>
<td>NE</td>
<td>34</td>
<td>E</td>
<td>90</td>
<td>NW</td>
<td>315</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alum Creek</td>
<td></td>
<td>Big Run</td>
<td></td>
</tr>
<tr>
<td>R4</td>
<td>W</td>
<td>267</td>
<td>W</td>
<td>270</td>
<td>NE</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Big Darby Creek</td>
<td></td>
<td>South Fork Indian Run</td>
<td></td>
</tr>
<tr>
<td>R5</td>
<td>SSE</td>
<td>99</td>
<td>W</td>
<td>270</td>
<td>ENE</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Scioto River</td>
<td></td>
<td>No name</td>
<td></td>
</tr>
<tr>
<td>R6</td>
<td>SE</td>
<td>129</td>
<td>SW</td>
<td>225</td>
<td>NE</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Big Walnut River</td>
<td></td>
<td>No name</td>
<td></td>
</tr>
<tr>
<td>R7</td>
<td>NW</td>
<td>310</td>
<td>E</td>
<td>90</td>
<td>NE</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Scioto River</td>
<td></td>
<td>Scioto Big Run</td>
<td></td>
</tr>
<tr>
<td>R8</td>
<td>SSE</td>
<td>144</td>
<td>NE</td>
<td>45</td>
<td>NE</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Big Darby Creek</td>
<td></td>
<td>Bridenstine Ditch</td>
<td></td>
</tr>
</tbody>
</table>

Table 20: Direction of gateways and to major and minor water for the random points.
<table>
<thead>
<tr>
<th>Site name</th>
<th>Distance to karst in km</th>
<th>Direction in degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adler</td>
<td>11.98</td>
<td>88</td>
</tr>
<tr>
<td>Briggsdale</td>
<td>10.22</td>
<td>334</td>
</tr>
<tr>
<td>CCC</td>
<td>18.1</td>
<td>320</td>
</tr>
<tr>
<td>Dominion</td>
<td>3.97</td>
<td>238</td>
</tr>
<tr>
<td>Holder-Wright(^1)</td>
<td>0.42</td>
<td>210</td>
</tr>
<tr>
<td>Jackson Fort</td>
<td>6.47</td>
<td>312</td>
</tr>
<tr>
<td>Orange</td>
<td>3.67</td>
<td>280</td>
</tr>
<tr>
<td>Spruce</td>
<td>11.76</td>
<td>275</td>
</tr>
<tr>
<td>Worthington</td>
<td>2.25</td>
<td>137</td>
</tr>
<tr>
<td>R0</td>
<td>4.04</td>
<td>24</td>
</tr>
<tr>
<td>R1</td>
<td>0.8</td>
<td>223</td>
</tr>
<tr>
<td>R2</td>
<td>7.4</td>
<td>290</td>
</tr>
<tr>
<td>R3</td>
<td>11.41</td>
<td>194</td>
</tr>
<tr>
<td>R4</td>
<td>6.16</td>
<td>5</td>
</tr>
<tr>
<td>R5</td>
<td>30.35</td>
<td>343</td>
</tr>
<tr>
<td>R6</td>
<td>18.62</td>
<td>305</td>
</tr>
<tr>
<td>R7</td>
<td>10.1</td>
<td>358</td>
</tr>
<tr>
<td>R8</td>
<td>15.67</td>
<td>80</td>
</tr>
</tbody>
</table>

\(^1\)The distance and direction from Holder-Wright to the karst areas are based on my own observations, not the data coverage's. Having visited the site on numerous occasions I know that the closest karst area is to the SW of the site, not to the north as the coverage shows. To that end, I measured the distance on the GIS to the area I know to have caves at this site.

Table 21: Distance and direction to karst topography for the 18 sites.
Table 22: Information about alignments of gateways for the 18 sites to sun, moon, stars and water.

1 These events are for Central Ohio. The compass degrees have been rounded, and they have not been corrected for slight temporal differences in the solar and lunar cycles dating back to the Woodland period.
<table>
<thead>
<tr>
<th>Site</th>
<th>Gateway to major water</th>
<th>Gateway to minor water</th>
<th>Solar or lunar alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adler</td>
<td>Yes</td>
<td>No</td>
<td>Solar</td>
</tr>
<tr>
<td>Briggsdale&lt;sup&gt;a&lt;/sup&gt;</td>
<td>No</td>
<td>Similar</td>
<td>No</td>
</tr>
<tr>
<td>Briggsdale&lt;sup&gt;b&lt;/sup&gt;</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Columbus Country Club</td>
<td>Yes</td>
<td>No</td>
<td>Solar</td>
</tr>
<tr>
<td>Dominion</td>
<td>No</td>
<td>No</td>
<td>Similar Lunar</td>
</tr>
<tr>
<td>Holder-Wright&lt;sup&gt;a&lt;/sup&gt;</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Holder-Wright&lt;sup&gt;b&lt;/sup&gt;</td>
<td>No</td>
<td>No</td>
<td>Similar Solar</td>
</tr>
<tr>
<td>Holder-Wright&lt;sup&gt;c&lt;/sup&gt;</td>
<td>No</td>
<td>Yes</td>
<td>Solar</td>
</tr>
<tr>
<td>Jackson Fort</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Orange Twp</td>
<td>No</td>
<td>No</td>
<td>Similar lunar</td>
</tr>
<tr>
<td>Spruce Run&lt;sup&gt;b&lt;/sup&gt;</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Worthington Works&lt;sup&gt;a&lt;/sup&gt;</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Worthington Works&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Similar</td>
<td>Yes</td>
<td>Similar Lunar</td>
</tr>
<tr>
<td>Worthington Works&lt;sup&gt;c&lt;/sup&gt;</td>
<td>No</td>
<td>No</td>
<td>Similar Solar &amp; Lunar</td>
</tr>
<tr>
<td><strong>Total yes + similar</strong></td>
<td><strong>2+1</strong></td>
<td><strong>3+1</strong></td>
<td><strong>1+5</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site</th>
<th>Gateway to major water</th>
<th>Gateway to minor water</th>
<th>Solar or lunar alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>R1</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>R2</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>R3</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>R4</td>
<td>Similar</td>
<td>No</td>
<td>Similar Solar</td>
</tr>
<tr>
<td>R5</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>R6</td>
<td>No</td>
<td>No</td>
<td>Similar Lunar</td>
</tr>
<tr>
<td>R7</td>
<td>No</td>
<td>No</td>
<td>Similar Lunar</td>
</tr>
<tr>
<td>R8</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Total yes + similar</strong></td>
<td><strong>0+1</strong></td>
<td><strong>0</strong></td>
<td><strong>0+3</strong></td>
</tr>
</tbody>
</table>

