This is to certify that the
dissertation entitled

HUNTER-GATHERER CULTURAL LANDSCAPES:
A CASE STUDY FOR A GIS-BASED RECONSTRUCTION OF THE
SHELL MOUND ARCHAIC IN THE FALLS OF THE OHIO
REGION OF INDIANA AND KENTUCKY

presented by

Sarah L. Surface-Evans

has been accepted towards fulfillment
of the requirements for the

Ph.D. degree in Anthropology

Lynne Goldstein
Major Professor's Signature

June 30, 2009

Date

HUNTER-GATHERER CULTURAL LANDSCAPES:
A CASE STUDY FOR A GIS-BASED RECONSTRUCTION OF THE SHELL MOUND ARCHAIC IN THE FALLS OF THE OHIO REGION OF INDIANA AND KENTUCKY

VOLUME I

By

Sarah L. Surface-Evans

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Anthropology

2009

HUNTER-GATHERER CULTURAL LANDSCAPES: A CASE STUDY FOR A GIS-BASED RECONSTRUCTION OF THE SHELL MOUND ARCHAIC IN THE FALLS OF THE OHIO REGION OF INDIANA AND KENTUCKY

By

Sarah L Surface-Evans

Archaic shell middens are conspicuous features of the landscape in many riverine settings in the Eastern Woodlands of North America. These sites are remarkable, because they represent a shift from a previously mobile hunter-gatherer adaptation to increasing sedentism and social complexity. There are two predominant models explaining this shift in adaptation: subsistence intensification (cf. Dye 1996; Janzen 1971, 1977; McBride 2000) or mortuary/ceremonial elaboration (cf. Bender 1978; Claassen 1996; Crothers 1999; Marquardt 1985; Marquardt and Watson 1983). These models unnecessarily dichotomize the economic and social aspects of society. Alternatively, examining shell mounds in terms of the *landscape* in which they are situated provides a more complete picture of historic, social, and environmental contexts contributing to this cultural change.

As a case study, Shell Mound Archaic sites of the Falls of the Ohio region are examined from a landscape perspective. Existing archaeological and environmental data were collected and studied within a Geographic Information System (GIS) platform in order to model and reconstruct Shell Mound Archaic landscape contexts. A variety of GIS spatial analyses and spatial statistics techniques are used, including: linear distance modeling, cost-distance and corridor modeling, and nearest neighbor analysis. The results of this study suggest that shell mound locales are not randomly placed on the landscape, but represent complex relationships in both economic and social realms of the Archaic life.

In loving memory of Michael Otis Surface,

Your creative mind always inspired me to go further.

Dedicated to Sean Evans,

For your unending advice, keen observation, and love.

&

Liam Michael Evans,

Follow your dreams.

Acknowledgements

Many people have mentored me along this path or have contributed to my research. I gratefully acknowledge my committee, Drs. Lynne Goldstein, William Lovis, Alison Rautman, Alan Arbogast, and Ashton Shortridge, for their insights and comments on my research. I would like to especially thank my adviser, Dr. Goldstein, who was a sounding board for my ideas and a supportive critic when I needed it most. I appreciate tireless effort of Dr. Rautman to help me find clearer ways to present my ideas. Dr. Ashton Shortridge's invaluable guidance with GIS technology and spatial methods strengthened my research and provided inspiration for some of my analyses.

I would like to express gratitude to Dr. George Crothers of the Kentucky Office of the State Archaeologist and Dr. Rick Jones of the Indiana Department of Natural Resources, Division of Historic Preservation and Archaeology for allowing me access to site records and reports, without which this research would not be possible. Philip Mink, of the Kentucky Office of the State Archaeologist, graciously shared GIS layers of archaeological sites used in this research.

I am exceedingly grateful to my friends and colleagues who helped me in so many ways. I would like to thank Rick Burdin for so freely sharing ideas and data on the Ohio Falls Region. I am also grateful to Anne Bader and Perry Harrell, who shared their time and knowledge of Falls archaeology. Dr. Amy Hirshman gave much of her valuable time editing and discussing chapters. I must also acknowledge my family, who supported me through it all. I am particularly grateful to my husband, Sean Evans, who provided valuable insights, editorial assistance, and a listening ear.

Lastly, I would like to acknowledge that this research was partially funded by the following grants and fellowships: Michigan State University Research Enhancement Fellowship and Michigan State University Dissertation Completion Fellowship, Geological Society of America - Grants-in-Aid of Research, and Central States Anthropological Society - Leslie A. White Award.

Table of Contents

List of Tables

List of Figures

Images in this dissertation are presented in color.

CHAPTER 1

INTRODUCTION

"The large concentrations of shells on the river banks, mingled with other forms of debris of an Indian occupation site, commonly called shell mounds, are outstanding features of the river terrain" (Webb 1946:115).

WHAT IS INTERESTING ABOUT THE SHELL MOUND ARCHAIC?

A recent special issue of the *SAA Archaeological Record* (cf. Sassaman 2008) draws attention to the fact that many aspects of prehistoric social complexity observed in the United States originated amongst Archaic hunter-gatherers. Throughout the midcontinent, intensification of long-distance trade networks, mortuary elaboration, subsistence specialization, and increased sedentism can be recognized as early as the Middle Archaic period (Phillips and Brown 1983; Price and Brown 1985; Sassaman 2008). These trends are particularly notable in some portions of the rich riverine environments of the Midwest and Southeast, where archaeologists find a variety of Archaic period sites and artifacts that they define as the Shell Mound Archaic (SMA) tradition. Shell mound sites are conspicuous features of the river valleys in the midcontinent. Because of their prominence on the landscape, shell mounds have been the subject of scholarly archaeological inquiry for nearly a hundred years (eg. Moore 1916).

Webb's (1946) work in the Green River valley defined the SMA tradition based on the presence of a number of characteristics at Archaic sites: middens of freshwater mussel shell, Middle and Late Archaic side-notched and stemmed hafted bifaces, bannerstones and atlatl hooks, bone pins and awls, charred nut remains and nut-processing tools, various exotic trade items such as copper and marine shell, and human and canine burials. Since Webb's definition of the tradition, SMA research has focused on refining our understanding of many of these variables, such as the age of deposits (Janzen 1977), duration and intensity of site use (Hensley 1994; McBride 2000), the characteristics of the burial population, mortuary practices used, population demographics (cf. Buikstra and Charles 1999; Charles and Buikstra 1983; Rothschild 1979), faunal and botanical remains (Crawford 1982, 2005; Marquardt and Watson 1983; Styles 1986), composition and depositional history of the middens deposits (Stein 1980, 1992), artifact assemblage and exotic raw materials (Claassen 1996; McBride 2000; Webb 1946), and even the various species of mollusks present in midden deposits (Claassen 1986; Morey and Crothers 1998; Parmalee and Klippel 1974; Styles 1986).

Given the nature of SMA deposits, archaeologists infer that these sites represent the beginning of a shift in hunter-gatherer behavior towards practices that include subsistence intensification, increased sedentism, exchange, and mortuary elaboration (Marquardt and Watson 2005a). These changes are considered part of a larger, long-term trend towards increasing social and economic complexity in the Eastern Woodlands (Sassaman 2008). Furthermore, these "new" adaptations appear related to a shift toward an approach that includes logistical mobility in a collector strategy (cf. Binford 1980). The underlying assumption is that SMA sites are positioned on the landscape in order to maximize hunter-gatherer access to seasonally abundant and diverse resources (cf. Janzen 1977).

If this assumption is true, the relationship between economic intensification and social elaboration can be explained in terms of developing systems of exchange and social interaction among hunter-gatherer groups as they negotiate and maintain resource accessibility (e.g. Bender 1985; Bettinger 1991; Buikstra and Charles 1999; Crothers 1999). Thus, some archaeologists (cf. Crothers 1999; Marquardt and Watson 2005a) consider that SMA sites are key to 1) understanding how cultures transition from relatively mobile and non-hierarchical hunter-gatherers to so-called "complex" hunter-gatherers (Price and Brown 1985; Sassaman 2008); and 2) understanding the relationship between economic intensification and social elaboration in middle-range societies (Bender 1985; Buikstra and Charles 1999; Kelly 1995).

UNRESOLVED PROBLEMS IN SMA ARCHAEOLOGY

There are currently two unresolved problems in SMA archaeology. First, shell midden sites actually exhibit far more variability than commonly assumed, which makes it difficult to elucidate their economic and social functions within Archaic lifeways. In practice, nearly any Archaic site that has significant deposits of freshwater mollusk remains is classified as a SMA site. Such a broad definition means that "shell mounds" are often quite diverse in terms of their content, size, structure, and chronology. In fact, shell mounds exist along a continuum ranging from small, unstratified middens with predominately subsistence-related refuse to large, stratified sites with multiple burials, cultural features, and exotic trade goods.

There is currently no coherent explanation of the role of shell mounds within the Archaic settlement-subsistence patterns of the midcontinent. Shell mounds have been interpreted as: 1) residential base camps (cf. Janzen 1977; Webb 1946), 2) extraction sites (cf. Granger 1988), and alternatively, 3) ritual or community activity sites (cf. Claassen

1996). These three functional explanations reflect the variability in the nature of shell mound cultural deposits and the diverse interpretations of this variability. Each interpretation has very different implications for our understanding of the Middle to Late Archaic transition from "simple" to increasingly "complex" hunter-gatherers.

If shell mounds represent residential base camps, then this raises the question of whether they were used year-round or seasonally. The degree of sedentism is significant, because reduced mobility is one aspect of the seemingly complex array of new behaviors that emerges during the Middle to Late Archaic (cf. Brown and Vierra 1983; Charles and Buikstra 1983; Jefferies 1996b; Marquardt 1985; Price and Brown 1985). As extraction sites, shell mounds appear to represent a more mundane aspects of Archaic subsistence strategies. However, subsistence intensification, the advent of shellfishing, and the relationship of these behaviors to Hypsithermal environmental change are also significant questions in hunter-gatherer studies in North America (Claassen 1986; Morey and Crothers 1998; Parmalee and Klippel 1974; Styles 1986). Lastly, if shell mounds are interpreted as the result of feasting, community gatherings, and mortuary activities, then these activities represent a significant shift in behavior and worldview during the Middle to Late Archaic periods (cf. Charles and Buikstra 1983; Claassen 1996; Crothers 1999).

A second and interrelated problem is that previous SMA research traditionally focused on the scale of the site, dealing primarily with the observed characteristics of midden deposits. None of the previous research on the SMA tradition has taken a spatial perspective or examined site location as an expression of hunter-gatherer decision-making within a region. Previous research on SMA sites simply assumes that the Archaic hunter-gatherers employed a "positioning" strategy in which the location of sites in the landscape is specifically related to the role or function of SMA sites (i.e. base camps, extraction locales, or centers of social activity). However, no one has really tested this assumption.

It is possible to consider SMA sites within their landscape contexts because economic strategies and social organization both affect people's use of the landscape. Crothers (1999) proposed an evolutionary model for SMA sites in the Green River valley, which argued that shell mounds began as extraction sites and eventually some locales gained both economic and social importance. These sites later became base camps and/or centers for exchange and ritual (1999). If this is the case, then it should be possible to examine the landscape context in which SMA sites become something more than extraction sites and gain social importance within the SMA worldview. Thus, the above problems can be overcome by examining SMA sites from a regional landscape perspective. The focus of this research is on *developing and implementing a method to test whether SMA sites are in fact "positioned" within the landscape to access and control key resource patches.*

EXPECTATIONS FOR HUNTER-GATHERER BEHAVIOR

This dissertation examines how SMA hunter-gatherers utilize the landscape as part of their economic and social strategies. In this research I look at the relationship between landscape features and archaeological site locations to reconstruct the land use decisions made by Middle to Late Archaic peoples. Ethnographic data on hunter-gatherers provide some baseline expectations for how Archaic foragers may have chosen locales for extraction, base camps, or social centers (cf. Binford 1980, 2001; Bettinger

1991; Kelly 1995). For example, if shell mounds are interpreted primarily as extraction locales, where people came seasonally or periodically to collect and process mollusks and other freshwater resources, then we might expect that their landscape contexts should conform to the following general expectations for extractive camps (cf. Binford 1980):

1) Access to one seasonally available and extremely abundant resource
2) Frequent residential moves in a seasonal round
3) Limited visibility of site and less cultural deposits

On the other hand, if we interpret Archaic shell mounds as primarily functioning as base camps or social centers where people gather to coordinate their activities, to obtain and process a variety of resources, or even to monitor and control access to key resource zones (cf. Binford 1980, 2001; Bettinger 1991; Kelly 1995), then we expect that their landscape contexts will exhibit different characteristics. According to these ideas, we might then expect to see:

1) Access to multiple resource zones or points of interest within a daily foraging area (e.g. physiographic zones, water features, and chert sources)
2) High resource abundance (although resources may be seasonal)
3) Reduced mobility and fewer residential moves per year
4) Limited competition from other groups of hunter-gatherers
5) Evidence for "marking" and maintaining territories

These two different strategies considered here are heuristic devises, that is, generalized land use strategies that likely form the boundary conditions of a complex range of variables. It is highly unlikely that study of the landscape of SMA sites will show that Archaic hunter-gatherers adhered exactly to one or the other of these idealized scenarios. Rather, these expectations are presented as generalized or idealized models based on ethnographic evidence of hunter-gatherer land-use under modern environmental and social conditions. Archaic hunter-gatherers will likely exhibit a unique combination of these strategies due to temporal and spatial variation in factors such as climate, resources, technology, social organization, and politics. However, these models help focus attention on which variables might best help us understand Archaic people's use of the landscape, and gives us a perspective to evaluate the significance and meaning of the archaeological data. Each of these idealized expectations can be evaluated by reconstructing the spatial configuration of SMA sites in their landscape setting, and by specifying the role of these variables in the overall subsistence and settlement system.

RESEARCH QUESTIONS AND SMA EXPECTATIONS

This research is comprised of several stages of analysis. First, the location of shell mounds and their local environmental contexts is reconstructed. The general question guiding this stage of the research is *what are the landscape characteristics at shell mound locales*? The goal of this stage of the research is to reconstruct the environmental contexts of SMA sites. Based on the ethnographic data (Bettinger 1991; Binford 2001; Kelly 1995), I expect that Middle to Late Archaic peoples are selecting locations for SMA sites based on proximity to multiple ecological or physiographic zones, geologic units containing lithic resources for tool manufacturing, and highly productive riverine, wetland, or spring settings. I will test this expectation by reconstructing the environmental conditions at and surrounding SMA sites and by looking for patterning within these contexts.

Second, I will examine how resources and other SMA sites are accessible from each other. This aspect of the research is focused on the broad question *what is the relationship of SMA sites with other features of the landscape and how are they accessible?* If, as argued above, the accessibility of different locales represents a critical variable for hunter-gatherer decision-making, then I expect that SMA sites will occur in areas with high access to resources needed for food collection and production of tool technologies. Because SMA sites are one component of a broader settlement territory, I also anticipate that SMA sites will be accessible to each other. I will test these general expectations using several measures of accessibility, including: site-catchments, cost pathways, and cost corridors. The accessibility portion of this research goes beyond reconstructing static environmental contexts to modeling how people moved in the landscape. Specifically, the goal is to develop a strategy for simulating hunter-gatherer movement and land use patterns within the reconstructed landscape.

In the course of modeling these land use patterns, I also address a methodological question, *what is the most productive and efficient resolution of analysis when modeling hunter-gatherer movement*? I modeled cost-weighted pathways and corridors between SMA sites at two different levels of resolution. This methodological issue also yielded information that contributes to a more nuanced understanding of the role of data resolution in computer-aided modeling of human settlement and land use behavior.

Reconstructing the past SMA landscape will be accomplished through a combination of exploratory analysis, modeling, and spatial statistics. The majority of this research is conducted in a Geographic Information Science (GIS) platform. As an analytical tool, GIS allows hypothetical spatial reconstruction of SMA sites in their environmental and cultural contexts. Another asset of conducting analysis with GIS is that it is possible to shift between scales of inquiry. Therefore, GIS allows both local-level and regional-level contexts of SMA sites to be examined.

MODELS OF LAND USE AND ACCESSIBILITY

Modeling of hunter-gatherer land use during the Shell Mound Archaic necessarily involves evaluation of the natural, as well as social features of the landscape. The variables of site spatial location vis-à-vis other sites and in relationship to natural features are therefore of paramount importance. These variables allow us to model land use and accessibility, the local contexts of SMA sites, their surroundings, and the ease in which people can move through a given terrain. The model that I develop here focuses on addressing these general variables in greater detail. Specifically, this research uses several modeling techniques to explore the following six questions.

#1 – Are there common spatial characteristics shared by SMA site locales? This issue is important because there is a direct relationship between the function of SMA sites and their placement on the landscape. The immediate environmental context of SMA sites was reconstructed and the accessibility of resources was evaluated with site-catchments. From these contexts, it appears that SMA sites conform to the expectations for residential base camps, not extraction locales. That is, most SMA sites have access to multiple ecological zones and abundant resources.

#2 – Is there a better way to model accessibility to resources and other sites on the landscape than catchment analysis? In this research I model accessibility with site-catchment analysis (cf. Vita-Finzi and Higgs 1970) and cost-weighted corridors. Archaeologists often use catchment analysis to quantify the resources within site use-areas (Kelly 1995). Cost-weighted modeling is a relatively new method in archaeology for reconstructing accessibility that is based on the relative costs of moving through a landscape (cf. Kantner 1996; White 2007). The advantage of this type of modeling is that it provides a more realistic picture of hypothetical human movement patterns. I expected that site-catchments would be simplistic, when compared to cost-weighted models. The results of this research determined that site-catchment analysis is suitable for monitoring static ecological conditions, but falls short of quantifying human features of the landscape – e.g. other SMA sites.

#3 – What is the spatial relationship of shell mound sites to each other? Are they highly accessible to one another? SMA sites are expected to be accessible to each other because each site is one component of a seasonal or annual round. Inter-site accessibility and mobility was examined through a combination of catchment analysis, cost-weighted corridor and pathway modeling, and cluster analysis. Catchment analysis and cost-weighted corridors determined that multiple SMA sites generally fall within a daily foraging area. This result caused me to explore the patterning of SMA sites in more detail through Kernel Density Estimation and Nearest Neighbor clustering algorithms. These techniques determined that SMA sites are clustered at different geographic scales. Shell mounds appear to cluster at distances of 2.5 km, 6 km, and 17.5 km. Differences in the scale of clusters may be due to both ecological and social variables. For example, because mollusk reproductive patterns require time for populations to rebound, SMA peoples would have had to frequently vary where they extracted these resources. This may account for the small-scale clusters.

#4 – How do the SMA site clusters differ from one another? Understanding the similarities and differences between site clusters can help inform interpretations of why clustering occurs. Site clusters were examined statistically to compare their relative accessibility to ecological resources and other SMA sites. Large-scale clusters appear related to regional differences in landscape configuration. The temporal range of sites within clusters was also examined in order to determine whether clusters were used similarly over the entire duration of the SMA tradition. At both the large- and small-scales, clusters appear to be utilized throughout the Middle and Late Archaic periods, spanning the SMA tradition. The presence of sites that include multiple SMA components in each cluster indicates that some locales were significant to the SMA peoples. Perhaps these sites attained socio-political importance, as predicted by Crother's (1999) evolutionary model.

#5 – Can pathways between SMA sites predict probable locations of non-shell mound Middle-Late Archaic sites? Cost-weighted pathways are an indicator of ease of access. Therefore, locations where predicted pathways often intersect or converge should represent areas of intense use by SMA peoples. I used the locations of cost-weighted pathways to develop a predictive model of other Middle to Late Archaic sites that comprise the SMA landscape. This issue has significant ramifications, because Middle to Late Archaic settlement patterns in the uplands are poorly examined and understood in many areas of the mid-continent. I expect that areas of heavy travel should be associated with other components of the Middle to Late Archaic settlement landscape. I tested the model in a limited fashion and found that sites frequently occur where pathways predict heavy travel.

#6 – Does more detail (higher resolution) in the modeling universe make any difference in monitoring accessibility determined through cost-weighted modeling? Pathway and corridor modeling was conducted at two spatial resolutions: 10 m and 90 m. I expected that resolution would have a significant impact on the accuracy of hypothetical models. However, there was no significant difference between the results of the 10 m and 90 m models. This finding is significant, because it indicates that high-resolution models are not always worth the extra time and effort.

#7 – How does the modeling algorithm affect the outcome of least-cost pathways and corridors? This question explores the methodological issue of whether model algorithms will influence the hypothetical pathways and corridors developed. Specifically, I will compare Waldo Tobler's hiking function (Tobler 1991) with the built-in least-cost algorithm in ArcGIS. The results of this analysis indicate that different model algorithm produce different outcomes. This serves as a caution to archaeologist using these methods and suggests that researchers should use an exploratory technique to determine which algorithm is best suited for their landscape and archaeological culture.

THE CASE STUDY

The Shell Mound Archaic (SMA) sites of the central Ohio River valley are the particular case study for this research. The Falls of the Ohio River region is situated approximately 120 miles upriver from the confluence of the Green and Ohio Rivers (Figure 1.1). The Falls region is ideal for this study because a large database of existing archaeological site data is available. Of the more than 800 documented Archaic sites (Burdin 1998), a total of twenty-nine are SMA sites (Figure 1.2). Falls region shell mounds date between cal 7173 to 5036 BP, roughly corresponding to the Old Clarksville, French Lick, and Lone Hill phases of the Middle and Late Archaic periods, as defined by Granger (1988), and Munson and Cook (1980). Falls shell mound sites display the same

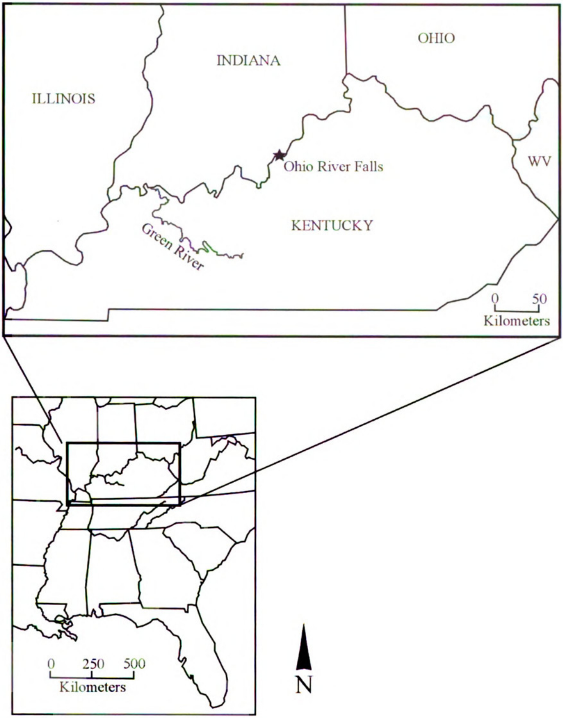


Figure 1.1. Map of the United States midcontinent showing the proximity of the Ohio Falls and Green River Shell Mound Archaic regions.

Figure 1.2. Photograph of a portion of the Breeden Shell Midden (12-Hr-11) exposed in the eroding riverbank in Harrison County, Indiana. Photograph taken by the author in June 1999 (In color).

degree of variation seen elsewhere in the midcontinent; they range from large stratified mounds to small shell lenses within rock and earth middens.

Unfortunately, few archaeological excavations have been conducted at the Falls SMA sites. The SMA dataset acquired for the Falls region has remained unexamined up to this point because most sites were not excavated by professionals, some sites have been destroyed, and the site-level data available is highly variable. However, the methods used in this research can overcome these difficulties to conduct meaningful analysis on the spatial attributes of existing site records.

ORGANIZATION OF DISSERTATION

This dissertation research is presented in the following chapters. In Chapter 2, I provide historical background on SMA archaeology, with an emphasis on the Green River Valley. This discussion places the current research within context and provides a rationale for the alternative research strategy employed in this dissertation. Chapter 3 presents the research paradigm of landscape archaeology, where I review research themes in landscape archaeology and describe how my research benefits from this perspective. I also discuss the interface between landscape theory and GIS methodologies.

Chapters 4 through 6 introduce the research area. Specifically, the physiography (Chapter 4), geoarchaeology (Chapter 5), and Archaic Period research (Chapter 6) of the Falls region are presented. Together, these chapters paint a picture of the Ohio Falls landscape. Chapter 4 describes the development of the Ohio River in the Falls region, as well as the diverse physiographic zones that comprise this region. Chapter 5 provides a discussion of geoarchaeological research in the Falls region and how this has contributed to our understanding of site bias in the study region. Chapter 6 is an overview of Archaic period research and cultural phases in the Ohio Falls region. In chapter 6, I also discuss the available data from excavated SMA sites in the study area, including the temporal ranges of sites.

In Chapter 7 I review the methodological strategies used in this research. I discuss how the archaeological and environmental databases were created, as well as the methods for 1) recreating site contexts, and 2) modeling movement in the SMA landscape. Chapter 8 is a discussion of the results of questions 1 through 4, including site-level reconstructions, catchment analysis, and linear distance studies. As foreshadowed above, the results of this research determine that SMA sites are not randomly placed on the landscape, but represent a positioning strategy that suggests at least some SMA sites became base camps with significance in the social lives of Archaic peoples. Chapter 9 discusses the results of questions 5 through 7, concerning the cost-weighted pathway and corridor modeling. I also compare and contrast cost-weighted models conducted using different spatial resolutions and modeling algorithms. In Chapter 10 I summarize the results of each of the research questions, as well as the contributions of my research and some future research directions.

CHAPTER 2

HISTORICAL SKETCH OF SMA RESEARCH IN THE GREEN RIVER VALLEY

"The Green River Shell Mound Archaic (SMA) is like a precious and hallowed old scripture – a multi-authored text that lends itself to multiple interpretations" (Marquardt and Watson 2005b:629).

INTRODUCTION

The Shell Mound Archaic (SMA) tradition of the North American mid-continent covers a large area from the Mississippi valley, east to the central Ohio Valley and from the southern Great Lakes, south to the Tennessee valley (Figure 2.1). Ever since shell mounds were first noted in the major river valleys of the mid-continent, they have been considered unusual archaeological features and indicative of significant cultural changes (cf. Moore 1916). This chapter discusses the development of SMA research, with a special focus on the Green River Valley "heartland" of western Kentucky. As the above quotation from Marquardt and Watson (2005b) indicates, SMA sites in the Green River valley are intensively studied, yet there is little consensus. The historical development of Green River SMA archaeology has profoundly affected archaeological interpretations of the SMA phenomenon throughout the Eastern Woodlands, including my research area. This chapter is meant to provide a brief background to contextualize this research in the Ohio River valley and is by no means an exhaustive discussion of the Green River SMA. Additional detailed summaries of SMA research in the Green River valley can be found in Crothers (1999), Hensley (1994), McBride (2000), and Watson and Marquardt (2005).

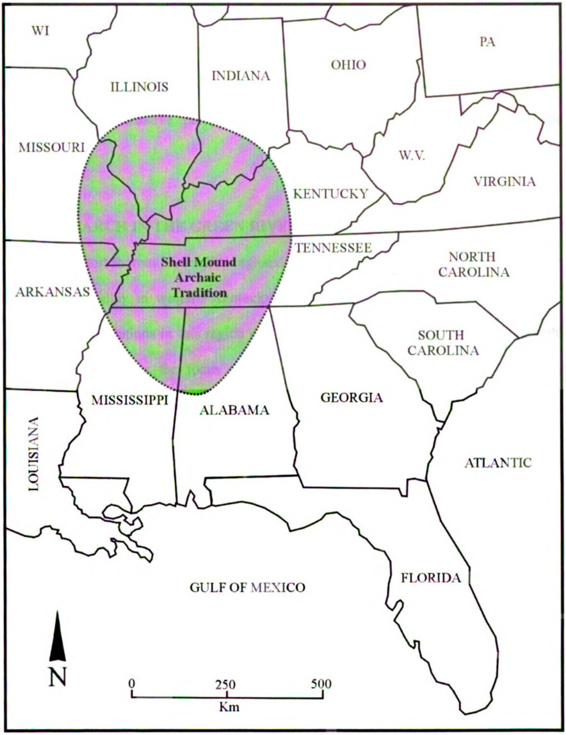


Figure 2.1. Map showing the distribution of riverine SMA sites in the United States midcontinent.

I will also discuss the difficulties associated with interpreting the variability observed in SMA sites and critique previous models. In particular, previous researchers do not account for the variability observed in SMA sites. This oversight is one argument for developing an alternative perspective for studying the SMA based in landscape archaeology.

SMA RESEARCH IN THE GREEN RIVER "HEARTLAND"

The most thoroughly studied regional expression of Archaic shell mounding is the Green River valley in western Kentucky (Figure 2.2). Consequently, reviewing the history of investigations in this region contextualize the current status of SMA research. The Green River was the focus of intensive SMA investigations due to the early exploration of shell mounds (cf. Funkhouser and Webb 1932; Moore 1916) and the high density of these sites in the middle Green River valley (Crothers 1999).

The first excavation of the Green River SMA sites was conducted by C. B. Moore in 1915 (McBride 2000; Moore 1916). He examined five Archaic shell midden sites, but conducted the most extensive excavations at Indian Knoll (15-Oh-2). During nine weeks of investigation at Indian Knoll, 298 burials were excavated. Nearly half (n=148) of the burials included grave goods (Moore 1916: 445). One of Moore's significant contributions was the documentation of these burials and the contexts of their associated cultural materials. Moore described the type of burial interments, the apparent age of individuals, and the type and location of grave goods. In his research, he documented numerous types of artifacts from shell midden deposits including: stemmed and corner-notched hafted bifaces, grooved axes, nutting stones, pestles, bone awls and pins, bone

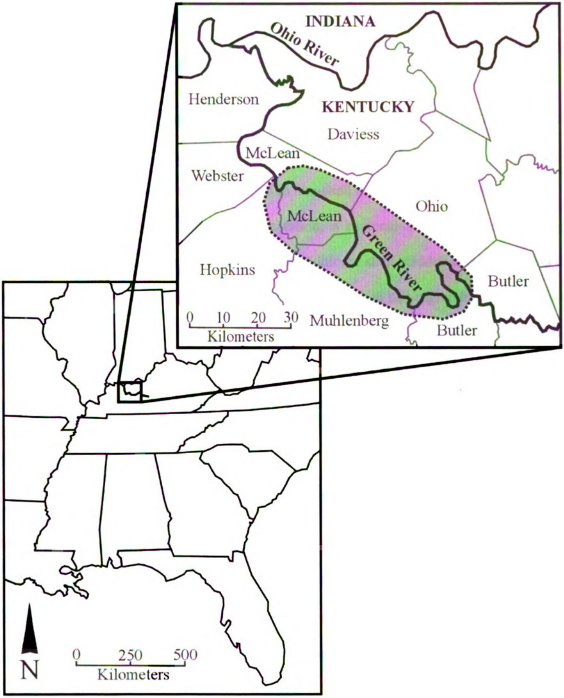


Figure 2.2. Map showing the distribution of SMA sites in Kentucky counties and the location of the Green River valley in the southeastern United States.

fishhooks, freshwater and marine shell beads, shell gorgets, perforated wolf and bear canines, bannerstones, and bone atlatl hooks (Moore 1916). In addition, Moore also described several instances of violence at Indian Knoll, such as trauma to the skull and an antler projectile point imbedded in a vertebra (cf. Moore 1916: 469, 473). Moore recognized that the cultural materials recovered from shell midden sites were unparalleled in their preservation compared to non-shell midden sites in the region.

Following Moore's initial documentation, a regional survey of Kentucky by Funkhouser and Webb (1932) documented 21 additional shell midden sites in the Green River valley. The identification of so many shell mounds in this region brought national archaeological attention to the Green River valley. It was also during these investigations that Funkhouser and Webb (1932) first suggested that shell mounds might represent semi-sedentary populations, an important observation that has become a working hypothesis in SMA research.

The first extensive research on SMA sites in the Green River valley occurred as Works Progress Administration (WPA) projects in the 1930's and 40's (Crothers 1999; Hensley 1994; McBride 2000). Webb initiated numerous WPA projects in the Green River valley of Kentucky in 1937 (Crothers 1999). A total of nine shell mound sites were excavated during these investigations. Careful analyses and detailed descriptions of cultural materials from large shell mound sites, such as Indian Knoll (15-Oh-2), Calston Annis (15-Bt-5), and Read (15-Bt-10), allowed Webb (1946, 1950) to summarize a suite of characteristics for this region and define the SMA tradition.

Another significant observation made by Webb was the recognition that *non-shell* bearing Archaic midden sites may also be part of the same cultural complex as SMA sites

(Webb 1946). Webb studied at least seven other non-shell midden Archaic period sites that shared traits with SMA sites, such as flexed human burials with grave goods. It is not surprising that Webb viewed these large Archaic sites (both shell-bearing and non-shell-bearing) as indicative of a shift towards sedentism, given the density of burials and their associated grave goods.

Nearly three decades later, Patty Jo Watson and her students began long-term investigations in the Green River valley. Watson's research of Archaic shell mounds started as a search to find the antecedents of Woodland horticulture in the Eastern Woodlands (Marquardt and Watson 1983). The SMA was a logical choice for looking at the origins of horticulture, given that shell mound sites were generally accepted to be indicative of increasing complexity and sedentism. Together with William Marquardt, Watson initiated the Shell Mound Archaeological Project (SMAP) in 1971 (Watson 1996; Watson and Marquardt 2005). Research conducted by SMAP included systematic excavation and a wide range of specialized studies to examine paleoenvironment, formation processes, and seasonality of shell mounds. Some of their research is discussed below (Marquardt and Watson 1983, 2005a).

The first work of SMAP was to recover and analyze archeobotanical remains (Crawford 1982, 2005; Marquardt and Watson 1983; Watson 1996). Considerable subsistence data was collected and studied in at the Carlston Annis and Bowles shell middens. At these sites approximately 90 percent of the botanical remains were comprised of nutshell including hickory and acorn (Crawford 1982, 2005). Other wild collected plants included blackberry, grape, honey locust, knotweed, persimmon, and various grass species (Crawford 2005; Marquardt and Watson 1983). Surprisingly, little evidence for horticulture was recovered, with the only cultigens consisting of 13 fragments of *Cucurbita* rind (Crawford 2005). A single *Chenopodium* seed was also recovered from Carlston Annis that appears "intermediate between domesticated and wild" (Crawford 2005: 181). The results of these studies suggest a Middle to Late Archaic subsistence pattern with specific botanical species targeted such as nut mast and seasonally available fruits (Crawford 2005). With this information, the SMA focus on freshwater mussel procurement looks less mysterious and more like a part of an overall system of *intensified* subsistence procurement.

The next phase of SMAP research focused on developing an understanding of how shell mounds were created (Watson and Marquardt 2005). Julie Stein undertook this work in the late 1970's. Stein (1980) conducted detailed geoarchaeological research at the Carlston Annis site in order to "identify the natural and cultural processes responsible for the formation" of the shell mound (Stein 1980:200). Her research determined that shell mound sites in the Green River valley were characterized by considerable post-depositional mixing, which largely obscure the cultural mechanisms of site formation (Stein 1980). The degree of post-depositional disturbances at shell mound sites explains why many of these sites lack clear stratigraphy. Stein's work clearly demonstrates the difficulties in interpreting Archaic behavior from these complex deposits.

Stein (2005) also examined local environmental characteristics of the Green River valley in order to locate prehistoric shell sources. While it is extremely difficult to reconstruct ancient river-channel configurations, Stein (2005) argued that mussel species likely came from rock outcrops, point bars, and riverbanks. According to Stein the relatively widespread nature of mussels prehistorically suggests "the shellfish beds themselves were not the only factors contributing to site location" (Stein 2005: 128). Stein's insight contribute to my approach of studying the spatial characteristics of shell mounds within the landscape. Based on her work, I also assume that shellfish were fairly ubiquitous in the larger streams and rivers of the midcontinent.

Marquardt conducted excavations at several Green River shell mounds throughout the 1970's (Watson and Marquardt 2005). One issue that Marquardt (1985) explored is the relationship between social differentiation and exchange networks among the Green River shell mounds. Using patterns of exotic goods in mortuary contexts, Marquardt (1985) proposed that there were changing patterns of interregional access to information and resources during the Middle to Late Archaic. He also argued that mortuary items indicate change in the relationship between religious-political and economic-technological aspects of society, in which some achieved social differences were marked by materials goods at death (Marquardt 1985).

For example, Marquardt (1985) proposed that individuals who traveled and participated in interregional exchange may have possessed information and exotic goods that increased their status. In turn, such individuals may have served as leaders among their people because they had the knowledge "that leads to local group prosperity" (Marquardt 1985: 81). In this manner, local groups varied in their regional status based on control of information. Marquardt (1985) suggested that the SMA were not complex in terms of hierarchy, but by political organization and esoteric knowledge of ecology and other regions.

Nan Rothschild (1979) also finds evidence for rudimentary inequality among SMA peoples based on analyses of exotic goods in mortuary contexts. She compared mortuary data from Indian Knoll with the Mississippian period Dickson Mounds (Rothschild 1979). Her expectations were that the Archaic burials would be egalitarian in their organization and the Mississippian burials hierarchical (Rothschild 1979). However, the results of her study suggest that the SMA were not entirely egalitarian. Rothschild observed two social groups among adult males, defined by 1) higher occurrences of tools and 2) items of adornment, within the sample population at Indian Knoll (Rothschild 1979). These two groups could indicate differences in achieved status during life. Distinctions were also made between the sexes, as females were less likely to have grave goods. However, male child burials do contain grave goods, and can be distinguished by the same clusters as adult males. Like Marquardt, Rothchild viewed the SMA as moving towards complexity on a continuum from simple to complex.

> The information on social organization yielded in this study supports the growing body of data in anthropology and archaeology that contravenes earlier normative models of social systems as either simple or complex, depending on whether they collected or produced food (Rothschild 1979: 673).

The work of Marquardt and Rothschild helps to clarify the burgeoning social complexity of the SMA and provides a picture of how it was expressed. However, Marquardt and Watson (2005b) argue that the SMA must be viewed from a "definition of complexity that includes aspects of differentiation and integration" (637). They see no evidence for ascribed status among the Green River SMA in the mortuary data. Rather, they propose that differences marked at death were from achieved distinctions in life, for example as healers, story-tellers, hunters, warriors, or traders. These categories may be archaeologically visible in the types of grave goods associated with burials.

In the 1980's Cheryl Claassen conducted a study of the seasonality of shellfish collection at the DeWeese and Carlston Annis shell mounds, as well as other SMA sites in Ohio, Georgia, and Texas (Claassen 1986, 2005). Her research focused on examining the role of shell mounds within Archaic subsistence and settlement strategies. Claassen (1986) determined that mussels were collected in spring through fall at the Green River sites based on growth lines from shell samples. Shellfish collection during the warm season also corresponds with the fast growth period for most mussel species (Claassen 1986). Claassen (2005) provided a detailed discussion of the seasonality data from over 2 m of deposits at the DeWeese mound. She noted that shellfish in midden deposits had an alternating pattern of fast and slow growth seasons. Claassen argues, "each time a fast death proportion falls below 50 percent, a new shellfishing season has commenced" (2005: 290). Claassen identified a minimum of 5 shellfishing seasons at the DeWeese Mound (Claassen 2005). Claassen's study has the potential to clarify the duration and intensity of SMA occupation at shell mounds, which, as Stein (1980; 2005) previously discovered, can be difficult to ascertain from depositional strata alone. For example, at the DeWeese mound, significant deposits resulted from relatively few collection episodes.

Claassen (2005) also made a case for using seasonality data to understand why shellfishing was eventually abandoned at SMA sites. She proposed that cessation of shellfishing may be related to a shift to another food source that posed a seasonal scheduling conflict with shellfishing during the warm months (Claassen 2005). According to Claassen, if this is the case, then the end of SMA adaptations may be associated with the advent of horticulture. Claassen (1996) also proposed that the development of shell mounding is a social phenomenon related to repeated ceremonial use of locales. She argued that Archaic shell and earthen mound construction was part of a strategy related to exchange and mortuary activities (Claassen 1996). While Claassen's model is interesting, it does not explain *why* shell mounding was necessaily associated with mortuary activities. In addition, there has yet to be any strong evidence to support a model of horticulture replacing shell fishing (ie. Crawford 2005).

Research conducted in the late 1980's and early 1990's by Christine Hensley investigated the contemporaneity of non-shell-bearing middens and SMA sites in the Green River valley (Hensley 1994, 1991, 1988). Her research was aimed at understanding the relationship between shell middens and non-shell or "dirt mounds" within Archaic settlement-subsistence patterns. Her primary objective was to collect botanical materials from non-shell midden sites in order to evaluate Bruce Smith's (1987) model of plant domestication and sedentism (Hensley 1988).

Like previous studies (eg. Crawford 2005), Hensley found little evidence for cultigens at the Green River Archaic sites. Consequently, she relied on the structure of deposits to determine site function. Hensley (1994) identified several different types of Archaic sites within the Green River study area including: floodplain and upland lithic scatters, rockshelters, upland camps, shell middens, and earth-rock middens. In her comparison of shell- and earthen-middens, Hensley noted considerable variability in shell density of so-called "shell midden" sites. Shell is absent in some sites and is extremely abundant in others (Hensley 1994). Some sites even had discrete lenses of shell within a largely dirt or rock midden. According to Hensley, some shell middens and adjacent non-shell middens were assigned separate site numbers in Kentucky (1994:230). The exclusion of non-shell middens from the SMA component seems to indicate a general lack of understanding of the Archaic settlement structure and land use.

Hensley also identified variation in burial density, burial placement, paleodemography, feature density, and artifact density among both shell midden and earth-rock shell midden sites. She interpreted differences between midden sites as a result of differing site function (Hensley 1994). It is important to note that she argued that *functional differences do not strictly separate shell and non-shell midden sites.* Rather, she determined that six shell mounds and one non-shell earthen-midden have characteristics of residential base camps or long-term seasonal sites (Hensley 1994:239). These "long-term base camp" sites also had significant mortuary components. Hensley additionally argued that several small shell middens, which lacked extensive mortuary components were short-term base camps or extractive sites (Hensley 1994).

Hensley's research is extremely insightful because it explored the variation within shell mounds and compared them with other components of the Archaic settlement-subsistence system. In doing so, she found that shell mounds are not restricted to one "function", but may be either long-term base camps or short-term residential camps. Her research also demonstrated that shell-mounding behavior is not necessarily connected to mortuary activities (*contra* Claassen 1996). Rather, Hensley (1994) found that mortuary activities were a marker of long-term base camps, regardless of shell content. My research explores the extent to which such functional differences may be visible through regional-scale landscape configuration.

In the 1990's, research by Crothers (1999) examined the possible role of SMA sites in social activities such as trade and feasting. He conducted an analysis of shell midden components, the vertical distribution of materials within the midden, and the vertebrate faunal remains at the DeWeese and Haynes shell mounds. His most significant finding was related to the distribution of shell in the midden profiles. Crothers (1999) found that all midden components, excluding shell, were randomly distributed. Shellfish remains, however, varied in their distribution by level (Crothers 1999). Initially shellfish was abundant at both sites. In the middle levels, shell decreased at Haynes and peaked at Deweese. In the upper levels of the middens shell decreased at Deweese and increased at Haynes. Shellfish deposits also appeared independent of other midden contents. Based on these observed patterns, Crothers proposed that shell midden sites were being utilized regardless of whether shellfishing was taking place (1999).

Crothers (1999) argued that the key to understanding shell mound sites is the notion of property rights. He proposed that rights to resource-rich shellfish locales were negotiated through a dynamic process of interaction between mobility, kinship, exchange, and social alliances. Over time, shell mound sites "became venerated, and continued to be important, independent of their yields in shellfish" (Crothers 1999:iii). In other words, Crothers argued that shell mound locales were originally associated with subsistence-related activities, but gradually gained social-political significance through time.

Crothers' model provides an explanation for why SMA sites vary in size, structure, and content (as noted by Hensley), as well as a mechanism for how short-term camps became long-term camps. Crothers' view of SMA sites is based on considering the relationship of both environmental contexts and internal social processes on cultural change. Such a dynamic model begins to shed light on the complex and variable nature of these sites within Archaic lifeways and is a perspective that I incorporate into my research.

In 2000, John McBride completed a reanalysis of WPA era excavation materials and records from the Baker site. This site is the only documented single component late Middle Archaic period site in the Green River valley (McBride 2000). As such, it offered an opportunity to examine late Middle Archaic adaptations and compare them with multicomponent Archaic sites in the region. McBride (2000) evaluated whether the Baker site best fit expectations for an extractive camp, base camp, or residential camp as defined by Carlson (1979). Carlson proposed these settlement types using 1) population composition, 2) range of activities performed at the site, 3) subsistence strategy, and 4) duration of occupation. To briefly summarize the Carlson model expectations, base camps should have evidence for diverse resource exploitation, multiple activities, reoccupation, and be occupied by macrobands. Residential camps are similar to bases, but are less likely reoccupied. Extraction camps have evidence for a limited variety of resources, restricted activities, are occupied by specific members of a band, and are not likely to be reoccupied unless located at an important resource.

To examine the Baker site, McBride conducted a functional study of artifacts (via use-wear analysis) and examined their spatial patterning within the site using the data available from WPA excavation notes. He determined that the Baker site does not fit easily into the settlement types proposed by Carlson. Rather, the Baker shell midden has characteristics of both a base camp and a residential camp (McBride 2000). He proposed that Baker may represent an intermediate type of site between residential and base camps. If this is the case, then change in mobility strategies is more gradual in the Green River valley than at the Koster site where Carlson developed his model (McBride 2000). These results are support Crother's evolutionary model of SMA site development and function.

McBride's study, while limited in scope, has two important contributions. First, it established the utility of revisiting materials from previously excavated sites. Second, it demonstrated that some of the variation observed in shell mounds may be temporal in nature. In other words, the type of settlement or occupation expressed at shell mound sites may vary through time. Between Middle to Late Archaic periods shell mounds may have shifted from extraction locales, to residential camps, and eventually some sites became longer-term base camps. McBride's (2000), Crothers' (1999), and Hensley's (1994) research demonstrates that shell mounds are not a uniform "type" of site, but vary in function and usage through time and space. Therefore, temporal variation in SMA sites may be the key to understanding the complex roles these sites had within Middle to Late Archaic lifeways.

Summary of What is Known about the SMA from the Green River

Marquardt and Watson (2005b) concisely summarize our present archaeological understanding of SMA sites in their recent edited volume on the Green River. The SMA sites are a "riverside" component of Middle to Late Archaic settlement and subsistence strategy (Marquardt and Watson 2005b). Other Middle to Late Archaic sites in the Green River landscape include: rock shelters, ephemeral camps, and extraction loci. Despite expectations, shell mound sites have not produced data on the origins of agriculture in the Eastern Woodlands (Marquardt and Watson 2005b). Surprisingly, mussel shell is not typically the dominant content in SMA deposits. Rather, fire-cracked-rock, bone, floral remains, and organic-rich earthen midden are also significant deposits at SMA sites.

SMA peoples in the Green River were hunters, fishes, gatherers, and to a limited extent gardeners (Marquardt and Watson 2005b). Riverine resources were commonly exploited at these sites, as well as a variety of small and large land animals and numerous nut, fruit, and seed plants. Shell mounds may have been seasonally occupied in the summer and fall, based on studies of floral and faunal remains. Marquardt and Watson (2005b) propose that communities dispersed into the uplands during winter and spring. It is possible that this pattern of dispersal contributed to intercommunity violence observed in the skeletal record, when groups competed for access to summer shellfishing locales. Traditions of exchange and inter-group interaction, as observed from exotic items (e.g. marine shell and copper) likely developed out of the need for communities to negotiate rights of access to preferred summer campsites (Burdin 2004; Crothers 1999; Jefferies 1997).

While SMA sites appear to have been occupied long enough to construct shelters, there is little archaeological evidence for structures and formal hearths. The lack of structural features may be the result of continual site re-use and a variety of natural and human factors that contributed to the mixing of deposits at SMA sites. At some shell middens, SMA peoples buried their dead in flexed and semi-flexed positions. Accord to Marquardt and Watson (2005b) grave goods were included in approximately one-third of burials. Grave goods included items of adornment, as well as utilitarian goods and possible shamanistic or ritual items. While grave goods vary by sex and age, it does not appear that SMA peoples had hierarchical or inherited status. Rather, grave goods indicate possible achieved distinctions, particularly among adult males.

Comparison of the Green River SMA patterns to SMA research elsewhere in the midcontinent, suggests that similar trends existed in other river valleys. It is likely that similar patterns occurred in the Ohio Falls region, where this dissertation research is focused.

ADDRESSING VARIATION IN SMA SITES

In many ways, previous research conducted on the Green River SMA has posed more questions than it has answered, particularly as research uncovered more evidence for variability between sites. Traditionally, shell mounds are defined as those sites containing middens or lenses of freshwater mussel shell. Yet, shellfish are rarely the dominant component within midden deposits (Hensley 1994; Stein 2005). Moreover, research by Hensley (1994: 229) and McBride (2000) points out that there tends to be more differences between shell mound sites than similarities. The emphasis on shell obscures the interesting variation in behavior at these sites.

One significant source of variation in shell mounds is the temporal range of these sites between regions. In some regions, Archaic shell mounds are considered primarily late Middle Archaic occupations, while in other areas shell mounds are considered Late Archaic. For example, large shell and earthen middens in the Green River valley primarily date between 6,600 and 3,400 calibrated years BP (Watson and Marquardt 2005b). In the Tennessee valley, shell mounds reportedly date as early as 8,100 calibrated years BP (cf. Dye 1996). In the central Ohio River valley, shell mounds date between 6,200 and 4,300 calibrated years BP. Temporal variation (Table 2.1) has significant ramifications for the interpretation of these sites, especially since it has been suggested that shell mounding is related to climatic changes that simultaneously improved riverine resources and degraded upland resources, during the Hypsithermal (ca. 8,000 – 5,000 BP) (cf. Anderson 2001; Marquardt and Watson 2005b; Styles 1986).

Table 2.1. Temporal Ages of SMA Sites in Several Regions

Region	Cal radiocarbon years BP	Source
Central Tennessee	8100 - 6700	Dye 1996
Southern Illinois	7300 - 4900	Styles 1986
Green River	6600 - 3400	Marquardt and Watson 2005b
Ohio Falls	6200 - 4300	Janzen 1977

A second significant source of variation in shell mounds occurs in the size and structure of deposits. While all shell midden sites contain freshwater mussel remains, there is considerable variation in their abundance. Some mounds are very large and deeply stratified with deposits measuring many meters in depth. These large middens are typified by sites such as Indian Knoll (Webb 1946), which have been generally interpreted as base camps or possible aggregation locales (cf. Hensley 1994, 2005). The vast majority of shell mounds are actually small and thin middens with lenses of mussel shell within a larger earthen midden. Hensley's (1994, 2005) research suggests that these smaller sites were short-term residential camps or limited-use extraction sites. As mentioned above, variation in size and structure may also be related to shifting degrees of sedentism between the Middle and Late Archaic (McBride 2000).

Regardless of the amount of mussel remains present, intensive subsistence procurement appears to be a significant activity at these sites. Shell mounds typically contain significant deposits of charcoal (May 2005), carbonized plant remains – particularly hickory nuts (Crawford 2005), and faunal remains (Crothers 2005). It is significant to note that even at these larger sites, the dominant midden content may actually be fire-crack-rock, rather than shell (Hensley 1994, 1991, 1988). All of these patterns indicate subsistence intensification and concentrated collection of specific resources.

The third source of variation in shell mounds occurs in the cultural materials recovered from midden deposits. Artifacts include a wide range of side-notched and stemmed hafted-bifaces, dating to the Middle and Late Archaic periods. In the Ohio valley, considerable research has been devoted to understanding the chronology of hafted bifaces recovered from shell middens and other Middle to Late Archaic base camps (cf. McGrath et al. 2005). Cultural deposits at stratified Archaic sites suggest that side-notched forms, including Matanzas, predate stemmed varieties such as McWhiney/Rowlett (McGrath et al. 2005). Using these findings, as well as radiocarbon dates, it appears that the most intensively used sites were occupied between cal 6,200 and 4,200 years BP in the central Ohio valley (McGrath et al. 2005; Justice 1995). These dates roughly span the late Middle and Late Archaic periods.

Additional SMA artifacts include various ground stone implements for processing plants, bone tools and items of adornment, and regional exchange items such as Great Lakes copper and Gulf Coast marine shells. Jefferies (1997) studied bone pins from shell mound sites. Based on the morphological characteristics of carved and engraved pins, Jefferies argued that they were used as markers of social affiliation and integration. Regional distributions of pin styles also suggests that large-scale social networks existed between Middle Archaic groups in the Middle Mississippi and Lower Ohio valleys (Jefferies 1996a, 1997). Burdin (2004) conducted a similar stylistic study using bannerstones or atlatl weights. His study encompassed the Lower Ohio and Wabash valleys. Based on spatial distribution of artifacts with similar morphologies, he was able to discern four cultural zones of interaction within these regions. These and other studies (cf. Claassen 1996) demonstrate that there is a degree of regional integration or "tribalization" developing during the Middle Archaic period. At the same time a system of communication and trade between regional groups is also clearly developing.

The final type of variation in SMA sites relates to mortuary practices. Much attention has been paid to burials at SMA sites. Some archaeologists (cf. Claassen 1996) argue that shell mounds could have served as ceremonial or burial centers. Claassen (1996) proposed that shell mounds were an early form of intentional monumental construction for formal cemeteries. These ceremonial sites were locales for regional integration and exchange (Claassen 1996). However, burials are not ubiquitous among shell mounds and there is considerable variation in mortuary treatment. Hensley's (1994) work in the Green River valley demonstrates that cemeteries are generally only found at large shell midden locales, such as Indian Knoll. In these contexts, burials can be viewed as part of the range of activities conducted at base camp locales.

Interpreting the observed variation in SMA sites is complicated by the fact that shell mounds have extremely complex site histories. These sites can be thought of as palimpsests of numerous cultural and natural processes, which have affected their formation and preservation (cf. Stein 1980, 1992). Stein's (1980) research determined that shell mound sites in the Green River valley were characterized by considerable post-depositional mixing, which largely obscure the cultural mechanisms of site formation.

The degree of post-depositional disturbances at shell mound sites explains why many lack clear stratigraphy.

With all the observed variability and complex structure of SMA sites it is difficult to compare site assemblages or to understand their formation. Based on the lessons learned from previous studies, I believe three components are necessary to understand the complexity and variation of shell mound sites. First, Hensley (1994) demonstrated that the range of variation observed in SMA sites may be attributable to site function and duration of use. Second, Stein's (1980, 2005) work illustrated the need for regional-level analysis to examine factors influencing site placement and SMA land use. Third, Crothers' (1999) research demonstrated that considering *both* social and environmental contexts provide a more robust picture of the processes involved in the development of shell mound sites. Consequently, SMA research would benefit from a framework that considers 1) the dynamic interaction of environmental and socio-historical contexts, 2) in a regional spatial perspective, such as with landscape archaeology. The approach used in this research can be summarized by the general question *to what extent can the variation in SMA sites be explained by their regional spatial contexts*?

While many variables of shell mound sites have been explored, no previous study has explicitly examined the spatial characteristics of these sites. My study contributes an alternative method for examining the economic and social roles of shell mound sites in Archaic lifeways. A spatial technique is significant, because the archaeological record alone has not produced adequate information for assessing decision-making strategies of SMA people. As Jochim argued "hunter-gatherers generally distribute their activities over a large landscape" (1998:2). This means that the archaeological deposits at hunter-gatherer sites represent just a portion of the total range of behaviors possible (Binford 2001; Jochim 1998). It also means that the examination of how SMA peoples positioned themselves on the landscape can clarify issues of whether shell mounds represent residential camps, extractive locales, ritual centers, or some combination of these. It may also determine which factors influence some locales to become base camps, while others were only extraction sites. An understanding of shell mounding as an adaptation can be greatly facilitated by a large-scale, spatial approach. Chapter 3 will outline landscape theory and further explore the benefits of this approach for the SMA problem.

CHAPTER 3

VISUALIZING THE SHELL MOUND ARCHAIC LANDSCAPE

"Landscape is personal and tribal history made visible" (Tuan 1979:157).

INTRODUCTION

Landscape archaeology encompasses an extremely diverse body of research that can incorporate both processual and post-processual paradigms (Anschuetz et al. 2000). While landscape theory has its roots in geography, archaeologists have applied it to various archaeological questions. In 2000, Anschuetz et al. summarized the three principle areas of landscape research in archaeology as 1) settlement ecology, 2) ritual landscape, and 3) ethnic landscape. The diversity of these research areas underscores how landscape archaeology interweaves both natural and cultural dimensions; which, examined together, have the potential to provide a holistic view of cultural adaptations, social interactions, and ideology. The fact that so many aspects of the human experience can be studied from a landscape perspective demonstrates how intimately culture, society, and the individual are emplaced in space. Each of these research areas has relevance for studying the SMA because, as discussed in Chapter 2, these sites have variable and diverse roles in Archaic lifeways. Landscape allows both the economic and ritual aspects of shell mounds to be examined, while previous approaches were limited to one aspect or the other.