Table 23: Gateways alignments for the 18 sites. Gateways were arbitrarily assigned to the random points to allow comparison.
<table>
<thead>
<tr>
<th>Data used in this study</th>
<th>Type of test</th>
<th>Statistic results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point elevation</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.489</td>
</tr>
<tr>
<td>Elevation range within 1 km of the site</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.005</td>
</tr>
<tr>
<td>Number of slope classes within 1 km of site</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.013</td>
</tr>
<tr>
<td>Major soil associations % by county</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.027</td>
</tr>
<tr>
<td>Minor soil associations % by county</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.004</td>
</tr>
<tr>
<td>Elevation range of minor soils found at sites</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.015</td>
</tr>
<tr>
<td>Distance to major water</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.243</td>
</tr>
<tr>
<td>Direction to major water (degrees direction)</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.435</td>
</tr>
<tr>
<td>Distance to minor water</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.112</td>
</tr>
<tr>
<td>Direction to minor water (degrees direction)</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.221</td>
</tr>
<tr>
<td>Distance to karst areas</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.273</td>
</tr>
<tr>
<td>Direction to karst areas</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.354</td>
</tr>
<tr>
<td>Gateways</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.4</td>
</tr>
<tr>
<td>Viewshed area</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.762</td>
</tr>
<tr>
<td>Comparison of 15 variables</td>
<td>2 tailed Monte Carlo</td>
<td>p &lt; 0.0001</td>
</tr>
<tr>
<td>Hydrogeologic setting and glacial lithology</td>
<td>MCA</td>
<td>$X^2 = 169.174$ where $X^2_{0.05}$ $df = 81 = 103.010$ p = &lt; 0.0001</td>
</tr>
<tr>
<td>Hydrogeologic setting and soils drainage type</td>
<td>MCA</td>
<td>$X^2 = 191.109$ where $X^2_{0.05}$ $df = 100 = 124.342$ p = &lt; 0.0001</td>
</tr>
<tr>
<td>Minor soil type and where soil found</td>
<td>MCA</td>
<td>$X^2 = 239.143$ where $X^2_{0.05}$ $df = 100 = 124.34$ p = &lt; 0.0001</td>
</tr>
<tr>
<td>Eight variables</td>
<td>MCA</td>
<td>$X^2 = 1068.67$ where $X^2_{0.05}$ $df = 961 = 1034.23$ p = &lt; 0.007</td>
</tr>
</tbody>
</table>

Table 24: Summary of the statistical results in this study.
<table>
<thead>
<tr>
<th>Name</th>
<th>Aquifer name and setting(^1)</th>
<th>Glacial Lithology</th>
<th>Hydrogeologic setting</th>
<th>Soils drainage</th>
<th>Soil setting</th>
<th>Soil type</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD</td>
<td>Hilliard ground moraine</td>
<td>Tsg Till w/ sand &amp; gravel lenses</td>
<td>Be outwash over limestone</td>
<td>Somewhat poorly</td>
<td>Outwash</td>
<td>Silt loam</td>
</tr>
<tr>
<td>BR</td>
<td>Hilliard ground moraine</td>
<td>Tsg Till w/ sand &amp; gravel lenses</td>
<td>D buried valley</td>
<td>Somewhat poorly</td>
<td>Till plain</td>
<td>Silt loam</td>
</tr>
<tr>
<td>CCC</td>
<td>Westerville thin upland</td>
<td>T Till</td>
<td>Ae glacial till over shale</td>
<td>Somewhat poorly</td>
<td>Moraine</td>
<td>Silt loam</td>
</tr>
<tr>
<td>DO</td>
<td>East Columbus complex</td>
<td>Tsg Till w/ sand &amp; gravel lenses</td>
<td>D buried valley</td>
<td>Somewhat poorly</td>
<td>Moraine</td>
<td>Silt loam</td>
</tr>
<tr>
<td>HW</td>
<td>West Columbus complex</td>
<td>T Till</td>
<td>Ae glacial till over limestone</td>
<td>Somewhat poorly</td>
<td>Till plain, moraine</td>
<td>Silt loam</td>
</tr>
<tr>
<td>JF</td>
<td>East Columbus complex</td>
<td>Tsg Till w/ sand &amp; gravel lenses</td>
<td>D buried valley</td>
<td>Somewhat poorly</td>
<td>Moraine</td>
<td>Silt loam</td>
</tr>
<tr>
<td>OR</td>
<td>Worthington thin upland</td>
<td>T Till</td>
<td>C moraine</td>
<td>Moderately well</td>
<td>Moraine</td>
<td>Silt loam</td>
</tr>
<tr>
<td>SP</td>
<td>New Albany Thin upland</td>
<td>T Till</td>
<td>Ec alluvium over sediment</td>
<td>Somewhat poorly</td>
<td>Moraine</td>
<td>Silt loam</td>
</tr>
<tr>
<td>WO</td>
<td>West Columbus end moraine</td>
<td>T Till</td>
<td>D buried valley</td>
<td>Moderately well</td>
<td>Till plain, moraine, uplands</td>
<td>Silt loam, loam</td>
</tr>
</tbody>
</table>

\(^1\) Place name removed for analysis, e.g. Scioto buried valley and Baltimore buried valley would both be analyzed as a buried valley.