A regional and explicitly spatial perspective underlies landscape archaeology. Viewing SMA sites from a regional level is a dramatic change from previous shell mound studies, which primarily focused on site-level variables. Landscape archaeology recognizes that historical contexts and spatial configuration of landscape elements are essential aspects of regional trajectories and adaptations. My research focus is on developing a detailed descriptive and predictive model of SMA site location within Falls region of the central Ohio River valley. These spatial contexts will provide an alternative and previously unstudied line of evidence from which the complexity and variability of shell mound sites may be evaluated.

In this chapter, I elaborate on some of the areas of landscape archaeology that are most relevant to my research. In doing so, I describe several examples and place them within the context of this study. I will also discuss the intersection of landscape theory and Geographic Information Science (GIS) techniques by highlighting some recent research that employ both.

MODERN RESEARCH THEMES IN LANDSCAPE ARCHAEOLOGY

The following section provides an overview of the three research themes identified by Anschuetz et al. (2000): settlement ecology, ritual landscape, and ethnic landscape. This brief discussion is meant to define concepts and highlight some of the recent research in each of these areas. In addition, I draw attention to ideas in landscape theory that influence my study.

Landscape as Settlement Ecology

Fisher and Thurston (1999) argue that landscape settlement ecology is a complimentary approach to more traditional regional settlement studies. However, they define landscape as a more holistic and inclusive framework that includes social, political, and economic systems. They also recognize that anthropogenic ecosystems are constructed, conceptualized, and experienced (Fisher and Thurston 1999). From a landscape perspective, the environment includes physical-natural and socio-ideological components (cf. Bradley 1993, 1996; Butzer 1990, 1996; Richards 1996). In addition, landscape assumes a recursive link between culture and the so-called "natural" environment.

Settlement ecology studies in landscape assume that there is reciprocal dynamic or co-evolution between natural and cultural systems and seek to explore these relationships (Hammett 1992; Kent and Vierich 1989; McGlade 1995). This is an important deviation from traditional ecological models of land use because it recognizes the ability of humans to have affect on their environment as active agents in the formation of their landscape (Fisher and Thurston 1999). Thus it is possible to examine both external and internal factors contributing to cultural change (cf. Dovey 1985; Fisher and Thurston 1999; Kuna and Adelsbergerova 1995; Tacon 1999; Wandsnider 1987). All of these aspects of landscape settlement ecology make it suitable for the SMA problem.

The following study by Zedeno (1997) demonstrates one facet of landscape settlement ecology research. Zedeno (1997) formulates an empirical definition of territory using spatial, material, and historical variables to examine land use behavior. Zedeno (1997) argues that all human-land interactions modify and have an affect the landscape to some extent (1997). He defines a "territorial unit" as a combination of land, natural resources, and "objects of human manufacture" (Zedeno 1997:72). His definition stresses the integration of "natural" and "built" environments (Zedeno 1997). With ethnographic data from Native American land claims, Zedeno developes a generalized model for the processes responsible for the formation, maintenance, and transformation of territories.

Zedeno identifies three types of human-land interactions that compose the life history of a territory: 1) interactions between society and landscape (land use), 2) interactions between sectors of society (which define internal boundaries and ownership), and 3) interactions between society and its neighbors (which determine external boundaries). According to Zedeno, a group becomes established in a territory through a continuum of exploration, colonization, and settlement (1997). Once established in a territory, it is maintained through processes of expansion, consolidation, and fission. Territories can be transformed through processes of use change, abandonment, and reclamation. Together, these processes comprise a wide range of land use behaviors that form a territory's "life history" (Zedeno 1997).

Zedeno (1997) uses Hopi ethnographic data on settlement patterns and land use in the 1800's to develop numerous expectations for recognizing territory "processes" in the archaeological record. For example, Zedeno proposed that the process of exploration is observed as caches and ephemeral shelter sites. Archaeological evidence of colonization includes permanent housing, ritual features, and agricultural modification to the landscape. During the process of settlement, space becomes organized as certain locales become habitually exploited. According to Zedeno (1997), integrative facilities and other modifications of the landscape (such as boundary markers) also appear during settlement. When territories are transformed, changes in land use may result. Specifically, new types of landscape modifications may occur to "bring marginal lands into active production" (1997:92).

Zedeno's model is extremely useful because it can be applied cross-culturally to explore long-term and large-scale settlement patterns and territory formation. Therefore, his model of territoriality can also be applied to hunter-gatherer research. In particular, it could be useful in examining the cultural transitions and changes of the Middle to Late Archaic periods. Zedeno's procedures, however, are dependent on 1) finding a reliable ethnographic correlate, and 2) having a representative sample of the "entire range of land- and resource-use behaviors" of the prehistoric group in question (1997:95). At this time, only general ethnographic information on hunter-gatherer behavior is available for my research. The requirement of a "complete" site database also cannot be met for the SMA case study in the Ohio Falls region.

Yet, the expectation that both natural features and culturally modified sites can comprise territory boundaries could be useful in my research. In particular, Zedeno's research suggests that significant natural landmarks, such as rivers, can mark boundaries. Thus, I expect that in my study region, the Ohio River and the rapids at the falls may have been territorial boundaries. Additionally, if multiple groups of SMA peoples had home-ranges in the Falls region, then shell mound locales with mortuary components and evidence for long-term re-use may also mark boundaries between group territories.

Ritual Landscapes

Because the structure of the archaeological record reflects the historical relationship of social systems and the physical environment, it is possible to examine landscapes of ritual and social activities (Erickson 1999; Thurston 1999). Landscape embodies the structure of society because social change and human experience are interwoven with the landscape (Alcock 1993; Bender 1992). As a perspective, ritual landscape provides a means of interpreting changing land use patterns through historical and social contexts. Methodologically, ritual landscapes are often reconstructed using "idealized cognitive spatial models derived from ethnographic materials to look for patterns of similarity and dissimilarity in the past" (Anschuetz et al. 2001:179). Zedeno's (1997) methodology for examining settlement landscapes is similar, but it does not explore the ritual aspect of landscape. The following study by Goldstein (1995) uses a regional approach to examine the ritual landscape of Effigy Mound Tradition sites in southeastern Wisconsin.

According to Goldstein (1995), focusing on the purpose of effigy mounds is not useful due to the variability in mortuary treatment at mound sites. Rather, she argued that effigy mounds should be viewed as artifacts in themselves (Goldstein 1995). She suggested that these sites are symbolic representations of form and space and may have been a sort of symbolic map to those who built them (1995). While we may not be able to "completely read the map with our particular Western orientation" regularities and relationships may be recognized (Golstein 1995:118). Goldstein's research allows one to explore the characteristics of the mounds in terms of the surrounding social and natural landscape.

Like Zedeno (1997), Goldstein's study was also conducted by examining regional-level spatial contexts. According to Goldstein (1995), the location and physiographic contexts of effigy mounds sites indicate a preference for rich resource areas. The differential distribution of effigy mounds also indicated that these sites may have been used as symbols for corporate group aggregation sites. The presence of numerous mounds in particular areas may be indicative of long-term and repeated use of certain sites. Mortuary data also supports the interpretation of these sites as aggregation areas (Goldstein 1995).

Many aspects of this study are useful to hunter-gatherer studies in general, as well as my particular case study. Goldstein's research demonstrates how a landscape approach can explore the interaction between settlement, ritual mortuary practices, and land use – all of which are potentially important aspects of the SMA landscape. While shell mounds are perhaps less symbolic than effigy mounds, the role of shell mounds is certainly complex and varied (see Chapter 2). In fact, Goldstein argues "even for cultures with less social differentiation, a regional perspective can provide important information on social organization" (1995:101). Additionally, the concept of treating effigy mounds as "artifacts" is also useful for SMA sites, because it provides a means for getting beyond variation in the contents and structure of SMA locales to look for regional patterns in site placement.

Several expectations from Goldstein's research parallel expectations for shell mound sites in the Ohio Falls region. First, sites are placed to "emphasize certain rich resources" (Goldstein 1995:113). Second, some sites may represent seasonal aggregation locales for multiple family groups. Third, long-term reuse of these locales, along with burial of deceased family members, may indicate that the people who used them viewed these locations as both economically and socially significant (Goldstein 1995).

Landscape and Identity

Research on the relationship between landscape and identity includes issues of power, temporality, cosmology, and ethnicity (cf. Bender 1992; 2002; Hood 1996; Ingold 1993, 2000; Wandsnider 1987; 1992). Because landscapes are intimately connected with community and individual identity (Cosgrove 1984), it is possible to examine how communities develop ethnic identities. Research of ethnic landscapes primarily developed out of cognitive and phenomenological perspectives (cf. Bell 1994; Bender 2002; Dovey 1985; Feld 1996; Hood 1996; Ingold 1993; Tilley 1994; Tuan 1977, 1979). This perspective attempts to explain spatial patterning of past human activities in terms of identity; particularly the relationship between identity development/maintenance and the construction of landscapes at the individual and social levels (cf. Bender 1993; Cosgrove 1984; Hood 1996; Kent and Vierich 1989; Tuan 1977, 1979).

Landscapes of sociocultural identity or ethnicity may be expressed as symbols of social cosmology and experience (Bender 1992; Buikstra and Charles 1999; Edmonds 1999; Kus 1983). In some cases, the landscape is physically modified to reflect cosmological principles organizing space (Bender 1993; Edmonds 1999). Whether or not overt modification is present, however, landscape may still be viewed as a symbolic artifact through which identity, ethnicity, and power relationships are expressed (cf. Cosgrove 1984; Kus 1983). Cosgrove (1984) and Kus (1983) propose that landscapes are a map of both activity and cosmology (Kus 1983).

Most research into landscape and identity has been primarily limited to either historical sites or megalithic monuments. There is an inherent difficulty in understanding how individual and social identity become expressed as ethnicity in the landscape, particularly in prehistoric contexts. Yet, the relationship between landscapes and identity is useful because it provides a means for exploring ideological aspects of a society, while grounding them in empirical elements of the landscape (cf. Bell 1994; Bender 1992; Edmonds 1999; Feld 1996; Tilley 1994; Zubrow 1994). In addition, this framework considers the cosmological factors influencing land use and settlement decision-making practices (Bender 1992; Zubrow 1994). Tacon's (1999) study of Australian Aboriginal rock art illustrates the relationship between the human-modified landscape and sociocultural identity.

Tacon's research focuses on the processes through which the physical landscape becomes a social landscapes (1999). Tacon's research is similar to Zedeno's in that he explored how territories are developed; however, Tacon investigates further into the symbolic realm. Tacon (1999) aims to understand human relationships to places and spaces by examining the structure and organizing principles of rock art. Due to the large body of ethnographic data, he conducted this analysis with the Australian Aborigines (Tacon 1999). Tacon identifies four types of locales that evoke strong human responses; these include 1) mountains with steep valleys, 2) waterfalls, 3) caves, and 4) places with panoramic views of varied landscape features.

According to Tacon (1999), the above locales connote boundaries or connections between various levels of existence. These places on the landscape act as an "axis mundi" and are often considered sacred. The level of sacredness of particular locales may vary, and some sites are more sacred than others (Tacon 1999). The association of sacred activities or events with particular locales serves to increase their relative importance and status within a society. Often sacred activities involve *human* *modification* of these locales. For example, sacred "natural" sites are often made more sacred by burial of deceased relatives in these areas. Tacon suggests that the association of human remains with these locales "effectively bonded people with nature, with geography, and with the landscape" (1999: 41). Locales become "socialized" or interwoven with identity through a process of use and modification over generations.

Tacon's perspective is similar to Crother's (1999) interpretation of shell mound locales developing from economic sites to significant loci of cultural activities and cultural memory. Another concept from Tacon that is particularly useful in SMA research is the notion that valleys, waterfalls, caves, and panoramic views have social and cosmological significance to hunter-gatherers. All of these landscape features are components of the Falls region. Therefore, I expect that SMA sites that have social significance to Archaic peoples will display a spatial relationship to these significant environmental features of the landscape.

LANDSCAPE ARCHAEOLOGY & GIS

The above discussion of landscape theory in archaeological research demonstrates that landscapes are extremely complex and include a wide range of spatial and cultural variables. Consequently, the process of examining spatial relationships to look for patterning requires a regional, multi-layered, and detailed approach. Until fairly recently, there were few tools available for synthesizing or analyzing such large bodies of spatial and formal data. Geographic Information Science (GIS) is one such tool that can assist archaeologists in examining anthropological questions. With GIS and ever-increasing computing power, it is now possible to examine immense databases of regional cultural and environmental variables with greater ease (Savage 1990a; Wheatly and Gillings 2002).

GIS can be broadly defined as a system for collecting, storing, managing, disseminating, displaying, and creating spatially referenced data (Savage 1990a). The particular usage of GIS is determined by a researcher's goals and theoretical perspective. Thus, GIS is merely a tool for problem- and theory-driven spatial analysis. In a GIS, variables have both geographical location information and attribute information. It is possible to examine temporal change in a GIS by examining "similar data sets for different times" (Savage 1990a: 23). While primarily known for its data visualization capabilities, GIS is also a useful tool for spatial data exploration and analysis (cf. Allen et al. 1990; Kuna and Adelsbergerova 1995; Savage 1990a; Wheatly and Gillings 2002; Zubrow 1994). In addition, GIS provides a platform for systematic research that has the flexibility to model multiple scenarios (Wheatly and Gillings 2002). Therefore, GIS is the perfect tool to analyze the regional spatial contexts of SMA sites for my research.

There are three major areas of GIS research in archaeology (Allen et al. 1990; Savage 1990a; Wheatly and Gillings 2002). These research themes include: 1) predictive site location models (cf. Carmichael 1990; Church et al. 2000; Warren 1990; Zubrow 1990), 2) studies on the applications of GIS, and 3) "studies that address larger theoretical concerns related to landscape archaeology through GIS methods" (Savage 1990a: 22). My research considers each of these areas, but is particularly focused on the relationship between anthropological theory and GIS methodology. According to Savage, GIS research has "great potential for...research oriented, theory building methodology in landscape archaeology" (1990a: 29).

My dissertation research is focused on developing and implementing a method to test the archaeological assumption that SMA sites are "positioned" within the landscape to access and control key resources. In this research I look at the relationship between landscape features and archaeological site locations to reconstruct the land use decisions made by Middle to Late Archaic peoples. Ethnographic data on hunter-gatherers provide some baseline expectations for how Archaic foragers may have chosen locales for resource extraction locales, base camps, or social centers (cf. Binford 1980, 2001; Bettinger 1991; Kelly 1995). The following are two examples how GIS can contribute to theory-driven questions about hunter-gatherer behavior.

Example 1: Modeling Paleoindian Colonization and Settlement

In a study by Anderson and Gillam (2000), GIS is used to explore hunter-gatherer adaptations in the Pleistocene. They conducted a macro-scale least-cost model for Paleoindian colonization of the New World. The overall goal of their research was to suggest the routes, rates of movement, and reasons for Paleoindian population dispersal based on ethnographic models of hunter-gatherer behavior and physical attributes of terrain and ecology. In particular, they tested Sauer's ice-free corridor model (1944) and Martin's overkill hypothesis (1973).

For their analysis Anderson and Gillam conducted least-cost modeling between presumed entry points and 45 known archaeological sites in the New World (2000). Anderson and Gillam (2000) modeled four different least cost paths, 1) ice-free corridor, 2) Northwest Coast, 3) Panama running south, and 4) Panama running north, to compare each model for Paleoindian colonization. They collected data on terrain, and the locations of ice sheets and pluvial lakes to model possible movement corridors ca. 12,000 BP. Digital Elevation Models were used to develop a "roughness" layer, which was based on slope and aspect. They calculated least-cost paths from the resulting roughness layer. This type of cost-weighted modeling estimates the relative costs of moving over a given terrain.

To evaluate the cost-models they developed, Anderson and Gillam (2000) used demographic and archaeological evidence. They examined variables such as founding population size, group size, population growth rate, group range, and size at which fissioning occurred. When even using the most conservative parameters for population growth, they determined that the New World could have been colonized and populated in 4,556 years (Anderson and Gillam 2000). According to Anderson and Gillam, if Paleoindian population growth and movement was similar to modern foragers, then Paleoindians could have colonized the New World in as little as 2,000 years (2000).

Anderson and Gillam (2000) also evaluated two migration scenarios: string-of-pearls (which assumes adjacent movement) and leap-frog (which assumes greater spread upon fissioning) using demographic data. The string-of-pearls model estimated a 5,000 year span for colonizing the New World by interior routes and 4,000 year span for coastal routes. In the leap-frog model, Paleoindians could have effectively spread throughout the western hemisphere in a couple generations. Anderson and Gillam concluded that the leap-frog model is in is the best fit for the Paleoindian, because this model explains the widely scattered distribution of early Paleoindian points in the United States (as seen through archaeological data) and fits the subsistence expectation that Paleoindian foragers exploited "mega-patches" (Anderson and Gillam 2000:59).

Anderson and Gillam's (2000) research demonstrates that least-cost modeling techniques can be used to test specific questions regarding hunter-gatherer behavior. I will use similar techniques to examine SMA site distributions and model accessibility to points of interest in the Falls landscape. I expect that SMA sites should have high accessibility to other Archaic sites within the settlement system, because shell mounds represent only one portion of the total mobility system. Based on ethnographic literature on logistically organized hunter-gatherers (c.f Binford 1980, 2001), I also expect that the resources accessible from SMA sites will be high in diversity and abundance.

Example 2: Social Change, Late Archaic Settlement Patterns, and Territoriality

Savage (1990b) examined the social landscape of Late Archaic hunter-gatherers in the Savannah River valley. The goal of his research was to understand the process of tribalization and territory development among Late Archaic hunter-gatherers. Specifically, Savage was interested in how these social changes were expressed as changes in human landscape structure and usage. Savage's study is based on the assumption that social organization generates distinct patterns in the "social, cognitive and physical landscapes in which people live" (Savage 1990b:330). Using theories on hunter-gatherer bands from Wobst (1974), Dennell (1983), and Clark (1975), Savage developed a set of expectations to test using Late Archaic site data in the Savannah valley: 1) Archaic peoples place base camps in the center of habitual use areas, 2) sites within a settlement system should be easily accessed from one another and are therefore, clustered within habitual use areas, 3) each cluster of sites should contain the full range of site types to be a territorial unit, and 4) people may view "boundaries" as either edges or centers of habitual use areas (Savage 1990b: 341).

Savage (1990b) evaluated the first three expectations using nearest neighbor statistics and by looking at the range of sites within clusters. He determined that sites were clustered and delineated clusters with Thiessen polygons around the large base camp sites. Savage (1990b) identified six different habitual use areas within the study region. Each of these use areas contained the full array of Late Archaic sites types. Savage examined the sites located at the boundaries of the Thiessen polygons to look for evidence of sites that acted as centers of exchange and social interaction between the six clusters. He noted that sites were indeed clustered along boundaries in several areas. Savage (1990b) interpreted these sites as possible centers for exchange and interaction between band territories.

Each of the four expectations examined by Savage (1990b) are also relevant for the SMA of the Ohio Falls region. I expect that shell mounds are centered in a habitual use area and that these sites will be clustered within these zones. However, GIS methods have developed since Savage conducted his research nearly two decades ago. I will use a combination of catchment analysis, cost-distance modeling, and cluster analysis to examine 1) how SMA peoples are placing sites, 2) whether SMA sites are clustered, and 3) what cultural and natural features are accessible to SMA peoples at these sites.

SUMMARY

Landscape research in archaeology generally fits into one of the three themes defined by Anschuetz et al. (2000): settlement ecology, ritual landscape, and ethnic landscape. Aspects of each of these research areas could potentially be useful to examine the settlement and subsistence, mortuary, and socio-political aspects of the SMA phenomenon, because shell mounds represent cultural transformations in economic, ritual, and social realms of Middle to Late Archaic society. However, due to the 1) time-depth, 2) absence of historical documents, and 3) lack of clear linkage to modern tribal groups, it is difficult to pursue ritual and ethnic landscapes for the SMA. However, examination of SMA settlement landscape can be facilitated by using expectations derived from ethnographic research, as discussed in Chapter 1.

Anderson and Gillam (2000) and Savage (1990b) demonstrate how GIS applications in landscape archaeology can explore theoretical questions in hunter-gatherer studies. GIS provides a means for testing hypotheses on specific aspects of human behavior. Anderson and Gillam tested theories of Paleoindian colonization through least-cost modeling. Their study was based on expectations for hunter-gatherer foraging strategies. Savage (1990b) tested how Late Archaic group socialization and territorialization is expressed in land use choices. Many of the techniques used by Savage (1990b) and Anderson and Gillam (2000) are applicable to my research. For example, ethnographic expectations for hunter-gatherer movement can be used to build a model of least-cost travel between SMA sites in my study area.

This dissertation is concerned with understanding hunter-gatherer subsistence and settlement systems, and how Archaic people viewed and utilized their natural surroundings. In order to do so, I'm using a perspective called landscape analysis, that involves reconstructing the SMA landscape for the Ohio Falls region. Because a landscape approach is used, it is necessary to contextualize the geographic, environmental, and cultural characteristics of the region. The next three chapters will provide a sketch of the Falls landscape. Chapters 4 and 5 describe the physical environment and provide background on how the features that comprise the landscape were created. Chapter 6 is an overview of the Archaic period archaeology for the study region. I outline our current knowledge of SMA and broader Archaic period trends in the Ohio Falls area.

CHAPTER 4

PHYSIOGRAPHIC AND GEOMORPHIC BACKGROUND OF THE FALLS OF THE OHIO REGION

In the early nineteenth century, Increase A. Lapham observed "the scenery of these falls is the best calculated to give man an idea of the superior works of nature and of his own inferiority..." (Thomas and Conner 1971).

INTRODUCTION

The Falls landscape represents an area where multiple and varied physiographic zones meet within a relatively small area. Geological circumstances have compressed a wide range of ecological niches near the Falls. This chapter discusses the geomorphic development of the Falls region within the contexts of the central Ohio River valley. The primary goals of this overview are to 1) explore the geological processes affecting the development of the central Ohio valley and 2) provide a sketch of the Falls region geomorphology and physiography. This background contextualizes human behavior within the Ohio Falls region to model Archaic lifeways, movement, and interaction in the Falls landscape.

There is a substantial geo-environmental database from geomorphological research for the central Ohio River valley and the Falls of the Ohio region. Therefore, it is possible to reconstruct the geomorphic history of this region, an essential requirement for conducting a landscape study. Both environmental and cultural factors influenced Archaic peoples land use decisions. Therefore, reconstructing regional physical and environmental contexts is crucial to developing a model for how SMA peoples interacted and modeified their landscape. These contexts provide crucial information to interpret human adaptations and decisions, such as resource availability or distribution and restrictions to mobility, and to understand why shell mounds do not occupy space randomly within the Falls region.

GEOMORPHIC DEVELOPMENT OF THE CENTRAL OHIO VALLEY

The Ohio River valley links the North American Northeast, Midwest, and Midsouth, draining nearly 141,000 square miles through its numerous system of tributaries. Crossing diverse physiographic regions and topography, from the Appalachians to the Midwestern lowlands, the Ohio River offers varied and abundant resources (Fowke 1925). This landscape was a hub for human settlement, transportation, and utilization during both prehistoric and historic times. Each of these factors makes the Ohio River valley a significant landscape within the larger riverine setting of eastern North America.

The Falls of the Ohio region is located within the central Ohio River valley (Figure 4.1) between river miles 440 and 725 (Ray 1974). The central Ohio valley may be subdivided into two general physiographic areas, the glacial (miles 440 – 625) and constricted valleys (miles 625 – 725) (Ray 1974; Veatch 1898) (see Figure 4.1). The glacial valley is steep-walled and tends to be 1 – 2 miles wide. The constricted valley is deep and narrow, between 1/2 – 1 mile wide, and is bounded by steep bluffs. Differences between these sub-regions are primarily due to bedrock characteristics and to glacial histories in and around these areas. These sub-regions of the Ohio valley have distinct geomorphic characteristics today.

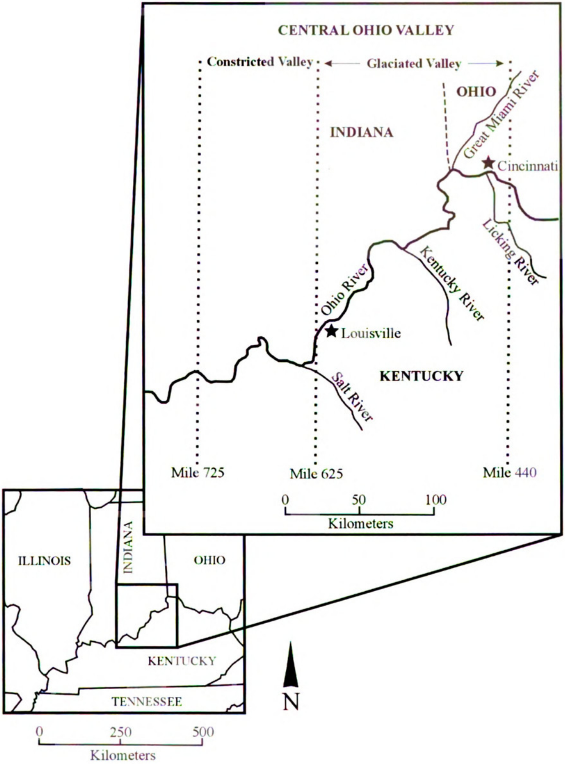


Figure 4.1. Detail of the central Ohio River showing the glaciated and constricted portions of the valley.

The central Ohio valley has been the focus of considerable geomorphic research for more than a century, although there has been little research in the past thirty years. There are numerous theories explaining changes and developments in drainage patterns (e.g. Fenneman 1914; Fowke 1925; Ray 1974; Tight 1903; Veatch 1898; Wayne 1952). It should be noted that the developmental models described here are rather antiquated in terms of their language and geologic outlook. These researchers viewed Quaternary geologic history in terms of the traditional four-part glacial stage model that included the Nebraskan, Kansan, Illinoisan, and Wisconsin. This model is now considered to be far too simplistic, as oxygen isotope studies clearly demonstrate that many more Pleistocene glacial periods actually occurred (e.g. Shackelton and Opdyke 1976). Nevertheless, it is useful to review the geomorphic work on the central Ohio valley because it demonstrates that the valley is a relatively young geomorphic feature and its course was significantly influenced by glaciation. The following is a summary of the most widely accepted hypotheses concerning geomorphic evolution of the central Ohio valley from glacial to modern drainage systems, based on what is currently known.

Glacial History

While portions of the Ohio River valley existed prior to the Pleistocene, it did not exist as a through-flowing stream until the Pleistocene (ca. 1.8 mya to 12,500 BP) (Fowke 1925; Ray 1974). Consequently, the present configuration of the Ohio River valley is a relatively recent physiographic feature resulting from a series of glacial derangements and modifications of prior pre-glacial drainages. Most researchers have developed a chronology for the evolution of the Ohio River that is linked to the traditional named glacial intervals: Nebraskan, Kansan, Illinoian, and Wisconsin (e.g. Ray 1974; Frasher & Fishbaugh 1986). This model was created by reconstructing the stratigraphic relationships of loess deposits and paleosols formed during interglacial intervals (Aftonian, Yarmouth, and Sangamon). As little radiometric dating has been conducted in this region, the chronology discussed here will be related to these general glacial and interglacial periods.

While there is some disagreement concerning the timing of various events, there is surprising consensus on the sequence of events that led to the modern central Ohio River valley. It appears that "each glacial and interglacial time played an essential role in river and valley formation" (Ray 1974). The nature and sequence of glacial drainage changes were reconstructed by studies of 1) till deposits on the uplands surrounding and adjacent to the Ohio valley, 2) outwash and valley train deposits and associated loess sequences, 3) ancient river valleys and terraces, and 4) alluvial deposits on terrace and floodplain landforms. Much of this research has been associated with archaeological and mineralogical investigations of the Ohio River valley (e.g. Gray 1979, 1984; Russell 1996a; Stafford 1995). The most widely accepted interpretations of the glacial history of the central Ohio valley can be found in Ray (1974) and in Frasher and Fishbaugh (1986).

Tight (1903), Wayne (1952), and Ray (1963, 1974) agree that an early glacial advance brought about the derangement of the hypothetical pre-Pleistocene Mahomet-Teays River and initiated drainage changes that led to the formation of the central Ohio valley. Ray (1974) suggested that this event can be correlated with the so-called Nebraskan glaciation (roughly ca. 680 – 620 kya), based on his studies of deeply weathered Nebraskan glacial drift in northern Kentucky and southern Indiana. Ray

(1974), Fowke (1925), and Wayne (1952) proposed that pro-glacial blockage and ponding of the Mahomet-Teays system between the Madison and Manchester divides caused new drainage patterns to develop once the divides were overtopped. This caused flow reversal for those streams that were once tributary to the Mahomet-Teays River, diverting the once north-flowing streams to the southwest through the Madison divide and into the present Ohio valley (Wayne 1952; Coffee 1958). However, as glacial ice advanced into northern Kentucky, this drainage pattern was disrupted once again. The Salt River, which flowed west to the Mississippi embayment, then became the principle drainage for glacial meltwater (Ray 1974). The incision of the Salt River drainage included a portion of the present Ohio valley and contributed to the development of the central Ohio valley. Therefore, at the end of the Nebraskan glaciation the Ohio River finally existed as a continuous, westward flowing stream.

During the Aftonian interglacial period (roughly ca. 620 – 455 kya), the newly developed drainage of the lower Ohio River valley and its tributaries went through a period of incision and erosion. At the beginning of the so-called Kansan glaciation (roughly ca. 380 – 300 kya), the Ohio River essentially followed its modern path to the southwest, except for its northern path around Cincinnati, Ohio (Ray 1974). Kansan drainage modifications were not as pronounced as the Nebraskan, because this glaciation did not extend as far into the region. However, as the ice sheet advanced to Cincinnati, Ohio and then to Madison, Indiana, drainage direction was reversed down the Licking and Kentucky Rivers, respectively (Ray 1974). This resulted in the straightening of the Kentucky River, which brought it closer to its current course. While the glacier occupied the Ohio valley the Salt and Muscatatuck Rivers were the principle outlets for glacial meltwater west of Madison, Indiana (Ray 1974). Ray (1963) speculates that as the Kansan glacier retreated from the Ohio valley area, the westward flow of the Ohio River was resumed. Significant amounts of outwash were probably deposited as valley train during the Kansan glaciation; however, the Yarmouth interglacial marked another significant period of valley erosion (Ray 1963).

The Yarmouth (roughly ca. 300 – 200 kya) was the longest interglacial period during the Pleistocene, allowing ample time to significantly alter the central and lower Ohio valley landscape (Ray 1974). This period was dominantly a time of degradation, where Kansan aged valley train was removed and bedrock heavily eroded. Consequently, the Yarmouth has been identified as the "deep stage" of the Ohio River, when erosion entrenched the central Ohio valley more than 400 feet into bedrock (Brand 1934; Coffee 1958; Ray 1963, 1974). According to Powell (1999), the deep bedrock valley at the Falls of the Ohio was created by this scouring. Tributaries to the Ohio River were also deeply incised during this time, creating much of the topographic relief that is still expressed today in the glaciated portion of the central Ohio valley (Ray 1974).

Deeply weathered Kansan loess with Yarmouth-aged soils may be found at some locations in the unglaciated portion of the lower Ohio valley, but these deposits are extremely rare (Ray 1957, 1963). Ray (1960, 1963) reports that most loess deposits along the central and lower Ohio valley have a genetic relationship to glacial valley train. These aeolian loess deposits were formed from the deflation of non-vegetated valley train deposits (Ray 1960, 1963).

Modification of drainage in the Cincinnati area into its modern configuration occurred during the Illinoian glacial period (roughly ca. 300 – 130 kya) (Ray 1974). A series of derangements and drainage developments due to the intrusion of the Illinoian glacier caused the Ohio River to migrate south of present-day Cincinnati (Fowke 1925; Brand 1934). Major tributaries affected by the drainage change included the Whitewater, Great and Little Miami, Kentucky, and Licking Rivers (Brand 1934; Ray 1974). In the unglaciated portions of the central Ohio valley, the deflation of the Illinoian valley train led to the deposition of Loveland Loess, which was heavily weathered during the Sangamon interglacial (Ray 1957, 1960, 1963).

By the beginning of the Sangamon interglacial (ca. 130 – 110 kya) the configuration of Ohio River and its tributaries followed their present paths. Once again, this interglacial interval was a time of degradation along the Ohio valley (Straw 1958; Ray 1974). The extensive erosion removed the Illinoian valley trains in all but in a few chance locations (e.g. Russell 1996a). This process of erosion also led to the stabilization of the newly constructed drainage pattern in the Ohio valley, as well as its tributary streams in the uplands. Paleosols in the Loveland loess are found buried below Wisconsin-aged loess sequences in the unglaciated portions of the central Ohio valley (Ray 1960).

The Wisconsin glacial episode (ca. 110 – 12 kya) was the last and most recent glacial intrusion into the Ohio valley region. The only significant drainage change that occurred during the Wisconsin interval was at the confluence of the Ohio and Mississippi Rivers, well below the project area. In the Falls region, glacial meltwater left significant deposits during the Wisconsin period (Ray 1974; Russell 1996b). Deposits from glacial substages are characterized by unconsolidated sands and gravels, while interglacial deposits are typically fine-grained muds and silts (Frasher & Fishbaugh 1986). A series of terraces were formed during the oscillation of glacial substages, creating the modern valley topography. Late Pleistocene terraces of the lower Ohio valley have been named after the glacial substages during which they were formed. The evolution of Ohio valley terraces during the Wisconsin has been the principle focus of most geomorphic research in this region. Two regionally expressed terraces, Tazewell and Cary, have been recognized (e.g. Ray 1974; Gray 1979; Frasher & Fishbaugh 1986; Russell 1996a).

The Tazewell valley train was deposited during the Wisconsin glacial maximum (ca. 18 kya) under an aggradational regime (Ray 1974) that deposited as much as 30 meters of gravel. The principle source for Tazewell glacial outwash into the central Ohio valley was the Miami-Whitewater tributary system (Ray 1974; Gray 1979; Frasher & Fishbaugh 1986). As the ice retreated at the end of the Tazewell, the reduced energy led to the downcutting and entrenchment of the Ohio River in the Tazewell valley train. The Tazewell terrace was formed when the Ohio River incised a channel as much as 9 m into the outwash and alluvium (Frasher & Fishbaugh 1986). During the reduced energy regime, a mantle of fine alluvium formed as overbank deposits. A muted braided pattern is discernable on this terrace in most valley segments throughout the central Ohio valley (e.g. Gray 1979; Frasher & Fishbaugh 1986; Russell 1996a). Russell (1996a, 1996b) and Boulding (1993) suggest that a muted braided pattern is characteristic of the early stages of entrenchment and development of the Ohio River as a braided stream approximately 18,000 – 15,000 years BP.

A second aggradational period occurred during the Cary advance of the Woodfordian period (ca. 16.5 – 12.5 kya) (Ray 1974; Frasher & Fishbaugh 1986). The Cary valley train deposits also appear to originate from the Miami-Whitewater tributary system, but tend to be finer than Tazewell gravels (Frasher & Fishbaugh 1986). Between 15,000 – 13,000 years BP, another period of degradation began as glacial meltwater discharge dissipated (Straw 1958; Ray 1974; Gray 1979; Smith et al. 1999; Surface-Evans 2002). According to Gray (1979, 1984) the Ohio River changed from a braided stream to a meandering stream at this time. Consequently, the Late Pleistocene was a period of degradation and lateral migration of the Ohio River, a pattern that persists in the Holocene (Ray 1974). This led to the deposition of fine-grained overbank deposits on the Cary terrace.

Holocene History

At the beginning of the Holocene (ca. 12,500 – 8,000 years BP) there was a significant shift in the environment to warmer and dryer conditions. This trend continued and was amplified during the Middle Holocene or "Hypsithermal Interval" (ca. 8,000 – 5,000 years BP) leading to development of the "modern" environmental and vegetational configuration. The Holocene was also the first period in which long-term human occupation of the Ohio River valley occurred (Burdin 1998). The drainage regime since the Wisconsin period is characteristically lower energy than the Pleistocene (Brand 1934). Consequently, there is a distinct textural break between Pleistocene and Holocene alluvial deposits (Frasher & Fishbaugh 1986). Holocene landform formation primarily consists of fine-grained overbank and levee deposits on the terraces and floodplain (Gray 1979; Frasher & Fishbaugh 1986; Russell 1996a; Surface-Evans 2002).

Unlike the Wisconsin terraces, the Holocene terraces and modern floodplain have not been traced throughout the lower Ohio valley. It appears that the development of these landforms may have been determined by local conditions within each valley segment, making them difficult to correlate on a regional scale (Gray 1979). The localized control of landform evolution during the Holocene poses a significant interpretational challenge. For example, Gray (1979) and Russell (1996a) propose that the development of the Holocene terraces in the glaciated valley was relatively rapid, with most terraces formed by approximately 10,000 years BP. Further downstream in the alluvial valley, Frasher and Fishbaugh (1986) suggest that floodplain formation began as recently as 4,000 years BP.

The ages of Holocene landforms have been largely determined by the depths and ages of cultural materials found in overbank deposits on point-bars (Munson 1976; Gray 1984). In fact, Holocene landforms have been primarily studied within the contexts of archaeological investigations, which will be discussed further in Chapter 5. The evolution and timing of Holocene floodplain development is significant to archaeological research because of the high potential for deeply buried cultural deposits (Russell 1996b).

DEFINING THE "FALLS" REGION

As the only cataract in the 981-mile course of the Ohio River, the "Falls" is a significant geographic feature within the central Ohio valley (Figure 4.2). But how has this feature come to be recognized as a distinct region? In addition to the unique geological conditions that produced the rapids at the Falls, the unusual configuration of several geographic and environmental features in proximity to the Falls also sets this region apart from the surrounding area. Due to the complex glacial history of the central Ohio River valley, multiple physiographic zones converge near the Falls. In essence, the

Falls represents a compressed landscape, in which *large-scale regional diversity is localized*, making in an ideal local for a regional landscape study. The following sections describe the geology and hydrology of the Ohio River at the Falls as well as the physiographic characteristics of the Falls Region.

Figure 4.2. Photograph taken from the Clark's Point (12-Cl-3) shell midden site, overlooking the Ohio River Falls and modern city of Louisville, Kentucky. Taken by the author, July 2005.

Geology of the Falls and Prehistoric Hydrology of the Ohio River

The Falls of the Ohio is the only locale in the course of the Ohio River valley where bedrock is exposed across the entire riverbed (Powell 1999). This feature was formed by several geological processes. As mentioned previously, the greatest period of valley erosion occurred during the Yarmouth interglacial, and a deep channel was scoured into the bedrock at the Falls (Powell 1999). Later, the Wisconsin glaciation buried the deep channel with outwash deposits. During the late Pleistocene and early Holocene, the Ohio River channel eroded through the Wisconsin aged sediments to re-expose the bedrock valley that comprises the Falls (Powell 1999). Today, these bedrock deposits are one of the few locales where Devonian-aged deposits, rich in marine fossils, are exposed at the surface.

The modern hydrology of the central Ohio valley is largely controlled by an extensive system of locks and dams, which has submerged five-sixths of the former area of rapids (Powel 1999). Prior to damming and canalization, the Falls was composed of a large expanse of bedrock interrupted by several chutes and rapids (Figure 4.3). When the first Europeans came to the Falls, they were astonished by the series of rapids that stretch across the width of the river (Powell 1999). The most notable characteristic of the pre-canalized Ohio River were seasonally shallow water conditions. "Prior to the construction of Shippingport Canal [ca. 1826-1830], large rafts and boats were forced to wait for high water to negotiate the channels or chutes over the falls" (Powell 1999:3).

Accounts of Increase A. Lapham, who worked as a surveyor during the construction of Shippingport Canal, between 1827 and 1830 provide valuable insight into the seasonal hydrology of the river. During these years, Lapham maintained careful notes concerning river conditions, as well as geological, botanical, and archaeological observations of the Falls region. It is clear from his notes that the Ohio River was prone to flooding after heavy rains. One account describes a sudden flash flood after a brief thunderstorm in April of 1828,

> It now appeared to thunder and lighten and we had all the appearances of an approaching storm...after some delay on account of the rain we proceeded on our

way home got into our skiff at sliver-creek and in attempting to row across [the Ohio River] we was driven so far down stream by the rapidity of the current that it became necessary to land on Gravel Island (Thomas and Conner 1971:200).

It is likely that from the mid-Holocene to early historic era the central Ohio valley exhibited similar patterns of low water and flash flooding. The river hydrology was also probably controlled locally by physiographic contexts, which vary widely in this region.

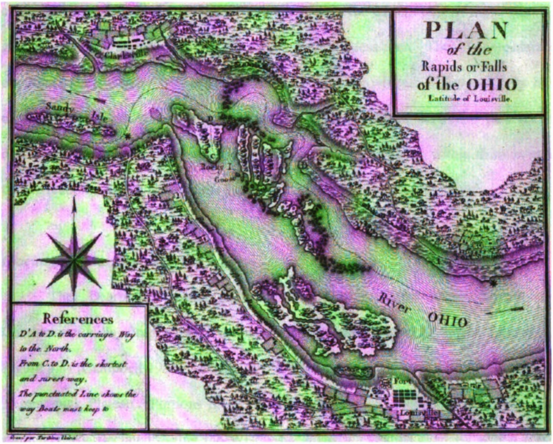


Figure 4.3. Historic map of the Falls of the Ohio drawn in 1796 by P. F. Tardieu for George Henri Victor Collot's "Journey to North America". The path in the River shows the navigable route through the Falls. From the David Rumsey Map Collection.

PHYSIOGRAPHIC CHARACTERISTICS OF THE FALLS REGION

Seven distinct physiographic provinces can be found within a 80 km radius of the Ohio Falls (Figure 4.4). From east to west these provinces are 1) Dearborn Upland, 2) Muscatatuck Plateau/Outer Bluegrass, 3) Scottsburg Lowland, 4) Charlestown Hills, 5) Norman Upland/Muldraugh Hill, 6) Mitchell Plateau/Mississippian Plateau, and 7) Crawford Upland. Each province was defined on geomorphic and ecological characteristics. Due to the course of glacial advance, the eastern half of the region is a glacial landscape and the western half is a karstic driftless area. There is considerable environmental diversity between these physiographic provinces, which not only have distinct geomorphic histories, but different ecological settings as well. This section describes each province and a summary of the resources available within them in order for the reader to gain a sense of the Falls landscape and its diversity.

Glaciated Physiographic Zones

The Dearborn Upland, Muscatatuck Plateau, Scottsburg Lowland and Charlestown Hills comprise what is called the Bluegrass Natural Region in Indiana (see Figure 4.4) (Campbell 1997). Across the Ohio River, this area of Kentucky is called the Muscatatuck Plateau. Portions of the Bluegrass region of Indiana and Kentucky were most recently glaciated during the Wisconsin advance. Glacial deposits in this region tend to be thin, relative to regions further north. Bedrock is buried in the uplands and is exposed along stream canyons where glacial deposits were eroded. Prior to the European settlement of the bluegrass area, it was predominantly forested with beech-maple plant communities in the uplands and Western Mesophytic communities in

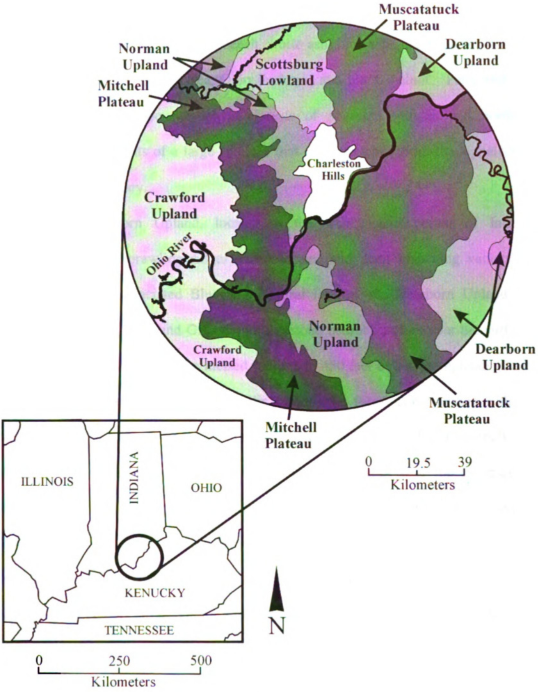


Figure 4.4. Map of Physiographic Provinces within an 80 km radius of the Falls.

canyon and ravine settings. A typical mesophytic forest includes yellow buckeye, white basswood, black locust, American beech, white ash, blue ash, sugar maple, pin oak, red oak, shagbark hickory, tulip tree, Ohio buckeye, and black walnut. Petty and Jackson (1966) suggest that the mesophytic forests of southern Indiana and north-central Kentucky are remnants of a large ecozone that once stretched from the Appalachians to the central Ohio valley.

The Dearborn Upland, located in the southeastern corner of Indiana, is "characterized by sprawling ridges, steep slopes, and deep branching valleys" (Gray 1997:30). Of the glaciated Bluegrass Natural Region, the Dearborn Upland has the thinnest glacial deposits and Ordovician limestone bedrock occurs near the surface. In this region, the streams may be incised more than 450 feet below the uplands (Campbell 1997). These deep ravines contain relic mesophytic forest communities with a wide variety of tree species, some of which have affinities with Appalachia (Campbell 1997). Both Jeffersonville and Laurel chert are found in outcrops near the interface of the Dearborn Upland and Muscatatuck Plateau (Figure 4.5) (Cantin 1994). While the distribution of these cherts is not fully known, they tend to be found in widely scattered outcrops along steam beds and in the bluffs that separate the uplands from the Ohio River valley. These cherts are also commonly found as glacial cobbles in the Ohio River valley in the Falls region. Both Jeffersonville and Laurel chert are somewhat fossiliferous and vary from chalky to slightly glossy in luster and medium-coarse to medium-fine grain in texture (Cantin 1994). Colors in both cherts vary from white to tan. Because of the similarities between these chert types, Jeffersonville is often mistaken for Laurel chert. A

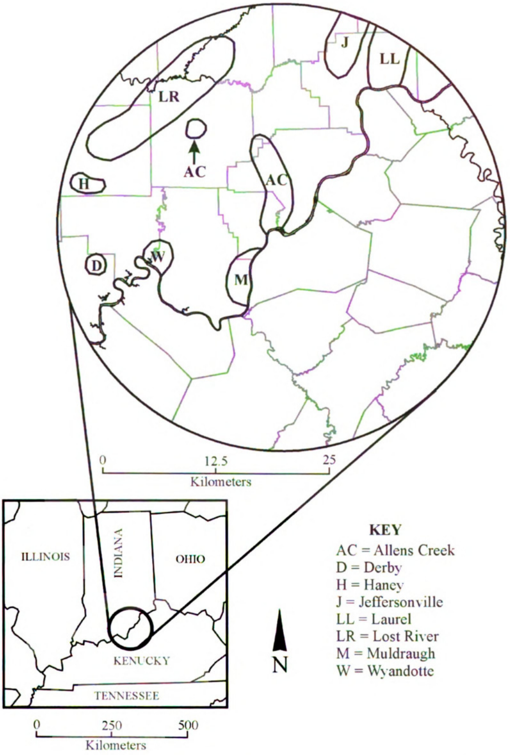


Figure 4.5. Map known Indiana chert sources within 80 km radius of the Falls, adapted from Cantin (1994).

higher quality Laurel chert can be differentiated, however, and is generally given the name Marble Hill (Cantin 1994).

The Muscatatuck Plateau begins where Laughery Creek joins the Ohio River in Jefferson County, Indiana (see Figure 4.4) (Gray 1997). This region is characterized by a broad flat upland comprised of glacial drift between 20 to 25 feet deep (Campbell 1997; Gray 1997). In the upland of the Muscatatuck Plateau is a unique biotic community called "Crawfish Flats" (Campbell 1997). These wet beech-maple forests are created by a perched water table in fragipan soils and are a preferred habitat for crawfish. Like the Dearborn Upland, the streams in the Muscatatuck Plateau are deeply incised and remnant mesophytic forests are typical in the ravines. Small areas of karst features and springs can be found along the margins of river valleys, where bedrock is exposed (Figure 4.6). Silurian and Devonian aged limestone and dolomite underlie glacial drift deposits. This bedrock gently dips to the west, dropping over 350 feet from the Laughery escarpment to the Scottsburg Lowland on the western boundary of the Muscatatuck Plateau (Campbell 1997; Gray 1997). Outcrops of Jeffersonville chert occur in this provenience. Cobbles of both Jeffersonville and Laurel chert are abundant in the glacial outwash deposits along the Ohio valley.

The Scottsburg Lowland and Charlestown Hills mark the western edge of the glacial landscape in Indiana and extends into Kentucky as only small discontinuous areas. The Scottsburg Lowland and Charlestown Hills are characterized by broad, low glacial drift and till deposits overlying relatively easily weathered bedrock (Campbell 1997; Gray 2000; Powell 1999). This zone was considerably eroded by Pleistocene glacial

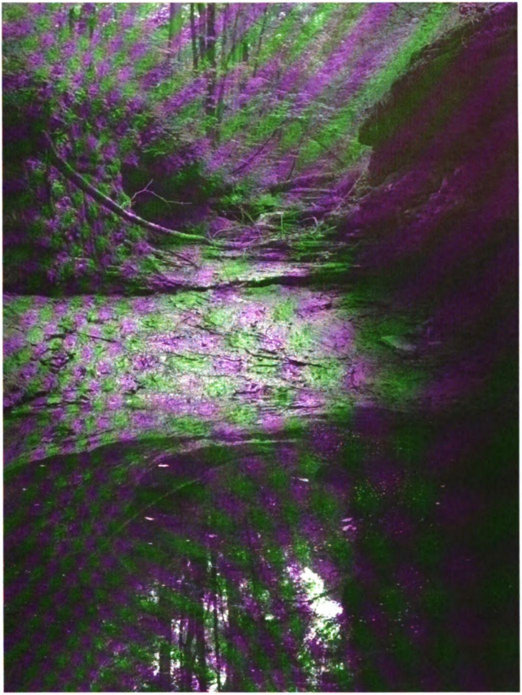


Figure 4.6. Photograph of a karst spring located in the valley of Fourteen Mile Creek in Clark County, Indiana. Photograph taken by the author, July 2005.

advances due to the presence of soft Late Devonian and Early Mississippian shale bedrock (Powell 1999).

The most outstanding features of the Scottsburg Lowland are numerous wide alluvial and lacustrine plains along rivers such as the White and Muscatatuck. The Muscatatuck River, which derives its name from the Delaware word "mosch-ach-hit-tuck or "stream flowing through swampy land" (McPherson 1993) is a slow-moving, low-gradient river (Campbell 1997). The Muscatatuck River did not carry glacial outwash and is characterized by a broad lowland of lacustrine silt and clay deposits (Gray 2000). Wind-blown deposits of sand are found along the broad alluvial plain of the White River (Campbell 1997), indicating that this river did discharge Wisconsin glacial outwash (Gray 2000). The dominant plant community in this region is floodplain forest, which is typically comprised of sweetgum, swamp chestnut oak, swamp white oak, black gum, shellbark hickory, and pecan (Campbell 1997).

The Charlestown Hills lies within the drainage of Silver Creek and the Ohio River (Gray 2000). The Charlestown Hills is essentially very similar to the Scottsburg lowland, but with a lower overall elevation of 500 feet above mean sea (Gray 2000). As the name implies, the Charlestown Hills is defined by low rolling hills of discontinuous, thin glacial till deposits (Gray 2000). Bedrock outcrops are more common in the Charlestown Hills than the Scottsburg Lowland (Gray 2000).

Karstic Physiographic Zones

The karst portion of the project area was not glaciated during the Wisconsin advance. This landscape has highly dissected surface topography and contains numerous caves, springs & karst seeps, rockshelters, and sinkholes. Some of the caves, such as Harrison and Wyandotte caves in Indiana are extremely large. These caves are part of the same geologic system as the famous Mammoth cave in Kentucky's Edmondson county, which located to the south of the project area. Prehistoric mining of chert nodules, and the cave minerals epsomite and aragonite, have been documented at Wyandotte cave as early as the Late Archaic period (Munson and Munson 1990). Other karst features would have also been considered significant locales in the landscape to SMA peoples. For example, karst springs and sinkholes would have held abundant wetland resources, as well as attracting game animals.

The eastern glacial landscape is separated from the karst landscape by a prominent escarpment of Mississippian limestone from the Borden Group (Powell 1999), known as the Knobstone Escarpment. The escarpment rises over 600 feet above the Ohio River and in some places has an elevation of over 900 feet above mean sea level (Figures 4.7 and 4.8) (Gray 1997, 2000; Homoya and Huffman 1997; Powell 1999). The Knobstone Escarpment is a natural drainage divide between the glacial and karstic landscapes (Powell 1997). This feature runs from the White river in Indiana, south into central Kentucky. The "Knobs" form the eastern boundary of the province known as the Norman Upland in Indiana and Muldraugh Hills in Kentucky.

The Norman Upland or Muldraugh Hill province "consists mainly of the dissected front of the Knobstone Escarpment" (see Figure 4.4) (Gray 1997:35). In this plateau of Mississippian limestone and siltstone from the Borden Group, the uplands are characterized by numerous steep slopes and flume ravines (Gray 1997, 2000; Homoya and Huffman 1997). The vegetation in this region is typically dry forest, consisting of

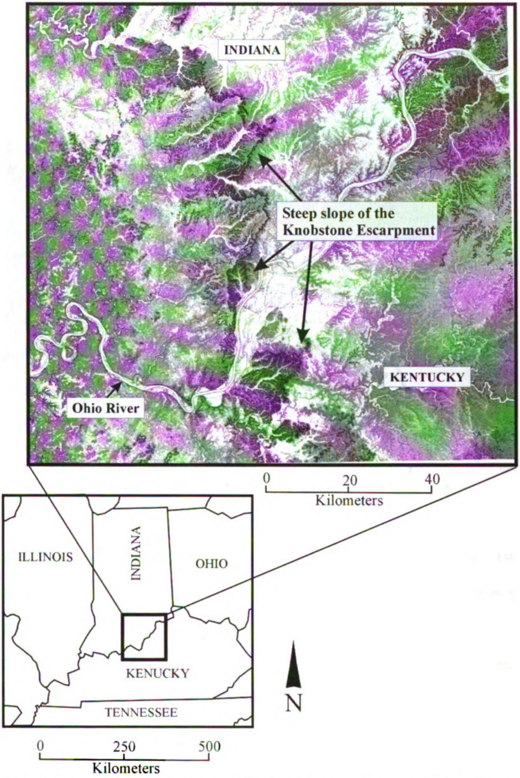


Figure 4.7. Slope of the Falls Region indicating the ruggedness of the Knobstone Escarpment. Areas of high slope are denoted by darker shading.

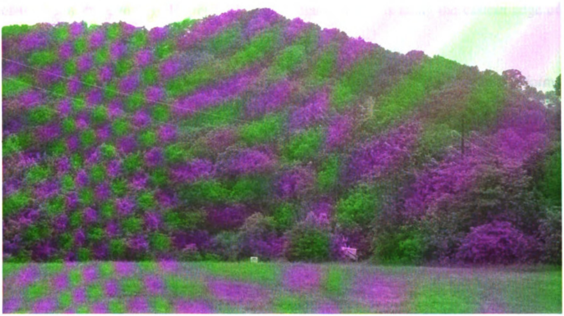


Figure 4.8. Photograph of the Knobstone escarpment from the Charlestown Hills on the campus of Indiana University, South in New Albany, Indiana. Photograph taken by the author, June 2005.

Virginia Pine, pignut and shagbark hickory, and black, white, and chestnut oak (Homoya and Huffman 1997). Another feature that occurs in this area is the siltstone glade (Homoya and Huffman 1997), which is a natural forest opening that occurs on upland slopes with desert-like dry and rocky soils. Trees that typically grow on the margins of siltstone glades include blackjack and chestnut oak (Homoya and Huffman 1997).

Two well- known chert resources may be found in the Norman Upland (see Figure 4.5). The fossiliferous Allens Creek chert is found in outcrops of the Floyds Knobs limestone member of the Borden Group (Cantin 1994). Muldraugh chert occurs on the western edge of the Muldraugh Hills in Kentucky (not shown in Figure 4.4). Muldraugh chert is a mottled, high quality chert that was utilized as early as the Paleoindian period (Cantin 1994). Outcrops of Muldraugh are also found in a small area of the Saunders Group in Harrison County, Indiana, which is along the eastern edge of the Mitchell Plain (Cantin 1994).