Table 25: Other variables at the known sites tested in this research.
<table>
<thead>
<tr>
<th>Name</th>
<th>Aquifer name and setting¹</th>
<th>Glacial Lithology</th>
<th>Hydrogeologic setting</th>
<th>Soils drainage</th>
<th>Soil setting</th>
<th>Soil type</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0</td>
<td>Bellefontaine ground moraine</td>
<td>Tsg Till w/ sand &amp; gravel lenses</td>
<td>Ac glacial till over limestone</td>
<td>Very poorly</td>
<td>Moraine</td>
<td>Silt clay loam</td>
</tr>
<tr>
<td>R1</td>
<td>Waldo thin upland</td>
<td>Tsg Till w/ sand &amp; gravel lenses</td>
<td>Ac glacial till over limestone</td>
<td>Very poorly</td>
<td>Moraine</td>
<td>Silt clay loam</td>
</tr>
<tr>
<td>R2</td>
<td>Olentangy River alluvial</td>
<td>Fsg Fines with sand and gravel lenses</td>
<td>Ac glacial till over limestone</td>
<td>Moderately well</td>
<td>Outwash, till plains, moraine, uplands, floodplains²</td>
<td>Clay loam</td>
</tr>
<tr>
<td>R3</td>
<td>East Delaware ground moraine</td>
<td>T Till</td>
<td>Ae glacial till over shale</td>
<td>Somewhat poorly</td>
<td>Till plain</td>
<td>Silt loam</td>
</tr>
<tr>
<td>R4</td>
<td>Powell end moraine</td>
<td>Tsg Till w/ sand &amp; gravel lenses</td>
<td>Ac glacial till over limestone</td>
<td>Very poorly</td>
<td>Till plain</td>
<td>Silt loam</td>
</tr>
<tr>
<td>R5</td>
<td>Scioto buried Valley</td>
<td>Sgf Sand and gravel with fines</td>
<td>D buried valley</td>
<td>Well</td>
<td>Floodplain</td>
<td>Silt loam</td>
</tr>
<tr>
<td>R6</td>
<td>Baltimore buried Valley</td>
<td>Fsg Fines with sand and gravel lenses</td>
<td>D buried valley</td>
<td>Somewhat poorly</td>
<td>Moraine</td>
<td>Silt loam</td>
</tr>
<tr>
<td>R7</td>
<td>Hilliard ground moraine</td>
<td>Tsg Till w/ sand &amp; gravel lenses</td>
<td>Ac glacial till over limestone</td>
<td>Moderately well</td>
<td>Till plain, moraine</td>
<td>Silt loam</td>
</tr>
<tr>
<td>R8</td>
<td>Prairie ground moraine</td>
<td>Tsg Till w/ sand &amp; gravel lenses</td>
<td>Ac glacial till over limestone</td>
<td>Somewhat poorly</td>
<td>Till plain</td>
<td>Silt loam</td>
</tr>
</tbody>
</table>

¹ Place name removed for analysis, e.g. Scioto buried valley and Baltimore buried valley would both be analyzed as a buried valley.
² Udorthent soils are found/formed on all land forms, thus point Random 2 has all soil settings.

Table 26: Other variables at the random sites tested in this research.
<table>
<thead>
<tr>
<th>Site</th>
<th>Aquifer setting</th>
<th>Hydrogeologic setting</th>
<th>Major soil association</th>
<th>Minor soil association</th>
<th>Glacial Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD</td>
<td>Ground moraine</td>
<td>7Ac</td>
<td>Crosby – Kokomo</td>
<td>Sleeth, SIA</td>
<td>Tsg</td>
</tr>
<tr>
<td>BR</td>
<td>Ground moraine</td>
<td>7Af NW&lt;sup&gt;1&lt;/sup&gt; 7D SE</td>
<td>Crosby – Kokomo</td>
<td>Crosby, CsA, CsB</td>
<td>Tsg</td>
</tr>
<tr>
<td>CCC</td>
<td>Thin upland</td>
<td>7Ae</td>
<td>Bennington – Pewamo</td>
<td>Bennington, BrB</td>
<td>T</td>
</tr>
<tr>
<td>DO</td>
<td>Complex</td>
<td>7D</td>
<td>Cardington – Alexandria – Bennington</td>
<td>Cardington, CbB, Bennington, BrB</td>
<td>Tsg</td>
</tr>
<tr>
<td>JF</td>
<td>Complex</td>
<td>7D</td>
<td>Bennington – Pewamo</td>
<td>Bennington, BeB</td>
<td>Tsg</td>
</tr>
<tr>
<td>HW</td>
<td>Complex</td>
<td>7Ac</td>
<td>Crosby – Kokomo&lt;sup&gt;2&lt;/sup&gt; East Glywood – Blount West</td>
<td>Blount, BoB, Glynwood, GwB, GwB2</td>
<td>T</td>
</tr>
<tr>
<td>OR</td>
<td>Thin upland</td>
<td>7C</td>
<td>Bennington – Cardington – Pewamo</td>
<td>Latham – Brooks, LbF, Glynwood, GwC2</td>
<td>T</td>
</tr>
<tr>
<td>SP</td>
<td>Thin upland</td>
<td>7Ec</td>
<td>Bennington – Pewamo – Centerburg</td>
<td>Bennington, BeA, BeB, Amanda, AmF</td>
<td>T</td>
</tr>
<tr>
<td>WO</td>
<td>End moraine</td>
<td>7D</td>
<td>Miamian – Celina</td>
<td>Celina, CFB, Hennepin, HeE2</td>
<td>T</td>
</tr>
<tr>
<td>R0</td>
<td>Ground moraine</td>
<td>7Ac</td>
<td>Blount – Wetzel – Pewamo</td>
<td>Pewamo, Pm</td>
<td>Tsg</td>
</tr>
<tr>
<td>R1</td>
<td>Thin upland</td>
<td>7Ac</td>
<td>Blount – Pewamo - Glywood</td>
<td>Pewamo, PwA</td>
<td>Tsg</td>
</tr>
<tr>
<td>R2</td>
<td>Alluvial</td>
<td>7Ac</td>
<td>Glynwood – Blount – Pewamo</td>
<td>Udorthents, UdB</td>
<td>Fsg</td>
</tr>
<tr>
<td>R3</td>
<td>Ground moraine</td>
<td>7Ac</td>
<td>Blount – Pewamo - Glywood</td>
<td>Blount, BoB</td>
<td>T</td>
</tr>
<tr>
<td>R4</td>
<td>End moraine</td>
<td>7Ac</td>
<td>Kokomo – Crosby - Lewisburg</td>
<td>Kokomo, Ko</td>
<td>Tsg</td>
</tr>
<tr>
<td>R5</td>
<td>Buried Valley</td>
<td>7D</td>
<td>Eldean – Genesee – Warsaw</td>
<td>Genesee, Gn</td>
<td>Sgf</td>
</tr>
<tr>
<td>R6</td>
<td>Buried Valley</td>
<td>7D</td>
<td>Bennington – Pewamo</td>
<td>Bennington, BeB</td>
<td>Fsg</td>
</tr>
<tr>
<td>R7</td>
<td>Ground moraine</td>
<td>7Ac</td>
<td>Crosby – Kokomo</td>
<td>Celina, Cfb</td>
<td>Tsg</td>
</tr>
<tr>
<td>R8</td>
<td>Ground moraine</td>
<td>7Ac</td>
<td>Crosby – Kokomo - Lewisburg</td>
<td>Crosby, CsA</td>
<td>Tsg</td>
</tr>
</tbody>
</table>

<sup>1</sup> The two circles at Briggsdale had two different settings in different parts of the site.