The Mitchell Plain is a continuation of the karst Mississippian Plateau that forms the Norman Upland (see Figure 4.4). This province is characterized by thousands of karst features such as sinkholes, sinking streams, springs, and caves (Figure 4.9) (Homoya and Huffman 1997). Because of the thin solum and water being trapped below

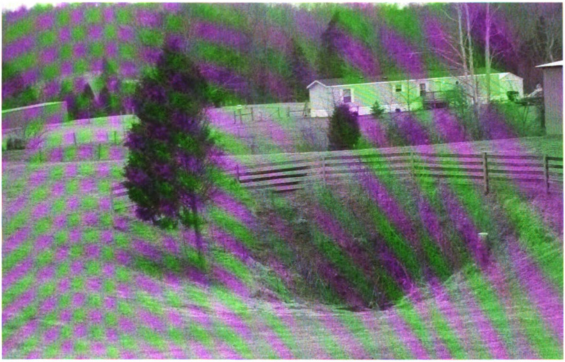


Figure 4.9. Photograph of one of thousands of karst sinkholes and springs in Harrison County, Indiana. Photograph taken by the author, March 2006.

the surface, most of the vegetation in this province is suited to drought and fire (Homoya and Huffman 1997). Prior to European settlement, the dominant vegetation consisted of open barrens with a "mosaic of herbs, shrubs, and scattered trees" (Homoya and Huffman 1997:167). However, rich wetland plant communities can be found at ponded sinkhole swamps which dot the landscape (Homoya and Huffman 1997).

The westernmost physiographic province in the Falls region is the Crawford Upland (see Figure 4.4). This region is bounded by a limestone escarpment of the St. Louis Formation on the eastern edge, which is referred to as the Chester Escarpment in Indiana and Dripping Springs Escarpment in Kentucky (Gray 2000; Homoya 1997). Wyandotte chert, a high quality kryptocrystalline chert, occurs in outcrops along this escarpment (see Figure 4.5) and can be found as nodules eroded from the limestone slopes or as tabular beds within limestone outcrops (Figure 4.10) (Seeman 1975). Due to the quality of Wyandotte chert for tool manufacture, this material was traded extensively throughout the Midwest and Great Lakes as early as the Middle Archaic period (Cantin 1994).

The topography of the Crawford Upland is extremely rugged, with local relief of 200 to 300 feet (Gray 2000). This is due to the presence of resistant sandstone interbedded with soluble limestone (Gray 2000; Homoya 1997). The bedrock in the eastern portion of the Crawford Upland is late Mississippian in age and the western bedrock is early Pennsylvanian (Gray 2000). Karst features tend to be most common in the eastern Mississippian bedrock, which is predominantly limestone (see Figure 4.9) (Gray 2000).

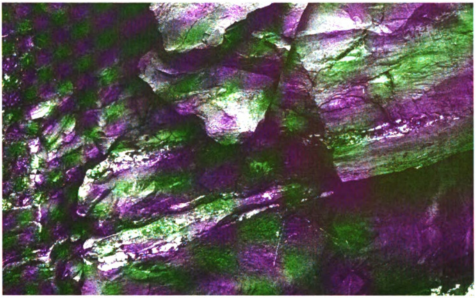


Figure 4.10. Photograph of one of many tabular outcrops of Wyandotte chert (lighter bands within the stone) found in the Crawford Upland province. Photograph take by the author, July 1998.

A variety of ecological communities can be found in Crawford Upland including: cliff communities, dry sandstone and limestone glades, and dry upland and mesic upland forest. Cliff communities contain several rare species, such as the woodrat (or packrat), timber rattlesnake, and green salamander (Homoya 1997). The dry upland forests are composed of black, white, and chestnut oak as well as pignut and shagbark hickories (Homoya 1997). Sandstone glades tend to be dryer and contain species such as slender knotweed, poverty grass, and prickly pear cactus (Homoya 1997).

Ohio River Lowlands

In addition to the upland physiographic zones, the Ohio River lowlands are another ecological and geological area (Figure 4.11). There are several large valley segments that make up the Ohio River lowlands within this region. These valleys are extremely rich habitats and based on the high density of prehistoric sites they must have been preferred locales for settlement. The ecology is complex, with distinct plant communities on the terrace ridges, wetland sloughs, and floodplain ridges (Petty and Jackson 1966). As the following nineteenth century account of Floyd County, Indiana demonstrates, floodplains contained impressive forest growth at the time of European settlement.

> The bottomlands along the Ohio were especially noted for the immense size and vigorous growth of timber. Giant sycamores, black walnut, hickory...grew luxuriantly and wonderfully large on the rich, broad bottoms where are now cultivated farms (Ford 1882:235).

The characteristics of the Ohio Valley in the vicinity of the Falls are discussed in more detail in Chapter 5.

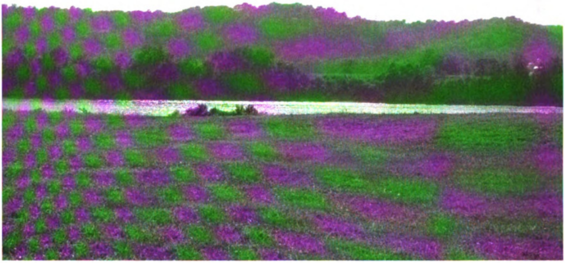


Figure 4.11. Photograph of the Ohio River at the Farnsley-Moreman Landing, in the Mill Creek Bottom of Southwestern Jefferson County, Kentucky. Photograph taken by the author, July 2005.

FAUNAL RESOURCES

This section briefly examines the types and quantities of faunal resources that may have been available to the SMA peoples of the Ohio Falls region. While there is currently no data concerning specific densities of faunal resources for each of the physiographic zones in the Ohio Falls region, Reidhead (1981) provides estimates that can be used to generalize animal productivity for the entire study area. Reidhead (1981) conducted a detailed reconstruction of faunal resources for the Haggs site, located near the confluence of the Great Miami River with the Ohio River at the southeastern corner of Indiana. His reconstructions were based on a variety of ethnographic, historic, and ecological sources throughout the North American Midcontinent. Table 4.1 provides a summary of major terrestrial and aquatic faunal resources and their estimated densities.

The density estimates listed in Table 4.1 are Reidhead's (1981) most conservative numbers. It is likely that the faunal densities were greater in the Falls region because Reidhead's figures are calculated for the smaller-order Great Miami River, not the Ohio River. Therefore, the actual densities of these faunal resources may have been much greater in the Falls region. The density figures suggest that the study area was indeed very productive. Reidhead (1981) also proposed the best seasons for procuring various faunal resources, based on animal life cycles and ethnographic data on hunting strategies. Most of the aquatic resources are best collected in the warm months, from late spring through early fall (Reidhead 1981). The terrestrial resources, however, are typically procured during the cold months (Reidhead 1981).

Table 4.1. List of common animal resources in the study area prior to European settlement (data estimated from Reidhead 1981)

Genera/Species Name	Common Name	Estimated Prehistoric Density	Season(s) of highest productivity
Terrestrial Resources			
Ursus americanus	Black Bear	0.5/sq mi	Winter
Odocoileus virginianus	White-tailed Deer	40/sq mi	Fall - Early Winter
Cervus canadensis canadensis	Elk	3/sq mi	Late Summer
Castor canadensis	Beaver	50/sq mi	Winter
Didelphis marsupialis	Opossum	50/sq mi	Fall
Procyon lotor	Raccoon	30/sq mi	Summer - Winter
Sciurus sp.	Squirrel	320/sq mi	Fall
Meleagris gallopavo	Wild Turkey	20/sq mi	Fall - Winter
Terrapene carolina carolina	Box Turtle	2/acre	Spring
n/a	Waterfowl	5/sq mi floodplain	Fall
Aquatic Resources			
Ondatra zibethica	Muskrat	8/acre	Spring
n/a	Fish	100kg/acre	Spring - Summer
n/a	Freshwater Mussels	200kg/acre	Summer - Fall
Chelydra serpentina serpentina	Common Snapping Turtle	0.5/acre	Late Spring - Early Fall
Terrapins	Aquatic Turtles	30/acre - wetland 15/acre - river	Late Spring - Early Fall
Trionyx	Softshell Turtles	1/acre	Late Spring - Early Fall

It is difficult to address the spatial distributions of these resources, other than in generalities. For example, most aquatic turtle species prefer slow-run water or wetland habitats (Reidhead 1981). Some species, such as wild turkeys or elk, have extremely large home-ranges. These animals move many kilometers in a day, often traveling between lowland and upland settlings in search of food resources (Reidhead 1981). Consequently, faunal resources cannot be assigned to a particular physiographic zone. Therefore, accessibility to these faunal resources cannot be easily estimated or modeled. Undoubtedly, SMA peoples had an intimate knowledge of the seasonality, behavior, and home-ranges of faunal resources and they would have planned their hunting excursions based on this knowledge. Because most animal species require some access to water (Reidhead 1981), floodplains and locales near springs may have been settings where faunal resources were reliably encountered. The faunal information presented here is meant to draw attention to the abundance of animal resources available in aquatic and terrestrial settings, but at present, this data is not specific enough to consider in the modeling universe.

SUMMARY

From the proceeding, it should be clear that the Falls region is a distinct area within the Ohio River valley. This region is geographically and ecologically diverse. Consequently, it provided a rich landscape for the settlement of prehistoric cultures. Seven distinct physiographic zones offered a variety of plant communities and diverse faunal resources. Some of the most productive areas were the Ohio River lowlands, because they contained nut mast, wetland, and riverine resources all within close proximity. Therefore, it is not surprising that some floodplain sites were repeatedly used for millennia.

Undoubtedly, Falls of the Ohio River was the most unique feature in this landscape. Therefore, it is likely that the Falls had both economic and social significance for SMA peoples. Additionally, several high-quality chert resources are also available in the Falls Region. Some of these cherts, like Wyandotte, were traded throughout the Eastern Woodlands. Another resource that has not been systematically mapped, but is present throughout the Falls region is salt springs. Early European settlers noted many "salt licks" in the region; which they utilized to mine salt and hunt game (Ford 1882). Presumably, this pattern of exploitation occurred prehistorically as well. Rugged terrain between lowland and upland areas may have placed constraints on travel, particularly in the karst portion of the region. However, the karst landscape also offers sinkholes and springs, which are rich in floral and faunal resources.

While the Falls landscape is complex and varied, hunter-gatherers would have had an intimate knowledge of the various resources available. It is likely that they positioned themselves to maximize their resource base and minimize the costs of traveling in this rugged landscape (i.e. Bettinger 1991; Kelly 1992, 1995). Previous research on SMA sites in the Ohio Falls region by Janzen (1977), suggests that sites are not located randomly in the landscape, but are part of an overall strategy for resource exploitation. In chapter 6, I will discuss previous research on SMA sites in the Falls region and introduce the data set used in this research.

CHAPTER 5

GEOARCHAEOLOGICAL INVESTIGATIONS AT THE FALLS

"Fireplaces of rude construction were found in the alluvial deposits twenty feet below the surface, upon which were brands of partly burnt wood, bones of small animals, and some human skeletons" (Ford 1882:18).

INTRODUCTION

The previous chapter presented the geo-environmental contexts of the Falls region and established that the Ohio River is a relatively young geomorphic feature. Because the Holocene was a period of ongoing landform evolution and stabilization it is crucial to characterize the impact of alluvial processes on the archaeological record. This chapter focuses on the contribution of geoarchaeological research to predict the impact of geological processes on Archaic period site preservation in the Ohio Falls region, and address the issue of geomorphological site bias (e.g. Stafford and Creasman 2002).

As the quote at the beginning of the chapter demonstrates, there is a high potential for archaeological sites to be deeply buried on the alluvial landforms near the Falls. To interpret prehistoric settlement patterns as accurately as possible, it is necessary to understand the processes affecting landform development and archaeological site preservation in the Falls region (cf. Holiday 1997; Mandel 2000; Rapp and Hill 1998; Schiffer 1987; Stafford and Creasman 2002; Waters 1992). In this chapter I describe which factors may skew the representation of Middle to Late Archaic and account for potential biases in the archaeological record by reviewing literature of significant geoarchaeological research conducted in Falls region valley segments during the past thirty years.

There are several large valley segments that have been the focus of geoarchaeological investigations in the study area. From east to west, these are the Bethlehem Bottom, Clark Maritime Archaeological District, Middle Creek Bottom, Knob Creek Bottom, Mill Creek Bottom, and New Amsterdam Bottom (Figure 5.1). The investigations described here suggest that the factors affecting Ohio valley geomorphology are extremely localized. However, regional patterns can be recognized – several of which have important ramifications for reconstructing the Shell Mound Archaic landscape. Geoarchaeological research suggests that the SMA database in the Ohio Falls region is reasonably complete and not significantly biased.

BETHLEHEM BOTTOM

Near the eastern edge of the Falls region, between River Miles 576 – 578, lies the Bethlehem Bottom in Clark County, Indiana (see Figure 5.1). This large valley segment has been intensively investigated in advance of sand and gravel mining operations. Geoarchaeological investigations have been conducted on three tracts of land, consisting of approximately 140 hectares. The Bethlehem Bottom is comprised of six landforms, including four terraces at elevations of 480, 470, 460, and 450 feet above mean sea level, and two floodplains at 445 and 440 feet above mean sea level (Figures 5.2 and 5.3).

Geoarchaeological investigations conducted by Boulding (1996), Russell (1996a, 1996b), and Surface-Evans (2002, 2005) resulted in a model of landscape evolution and

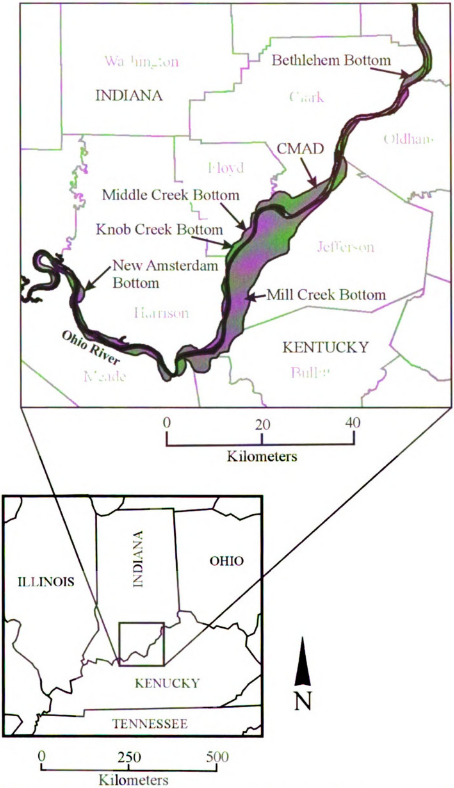


Figure 5.1. Locations of all Ohio River lowlands in the project area with names of valley segments discussed in this chapter.

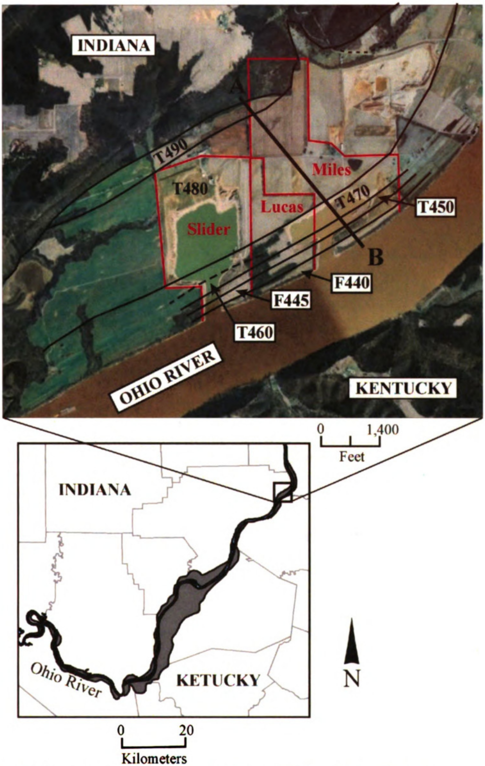
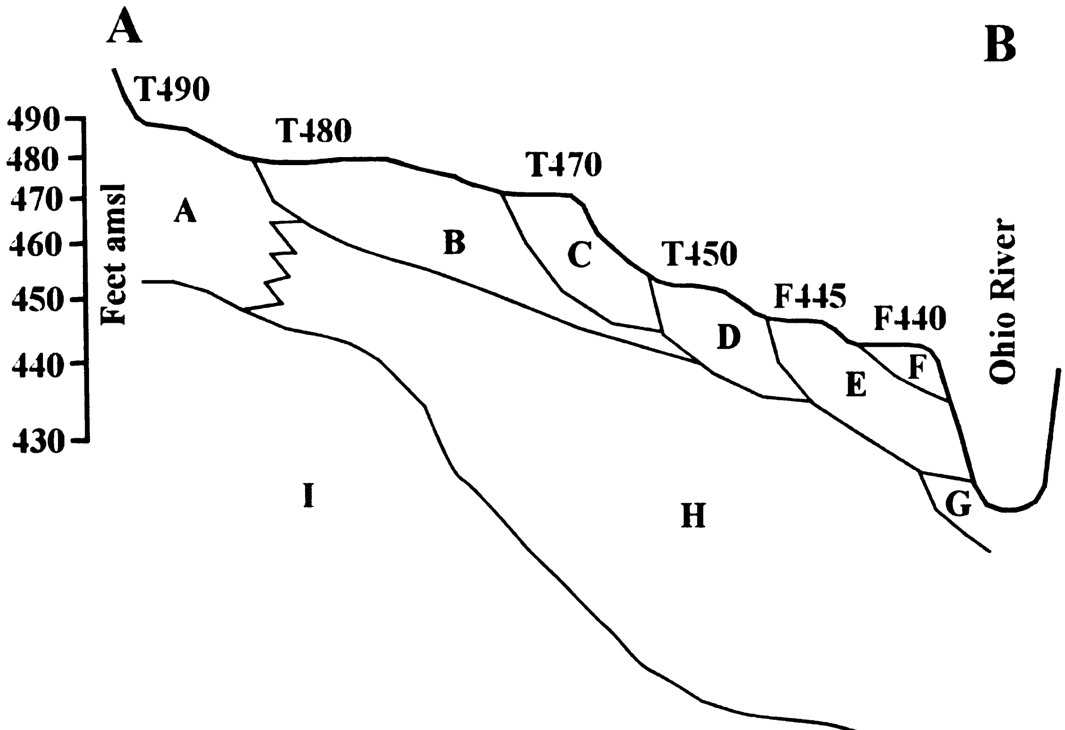


Figure 5.2. Locations of Bethlehem Bottom tracts, showing landforms as reconstructed by Russell (1996b) and Surface-Evans (2002). Cross-section A-B is shown in Figure 5.3. Base image acquired from Google Earth, 2009 (In color).



A - Colluvial Fan/Pleistocene
B - Late Wisconsin - Early Holocene Bar Deposits
C - Late Wisconsin - Early Holocene Overback Deposits
D - Early Holocene Overback Deposits
E - Middle Holocene Overbank Deposits
F - Middle - Late Holocene Overbank deposits
G - Wisconsin Outwash Sand and Gravel
H - Illinoian Outwash Sand and Gravel
I - Limestone/Dolomite Bedrock

Figure 5.3. Generalized cross-section of the Bethlehem Bottom between points A and B, as indicated on Figure 5.2.

human settlement in this segment of the Ohio valley. A wide range of data sources were drawn upon, including pedological and textural analyses of samples from trenches and auger cores, stratigraphy of cultural and natural deposits, and topography. Three general patterns were observed in the Bethlehem Bottom. First, fine-grained overbank deposits of silt and clay overlie Pleistocene sand and gravel outwash deposits on all of the landforms. Second, the depth of overbank deposits increases on the riverward landforms, with more than 10.0 m of alluvium present on the floodplain. Third, river entrenchment was accompanied by considerable lateral migration of the Ohio River channel, creating each of the floodplain landforms (Russell 1996a).

The upper two terrace landforms (T480 and T470) have been correlated to the Tazewell and Cary substages during the Wisconsin glaciation based on soil pedology (Russell 1996a; Surface-Evans 2002). Consequently, these landforms predate the Paleoindian occupation of the Ohio River valley and have a low potential for deeply buried cultural deposits. Based on analysis of soil weathering, Boulding (1996) and Russell (1996a, 1996b) propose that all of the late Pleistocene and early Holocene terrace landforms developed within a fairly short interval from roughly 15,000 to 10,000 BP. This conclusion is also supported by archaeological evidence. Early Archaic materials dating to 10,000 BP were recovered at the surface of all terrace landforms (Russell 1996a; Surface-Evans 2002). Therefore, there is a low likelihood for cultural materials to be in buried contexts on the terraces.

The development of floodplain landforms in the Bethlehem Bottom is more ambiguous. The F445 and F440 landforms are not continuous, but are found in different parts of the valley segment. Deeply buried cultural deposits were recovered from both of the floodplain landforms (F445 and F440). However, at the Slider Tract Middle Woodland materials were found more deeply buried than Early Archaic materials on the F440 landform (Boulding 1996). Boulding has suggested that this apparent juxtaposition may be due to a near equilibrium state of scoring and deposition since the early Holocene, the result of which is "local irregularities in the surface over time" (1996:36).

At the Miles Tract, there is no evidence for long-term stability of the floodplain surfaces. It appears that the F445 landform was seasonally inundated during the early Holocene and received moderate overbank deposition during the middle Holocene. Early Archaic materials are buried up to 1.3 m on this landform (Surface-Evans 2002). The F440 landform exhibited a classic succession of cultural deposits with Paleoindian and Early Archaic materials recovered 2.0 m below surface and Middle Archaic materials recovered approximately 1.2 m below surface at the Miles Tract (Surface-Evans 2002). A similar pattern was noted on F440 at the Lucas Tract (Surface-Evans 2005). At this location a possible Paleoindian feature consisting of cached anvil stones and lithic debitage was identified at 1.5 m below surface, Early Archaic materials were recovered 1.25 m below surface, and Late Archaic materials and features were identified at 0.4 to 0.8 m below surface (Surface-Evans 2005). The cross-section illustrated in Figure 5.3 shows the vertical distribution of cultural deposits within each landforms. This illustration is likely to be representative of site burial for most floodplain landforms in the Ohio Falls region.

Overall, there is a significant potential for Paleoindian through Late Archaic cultural materials to be buried on the F445 and F440 landforms. However, the depth of these materials may be variable. This suggests that there was active alluvial deposition on the F445 and F440 landforms during the early and middle Holocene (ca. 12,000 – 5,000 BP). By the Late Archaic period (ca. 3,000 BP), however, these landforms were fairly stable and are perhaps more representative of Boulding's (1996) model of scouring and deposition.

CLARK MARITIME ARCHAEOLOGICAL DISTRICT

The Clark Maritime Archaeological District (*hereafter*, CMAD) is located immediately upriver from the Falls and approximately twenty river-miles southwest of the Bethlehem Bottom, in Clark County, Indiana (see Figure 5.1). The port facility that comprises the Clark Maritime Centre is between river miles 596 – 597 (Bassett 1986). Five landforms or geomorphic features have been identified in the CMAD bottomlands including, the alluvial terrace at 460 feet above mean sea level, two floodplains at 440 and 425 feet above mean sea level, a back channel of the Ohio River, and Sixmile Island (Figure 5.4) (Bassett 1986). Based on borehole and soil data, Bassett (1986) determined the ages and depositional history of each of these landforms.

The terrace (T460) is comprised primarily of calcareous sand and gravel outwash deposits with a thin layer of silt loam less than 2.0 m thick. Bassett (1986) suggests a Pleistocene age for the T460 landform. This landform may correspond to the Cary terrace identified elsewhere in the Falls region (cf. Ray 1974), although the elevation of this landform is not regionally consistent. For example, in the Bethlehem Bottom, the Cary terrace was at an elevation of 470 feet above mean sea level. Due to the antiquity of the T460 landform, it has a low potential for deeply buried cultural materials. Archaeological investigations of this landform determined that there are no cultural materials present below plowzone (Bassett 1986).

The high floodplain F440 has a deep alluvial sequence of more than 7.0 m of silt loam deposits overlying late Pleistocene sand and gravel. Early Archaic period materials were recovered at a depth of 2.7 m below surface on this landform. Interestingly, "time equivalent archaeological zones at Clark Maritime occur at varying

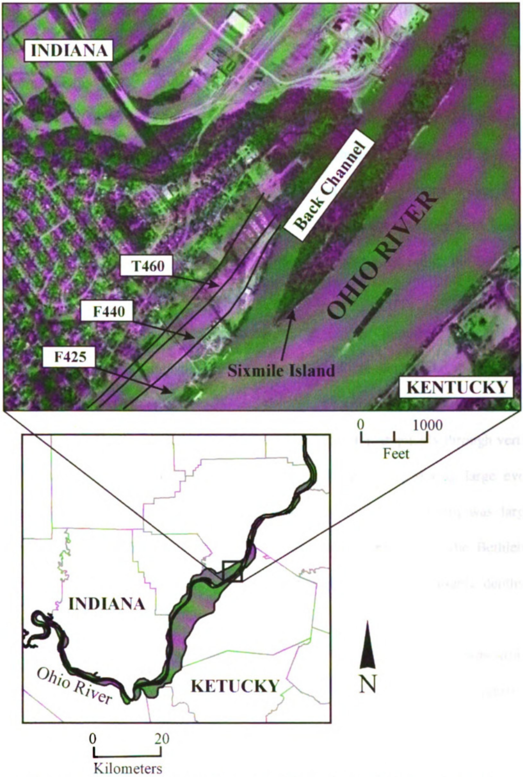


Figure 5.4. Approximate locations of landforms in the CMAD project area As reconstructed by Bassett (1986). Base Image acquired from Google Earth, 2009.

depths down the length of and across the floodplain segment" (Bassett 1986:29). In particular, Late Archaic period materials were found at depths of 0.46 m on the ridge separating the floodplain and terrace slough and at 1.06 m on the riverward ridge (Bassett 1986). Bassett (1986) points out that these vertical differences are separated by only 6.1 m of horizontal distance. In addition, Woodland period materials were found in shallow buried contexts on the landward floodplain ridge. Based on these patterns, it appears that rates of deposition on the F440 landform apparently varied considerably both spatially and temporally (Bassett 1986). The same pattern was also observed in the Bethlehem Bottom.

From sedimentological analysis of the floodplain deposits Bassett (1986) developed a model to explain the floodplain variability. He argues that the floodplain landforms in the CMAD area were created through a combination of both vertical and lateral accretion. He proposes that the F440 landform developed quickly through vertical accretion to become a "stable 'fossil' floodplain", flooded only during large events (Bassett 1986:41). Consequently, he suggests that the F440 landform was largely constructed by 8,000 BP. This is similar to the pattern observed in the Bethlehem Bottom and explains the presence of multiple floodplains and the variable depths of archaeological materials.

In the CMAD area the prehistoric settlement of floodplain landforms was strongly affected by changing geomorphic conditions (Bassett 1986). Bassett (1986) suggests that during the Archaic period, Sixmile island was part of the F440 floodplain segment. In addition, the riverward floodplain ridge was more pronounced during this time. Archaic materials are concentrated on this part of the landform. At around 2,200 BP, a back channel of the Ohio River developed. During this timeframe, the landward ridge was created and the F425 landform developed when the F440 floodplain was scoured. The newly developed landward ridge was a potential locale for Woodland period settlement, as it was fairly stable by this time in prehistory.

MIDDLE CREEK BOTTOM

The Middle Creek Bottom is located between river miles 612 – 613, south of the town of New Albany in Floyd County, Indiana (see Figure 5.1). Archaeological and geoarchaeological investigations were conducted at the Middle Creek Bottom prior to the construction of the Paddy's West Electrical Substation for the Louisville Gas and Electric Company (cf. Boulding 1993; Smith and Mocas 1993). The Paddy's West archaeological complex (*hereafter*, PWAC) includes four large multicomponent sites with substantial Archaic period components (12-Fl-46, 47, 48, and 52) (Smith and Mocas 1993). Site 12-Fl-46, known as the Dalhoff site, is an Archaic shell midden that was investigated during these excavations (Smith and Mocas 1993). Geoarchaeological research during the PWAC project was focused on determining whether the channel of the Ohio River was located immediately adjacent to the Dalhoff site at the time of occupation and formation of shell midden deposits (Boulding 1993). Boulding (1993) conducted an analysis of the cultural and natural stratigraphy at Dalhoff using data from exposed trench profiles and soil borings.

The Middle Creek Bottom is located downriver from the Falls, near the interface of the Charlestown Hills and Norman Upland. This valley segment is dissected by French and Middle creeks, which head in the Knobstone Escarpment (Boulding 1993).

The Ohio River flows nearly due south for approximately 15 miles in the vicinity of the Middle Creek Bottom and is confined on the western side by the Knobstone Escarpment (Boulding 1993). Unlike the previously mentioned valley segments, this bottomland does not exhibit the well-developed ridge and swale topography (Boulding). Four landforms were identified in the Middle Creek Bottom, a high lacustrine terrace at 470 feet above mean sea level, a Holocene terrace at 450 feet above mean sea level, a high floodplain between 430 and 420 feet above mean sea level, and a low floodplain at 410 feet above mean sea level (Figure 5.5) (Boulding 1993).

The T470 landform is comprised of slackwater deposits. Boulding (1993) proposes that this landform developed when the tributary streams were dammed during the Tazwell interval, which is presumed to be the highest period of outwash discharge during the Wisconsin glaciation (Boulding 1993). No archaeological deposits were recovered from either the T450 or T470 landforms (Boulding 1993). The T450 landform is dissected by French and Middle creeks (Boulding 1993). The soil associations mapped on this terrace indicate poorly developed soils. Boulding places the age for this landform roughly between 15,000 and 10,000 BP, when the Ohio River shifted from a braided to a meandering stream. Interestingly, this stretch of the river exhibits a fairly stable channel, with relatively little lateral migration. Boulding (1993) attributes the stability of the channel to the influence of the Falls and the Knobstone escarpment, which both reduce the stream gradient in this area.

The F430 landform, what Boulding (1993) terms the "active" floodplain, is the locus of the majority of archaeological deposits in the PWAC. According to Boulding,

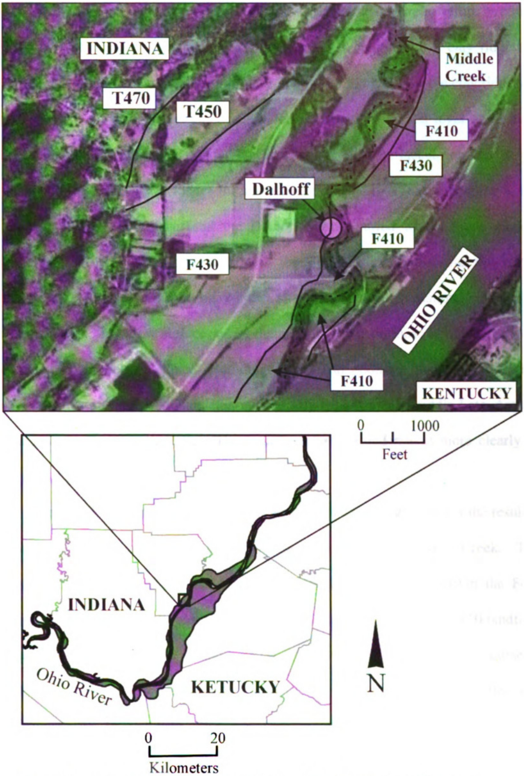


Figure 5.5. Approximate locations of Middle Creek Bottom landforms as reconstructed by Boulding (1993). Base Image acquired from Google Earth, 2009.

the F430 landform "lies within a slackwater area where vertical accretion from overbank deposition is dominant" (1993:66). One feature of this landform is a clay ridge that corresponds with the topographic high. According to Boulding (1993) the clay ridge was deposited when the Ohio River flooded at 410 feet above mean sea level and caused Middle Creek to back up. The ponded creek deposited a clayey lacustrine ridge at 430 feet above mean sea level. Evidence for lateral accretion and overbank deposition is also present on the F430 landform and the Dalhoff site is buried within these deposits (Boulding 1993). A trench profile through the site revealed that it was not buried uniformly. The landward portion of the site was relatively shallowly buried at approximately 1.5 m below surface, while the portion of the site near Middle Creek was more than 3.0 m below surface (Boulding 1993). In addition, there is no vertical separation between Early Archaic non-midden deposits and the Middle-Late Archaic shell-midden deposits at this site. These patterns can be understood more clearly by examining the F410 landform.

The low floodplain (F410) has a complex history of formation and is the result of the interaction between the flood events of the Ohio River and Middle Creek. This landform is not continuous, but in located in several isolated spots within the F430 landform (see Figure 5.4). Boulding (1993) proposes that portions of the F410 landform may represent a filled cutoff meander of Middle Creek. The present-day course of Middle Creek now runs to the east of the Dalhoff site, while the past channel filled with F410 deposits lies immediately adjacent to the site. Boulding (1993) suggests that the flood event that cause Middle Creek to cut a new channel may have also eroded some of the material that buried the Dalhoff site on the F430 landform. This model accounts for the differential depth of Archaic period materials at Dalhoff and for the lack of vertical separation of Early and Middle-Late Archaic deposits.

Unlike the Bethlehem Bottom and the CMAD, the Ohio River channel was fairly stable throughout the Holocene in the Middle Creek Bottom. Rather, the behavior of Middle Creek has significantly impacted archaeological deposits in this portion of the Ohio valley. Middle Creek appears to have been adjacent to the Dalhoff site during Archaic occupation. This would have provided easy access to both the Ohio River and the uplands. Subsequent to the Archaic occupation of Dalhoff, however, a flood event altered the course of Middle Creek to the east of the site and deeply buried Archaic period deposits.

KNOB CREEK BOTTOM

The Knob Creek Bottom is located at the edge of Floyd and Harrison Counties in Indiana and near the interface of the Norman Upland and Mitchell Plain (see Figure 5.1). This valley segment occurs on the outside of a gentle meander of the Ohio River and is bounded by the Knobstone Escarpment (Stafford 1995). The Knob Creek Bottom is characterized by subtle ridge and swale topography, with a Pleistocene terrace at 450 feet above mean sea level and several Holocene landforms at 430 and 420 feet above mean sea level (Figure 5.6) (Stafford 1995).

Geoarchaeological investigations were conducted in the Knob Creek Bottom in conjunction with the Caesars Archaeological Project (CAP). CAP consisted of archaeological investigations on 65 acres of land prior to the development of a marina and riverboat gambling facility (Stafford 1995). Five significant buried archaeological

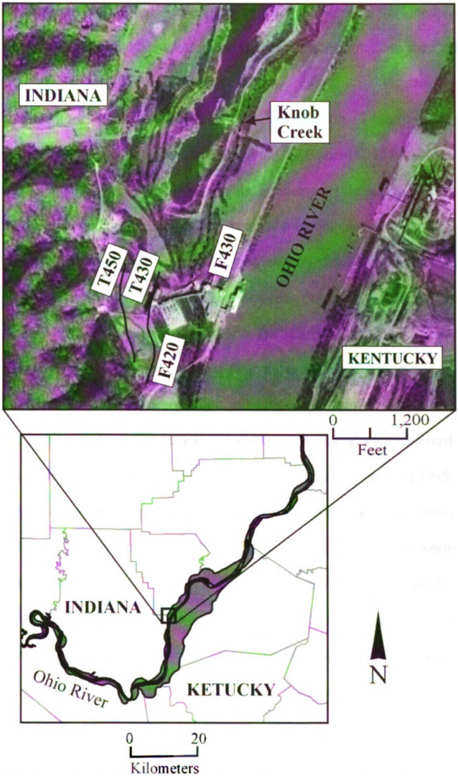


Figure 5.6. Approximate locations of Knob Creek Bottom landforms as reconstructed by Stafford (2004). Base Image acquired from Google Earth, 2009.

sites were identified during these investigations (12-Hr-481, 482, 483, 484, and 485); however, buried cultural remains were generally continuous throughout the CAP area in the upper 3.0 m of alluvial deposits (Stafford 2004).

Between 2 to 3 archaeological strata were identified on all landforms and in both the Early-Middle and Late Holocene deposits in the CAP area (Stafford 1995). Stafford (1995) used alluvial and archaeological deposits to reconstruct the evolution of this valley segment. He employed a combination of systematic trenching and auger cores, to collect data on soil weathering characteristics and sedimentary deposits. He designated two distinct soil-geomorphic units: Early-Middle Holocene fine-grain overbank deposits and Late Holocene vertical accretion deposits. The Early-Middle Holocene overbank deposits could be found on landforms of the Ohio River and Knob Creek.

Late Holocene alluvial deposits are present on the levee of Knob Creek and the riverward floodplain ridges. Two thick archaeological horizons were observed at 0.5 to 1.3 m, and 1.7 to 2.4 m below surface of the Knob Creek levee (Stafford 1995). On the two riverward floodplain ridges, three buried archaeological horizons were observed. The ridge nearest Knob Creek had a substantial Archaic earth midden between 0.35 and 1.1 m below surface (Stafford 1995). Two other strata are present at 1.2 to 1.8 and 1.9 to 2.2 m below surface. These deposits contain charcoal, burnt clay, and fire-cracked-rock. Although no culturally diagnostic materials were recovered from the archaeological deposits on this landform, Stafford (1995) proposes that they are Late Archaic or younger in age based on the degree of soil development. The riverward floodplain ridge has an extensive Middle Woodland midden buried between 0.8 and 1.5 m below surface (Stafford 1995). This was the only stratum that contain ceramic materials. The two underlying horizons, at 1.6 to 2.0 and 2.0 to 2.8 m below surface, contained charcoal, burnt clay, fire-cracked-rock, and lithic debitage (Stafford 1995). Stafford (1995) proposes that the sterile surface horizon on these landforms is due to recent historic alluvium.

Early-Middle Holocene alluvial deposits are found on the two landward terraces of the Ohio River (Stafford 1995). These landforms each have three buried archaeological strata. The upper most stratum of the riverward ridge consists of a Late Archaic rock midden approximately 0.50 m thick (Stafford 1995). These midden deposits cover a large area and contained abundant fire-cracked-rock and lithic debitage. Underlying the midden deposits are two strata at 1.0 to 1.5 m and 2.2 to 2.4 m below surface (Stafford 1995). These deeper deposits are more diffuse than the Late Archaic midden but "resemble a clear occupation surface" (Stafford 1995:30). The highest landform contained three archaeological strata at 0.0 to 0.3, 0.65 to 1.0, and 1.7 to 1.9 m below surface (Stafford 1995). While diagnostics were not recovered, Stafford (1995) argues that the level of soil development suggests that archaeological deposits on this landform are early to middle Holocene in age, based on the degree of soil weathering.

The vertical and horizontal distribution of archaeological deposits in the CAP area indicates that the depositional environment in the project area was dominated by a low-energy flood regime (Stafford 1995, 2004). These conditions were favorable for preserving archaeological deposits, rather than scouring them away (Stafford 1995). In addition, rates of deposition in the CAP area were high enough to preserve distinct occupation strata and prevent mixing of temporal units (Stafford 1995, 2004). In this valley segment it appears that overbank deposits from Knob Creek may have preserved archaeological sites, unlike the scouring observed in the Middle Creek Bottom or portions of Bethlehem Bottom (Boulding 1993, 1996).

MILL CREEK BOTTOM

The Mill Creek Bottom is located across the river from the Knob Creek Bottom, between river miles 621 – 625, in southwestern Jefferson County, Kentucky (see Figure 5.1). The Mill Creek Bottom is part of a larger valley segment that extends over much of Jefferson County, Kentucky. This is the largest valley segment in the Falls region, running approximately 50 km from Harrods Creek to immediately below Salt River in Kentucky (Figure 5.7) (Gray 1979). In the 1970's the Mill Creek Bottom was the focus of considerable archaeological investigations during the Southwestern Jefferson County Local Flood Protection Project (*hereafter*, SWJC) (Collins 1979). During these investigations, four large and stratified Archaic periods sites were excavated: Longworth-Gick (15-Jf-243), Villier (15-Jf-110), Rosenberger (15-Jf-18), and Spadie (15-Jf-14) (cf. Collins 1979). Numerous specialized analyses were conducted during these investigations including geoarchaeological and geomorphic studies (cf. Gray 1979).

Gray's (1979) work for the SWJC project represents one of the seminal geoarchaeological studies conducted in the Falls region. Gray proposed the following model for the development of the Mill Creek valley segment based on textural analysis of landform sediments and depths of buried cultural materials on the landforms. He identified five distinct landforms in this area, including a Pleistocene terrace and four Holocene floodplains (F1-F4) (see Figure 5.7). The Pleistocene terrace landform was formed as Ohio River began incising a channel into the outwash deposits. Gray (1979)

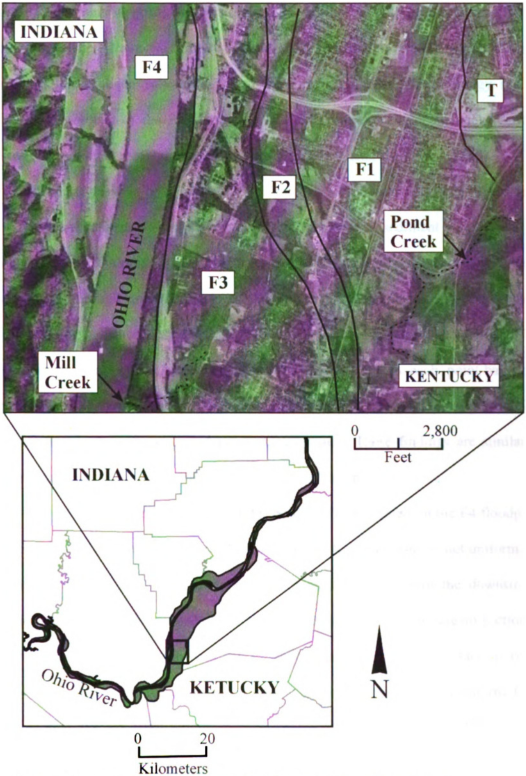


Figure 5.7. Approximate locations of Mill Creek Bottom landforms as reconstructed by Gray (1979). Base Image acquired from Google Earth, 2009.

suggests that loess deposits on this landform indicate a prolonged period of near equilibrium, where there was little downcutting or entrenchment of the river channel. The Ohio River began downcutting into the terrace deposits as the energy regime decreased at the end of the Pleistocene. Once entrenched, the river channel migrated westward, creating the series of four Holocene floodplain landforms (Gray 1979).

Textural analysis of deposits on the Holocene floodplain landforms determined two significant patterns. First, there is a gradual decrease in sediment size moving up through the landform profile, which indicates that there is a trend towards a lower energy flood regime through time (Gray 1979). Second, the lack of medium to fine sands in these deposits indicates suspended-load origin as overbank sediments (Gray 1979). According to Gray (1979), these two patterns suggest that as each point-bar ridge accreted vertically overbank deposits became fine-grain and less frequent. The result is a decrease frequency in floodplain deposition over time. These findings are similar to patterns observed by Stafford (1995, 2004) in Knob Creek bottom.

Of the four archaeological sites in the SWJC, all are located on the F4 floodplain landform. However, the depths of cultural deposits on this landform are not uniform. In particular, "Archaic occupation horizons were buried deeper toward the downstream (southern) end of the [floodplain] ridge. Cultural deposits in the downstream portion of the floodplain at the Longworth-Gick site as deep as 7 meters below the surface" (Collins 1979:474). Based on the locations and depths of cultural deposits on this landform, Gray proposes that the F4 landform must have developed during the early Holocene or approximately 10,000 BP. In addition, he hypothesizes that the floodplain ridges were formed as a series of point-bar features that prograded downstream. In Bethlehem and

Middle Creek Bottoms there is also strong evidence for progradation of floodplain landforms. Consequently, cultural deposits of the same age in this valley segment will vary in depth based on their location up or down stream. This phenomenon makes predicting site locations and depths in this portion of the Ohio valley particularly difficult.

NEW AMSTERDAM BOTTOM

The New Amsterdam Bottom is located near the western edge of the Falls region, inside a large bend in the Ohio River between river miles 656 – 658 (see Figure 5.1). This segment of the river, near the border of Harrison and Crawford Counties in Indiana, flows due north. The New Amsterdam Bottom is dissected by Indian Creek, a tributary stream of the Ohio River. Like many of the other tributary streams discussed above, the location of the Indian Creek channel changed during Holocene flood events. However, unlike the other tributaries discussed the former channel of Indian Creek has remained an oxbow lake called Overflow Pond (Figure 5.8 and Figure 5.9).

Five distinct alluvial landforms are present within the New Amsterdam Bottom: a floodplain of Indian Creek below 410 feet above mean sea level, low and high floodplains of the Ohio River at 410 and 420 feet above mean sea level, and low and high Pleistocene outwash terraces at 420 and 450 feet above mean sea level (Figure 5.10) (Boulding 1995). Lacustrine deposits are also found on a high terrace of Indiana Creek.

Geoarchaeological investigations in the New Amsterdam Bottom were conducted in conjunction with archaeological excavations at the Swan's Landing site (12-Hr-304),

Figure 5.8. Photograph of Over Flow Pond looking southeast from the F410 Landform northwest of the lake. Photo take by the author, August 2005.

Figure 5.9. Photograph of Over Flow Pond, looking west from the high Pleistocene Terrace east of the lake. Photo take by the author, October 2004.

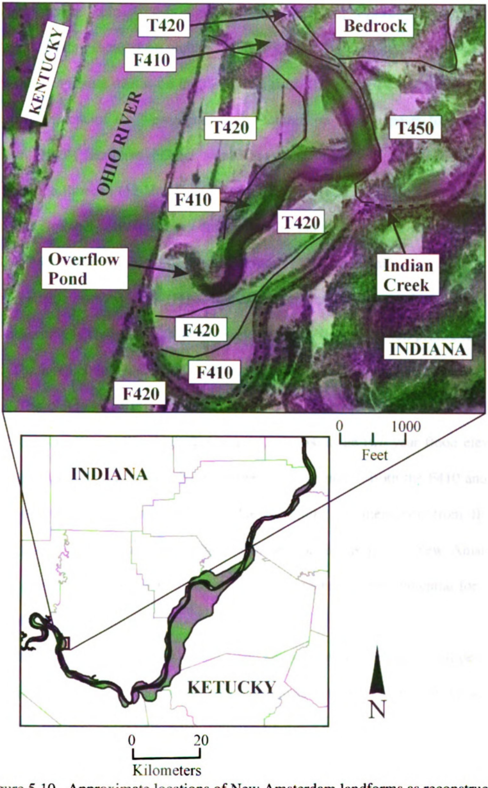


Figure 5.10. Approximate locations of New Amsterdam landforms as reconstructed by Boulding (1995). Base Image acquired from Google Earth, 2009.

an Early Archaic lithic workshop (cf. Mocas and Smith 1995). Investigations by Boulding and Gray focused on understanding why cultural deposits at Swan's Landing were buried at varying depths on the floodplain ridge (Boulding 1995). The site lies on the northern extent of the New Amsterdam Bottom, on what appears to be the high floodplain (F420) landform. Other significant Archaic sites in the New Amsterdam Bottom are the Breeden (12-Hr-11) and Overflow Pond (12-Hr-12) shell middens, which are located immediately upstream from Swan's Landing. Both the Breeden and Overflow Pond sites are located on the low terrace (T420) landform.

The tributary floodplain (Ft) is found along the modern channel of Indian Creek. This landform is fairly recent and demonstrates a poorly developed soil profile (Boulding 1995). The low floodplain (F410) is located along the Ohio River upstream from Indiana Creek. The elevation of this landform is below the two-year flood level of the Ohio River (Boulding 1995). The high floodplain (F420) is at the two-year flood elevation. This landform is found at the north end of the valley segment. Both the F410 and F420 landforms have weakly developed soils due to regular sedimentation from flooding (Boulding 1995). Because all of the floodplain landforms in the New Amsterdam Bottom have rapid sedimentation rates, these landforms have a high potential for deeply buried cultural deposits.

The two outwash terraces in the New Amsterdam Bottom have well-developed soil profiles. The low terrace (T420) is located parallel to the F410 landform south of Indiana Creek and along the Ohio River north of Indiana Creek. This terrace was formed by late Pleistocene outwash deposits and is capped by fine-grained Holocene overbank sediments (Boulding 1995). The Breeden and Overflow Pond sites are located on this landform. Neither of these Middle-Late Archaic sites are buried and midden deposits are not stratified with sterile alluvial sediments. Therefore, Boulding (1995) interprets that Holocene deposition on the T420 landform predates the SMA occupation and this landform was stable while these sites were occupied. Conversely, alluvial deposits may have been incorporated into the cultural midden deposits as these sites were continually reoccupied over several millennia. My recent study of stratigraphy at the Breeden site suggests that either scenario is possible (Surface-Evans 2006). I found no evidence for distinct layers of overbank deposits within the cultural midden, even though cultural strata were discernable.

The high terrace (T450) is predominately a late Pleistocene outwash landform with little to no Holocene deposition (Boulding 1995). This landform may correspond with the Tazewell terrace. Due to the age of this landform, it has a low potential for buried cultural deposits. From systematic auger cores across the Swan's landing site area, Boulding (1995) determined that the site is actually located on two landforms, the high floodplain (F420) and low terrace (T420). These two landforms are not distinguishable from each other topographically. No distinct slough is present between the F420 and T420 landforms and neither landform expresses a distinct ridge. However, during the Early Archaic period the T420 landform was approximately 3.0 m higher than the F420 landform (Boulding 1995).

This prehistoric difference in topography explains why deposits in the south end of the Swan's Landing site are buried up to 4.0 m below surface and only 1.0 m deep in the northern portion of the site. Since the site was occupied, the F420 landform has aggraded and is now the same elevation as the terrace (Boulding 1995). Conversely, the

T420 landform appears to have been extremely stable in the last 9,000 years, with minimal deposition over the Early Archaic occupation.

REGIONAL PATTERNS OF SETTLEMENT AND SITE PRESERVATION

Each of the valley segments discussed above have distinct histories of development. The number of landforms, the precise timing of development, and the processes involved differs throughout the region. However, there are several patterns common throughout the study area. First, terrace landforms appear remarkably stable since the early Holocene (with the exception of tributary landforms). In particular, Pleistocene terraces have a very low potential for buried sites. Any Archaic site located on a Pleistocene terrace is probably near the surface. This means that modern agriculture, development, and erosion may have destroyed or truncated some Archaic sites. Small or ephemeral sites are more likely to be disrupted by these modern processes, and thus larger sites may be better represented in the archaeological record. This means that while shell middens on Pleistocene landforms may be truncated, there is a low probability for complete site destruction.

Second, tributary landforms are fairly unstable, with evidence for stream derangement in most valley segments. Consequently, Archaic sites that were once located along a stream may now be some distance from water. Another effect of stream derangement is site burial, as seen in the Middle Creek Bottom. While unlikely, it is possible that some Archaic sites that were once located along tributaries have not yet been discovered due to being buried.

Third, Middle to Late Archaic deposits have the potential to be buried by alluvium at depths of 1.0 m or more on floodplain landforms (cf. Bassett 1986; Boulding 1995; Russell 1996b). Yet, few of the recorded shell midden sites in the Falls Region are deeply buried. Perhaps alluvial deposits were incorporated into the cultural midden deposits at SMA sites. Unfortunately, discrete layers of alluvial deposition have not yet been recorded within shell mound site stratigraphy, although discrete zones of cultural deposition have been noted (cf. Burdin 2008; Surface-Evans 2006). It is possible that internal mixing of cultural and natural deposits obscures alluvial deposits at these sites (cf. Angst 1998; Bellis 1968; Janzen 1977; Stein 1980). Regardless, it appears that shell mound sites are not significantly obscured by alluvial deposition on floodplain landforms.

It should be noted, however, that there is a complex interaction between the formation processes associated with site occupation and the relative stability of the riverine landform on which the occupation takes place. The results of this interaction may affect interpretations of the intensity of site occupation at sites generally, but also at shell midden sites (cf. Monaghan and Lovis 2005). Monaghan and Lovis (2005) remind us that there is an inverse relationship between landform stability and the relative vertical density and mixing of archaeological deposits. For example, when a riverine landform is fairly stable and has infrequent deposition, archaeological deposits may become more dense vertically, and more mixed by both cultural and natural processes. On the other hand, when river sedimentation rates are high, archaeological deposits may become stratified, may be lower density and more separated vertically, and are less likely to be disturbed (Monaghan and Lovis 2005). Alternatively, Stein's (1980) geoarchaeological research on shell middens of the Green River valley indicated that floodplain landforms were quite stable in this region during SMA occupation. At this time it is unclear which taphonomic scenario best suits the Falls SMA sites individually or collectively. The overall pattern suggests that there was more sedimentation occurring on Falls floodplains than in the Green River valley, but that there was enough landform stability for substantial accumulation of cultural deposits. Until more geoarchaeological data is available from SMA site contexts in the Falls Region, it is necessary to use cultural indicators, such as artifact diversity, to assess the relative intensity of shell mound site occupation.

In conclusion, geological conditions in the Falls region favor the preservation of shell middens, even those located on the active floodplain. The only exception is that riverboat traffic and modern hydrological controls that alter the pooling level of the river have hastened erosion of the floodplain ridge in many portions of the Falls region. However, erosion of the floodplain ridge is a recent phenomenon and is not likely to have completely destroyed all SMA sites prior to documentation. In addition, it is not likely that many Middle-Late Archaic sites remain "hidden" in deeply buried contexts. Therefore, the archaeological record is assumed to be relatively representative – this is one of the reasons that I selected the Falls region for this landscape study. The next chapter presents information about the Falls region SMA sites and a literature review of Archaic period research in the study region.

HUNTER-GATHERER CULTURAL LANDSCAPES: A CASE STUDY FOR A GIS-BASED RECONSTRUCTION OF THE SHELL MOUND ARCHAIC IN THE FALLS OF THE OHIO REGION OF INDIANA AND KENTUCKY

VOLUME II

By

Sarah L. Surface-Evans

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Anthropology

2009

CHAPTER 6

ARCHAIC PERIOD ARCHAEOLOGICAL DATABASE AT THE FALLS OF THE OHIO REGION

"There is no field so rich in remains of...[prehistoric] people as the country around the Falls of the Ohio" (Ford 1882:397).

INTRODUCTION

One of many regional expressions of the Shell Mound Archaic (SMA) tradition is found in the central Ohio River valley. Shell mounds in the central Ohio River valley are concentrated near the Falls, located near present-day Louisville, Kentucky. The Falls is approximately 120 river miles up river from the Green River valley (Figure 6.1). The proximity of this region to the Green River, as well as the high density of SMA sites, make the Falls well suited for this study. The abundance of archaeological sites dating to the Archaic period suggests that the Falls region was a rich locale for human settlement. There are more sites documented for the Archaic period than any other time in prehistory at the Ohio Falls region, with over 800 Archaic period sites (cf. Burdin 1998; Janzen 1977). Of these Archaic sites, 29 are shell middens documented in the Indiana counties of Clark, Floyd, Harrison, and Washington, and in Jefferson county, Kentucky (Figure 6.2).

This chapter provides a literature review of previous archaeological investigations of Middle to Late Archaic sites in the Falls region. This background demonstrates where gaps exist and where advances have been made. Other regional summaries of archaeological investigations in the Falls region may be found in Burdin

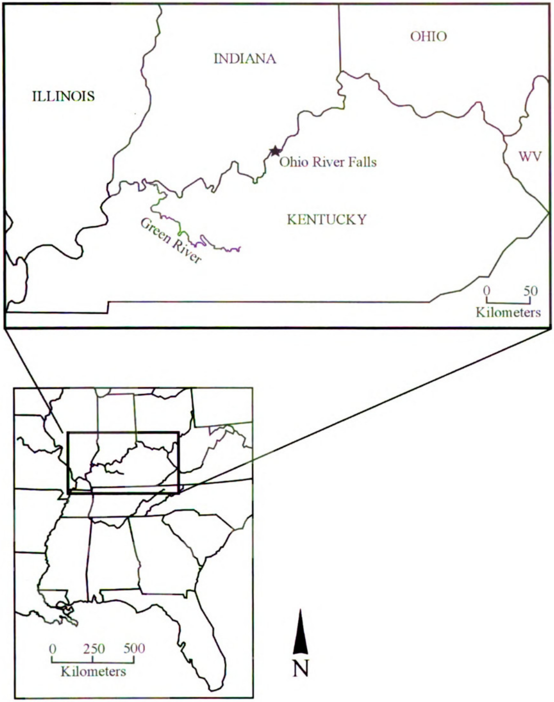


Figure 6.1. Map of the United States midcontinent showing the proximity of the Ohio Falls and Green River Shell Mound Archaic regions.

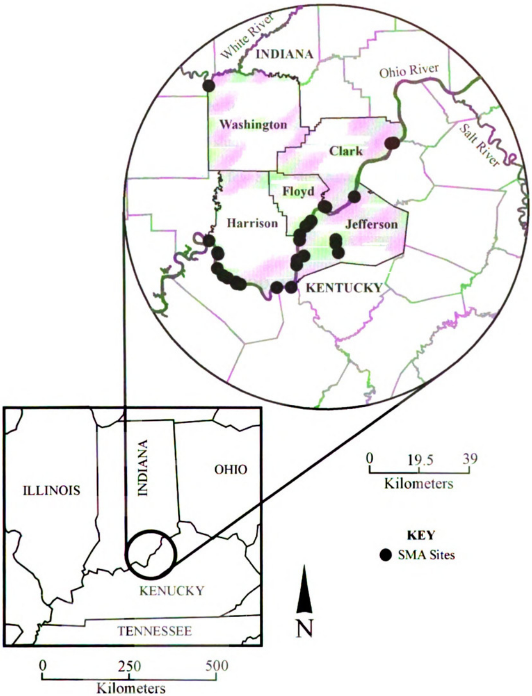


Figure 6.2. Map of the counties within 80 km of the Ohio Falls, showing the locations of Shell Mound Archaic Sites (counties containing SMA sites are highlighted).