<sup>2</sup> The site at Holder-Wright had two soil types in different parts of the site.

Table 27: Summary of aquifer setting, hydrogeologic setting, major and minor soils associations for the 18 sites in this study.
<table>
<thead>
<tr>
<th>Polygon ID</th>
<th>AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.11</td>
</tr>
<tr>
<td>1</td>
<td>5.70</td>
</tr>
<tr>
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<td>13.79</td>
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<tr>
<td>3</td>
<td>1.49</td>
</tr>
<tr>
<td>4</td>
<td>6.53</td>
</tr>
<tr>
<td>5</td>
<td>9.00</td>
</tr>
<tr>
<td>6</td>
<td>58.69</td>
</tr>
<tr>
<td>7</td>
<td>47.79</td>
</tr>
<tr>
<td>8</td>
<td>0.68</td>
</tr>
<tr>
<td>9</td>
<td>4.20</td>
</tr>
<tr>
<td>10</td>
<td>0.27</td>
</tr>
<tr>
<td>11</td>
<td>3.68</td>
</tr>
<tr>
<td>12</td>
<td>33.05</td>
</tr>
<tr>
<td>13</td>
<td>0.68</td>
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<tr>
<td>14</td>
<td>19.81</td>
</tr>
<tr>
<td>15</td>
<td>23.11</td>
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<tr>
<td>16</td>
<td>81.45</td>
</tr>
<tr>
<td>17</td>
<td>6.15</td>
</tr>
<tr>
<td>18</td>
<td>20.76</td>
</tr>
<tr>
<td>19</td>
<td>7.98</td>
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<td>20</td>
<td>69.47</td>
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<td>21</td>
<td>22.55</td>
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<td>22</td>
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<td>23</td>
<td>6.25</td>
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<tr>
<td>24</td>
<td>70.62</td>
</tr>
<tr>
<td>25</td>
<td>148.75</td>
</tr>
<tr>
<td>26</td>
<td>7.86</td>
</tr>
<tr>
<td>27</td>
<td>11.44</td>
</tr>
<tr>
<td>28</td>
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<td>29</td>
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</tr>
<tr>
<td>33</td>
<td>5.40</td>
</tr>
<tr>
<td>34</td>
<td>3.65</td>
</tr>
</tbody>
</table>

| 35         | 16.44 |
| 36         | 14.63 |
| 37         | 2.53  |
| 38         | 15.17 |
| 39         | 4.22  |
| 40         | 0.82  |
| 41         | 3.06  |
| 42         | 11.18 |
| 43         | 2.65  |
| 44         | 4.90  |
| 45         | 4.34  |
| 46         | 78.83 |
| 47         | 49.43 |
| 48         | 114.53|
| 49         | 0.02  |
| 50         | 2.18  |
| 51         | 112.93|
| 52         | 122.17|
| 53         | 78.21 |
| 54         | 8.41  |
| 55         | 6.79  |
| 56         | 0.07  |
| 57         | 0.03  |
| 58         | 69.23 |
| 59         | 0.10  |
| 60         | 12.84 |
| 61         | 2.54  |
| 62         | 4.36  |
| 63         | 61.25 |
| 64         | 2.33  |
| 65         | 0.0002|
| 66         | 1.83  |
| 67         | 0.053 |
| 68         | 0.12087|

| Totals     | 1582.82 acres |
|           | 6.41 km²     |
|           | Average 21 acres |

All numbers rounded.

Table 28: The area of the 69 Similar Environmental Groupings identified by the intersection of three variables in the GIS.
<table>
<thead>
<tr>
<th>New SEG number Four variables</th>
<th>Old SEG number Three variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Part 1</td>
</tr>
<tr>
<td>101</td>
<td>Part 28</td>
</tr>
<tr>
<td>102</td>
<td>Part 28</td>
</tr>
<tr>
<td>103</td>
<td>Part 28</td>
</tr>
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<td>104</td>
<td>Part 12</td>
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<td>105</td>
<td>Part 12</td>
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<tr>
<td>106</td>
<td>Part 14</td>
</tr>
<tr>
<td>107</td>
<td>Part 35</td>
</tr>
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<td>108</td>
<td>Part 16</td>
</tr>
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<td>109</td>
<td>Part 17</td>
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<td>110</td>
<td>Part 39</td>
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<tr>
<td>111</td>
<td>Part 15</td>
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<td>112</td>
<td>Part 39</td>
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<td>113</td>
<td>Part 44</td>
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<td>Part 44</td>
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<td>115</td>
<td>Part 50</td>
</tr>
<tr>
<td>116</td>
<td>Part 50</td>
</tr>
<tr>
<td>117</td>
<td>All 61</td>
</tr>
</tbody>
</table>