(1998), Granger (1988), Jefferies (1988), and Stafford and Cantin (2005). The second goal of this chapter is to provide a discussion of the three cultural phases defined for the Middle and Late Archaic periods at the Ohio Falls. These phases include: French Lick (Munson and Cook 1980), Old Clarksville, and Lone Hill (Granger 1988). The third goal of this chapter is to situate the SMA tradition within the larger Middle-Late Archaic patterns observed in the study region and discuss some of the SMA sites that have been investigated. Relatively few SMA sites have been professionally excavated in the Falls region.

OVERVIEW OF ARCHAIC PERIOD ARCHAEOLOGICAL RESEARCH IN THE FALLS REGION

Early Antiquarian Descriptions

Shell mound sites in the Falls area were recorded as early as the eighteenth century, as this region was explored and settled by Euroamericans. George Rogers Clark established the first historic settlement at the Falls in 1778 and was perhaps the first to take interest in the antiquities of the region (Anslinger 1996; Janzen 1972). In fact, his home was built on a large shell midden (12-Cl-3) at the Falls and is referred to today as the Clark's Point site (cf. White 2004). In letters to the editor of *American Museum*, Clark discussed the origins of earthen and shell mounds at the Falls, to which he ascribed Native American builders (Janzen 1972). Unfortunately, Clark's letters were never published.

The first published account of falls SMA sites occurred nearly a hundred years later, in a geological report of the Falls region. W. Borden (1874) published a geological report of the Falls region. He reported two shell middens immediately adjacent to the Falls, the Clark's Point (12-Cl-3) and Old Clarksville (12-Cl-1) sites. These two sites are part of what Borden (1874) defined as the "Clarksville" archaeological district. Additional geological surveys in Indiana between 1876 and 1878 also reported significant sites in Harrison County in Indiana (Cox 1879). Among these sites, J. Collett described "bone or shell banks" near the city of New Amsterdam, which is the first known account of the Breeden shell mound (12-Hr-11) (Cox 1879). According to Collett, the site consisted of "a mass of river and land shells, with a few nearly decayed bones" (Cox 1879: 420). He measured the site as nearly one hundred and seventy yards long, eighty-five yards wide (where not disturbed by river currents), and as much as six feet deep. Collett suggested "the large amount of shells, bones, etc...seem to indicate the permanent village of a resident people" (Cox 1879: 420).

A few years later in 1876, geologists Carr and Shaler published a brief manuscript on the archaeology of Kentucky. They focused on some of the various types stone tools recovered around the state and their raw materials. In particular, they describe several hafted bifaces from the central Ohio and Green valleys that are known to occur in shell mound sites. According to them, the Ohio and Green Rivers "abounding in fishes, were favorite resorts with prehistoric people...as is shown by the number and character of the remains along their shores" (Carr and Shaler 1876: 9). While this is a general statement, it indicates that prehistoric sites were a common occurrence on the floodplain landforms in the Green and Ohio River valleys.

Culture History in the Falls

In the early twentieth century, archaeological investigations waned in the Falls region. This is in part due to the fact that other regions in the midcontinent gained prominence in the archaeological community. For example, the Kentucky Green River valley substantially benefited from W.P.A. era excavation projects, where Webb made significant contributions during the 1930's and 40's. About this same time, E. Guernsey began the first interpretations of archaeological patterns in the central Ohio valley and made a case for the significance of this region (cf. Guernsey 1939, 1942). In particular, he identified the Falls region as one of two "principle occupation foci" in the Indiana portion of the Ohio valley (the other area being the confluence of the Wabash and Ohio Rivers) (Guernsey 1942: 27). He regarded the Falls sites as "among the largest and most important upon that archaeologically prolific stream" (Guernsey 1942: 60). While Guernsey never published a full report of his excavations in the Falls area, his interpretations and culture sequence are presented in two short articles (Guernsey 1939, 1942).

Guernsey developed a hypothetical culture sequence for the Falls region based on his excavations at six sites: Old Clarksville (12-Cl-1), Clark's Point (12-Cl-3), Prather (12-Cl-4), Koons, Willey, and Aydelotte (1939, 1942). Using cultural materials recovered from these sites, he identified five prehistoric cultural groups or periods. He distinguished a Late Prehistoric occupation and two different phases of Middle Mississippian mound building (which may actually correspond to Mississippian and Woodland periods in current cultural chronologies).

The remaining two periods are what Guernsey termed "Indian Knoll" and "pre-Indian Knoll" (1939). These periods were defined by comparisons with data published by Moore (1916) on the Green River shell middens. As Guernsey defines it, the Indian-Knoll period occupations generally correspond to the Middle and Late Archaic period, particularly the SMA tradition. The material culture characteristic of the Indian Knoll-like shell midden sites in the Falls area include: middens of mussel shell, flexed human burials, three-quarter grooved axes, cylindrical pestles, bannerstones or atlatl weights, fish hooks, bone points, atlatl hooks, and finely made stemmed or notched hafted bifaces (Guernsey 1942: 66).

The pre-Indian Knoll period is more broadly defined and encompass everything from Paleoindian to Early Archaic periods. This is primarily because Guernsey (1942) regards everything that predates the classic Indian Knoll pattern as the same culture. This interpretation is due, in part, to the limited data that Guernsey had at the time. To discuss the Indian Knoll component at the Falls, Guernsey used comparative data from two shell middens, Old Clarksville (12-Cl-1) and Clark's Point (12-Cl-3) (1942). Guernsey (1942) described the stratigraphy at these sites, noting that Mississippian, Indian Knoll, and pre-Indian Knoll occupations were present within the middens. Guernsey's "Mississippian" cultural deposits were found at the surface of these sites. The Indian Knoll period materials were between 2 to 4 feet deep and the pre-Indian Knoll deposits were between 4 to 8 feet deep. Deposits in the Indian Knoll and pre-Indian Knoll zones were primarily composed of shell and rock midden, with the densest midden in the upper 2 to 4 feet. Guernsey also apparently encountered five human burials in the upper portion of the shell midden.

Guernsey's contributions to Falls Archaeology were two-fold. First, he demonstrated that significant prehistoric occupations were present in the Falls area. The sites he excavated contained stratified, multicomponent deposits that demonstrated long-term use and resettlement of key locations. Second, he established that Falls prehistory shared similar cultural trajectories with nearby regions in the Midsouth. Guernsey viewed the Falls as a possible core of cultural development that shared some attributes with nearby regions.

Contributions of the New Archaeology

After Guernsey very little archaeological research was conducted in the Falls region for approximately thirty years (Stafford and Cantin 2005). However, this changed with the influence of the New Archaeology and cultural resource management legislation in the 1970's. Several significant studies from the 1960's and 70's contribute to our knowledge of Falls prehistory, particularly for the Archaic period. The following discussion summarizes the contributions of Janzen (1971, 1972, 1977) and Granger (1976) to these ends. These two studies represent the first professional and systematic investigations of Archaic sites in the Falls region. Consequently, many of the observations made from these studies influence interpretations of Archaic period sites in the Falls today.

Falls Archaeological Project

In the late 1960's and early 70's, Donald Janzen initiated a project to investigate culture change in the Archaic and Woodland periods in the Falls region. In part, Janzen was motivated to study the Falls area because it was considered "peripheral to the mainstream of prehistoric cultural development" in the midcontinent (Janzen 1977: 128). He was the first to define the Falls as a distinct region based on its geographic characteristics (Janzen 1971). He examined each physiographic zone within the region to identify potential natural and lithic resources, providing the first description of Falls chert sources. Janzen also conducted excavations at ten significant sites within the region. These include the SMA sites of Old Clarksville (12-Cl-1), Miller (12-Hr-5), Hoke (12-Hr-103), Reid (12-Fl-1), Ferry Landing (12-Hr-3), Hornung (15-Jf-60), Lone Hill (15-Jf-10), and the non-shell midden Archaic period sites of 15-Bu-33 and 15-Sp-8, as well as the Woodland period site of Riverwood.

Nineteen radiocarbon samples were dated from these sites and Janzen used this information to refine the regional chronology of the Middle and Late Archaic periods (Janzen 1977). Unfortunately, Janzen used bone, shell, and charcoal samples for these dates, so there is some question about whether they are comparable. In addition, there are some issues with the calibration of these dates (cf. Janzen 1977). However, the pattern that emerges from these radiocarbon dates suggests that SMA sites begin as early as the late Middle Archaic period, cal 6300 – 4800 BP at sites such as Reid, Miller, and Hornung. Other sites, such as Lone Hill in Jefferson County, Kentucky, were occupied during the Late Archaic period, ca. 4600 – 4200 BP.

From his systematic excavations of seven Falls SMA sites, Janzen provided the first descriptions of cultural deposits and stratigraphy at some of these sites. The results of Janzen's work is briefly reviewed at the end of this chapter in the summary of previous investigations at Falls SMA sites. Janzen argued that the "millennium following 4000 B.C. was a period of unparalleled prehistoric cultural growth in the Falls region" based on radiocarbon dates and the substantial midden deposits at the SMA sites he investigated (1977: 138). Janzen proposed that SMA sites in the Falls region were central-base camps within the Archaic settlement pattern. In other words, SMA sites are what we would refer to today as residential bases, using Binford's (1980) model of logistic settlement. In his "hub-and spoke" model, Janzen proposed that SMA sites were probably inhabited year-round, due to the seasonality of mollusks, other faunal remains, and botanical materials recovered at several large shell middens (Janzen 1977). Janzen argued that the SMA sites are positioned "in such a way to minimize seasonal movement" by their location near the interface of multiple physiographic zones (1977: 140). The proposition that there is indeed a relationship between SMA sites and physiographic zones in the Falls region has not been tested. My research corrects this gap and explicitly reconstructs and quantifies the relationships between SMA sites and physiography, as well as several other ecological and social aspects of the landscape.

Jefferson County Archaeological Survey

At the same time that Janzen conducted his research, Joseph Granger also initiated a survey of Jefferson County in Kentucky (Granger 1976; Granger et al. 1973). The goal of his research was to identify previously unknown archaeological sites and relocate sites reported to the state. Granger conducted large-scale pedestrian survey and shovel testing, as well as reviewing gray literature and interviewing avocational archaeologists. Prior to his survey, only 44 prehistoric archaeological sites had been reported for Jefferson County (Granger 1976). During the course of his investigations, Granger documented nearly 300 additional sites. Sadly, by the time that he published these results in 1976, approximately 30 percent of the sites in Jefferson County were destroyed by development in and around the city of Louisville (Granger 1976).

Compelled by the rapid loss of prehistoric sites in the Falls area, Granger proposed a research strategy for Jefferson County, which he submitted to the state of Kentucky (1976). Like Janzen, Granger felt that a geographic model was best suited for examining "data gaps and site clusterings" (Granger 1976: 2). He subdivided Jefferson County by soil associations and physiography into seven sub-regions (Figure 6.3) and provided a summary of the cultural patterns observed in each of these zones. I will focus on three zones that Granger identified as "hot spots" for Archaic settlement (1976).

First, of particular note is the Ohio Valley Floodplain zone. Within this section 145 sites were identified and 71 of these sites had culturally identified components (Granger 1976). Nearly 41 percent (n=29) of the floodplain sites belonged to the Archaic period. Second, south of the Ohio valley floodplain is an expansive area of lowlands Granger called the Central Alluvial Valley zone. Within this area 32 sites were identified. While only 12 of these sites could be attributed to a cultural component, Archaic period sites comprise 67 percent (n=8) (Granger 1976). Third, the North Outer Bluegrass portion of Jefferson County also has a large number of sites, with 112 identified (Granger 1976). Of these sites, 72 were identified by component and the Archaic period accounted for 50 percent (n=36) of them.

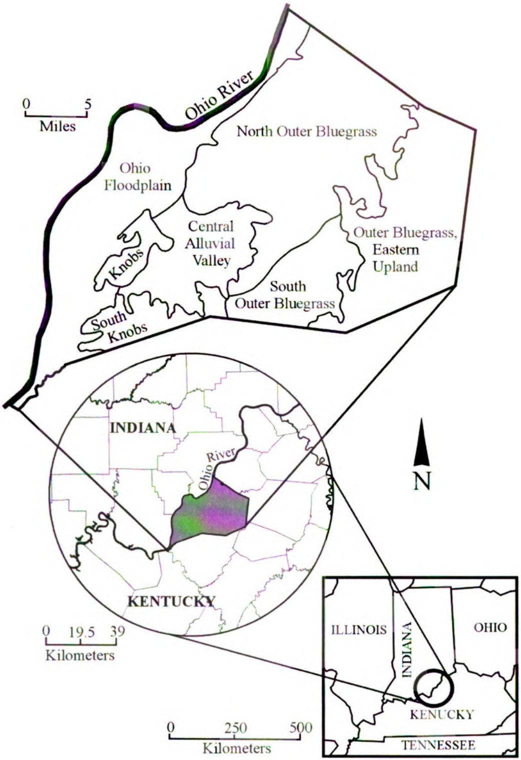


Figure 6.3. Map of Jefferson County in Kentucky, showing the boundaries of the seven sub-regions described by Granger (1976).

Granger also considered some of the environmental characteristics of the seven zones that would be attractive to prehistoric peoples. In particular, he lists notable physiographic features and tributaries to each zone and summarizes possible resource availability. In the Ohio Valley Floodplain zone he included the rapids and pools of the Falls, river terraces, stream deposited glacial gravels, and numerous navigable tributaries as important features of this area (Granger 1976). Potential resources included: large mammals, large and medium fish, riverine shellfish, waterfowl, herbaceous plants, nut masts, fruits, and chert, granite and quartzite cobbles from glacial gravels.

In the Central Valley Alluvial Valley zone a different suite of features and resources were available. This zone is particularly known for backwater and cutoff lakes, shallow sluggish streams, marshes, and dry knolls above marshes. Resources in this zone included a wide range of flora and fauna, such as: mid-sized and small mammals and fish, lacustrine shellfish, waterfowl, marsh plants, fruits, and herbaceous plants (Granger 1976). The North Outer Bluegrass zone probably had the greatest variety of physiographic features than any other area of Jefferson County. This area included features such as narrow upland ridges, high bluffs over streams, karst caves, rockshelters and ledges, well-drained uplands, broad alluvial lowlands, navigable streams, alluvial and colluvial fans, upland meadows and springs, and salt licks (Granger 1976). Due to the presence of bedrock out crops in this portion of the county, chert and lithic resources were also quite abundant. Food resources include mid-sized to large mammals, upland fowl, medium and small fish, herbaceous plants, oak and hickory nut masts (Granger 1976).

Granger developed a tentative model for site distributions based on his study of geographic and environmental characteristics of Falls sites. He hypothesized that the Ohio Valley Floodplain was seasonally exploited by hunter-gatherers and that the first terrace was the preferred locale for settlements. Shellfishing typically occurred along terrace knolls at major stream confluences (Granger 1976). In the Central Lacustrine Lowland hunter-gatherers exploited the dry knolls adjacent to ponds, marshes, and springs. Typically large midden deposits occur at these sites with human burials (Granger 1976), such as at the Lone Hills site (15-Jf-10). Due to the varied landscape in the Outer Bluegrass zone, hunter-gatherer sites are found in rockshelters and caves, near salt licks and chert outcrops, upland knolls above streams, and along stream terraces. According to Granger, sites in karstic areas or near salt licks and chert sources were most likely transient occupations associated with logistic forays.

Like Janzen, Granger's model places large Middle to Late Archaic earthen and shell midden sites within a logistical collector system (Binford 1980). However, Granger and Janzen disagree on the level of logistic mobility. Janzen argued for year-round settlement at SMA locales. Granger (1988), however, proposed a *seasonal* pattern of fission/fussion, where large SMA "base camp" sites were occupied from spring to fall and smaller extractive sites in the uplands were utilized from fall to spring. The problem with Granger's model is that we know relatively little about this other portion of the Middle to Late Archaic settlement pattern. As mentioned previously, no one has conducted systematic survey in the Falls region of the uplands, where winter camps are presumably located. Therefore, we currently know next to nothing about Middle to Late Archaic land use patterns in upland settings. The type of least-cost modeling that I am conducting to examine movement between SMA sites, also has the potential to predict the possible locations of "upland" sites within the larger settlement system. Regional-scale least-cost modeling of transportation essentially identifies areas in the study region that are accessible. Thus, highly accessible areas have greater potential for containing archaeological sites by virtue of the fact that SMA people could have used these areas more readily.

Cultural Resource Management and Falls Archaeology

Archaeological investigations at the Falls in the past twenty years have been dominated by Cultural Resource Management (CRM) projects (Angst 1998; Bader and Granger 1989; Baltz et al. 1992; Brinker et al. 1980; Chapman and Granger1971; Collins 1979; Duerkson and Bergman 1995; Granger 1980; Granger 1988; Granger and Bader 1991; Mocas and Smith 1994; Mocas and Smith 1995; Smith and Mocas 1993; White 2003, 2004). CRM projects have contributed to Falls archaeology by vastly increasing the database of prehistoric sites. The majority of CRM projects were associated with road and bridge improvements, power plants, and mining operations. Consequently, most of the large floodbasins in the Falls region have been extensively surveyed and investigated. Fewer projects have been conducted in the uplands, although accidental discoveries, such as the Meyer site (12-Sp-1082) (cf. Bader 2004), have contributed some information on upland settlement patterns.

Unfortunately, recent archaeological investigations have been conducted in a piecemeal fashion. These numerous, independent investigations are seldom linked together and there is very little interpretation of region-wide patterns other than broad comparisons. A notable exception is Cheryl Munson's and Joseph Granger's attempts to define Archaic cultural phases for the central Ohio valley in the 1980's. These phases and their impact on Falls archaeology are discussed in the following section.

MIDDLE AND LATE ARCHAIC CULTURAL PHASES

Even though numerous Archaic period sites have been investigated since the 1970's, the Archaic period chronology in the Falls region is still rather crude and poorly understood. This is partly due to the fact that most investigations were conducted at the survey level, with little actual excavation of sites (cf. Collins 1979). Consequently, there are few radiocarbon dates associated with Archaic period sites in the Falls region. To date, only 38 percent (n=11) of SMA sites in the Falls region have been radiocarbon dated (Table 6.1). The limited temporal data available suggests that Falls SMA sites span cal 6400 to 4300 BP. Because the radiocarbon dates obtained for shell mounds were taken on different materials and at different times in the last 40 years all dates reported in the text are in conventional radiocarbon years and are not calibrated unless noted. Calibrated dates, however, are provided in Table 6.1. Despite these difficulties, three cultural phases have been defined for the Middle and Late Archaic periods in and near the study region (cf. Granger 1988; Munson and Cook 1980). These phases are 1) Old Clarksville, 2) French Lick, and 3) Lone Hill.

Table 6.1. Radiocarbon Dates from Falls SMA Sites (2-Sigma)				
Site Name	**Site Number**	**Conventional ^{14}C Date**	**Calibrated ^{14}C Date**	**Source/ Citation**
Lone Hill	15Jf10	3935 +/- 95 BP	4377 +/- 136 BP	Janzen 1977
Old Clarksville	12Cl1	4180 +/- 180 BP	4719 +/- 245 BP	Janzen 1977
Breeden	12Hr11	4210 +/- 200 BP	4769 +/- 282 BP	Bellis 1981
Hornung	15Jf60	4240 +/- 95 BP	4772 +/- 139 BP	Janzen 1977
Ferry Landing	12Hr3	4365 +/- 120 BP	5029 +/-179 BP	Janzen 1977
Lone Hill	15Jf10	4365 +/- 185 BP	4982 +/- 269 BP	Janzen 1977
Lone Hill	15Jf10	4365 +/- 185 BP	4982 +/- 269 BP	Granger 1988
Hoke	12Hr103	4400 +/- 185 BP (bone)	5026 +/- 254 BP	Janzen 1977
Old Clarksville	12Cl1	4460 +/- 180 BP	5112 +/- 228 BP	Janzen 1977
Reid	12Fl1	4555 +/- 70 BP	5205 +/- 120 BP	Janzen 1977
Overflow Pond	12Hr12	4940 +/- 100 BP	5722 +/- 115 BP	Burdin 2008
n/a	12Fl73	4950 +/- 40 BP	5679 +/- 45 BP	Burdin 2002
KYANG	15Jf267	5010 +/- 90 BP	5768 +/- 102 BP	Bader & Granger 1989
Hornung	15Jf60	5085 +/- 85 BP	5823 +/- 90 BP	Janzen 1977
Hornung	15Jf60	5100 +/- 75 BP	5836 +/- 82 BP	Janzen 1977
Miller	12Hr5	5220 +/- 200 BP	5989 +/- 220 BP	Janzen 1977
Hornung	15Jf60	5220 +/- 230 BP	5990 +/- 246 BP	Janzen 1977
Breeden	12Hr11	5330 +/- 50 BP	6113 +/- 78 BP	Surface-Evans 2006
n/a	12Fl73	5350 +/- 130 BP	6111 +/- 139 BP	Burdin 2002
Hornung	15Jf60	5377 +/- 367 BP	6165 +/- 405 BP	Janzen 1977
Breeden	12Hr11	5380 +/- 40 BP	6174 +/- 85 BP	Surface-Evans 2006
Breeden	12Hr11	5420 +/- 100 BP	6180 +/- 119 BP	Burdin 2008
Reid	12Fl1	5480 +/- 90 BP	6274 +/- 100 BP	Janzen 1977
Breeden	12Hr11	5620 +/- 80 BP	6417 +/- 81 BP	Burdin 2008
Breeden	12Hr11	5750 +/- 70 BP	6554 +/- 81 BP	Burdin 2008

* Calibrated with CalPal correction curve CalPal2007_HULU

Middle Archaic Phases and Characteristics

The Middle Archaic period is generally considered to date from 8,000 to 5,000 BP in the central Ohio valley (Jefferies 1988). Based on this definition, the Middle Archaic corresponds with the mid-Holocene climatic interval known as the Hypsithermal. The Hypsithermal was a period of prolonged warming and drying that affected the climate of the Eastern Woodlands. Currently, there are no local climate data available to assess the potential impact of Hypsithermal climate change on SMA peoples in the Falls region (Surface-Evans 2006).

Two phases have been proposed for the late Middle Archaic period in the central Ohio valley: Old Clarksville and French Lick. The Old Clarksville phase, proposed by Granger (1988), is based on data from shell midden sites in the Falls area. This phase dates between cal 6400 and 4400 BP, based on radiocarbon dates from three shell midden sites in the falls region. The Old Clarksville lithic assemblage includes side-notched hafted bifaces, such as Godar, Raddatz, and Matanzas. Another artifact common to some Old Clarksville phase sites is engraved bone pins (Granger 1988; Jefferies 1997). Granger's Old Clarksville phase is similar to the Helton phase in Illinois, based on material culture and temporal range (White 2004).

The French Lick phase, proposed by Munson and Cook (1980), is based on data from the Patoka Lake area located west of the Falls region near French Lick, Indiana. This phase was defined for the southwestern portion of Indiana and includes the White River, Lower Wabash River, and portions of the Ohio River in the southwestern tip of Indiana. This phase dates from the terminal Middle Archaic to early Late Archaic. Munson and Cook (1980) assign a temporal range from 5000 to 4400 BP based on radiocarbon dates from extensive midden deposits at the Miler A site (12-OR-12). Diagnostic hafted bifaces associated with the French Lick phase include side-notched forms in the Old Clarksville phase, as well as straight and expanding stemmed point types such as Karnak (Munson and Cook 1980). French Lick can be considered analogous to the Old Clarksville Phase. Engraved bone pins are common traits to both phases.

Late Archaic Phase and Characteristics

The Late Archaic period spans from 5,000 to 3,000 BP in the Falls and Kentucky (Jefferies 1988; White 2004a). The boundary between the Middle and Late Archaic periods can be difficult to discern in the Falls region because many Middle Archaic trends continue into the Late Archaic period. Overall, the Late Archaic is viewed as a continuation of specialization and adaptation to regional environments (Jefferies 1988). In the Falls region, settlement patterns during the Late Archaic are similar to previous Middle Archaic patterns. However, large Late Archaic sites demonstrate evidence for increasing complexity, such as decreased mobility and more common mortuary activities, compared to Middle Archaic sites (Jefferies 1988).

One cultural phase is recognized for the Late Archaic period in the Falls area. This phase, known as Lone Hill, was defined by Granger (1988) based on data from shell midden sites like Lone Hill, large Archaic base camps such as Spadie, and Archaic cave sites like Bland Cave. Using radiocarbon dates from these sites, Granger (1988) dates the Lone Hill phase from cal 5,000 to 4,200 BP.

Diagnostic hafted bifaces associated with the Lone Hill phase include Late and Terminal Archaic stemmed forms, such as the McWhinney Heavy Stemmed (also known as Rowlett) point type. A charcoal sample from Spadie, collected from a McWhinney-bearing portion of the earth midden, was dated to cal 3090+/-150 BP (Maslowski et al. 1995). More recently, charcoal samples from mortuary features associated with McWhinney bifaces at the Miles site (12-Cl-158) produced dates of cal 4150+/40 BP and cal 4140+/-40 BP (White 2004b). Human interments are common to large Lone Hill Phase sites and are often accompanied with grave goods. Items of personal adornment, such as bear canine or shell beads also occur on Lone Hill phase sites.

This phase shares many characteristics with Winter's Riverton culture in the Wabash valley (1969), but is not entirely analogous. While stemmed projectile points are common to both phases, the Riverton phase also includes Merom Expanding Stemmed hafted bifaces. These points are much smaller than those found in the Lone Hill Phase sites. Additionally, small side notched points, such as Trimble, are found at Riverton Sites. Riverton sites date in the terminal Late Archaic range of 3600 – 2800 BP. This means that Riverton and Lone Hill Phases have some overlap, but that Riverton persists much later than Lone Hill.

SMA SITES IN THE FALLS REGION

Twenty-nine SMA sites have been identified in the Falls region. Investigations at these sites span nearly 100 years. Consequently, the quality and quantity of archaeological data varies considerably from site to site. In the following section, I will summarize the results of limited excavations conducted at the Falls Region SMA sites. Due to the inconsistent quality of the reports and data available concerning these excavations, the information I discuss here is also highly variable. I will describe SMA sites from east to west, following the course of the Ohio River through the project area (Figure 6.4). Table 6.2. is a complete list of the SMA sites currently known in the Falls region. Some of the information summarized in Table 6.2 includes: site name, cultural phase, whether the site was professionally excavated, the current condition or integrity of the site, whether human burials were document at the site, and the minimum season(s) in which the site was occupied. All radiocarbon dates mentioned in the text are also found summarized in Table 6.1.

Genuine Risk (12-Cl-10)

The Genuine Risk site is located on the floodplain ridge in the Bethlehem Bottom, near the eastern edge of the Falls region (see Figure 6.4). This site was reported to the state of Indiana as a shell midden or possible stone mound. No excavations have been conducted at this site, only survey-level investigations. Genuine Risk was first investigated by Brinker et al. in 1980, who conducted visual survey of the floodplain ridge, eroded riverbank, and beach. At the time of their investigations, the site had been damaged by erosion and relic-hunters who had dug into the riverbank. However, there were still considerable cultural deposits present. They describe the site as "deep, thick, and dense" near the confluence of Camp Creek with the Ohio River (Brinker et al. 1980:15). However, deposits gradually thin and become less dense nearly 2,000 feet east of Camp Creek.