Table 29: How the new Similar Environmental Grouping numbers based on four intersected variables relate to the portions of the old Similar Environmental Grouping numbers.
<table>
<thead>
<tr>
<th>FID</th>
<th>Area</th>
<th>New FID</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>0.002</td>
<td>116</td>
</tr>
<tr>
<td>14</td>
<td>0.28</td>
<td>114</td>
</tr>
<tr>
<td>9</td>
<td>0.41</td>
<td>109</td>
</tr>
<tr>
<td>12</td>
<td>0.61</td>
<td>112</td>
</tr>
<tr>
<td>17</td>
<td>1.56</td>
<td>117</td>
</tr>
<tr>
<td>1</td>
<td>2.15</td>
<td>101</td>
</tr>
<tr>
<td>15</td>
<td>2.18</td>
<td>115</td>
</tr>
<tr>
<td>13</td>
<td>2.60</td>
<td>113</td>
</tr>
<tr>
<td>11</td>
<td>2.95</td>
<td>111</td>
</tr>
<tr>
<td>10</td>
<td>3.61</td>
<td>110</td>
</tr>
<tr>
<td>3</td>
<td>3.65</td>
<td>103</td>
</tr>
<tr>
<td>7</td>
<td>4.56</td>
<td>107</td>
</tr>
<tr>
<td>4</td>
<td>4.88</td>
<td>104</td>
</tr>
<tr>
<td>2</td>
<td>5.40</td>
<td>102</td>
</tr>
<tr>
<td>0</td>
<td>5.50</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>6.90</td>
<td>105</td>
</tr>
<tr>
<td>6</td>
<td>11.55</td>
<td>106</td>
</tr>
<tr>
<td>8</td>
<td>20.04</td>
<td>108</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>78.9 acres</strong></td>
<td><strong>0.32 km²</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Averages 4.38 acres</strong></td>
</tr>
</tbody>
</table>

Table 30: The areas of the 18 newly identified Similar Environmental Grouping’s based on the intersection of four variables.
<table>
<thead>
<tr>
<th>Similar Environmental Grouping FID number</th>
<th>Sites within the Similar Environmental Grouping’s</th>
<th>Sites next to the Similar Environmental Grouping’s</th>
<th>Early or Middle Woodland affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
<td>FR194, 629</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>FR1922</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>FR1430</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>FR1801, 1802, 2082, 2083</td>
<td>FR2082 – Kramer Point</td>
<td></td>
</tr>
<tr>
<td>7 N</td>
<td>FR 2085 - 2087</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 N</td>
<td>FR54</td>
<td>Unnamed mound</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>FR105</td>
<td>Early Woodland</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>FR1448, 1452</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 N</td>
<td>FR536 – 542, 545, 555, 557, 566</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27 N</td>
<td>FR501</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35 S</td>
<td>FR1250, 1253, 1254</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42/43</td>
<td>FR94, 171, 178</td>
<td>FR94 – bladelets</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>FR589</td>
<td></td>
<td></td>
</tr>
<tr>
<td>61 N</td>
<td>FR286</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
<td><strong>7</strong></td>
<td><strong>4</strong></td>
</tr>
</tbody>
</table>

Table 31: Existing archaeological sites in or near the 69 Similar Environmental Grouping’s based on OAI records at SHiPO.
| Sites within Similar Environmental Grouping’s. All 33FR | Descriptions from OAI forms.  
Those marked with an * have a probable or possible affiliation with the Woodland period. |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>33FR 54</strong></td>
<td>Unknown mound, no description*</td>
</tr>
<tr>
<td>105</td>
<td>Missing OAI form – diagnostic artifacts from local collector, Mike Kish.*</td>
</tr>
<tr>
<td>501</td>
<td>Light to moderate lithic scatter</td>
</tr>
<tr>
<td>536</td>
<td>Diffuse lithic scatter</td>
</tr>
<tr>
<td>537</td>
<td>Brand Road #1-2 Diffuse lithic scatter</td>
</tr>
<tr>
<td>538</td>
<td>Brand Road #1-3 Light density lithic scatter</td>
</tr>
<tr>
<td>539</td>
<td>Brand Road #1-4 Light density lithic scatter</td>
</tr>
<tr>
<td>540</td>
<td>Brand Road #1-5 Diffuse lithic scatter</td>
</tr>
<tr>
<td>541</td>
<td>Brand Road #1A-6 Light density lithic scatter</td>
</tr>
<tr>
<td>542</td>
<td>Brand Road #1A-7 Light density lithic scatter</td>
</tr>
<tr>
<td>545</td>
<td>Brand Road #1A-10 Small lithic cluster</td>
</tr>
<tr>
<td>555</td>
<td>Brand Road #2-4 High density lithic concentration focused along prominent rise</td>
</tr>
<tr>
<td>557</td>
<td>Brand Road #2-3 Small lithic cluster</td>
</tr>
<tr>
<td>566</td>
<td>Corbin Site Moderate to high lithic scatter</td>
</tr>
<tr>
<td>1250</td>
<td>Single flake</td>
</tr>
<tr>
<td>1253</td>
<td>Single flake</td>
</tr>
<tr>
<td>1254</td>
<td>Single flake</td>
</tr>
<tr>
<td>1430</td>
<td>Small lithic cluster</td>
</tr>
<tr>
<td>1448</td>
<td>Flake fragment</td>
</tr>
<tr>
<td>1452</td>
<td>Small lithic cluster</td>
</tr>
<tr>
<td>1801</td>
<td>One flake</td>
</tr>
<tr>
<td>1802</td>
<td>Small lithic cluster</td>
</tr>
<tr>
<td>1922</td>
<td>Historic</td>
</tr>
<tr>
<td>2082</td>
<td>One point *</td>
</tr>
<tr>
<td>2083</td>
<td>Core?</td>
</tr>
<tr>
<td>2085</td>
<td>One flake</td>
</tr>
<tr>
<td>2086</td>
<td>One point</td>
</tr>
<tr>
<td>2087</td>
<td>Small lithic cluster</td>
</tr>
</tbody>
</table>

Table 32: The 28 previously known archaeological sites that fall within the 69 Similar Environmental Grouping’s.
Appendix B: Figures
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Figure 42: A stitched panoramic kite photograph taken from approximately 350 ft up the line showing the “C” enclosure as a soil drainage mark (original photographs and stitching courtesy © 2009 R. Joe Brandon).
Figure 43: The changing faces of Holder-Wright. A is from 2002 after a heavy rain and shows the “C” enclosure embankment as a soil mark (© 2010 US geological Survey, and SPOT and 2005 Google Earth ™). B is a recent image from Mapquest showing areas of standing water in the ditch areas (© 2010 Mapquest, and NAVTEQ and i-cubed.)
Figure 44: The changing faces of Holder-Wright. A shows a MORPC photograph from 1958 that shows the south-west circle, the “C” enclosure and the north-east circle quite well (arrowed). Yet in 2004, shown in B, all the site elements are barely discernable (© 2010 US Census Bureau and SPOT and Google Earth™).
Figure 45: Holder-Wright South Field with Gradiometer FM36 data collected April and May 2008. Geoplot processing with zero mean traverse, two interpolations and a low pass filter; brightness reduced and contrast increased in Adobe Photoshop CS2. Image overlay on Google earth satellite image. Areas of interest are marked with black dotted circles and lines. (Image © 2008 TeleAtlas, 2008 Google Earth™.)
Figure 46: The soil delineation at the Holder-Wright site, the circular elements are marked with white dotted circles and the “C” shaped enclosure is marked with a white arrow, the approximate position of Krumm mound is marked with a dotted arrow (this position is based on the current owners’ recollection). GwB is Glynwood silt loam, and BoB is Blount silt loam. (Image courtesy of the USDA Natural Resources Conservation Service, Web Soil Survey, National Cooperative Soil Survey).
Figure 47: A shows a contour map from the Franklin County Engineers office of the Jackson Fort site. B shows the map scaled and overlaid onto Google Earth™. (© 2009 TeleAtlas and Google Earth).
Figure 48: An aerial photograph (A) from 1938 showing the Jackson Fort site (within the area circled in white). Mill’s Atlas of 1914 (B) showing the site of Jackson Fort. (Image used with permission of Gustav’s Library).
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Path that passes through the embankment to overlook.

Figure 51: Aerial coverage from 2006 showing possible embankment outline (Image © 2009 Digital Globe, Europe Technologies and Google).
Figure 52: LiDAR data of Orange Township Works clearly showing the embankment outline (arrowed). (Data available from OGRIP, original image visualization courtesy of Jarrod Burks).
Figure 53: Orange Township works (A) as depicted in Whittlesey’s map scaled and overlaid onto Google Earth™. A possible part of the east embankment is arrowed in white. (Background image State of Ohio/OSIP, © 2009 Google Earth, Europe Technologies). B The site as depicted in Rodgers (1892). (Image clarified by Angel).
Figure 54: The half circle of Orange Township works as shown on Mill’s Atlas of 1914. (Image used with permission of Gustav’s Library).
Figure 55: The 1952 excavations at Orange Township works showing the profile of the embankment, and the color differences in the soils. (It should be noted that the colors in the photos are not exact and suffer from a phenomena known as ‘crossed curves’. That said, the relative color changes that can be seen are valid). (Image on file at the Ohio Historical Society).
Figure 56: The soil delineation at the Orange Township Works site, marked with a dotted line. GwC2 is Glynwood silt loam and LbF is Latham-Brecksville complex. (Image courtesy of the USDA Natural Resources Conservation Service, Web Soil Survey, National Cooperative Soil Survey).
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Figure 58: The original artifact drawings that accompanied Short’s report about the Spruce Run site. (Original image courtesy Peabody Museum of Archaeology and Ethnology, 79-85-10/100230.1.2).
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Figure 60: A 1951 aerial photograph scaled and overlaid onto Google earth™ showing how the flooded areas developed. (Black and White image © ODOT, background image ©2002 US Geological Survey, 2009 TeleAtlas and 2009 Google Earth).
Figure 61: Shorts’ map scaled and overlaid in Google Earth™. A shows the south circle at 300 foot diameter and B shows 300 yards between elements as indicated by the white line. (Background images same as Figure XX).
Figure 62: Earthwork symbols showing Spruce Run earthworks from Mill’s Atlas of 1914. (Image used with permission of Gustav’s Library).
Figure 63: The soil delineation at the Spruce Run site, marked with two circles and a dotted line showing the graded way (as per Short’s diagram). BeB and BeA are Bennington silt loam, and AmF is heavily sloped Amanda silt loam. (Image courtesy of the USDA Natural Resources Conservation Service, Web Soil Survey, National Cooperative Soil Survey).
Figure 64: Original plat map showing Plesenton Place and the 1.68 acre reserve (Reserve “A”, circled) put aside for Jeffers Mound. (Franklin County Recorders Office Book 40 Page 30).
Figure 65: The changing face of Worthington Works as depicted in Squier and Davis (A) 1848 and Fowke 1904  (B) (both images clarified by Angel).
Figure 66: The changing faces of Worthington Works as it appears in Rodgers (1892:46; image clarified by Angel).
Figure 67: A shows the diagram of Worthington from Fowke (1904) overlaid on the 1938 aerial photograph of the site, while B shows Fowke on the present day housing (© 2009 Google Earth and Europa Technologies)
Figure 68: A shows Jeffers Mound in an undated photograph while B is an oblique aerial from 1964. (© Images courtesy of the Ohio Historical Society).
Figure 69: Jeffers mound in 1964 (A) and 1965 (B). Portions of the embankment may exist in the yards of houses along the treeline (best seen in A). (© Images, clarified by Angel, courtesy of The Ohio Historical Society).
Figure 70: Jeffers Mound as it appeared in 2007 (A). (Image © Jules R. Angel). The various elements (B) of Worthington Works on Mill’s Atlas (1914). (Image used with permission of Gustav’s Library).
Figure 71: The original newspaper report of William McK. Heath’s excavation at Jeffers Mound (CMJ 1866).
Figure 72: An aerial photograph from 1938 showing the Worthington Works site. Jeffers mound is circled, and the other elements are arrowed.
Figure 73: The soil delineation at the Worthington site, the site is marked with a white square and two dotted line circles. BeB is Bennington silt loam. CfB and CeB are Celina soils, and HeH2 is Hennepin – Miamian soil. (Image courtesy of the USDA Natural Resources Conservation Service, Web Soil Survey, National Cooperative Soil Survey).
Figure 74: All the circular and geometric earthworks in this research shown in size order and designated by drainage.
Figure 75. Area enclosed by earthworks. Where a ditch or mound is outside the banked earthwork the covered amount of land has been added to the final total; these sites are marked by an *.
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Figure 78. Original extent of the Ohio DEM before clipping. The area clipped out and used in the analyses of Central Ohio is highlighted with the colored box.
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Figure 87: Distance to a minor water source for each site.
Figure 88: Direction to a major water source for all sites.
Figure 89: Direction to a major water source for all sites. Sites are shown inside the circle, and random points are shown outside as numbers.
Figure 90: Direction to a minor water source for each site.
Figure 91: Direction to a minor water source for each site. Sites are shown inside the circle, and random points are shown outside as numbers.
Figure 92: Known karst areas in Central Ohio with the 18 sites.
Figure 93: Distance from all the sites to karst areas.
Figure 94: Direction to karst for each site. Sites are shown inside the circle, and random points are shown outside as numbers.
Ad  Adler
Br\textsuperscript{a}  Briggsdale, western circle
Br\textsuperscript{b}  Briggsdale, eastern circle
CCC  Columbus Country Club
Dom  Dominion
Hw\textsuperscript{a}  Holder-Wright, “C” enclosure
Hw\textsuperscript{b}  Holder-Wright, southwest circle
Hw\textsuperscript{c}  Holder-Wright, northeast circle
Or  Orange Township
Sp\textsuperscript{b}  Spruce Run, north circle
Wo\textsuperscript{a}  Worthington, square enclosure
Wo\textsuperscript{b}  Worthington, north tripartite circle
Wo\textsuperscript{c}  Worthington, South circle
R0-8  Random points with randomly assigned gateways

Figure 95: Direction that gateways for all sites face. Jackson Fort and Spruce\textsuperscript{a} are not included due to incomplete date.
Figure 96: All nine known sites with the directions for gateways, and to major and minor water sources. (GW = gateway; Maj = major water; Mnr = minor water.)
Figure 96 continued

Holder – Wright\textsuperscript{b} Maj
\begin{itemize}
  \item GW
  \item Mrn
\end{itemize}

Holder – Wright\textsuperscript{c} Maj
\begin{itemize}
  \item GW
  \item Mrn
\end{itemize}

Jackson Fort
\begin{itemize}
  \item Maj
  \item Mrn
\end{itemize}

Orange Twp
\begin{itemize}
  \item Maj
  \item GW
  \item Mrn
  \item GW
\end{itemize}

Spruce Run\textsuperscript{b} Maj
\begin{itemize}
  \item GW, Mrn
\end{itemize}

Worthington\textsuperscript{a}
\begin{itemize}
  \item GW
  \item Maj
\end{itemize}

Continued
Figure 96 continued

Worthington$^b$

GW, Mnr
Maj
GW

Worthington$^c$

Mnr
GW
Maj
Figure 97. This illustrates how the 7 mile buffer for Adler fell outside of the DEM clip extent. This necessitated the buffer circle be cut out of the original Ohio DEM and the viewshed analysis was then run on the clipped buffer.
Figure 98: Viewshed area expressed in the number of pixels visible from a site.
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Figure 103: The distribution of Similar Environmental Grouping’s by their acreage. FID 17 shows the average for the entire group.
Figure 104: Showing the results of the moving kernel across the DEM clip area, and the 14 slope classes designated 0-13 (refer to Table 14 for slopes in degrees).
Focal statistics

- Slope classes 0 - 10
- 11 - 13
- Sites
- Randoms

Figure 105: Focal statistics with the areas where 11-13 slope classes (when using classes numbered 0-13) or 12-14 slope classes (when using classes numbered 1-14) occur within 1 km of a point in a roving 1 km diameter kernel.
Figure 106: Number of slope classes occurring in a 1 km roving kernel using focal statistics. The result was reclassified to show areas of the top three classes only.
Figure 107: The Similar Environmental Grouping’s of slope class, till lithology, aquifer type, and geologic setting. Not all of the 18 areas are not shown at this scale.
Figure 108: The Similar Environmental Grouping's of slope class, till lithology, aquifer type, and geologic setting. Not all of the 18 areas are shown at this scale.
Figure 109: The Similar Environmental Grouping's of slope class, till lithology, aquifer type, and geologic setting. Not all of the 18 areas are shown at this scale.
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Figure 111: SEG 3 cropped from a 1956 DOT aerial negative 651-3-13.
Figure 112: SEG 11 cropped from a 1950 DOT aerial negative 298-1-16.
Figure 113: SEG 20 from a crop of the 1938 negative BCF 1-30.
Figure 114: SEG 20 from a 2006 Google earth image. (© 2009 Europa Technologies, Google Earth)
Figure 115: SEG 20 from a 2007 Google earth image. (© 2009 State of Ohio/OSIP, Europa Technologies, Google Earth)
Figure 116: SEG 22 from a Google earth image. (© 2009 Europa Technologies, Google Earth)
Figure 117: SEG 25 from a Google earth image. (© 2009 Europa Technologies, Google Earth)
Figure 118: SEG 26 from a crop of the 1938 negative BCF 7-26.
Figure 119: SEG 26 cropped from a 1947 DOT aerial negative 100-3-11.
Figure 120: SEG 32 from a crop of the 1938 negative BCF 6-64.
Figure 121: SEG 32 cropped from a 1950 DOT aerial negative 298-1-20.
Figure 122: SEG 38 from a Google earth image. (© 2009 Google Earth).
Figure 123: SEG 50 cropped from a 1955 DOT aerial negative 621-12-85.
Figure 124: SEG 52 from a crop of the 1938 negative BCF 1-14.
Figure 125: SEG 52 cropped from a 1955 DOT aerial negative 621-15-10.
Figure 126: SEG 52 from a 2007 Google earth image. (© 2009 State of Ohio/OSIP, Europa Technologies, Google Earth)
Figure 128: SEG 63 from a 2007 Google earth image. (© 2009 State of Ohio/OSIP, Europa Technologies, Google Earth.)
Figure 129: SEG 63 from a Google earth image with vegetation signatures. (© 2009 Google Earth.)
Appendix C: Major Soil Descriptions

Description of major associations.

**Crosby  Kokomo** - On uplands, deep, nearly level with some sloping, somewhat poorly drained and very poorly drained, formed from medium textured and moderately fine textured glacial till.

**Glynwood Blount** – From fine textured till, moderately well drained to somewhat poorly drained soils on sloped and nearly flat land.

**Bennington Pewamo** - On uplands, deep, nearly level with some sloping, somewhat poorly drained and very poorly drained, formed from medium textured and moderately fine textured glacial till.

**Cardington Alexander Bennington** - Well to poorly drained, from medium to moderately fine textured till.

**Bennington Cardington Pewamo** - Ground moraine, moderately to very poorly drained soils.

**Miamian Celina** - On uplands nearly level to very steep, well drained to moderately well drained, formed from medium textured and moderately fine textured glacial till.

**Bennington Pewamo Centerburg** - Ground and end moraines, moderately to very poorly drained.

**Blount Wetzel Pewamo** - On uplands, poorly drained, formed from moderately fine textured till.

**Blount Pewamo Glynwood** - Ground moraine, moderately to very poorly drained, from till.

**Glynwood Blount Pewamo** - In ground and end moraines from till, moderately to very poorly drained.

**Kokomo Crosby Lewisburg** - On uplands, moderately to very poorly drained, formed from medium to moderately fine textured glacial till.

**Eldean Genesse Warsaw** - On outwash area, well drained moderately to coarse textured outwash and alluvial material.

**Crosby Kokomo Lewisburg** - From till, moderately to poorly drained soils.

(ODNR 1980a & b; 1981; 2001; 2002)
Appendix D: SAS Statistics Programs

An example of the two-tailed Monte Carlo test used in this research. This particular program is comparing point elevations at each of the 18 sites. For all the tests using this program different values were inserted into the line a = { } and b = { }.

```sas
proc iml;
reset noprint;
uct=0; vct=0; wct=0; xct=0;
simulation = 999;

/*--- data ---*/
a={901, 744, 769, 870, 867, 830, 921, 917, 747};
b={932, 919, 885, 920, 946, 679, 758, 829, 949};

na=nrow(a); pa=ncol(a); nb=nrow(b); pb=ncol(b);
print a, b;

/*--- means ---*/
ma = sum(a)/na;
mb = sum(b)/nb;
print ma, mb;

/*--- the statistic ---*/
t=(mb-ma);
print t;

do sim=1 to simulation;
d=j(18,1);

/*combine two matrices*/
c=a//b;
nc=nrow(c); pc=ncol(c);
/*print c;*/

/*--- randomize rows of combined matrix ---*/
/*at the end of the loop, C and D matrices will be the same. D acts as a matrix for temporary work*/
do i=1 to nc;
```
r=i+int(ranuni(0)*(nc+1-i));
x=c[r,]; /*print x*/; d[i,]=x;
c[r,]=c[i,]; /*print d*/
end;

/*--- separates total random matrix into two matrices of original size ---*/
a1=d[{1 2 3 4 5 6 7 8 9},1];
b1=d[{10 11 12 13 14 15 16 17 18},1];

/*print a1, b1;*/

/*--- means for random matrices ---*/
mal = sum(a1)/na;
mb1 = sum(b1)/nb;
/*print mal, mbl;*/

/*--- tests of random matrices ---*/
t1 =(mb1-mal); /*print t1*/;
if t1<=t then uct=uct+1;
if t1>=(-t) then vct=vct+1;
if t1>t then wct=wct+1;
if t1<(-t) then xct=xct+1;
end;

print uct vct wct xct;

quit;
A Multiple Correspondence Analysis SAS program. This particular program is comparing hydrogeologic setting and glacial lithology.

```sas
data a;
input site setting$ glacial$;
cards;
1 OWLS TSG
1 BV TSG
1 GTSH T
1 BV TSG
1 GTLS T
1 BV TSG
1 MOR T
1 AS T
1 BV T
0 GTLS TSG
0 GTLS TSG
0 GTLS FSG
0 GTSH T
0 GTLS TSG
0 BV SGF
0 BV FSG
0 GTLS TSG
0 GTLS TSG
;
proc corresp data=a observed mca;
tables site setting glacial; supplementary site;
run;
quit;
```
The MCA program in SAS for comparing hydrogeologic setting (using a different coding to the previous program) and soil drainage.

```sas
data a;
input site$ gwpp$ drain$;
cards;
A  bc SPD
B  af SPD
C  ae SPD
D  d  SPD
H  ac SPD
J  d  SPD
O  c  MWD
S  ec SPD
W  d  MWD
R0 ac VPD
R1 ac VPD
R2 ac MWD
R3 ae SPD
R4 ac VPD
R5 d  WD
R6 d SPD
R7 ac MWD
R8 ac SPD
;
proc corresp data=a observed mca;
tables site gwpp drain; supplementary site;
run;
quit;
```
The MCA program in SAS for comparing soiltype with and soil setting.

data a;
input site soiltype$ soilwhere$;
cards;
  1  SL OUT
  1  SL TP
  1  SL MOR
  1  SL MOR
  1  SL TMO
  1  SL MOR
  1  SL MOR
  1  SL TMU
  1  SL MOR
  0  SCL MOR
  0  SCL MOR
  0  CL OTMUF
  0  SL TP
  0  SL TP
  0  SL FP
  0  SL MOR
  0  SL TMO
  0  SL TP
;
proc corresp data=a observed mca;
tables site soiltype soilwhere; supplementary site;
run;
quit;
The MCA program in SAS for comparing 8 variables.

data a;
input site$ elevrangesoil$ soiltype$ soilwhere$ elevrangein$ majorsoils$ glacials glacial gwpp$ soildrain$;
cards;
  A  L  SL  OUT  HI  HMJS TSG bc SPD
  B  L  SL  TP   HI  HMJS TSG af SPD
  C  L  SL  MOR  HI  HMJS T ae SPD
  D  L  SL  MOR  HI  LMJS TSG d  SPD
  H  L  SL  TMO  HI  LMJS T ac SPD
  J  L  SL  MOR  HI  HMJS TSG d  SPD
  O  L  SL  MOR  HI  LMJS T c  MWD
  S  L  SL  MOR  HI  LMJS T ec SPD
  W  L  SLL TMU HI  LMJS T d  MWD
  R0 H  SCL MOR  LO  HMJS TSG ac VPD
  R1 H  SCL MOR  LO  HMJS TSG ac VPD
  R2 H  CL  OTMUF HI  HMJS FSG ac MWD
  R3 H  SL  TP   HI  HMJS T ae SPD
  R4 L  SL  TP   LO  LMJS TSG ac VPD
  R5 H  SL  FP   LO  LMJS SGF d  WD
  R6 L  SL  MOR  HI  HMJS FSG d  SPD
  R7 L  SL  TMO  HI  HMJS TSG ac MWD
  R8 L  SL  TP   LO  HMJS TSG ac SPD
;
proc corresp data=a observed mca;
tables site elevrangesoil soiltype soilwhere elevrangein majorsoils glacials gwpp soildrain; supplementary site;
run;
quit;