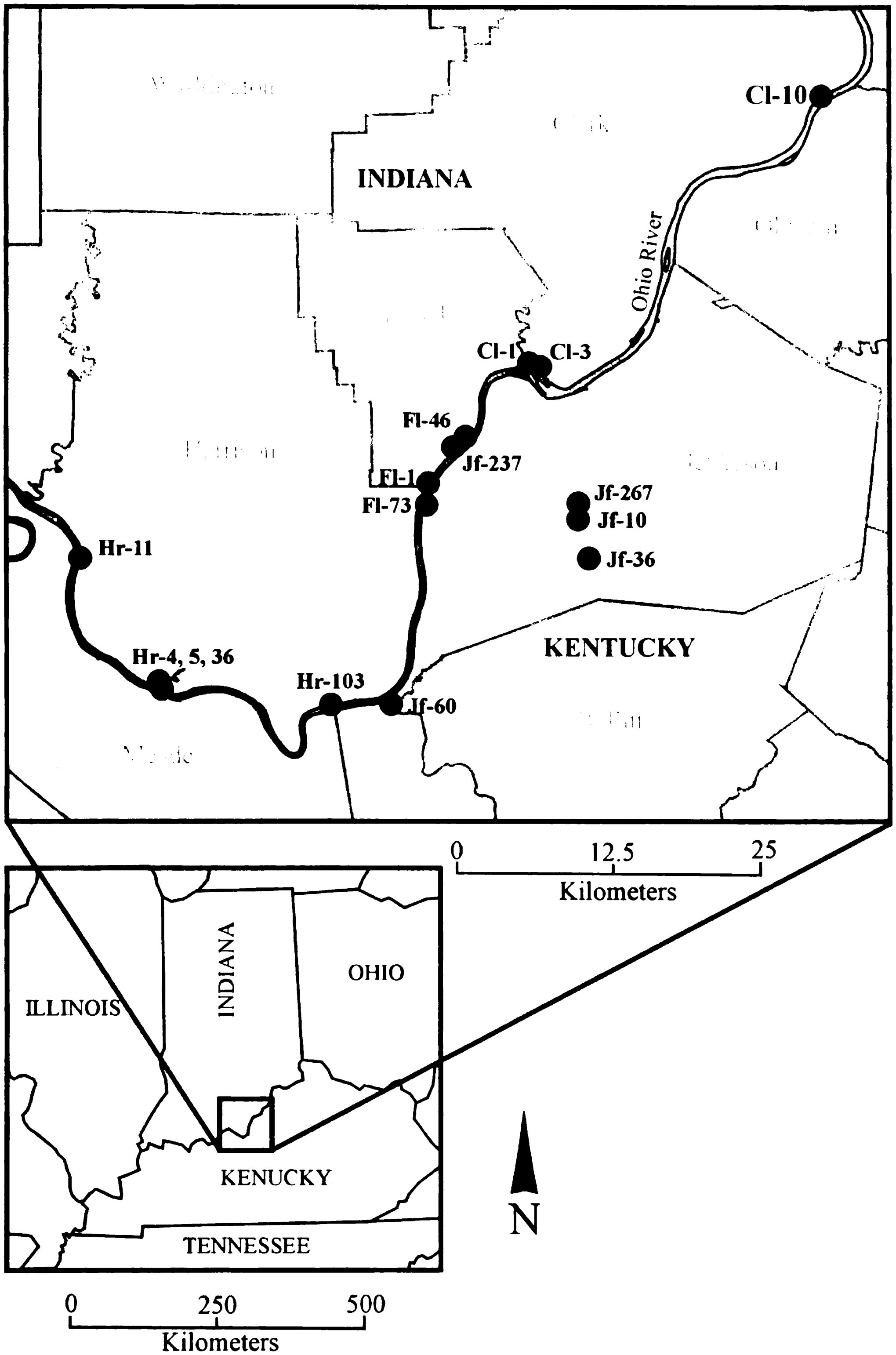


Figure 6.4. Locations of SMA sites that have been investigated in the Ohio Falls region.

Table 6.2. List of Falls SMA Sites						
Site Number	**Site Name**	**Cultural Phase**	**Professional Excavations?**	**Site Integrity**	**Human Burials?**	**Minimum Seasonality ?**
12-Cl-1	Old Clarksville	Old Clarksville & Lone Hill	Yes	Damaged	No	Spring - Fall
12-Cl-10	Genuine Risk	Old Clarksville & Lone Hill	Yes	Destroyed	No	Unknown
12-Cl-3	Clark's Point	Lone Hill	Yes	Damaged	Yes	Spring - Fall
12-Cl-78	n/a	Old Clarksville & Lone Hill	No	Unknown	No	Unknown
12-Fl-1	Reid	Old Clarksville & Lone Hill	Yes	Damaged	Yes	Spring - Fall
12-Fl-13	n/a	Old Clarksville & Lone Hill	No	Unknown	Unknown	Unknown
12-Fl-46	Dalhoff	Old Clarksville & Lone Hill	Yes	Damaged	No	Unknown
12-Fl-73	n/a	Lone Hill	Yes	Damaged	Yes	Spring - Fall
12-Hr-103	Hoke	Old Clarksville	Yes	Damaged	Unknown	Unknown
12-Hr-11	Breeden	Old Clarksville & Lone Hill	Yes	Damaged	Yes	Spring - Fall
12-Hr-113	n/a	Old Clarksville	No	Unknown	Unknown	Unknown
12-Hr-12	Overflow Pond	Lone Hill	Yes	Protected	Unknown	Spring - Winter
12-Hr-13	n/a	Unknown	No	Unknown	Unknown	Unknown
12-Hr-3	n/a	Old Clarksville	No	Unknown	Unknown	Unknown
12-Hr-36	n/a	Unknown	Yes	Protected	Unknown	Unknown
12-Hr-4	Ferry Landing	Old Clarksville	No	Destroyed	Yes	Unknown
12-Hr-6	Arthur Miller Village	Unknown	No	Damaged	Unknown	Unknown

Table 6.2. Continued.						
12-Hr-9	n/a	Old Clarksville & Lone Hill	No	Unknown	Unknown	Unknown
12-Hr-96	n/a	Unknown	No	Unknown	Unknown	Unknown
12-Ws-30	n/a	Unknown	No	Unknown	Unknown	Unknown
15-Hr-115	n/a	Unknown	No	Unknown	Unknown	Unknown
12-Hr-5	Miller	Lone Hill	Yes	Destroyed	Unknown	Spring - Fall
15-Jf-10	Lone Hill	Old Clarksville & Lone Hill	No	Destroyed	Yes	Unknown
15-Jf-217	n/a	Lone Hill	No	Unknown	Unknown	Unknown
15-Jf-237	Arrowhead Farm	Lone Hill	Yes	Destroyed	Yes	Spring - Fall
15-Jf-267	KYANG	Old Clarksville & Lone Hill	Yes	National Register, Damaged	Yes	Spring - Summer
15-Jf-36	Minors Lane	Old Clarksville & Lone Hill	No	Destroyed	Yes	Unknown
15-Jf-60	Hornung	Old Clarksville & Lone Hill	Yes	Unknown	Yes	Unknown
15-Jf-92	n/a	Unknown	No	Unknown	Unknown	Unknown

Brinker et al. (1980) identified two zones of deposition at 0 to 4 feet and 4 to 15 feet below surface. The second zone is intermittent and varies widely in depth. These deposits were primarily composed of dark earth, charcoal, and FCR. Brinker et al. (1980) found little evidence of a shell midden at the site during their investigations. They suggest that the bulk of the midden portion of the site had been destroyed, as nearly 100 feet of the floodplain had been lost to erosion and relic-hunting (Brinker et al. 1980:25). A Late Archaic period occupation was indicated by the find of a Trimble Side Notched hafted projectile point (Brinker et al. 1980; Mocas and Smith 1994).

In 1993, Mocas and Smith of the Indiana University Glenn A. Black Laboratory of Archaeology resurveyed a large segment of the Bethlehem Bottom floodbasin, known as the E. T. Slider Permit Area, for gravel mining operations. Genuine Risk was one of the many sites they examined (Mocas and Smith 1994). No attempt to survey the surface of floodplain ridge was made due to heavy vegetation. They conducted a visual survey of the riverbank and beach. At that time, large portions of the riverbank had slumped and caved in. The only cultural diagnostic materials they recovered were a lamellar blade and a Late Archaic-Early Woodland stemmed projectile point fragment (Mocas and Smith 1994).

Mocas and Smith interviewed the landowner to understand how much of the site had been lost to erosion. The landowner reported that the shell midden had been destroyed during a period of flooding in the 1970s, in which the riverbank near Camp Creek collapsed (Mocas and Smith 1994:161). Lucas described that the site had been on the west side of camp creek, not on the east side of the creek as reported by Brinker et al. (1980). It is possible that shell midden deposits were once present on both sides of Camp Creek.

In 2005, I conducted a beach and riverbank survey at the mouth of Camp Creek with one of the archaeologists from the 1980 survey, Perry Harrell. We examined the Ohio River bank on both the east and west sides of Camp Creek in an attempt to determine the actual location of the site. At that time, the riverbank was heavily eroded and slumped (Figure 6.5). In places, the beach was more than 50 m wide, indicating how much land had washed away from erosion. Small trees were growing on the slumped floodplain ridge at the time of the 2005 survey, which suggested that the bulk of the erosion occurred a decade or more ago.

No evidence of *in situ* cultural deposits were noted during the beach and riverbank survey. A light scatter of lithic debitage, possible pottery, and one Late Archaic Stemmed projectile point were observed on the beach (Figure 6.6). However, no mussel shells or fire-cracked-rock were noted on the beach or riverbank. It appears that the shell midden portion of Genuine Risk was not just at risk, but actually destroyed.

Figure 6.5. Photograph of slumped floodplain ridge at the former location of the Genuine Risk site (12-Cl-10) with archaeologist, Perry Harrell in foreground. Photograph taken by the author, July 2005.

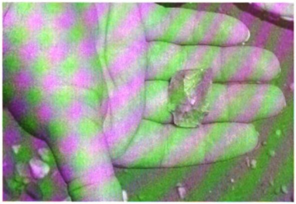


Figure 6.6. Photograph of Late Archaic stemmed hafted biface found on eroded beach at the former location of the Genuine Risk site (12-Cl-10). Taken by the author, July 2005.

Clarks Point (12-Cl-3)

The Clark's Point site is located on a floodplain ridge overlooking the Falls of the Ohio (see Figure 6.4 and Figure 6.7). Archaeological investigations at Clark's Point began in the mid-1930's with E. Y. Guernsey (1939, 1942). From his brief descriptions, we know that shell midden deposits were as much as 2.4 m below the ground surface. The upper 0.6 m of deposits considered of earthen midden and contained flexed human burials. Artifacts recovered at Clark's Point included: stemmed and notched hafted bifaces, groundstone axe and pestles, cannel coal beads, atlatl weights, bone or antler fish hooks, and antler projectile points (Guernsey 1942). Given the diversity and quality of cultural materials recovered from Clark's Point, Guernsey proposed that this site was a "tribal center" (1939). He argued that the characteristics of Clark's Point are similar to Indian Knoll, with the exception of copper implements that were lacking at Clark's Point.

Figure 6.7. Photograph of the Clark's Point site (12-Cl-3) taken by the author, July 2005. The remnants of this site are visible as a broad, flat mound nearly 2 meters above the floodplain ridge. A reconstruction of the George Roger's Clark homestead (left side of photo) is located on the site.

In 2002, Indiana University-Purdue University Archaeological Survey (IPFW-AS) and the Falls of the Ohio Archaeological Society (FOAS) conducted limited excavations at Clark's Point in advance of a chimney construction project for the George Rogers Clark historic home site (Figure 6.8) (White 2004). Excavations were conducted on a 1.85 by 2.45 m area on the east side of an existing log cabin structure. Excavation of the upper 1 m of deposits was overseen by IPFW-AS. Auger probes in the base of the IPFW-AS excavations determined that cultural deposits extended an additional 0.5 to 0.9 m. FOAS excavations continued at 1 m below surface, but were halted at 1.6 m when in situ human remains were encountered.

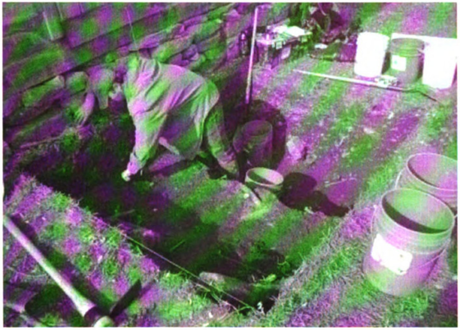


Figure 6.8. 2002 Excavations at Clark's Point site (12-Cl-3) by IPFW. Reproduced with permission of A. White.

A total of seven zones were identified during the IPFW-AS excavations. The upper three zones contained historic materials and indicated some disturbance to the prehistoric deposits from previous construction activities at the Clark cabin. The lower four zones, between 0.25 and 0.98 m below surface are prehistoric midden deposits. Volumetric flotation samples were collected from each zone in order to determine material densities and distributions. The density of mussel shell increased with depth. Broken and burnt rock was the most common artifact type, with as much as 179.6 grams/liter (White 2004). Rock decreased with depth in the midden deposits and appeared inversely related to the mussel shell deposits. White (2004) argued that the varying density and distribution of shell, rock, and burnt clay suggest that the upper and lower portions of the midden are distinct deposition episodes.

The artifact assemblage at Clark's Point included 5 Late Archaic Stemmed Cluster hafted bifaces. The lack of side notch varieties indicates that Clark's Point was probably a Lone Hill phase occupation. White (2004) noted that hafted bifaces and biface fragments at the site are predominantly manufactured from non-local cherts, while cores and unifaces are primarily made from immediately available cherts. White proposed that this pattern may be a factor of the limited excavations or could indicate that hafted biface manufacture occurred off site (2004:48). The second scenario implies that SMA sites are one portion of a Middle to Late Archaic settlement pattern. Bone and antler tools were extremely abundant at the site and included awls, incised bone, atlatl hooks, flaking tools, and antler pins (White 2004).

The materials recovered from Clark's Point indicate that a wide range of daily activities was carried out at this site. White (2004) argued that the Clark's Point site likely represents intensive and repeated occupation, although the duration of occupations and site reuse is unclear. There are some indicators of seasonality at this site. The highest density of shellfish is found in the lower midden deposits. Claassen (1986) determined that shellfish is typically collected from spring to summer. Conversely, the upper midden has a high density of nutshell (and burnt rock), suggesting a late summer to fall occupation. Thus, it appears that land use patterns may have changed over time at the Clark's Point site (White 2004).

Old Clarksville (12-Cl-1)

The Old Clarksville site is located near the Clark's Point site at the Falls of the Ohio (see Figure 6.4) This site was mostly destroyed in the 1937 flood and was thought to be completely destroyed by erosion from the McAlpine Dam (Janzen 1977, 2008). However, in 1969, Janzen was able to locate a small portion of the site that had not yet been disturbed. He excavated fifteen 5 by 5 foot units and a 10 by 20 foot trench at the site from 1969 to 1970. The Old Clarksville phase was defined based on the materials recovered during Janzen's excavations.

Janzen (1977) describes deposits that were three feet deep and homogenous. Freshwater mollusks were extremely abundant, with over 24,000 specimens recovered from one 5 by 5 unit that was excavated to depth of three feet. It appears that this site is limited to Archaic components (Janzen 1977). Like many shell midden sites in the Falls region, the dominant type of hafted projectile point at Old Clarksville was McWhinney Heavy stemmed. Janzen (2008) reports that the upper five excavation levels (each 3 inches deep) yielded primarily stemmed point varieties, while Middle Archaic side notched types like Matanzas were more common in the lower levels. This pattern indicates that the site may have been used and revisited numerous times over the course of the Middle and Late Archaic periods and actually has both Lone Hill and Old Clarksville Phase occupations. Janzen submitted three samples of charcoal for radiocarbon dating from excavated materials (Janzen 1977). Two samples were from the 27-47 inch excavation level and both produced a date of cal 5112 BP. The second sample was from the 15-18 inch excavation level and dates to cal 4719 BP. Articles of personal adornment, such as bone and shell beads, and incised bone pins were recovered at Old Clarksville (Janzen 2008). Some dog bones were present in the cultural midden. Janzen did not report, however, any human burials.

Subsistence data recovered at Old Clarksville indicates a varied diet that exploited both land and riverine foods. Faunal materials from the Old Clarksville site indicate that deer was the primary mammal exploited for food. Not surprisingly, riverine resources were also heavily exploited at Old Clarksville. Fish otoliths representing a minimum of 809 individual freshwater drumfish were recovered during the 1969 excavations (Janzen 2008). Fishing tools, including 46 fishhooks and numerous net sinkers were also recovered (Janzen 2008). Groundstone pestles and nutting stones were present, suggesting that nut processing was also conducted at the site. Hickory and walnut were the most common varieties of nutshell (Janzen 2008). An unusual artifact type recovered at Old Clarksville included nearly 200 clay "cooking" balls similar to clay objects recovered at Poverty Point in Louisiana (Janzen 2008). All of this data suggests that the Old Clarksville site was occupied in multiple seasons or that settlement patterns and land use shifted through time, as White (2004) proposed for the nearby Clark's Point (12-Cl-3) site.

Dalhoff (12-Fl-46)

The Dalhoff site is a multicomponent site that included a Middle to Late Archaic shell midden. At the time of occupation, Dalhoff was located along Middle Creek, a tributary to the Ohio River (see Figure 6.4). This site is one of the few shell middens not located along the main channel of the Ohio River. In Chapter 5, I discussed how the derangement of Middle Creek impacted deposits at this site. In 1991, Indiana University's Glenn A. Black Laboratory conducted archaeological and geoarchaeological investigations at the Dalhoff site (Smith and Mocas 1993). Prior to investigations, the upper portion of the site was damaged by earthmoving activities related to the construction of a power plant. Soil cores were taken in a grid pattern to access the depth and extent of cultural deposits. Coring revealed that deposits were quite deep and culturally "sterile" layers occurred within the deposits (Smith and Mocas 1993:85).

A 4 by 1 meter test trench was excavated in an area where soil cores indicated that cultural deposits were the deepest. Excavations revealed stratified deposits containing multiple occupation layers of shell and earthen midden. The density of cultural materials decreases between occupation horizons (Smith and Mocas 1993). In addition to these excavations, Smith and Mocas also investigated the exposed surface where bulldozers had scraped and removed the upper portion of the site. Their crew identified and excavated 39 cultural features in this exposure. The majority of the features excavated were hearth or "earth oven" features (Smith and Mocas 1993). Based on diagnostic hafted biface types recovered from the site, Smith and Mocas propose that Dalhoff contains Early through Late Archaic period deposits. Hafted projectile points in the Matanzas side notched typology were most commonly recovered at Dalhoff. This point type was radiocarbon dated at the Koster site in Illinois at 4700 to 4000 BP and Uebelhack site in Indiana at 3260+/-85 BP (Justice 1995). These dates narrow the potential time of occupation at Dalhoff to 4700 – 3200 BP. Therefore, it is likely that Dalhoff occupations date to the Lone Hill phase and possibly later Old Clarksville phase.

Reid (12-Fl-1)

The Reid site is located downriver from the Dalhoff site, in the Middle Creek Bottom in Indiana (see Figure 6.4). This site was first described by Borden (1874) as being fifteen to twenty feet high and oval in shape. The late nineteenth century landowner, Mr. Aydelotte, constructed a home on the top of the mound. Borden described the following discoveries from excavation of the house cellar:

> ...shells were met within a foot of the surface, and are continuous to the bottom of the cellar. A quantity of human bones, including fragments of a skull, with the bones of animals, and quite a number of bone implements, were exhumed (Borden 1874:185).

Nearly a century later, Janzen excavated a 5 by 5 foot test pit at the Reid site in 1971 (Janzen 1977). He intentionally chose to excavate his unit over a 100 feet south of the top of the mound, in order to avoid the deepest deposits at the mound crest, which were reportedly as much as 14 feet deep. Even in this peripheral location, Janzen encountered 6 feet of cultural deposits in two zones. The upper zone was 21 inches thick and consisted of an earthen midden containing Early and Middle Woodland pottery (Janzen 1977). The lower zone was a thick shell midden that included hafted projectile points and scrapers, bowl awls, and FCR (Janzen 1977). Janzen obtained two radiocarbon dates from the shell midden deposits that span nearly a millennia. The sample from the top of the midden produced a date of cal 5205 BP and the sample from the bottom of the midden produced a date of cal 6274 BP.

In 1995, emergency excavations were conducted at the site by 3/D Environmental Inc. after sand and gravel mining activities encountered a previously undocumented portion of the site to the northeast of the main midden deposits (Benz et al. 1997). Phase 1 survey conducted by 3D Inc. originally determined that the site covered 50 acres and was located outside the mining area, however, intact cultural deposits were encountered within the mining pit of Silver Creek Sand and Gravel Company (cf. Duerksen and Bergman 1995; Haywood 1995). The Indiana Department of Natural Resources Division of Historic Preservation and Archaeology (IDNR-DHPA) requested data recovery that included auger-testing, excavation of 0.5 by 0.5 m and 2 by 2 m test units and a profile of shell midden deposits where disturbed by mining activities (Benz et al. 1997). These limited excavations determined that cultural deposits were stratified and were as deep as 1.6 m below surface (Benz et al. 1997). The midden apparently consisted mostly of FCR, although Benz et al. (1997) make no mention of the shell or bone content of the midden. Benz et al. (1997) did not collect samples for radiocarbon dating.

More detailed salvage excavations were conducted by Archaeological Resource Management Service of Ball State University in 1997 (Angst 1998). Their excavations determined that some of the areas investigated by Benz et al. (1997) had been capped by a berm of soil by modern mining activities. Therefore, the previous investigation did not record the entire site profile or boundaries. They also determined that the site had been extensively truncated, as much as 0.45 m in some areas, by agricultural plowing and earth moving. Cultural deposits on this northern margin of the site were primarily earthen midden with heavy FCR content. In this portion of the sites, mussel shell occurred as discrete lenses within the midden rather than as thick sheets. Other midden components included burned nutshell, lithic debitage, lithic tools, bone, and Woodland pottery. Angst (1998) reported that the midden contents appeared heavily mixed and lacked stratigraphy. Middle to Late Archaic hafted biface types were found throughout the midden, but so was Middle Woodland pottery. In fact, Woodland pottery and a Late Paleoindian projectile point were recovered from the same depth within the midden (Angst 1998), indicating the degree of mixing at this site.

Projectile points from all cultural periods were discovered at Reid. However, the vast majority were Middle Archaic side-notched varieties or Late Archaic Stemmed types (Angst 1998). Lithic raw materials were primarily locally available Allens Creek, Muldraugh, or Wyandotte cherts. Pottery was fairly common at Reid, with over 800 pieces recovered. The dominant style was limestone-tempered Middle Woodland Falls Plain (Angst 1998). The bone assemblage was highly fragmentary and nearly 70 percent could not be identified. Of the identifiable remains deer was most common (Angst 1998). Other animals represented include: drumfish, snapping turtle, snakes, waterfowl, crow, squirrels, and small carnivores such as a skunk or weasel (Angst 1998). Like many other shell middens, black walnut and hickory nuts were very abundant at the Reid site. Unfortunately, no additional radiocarbon dates were acquired for the Reid site during salvage investigations.

12-Fl-73

Site 12-Fl-73 is located approximately 12 km downriver from the Falls in the Knob Creek Bottom (see Figure 6.4) (Burdin 2002). This site was accidentally discovered in 1998 when human remains were found eroding out of the riverbank. In 2001, S. R. Burdin of the University of Kentucky conducted grant-funded investigations at this site that included surface survey, riverbank survey, and test excavations. Surface and riverbank survey determined that midden deposits are present for nearly 200 meters upriver from the eroded find-spot. Burdin excavated five units and profiled five segments of the eroded portion of the site in order to salvage exposed features. Of the seven features excavated, one produced a fragment of carbonized *curcubita* rind (Burdin 2002). A charcoal sample from this feature provided a date of cal 6111 BP (Burdin 2002:65). This date is one of the oldest recovered for domesticated squash in the North American midcontinent (Burdin 2002: 123). The feature containing the squash rind was between 1.18 and 1.64 m below surface and at the base of cultural deposits in Profile 1.

The site stratigraphy is complex, with areas of earthen, shell, and rock midden that extend as much as 3.8 m below the modern ground surface in some areas. At the upriver portion of the site in Profile 1, shell midden deposits are not present. However, slightly downriver at Profile 2, shell deposits are found between 1.47 to 1.90 m below surface. Further downriver in Profile 3, shell midden deposits began at nearly 2 m below surface. Shell midden deposits appear to dip to the south, downriver. While geoarchaeological investigations were outside the scope of Burdin's project, he suggested that Gray's model of a prograding floodplain ridge (1979) may explain the pattern of deposition observed. Burdin proposed that early occupation at 12-Fl-73 occurred on the floodplain point bar. "Later occupations occurred after the point bar had been covered by alluvial depositions as the floodplain ridge continued to form towards its current position about one mile downriver" (Burdin 2002:124).

Within the shell midden portion of the site, Burdin identified three different zones of deposition (2002). A charcoal sample collected from within the shell midden deposits produced a date of cal 5679 BP, placing the shell midden occupation within the terminal Middle Archaic or early Late Archaic (Burdin 2002:71). Lone Hill phase materials are predominant at 12-Fl-73. Diagnostic hafted bifaces recovered from the site were typically from the Late Archaic Stemmed Cluster and include McWhinney Heavy Stemmed and Karnack types (Burdin 2002). Botanical remains from 12-Fl-73 were dominated by hickory and walnut and suggest that the site was occupied during the late summer to late fall (Bonzani 2002).

Site 12-Fl-73 has a significant mortuary component in the upper stratum. Burdin excavated eleven burial features, containing remains from 16 individuals. One of these burial features contained six human forearms and an engraved bone pin. The cache of arms is the only known example of "trophy" taking during the Archaic period in the Falls region (Lockhart and Schmidt 2007). Other possibly ceremonial materials recovered from the site include a cannel coal bead (cf. Colvin 2003; Cowin 1999), polished bear incisor, and red or yellow ochre (Burdin 2002).

Lone Hill (15-Jf-10)

The Lone Hill site is not located along the Ohio River, but within an area known as the Wet Woods in Jefferson County (see Figure 6.4) (Janzen 2008). The site was located on a prominent hill that once stood some 54 feet above a wetland setting and near a natural spring (Burnett 1963). The hill, composed of resistant shale, was capped by cultural midden deposits up to 10 feet deep (Burnett 1963). Granger (1988) complied information about Lone Hill from a variety of sources to develop his definition of the phase that shares its name. This site was relatively untouched until 1953, when the midden deposits were removed in order to mine the shale for use in constructing a Ford Motor Company plant. Unfortunately, no professional excavations were conducted at this site prior to its destruction. However, in 1963, Richard Burnett published the accounts of an avocational archaeologist by the name of Gene Atherton, who witnessed the destruction of Lone Hill.

Atherton reported that work crews first scraped the top of the mound and then cut a ditch around the base of the mound to drain run-off (Burnett 1963). Atherton recalled that the excavated ditch exposed 75 feet of burials within cultural deposits. A newspaper article about the remarkable finds brought many relic-hunters to the site. In response, all access to the site was denied by the landowner and they continued to remove the site deposits. By the end of the summer, the hill had been leveled and all of the former midden was piled nearby.

Atherton attempted to gain access to the remains of the site, which was finally granted in 1957 (Burnett 1963). He recovered a wide range of cultural materials from the disturbed midden deposits. Burnett (1963) reviewed Atherton's collection and describes them as "the same culture pattern (Archaic) as Indiana Knoll" (1963:85). Artifacts recovered include: Late Archaic stemmed hafted bifaces, small corner and side-notched hafted projectile points and drills, biface blanks, three-quarter grooved axes, atlatl weights, pestles, bone pins, antler atlatl hooks, antler points, and bone awls. Atherton did not collect any pottery from Lone Hill, but he did note red ocher at this site (Burnett 1963). Atherton also reported that burials were scattered over the entire hill (prior to its destruction) and that he observed them tightly flexed. Midden deposits at Lone Hill were primarily dark earth with lenses of mussel shell intermixed (Burnett 1963). Janzen (1977) and Granger (1988) acquired samples for radiocarbon dating.

These samples indicate that SMA activities at Lone Hill minimally span cal 4982 – 4377 BP.

While the site contexts are forever lost, Atherton's observations do provide a picture that is consistent with other shell midden sites in the Falls region. Both Middle and Late Archaic point types are present, suggesting that Lone Hill may have had both Lone Hill and Old Clarksville Phase occupations. Midden deposits are composed of both earthen and shell layers. This site may have had a significant mortuary component. In 1995, Kimberly Redman conducted an analysis of human skeletal fragments recovered from Lone Hill between 0.5 and 1.3 m below surface. Of the nearly five thousand faunal materials recovered from the site, 186 could be determined to be human (Redman 1995). Due to the fragmentary nature of these remains, it was not possible to determine the sex or age of individuals accurately. However, the 186 fragments represent a minimum of 146 individuals (Redman 1995). Seventeen percent (n=32) of the fragments were cranial, the remaining fragments were from the upper torso, arm, or hand. The only pathologies that could be identified were from dental remains. These include occlusal wear and a cavity (Redman 1995).

KYANG (15-Jf-267)

The Kentucky Air National Guard site or KYANG is located in the same lowland environment as the Lone Hill site (see Figure 6.4). KYANG is an extensive shell midden that was nominated to the National Register of Historic Places in 1973 after investigations by the University of Louisville Archeological Survey. Their excavations were conducted when the site was accidentally discovered during construction activities on the air base. Unfortunately, no field report was produced after their excavations and the subsequent nomination of the site. Some fifteen years later, Anne Bader and Joseph Granger of Granger Consultants company conducted investigations at the site in order to aid the Air National Guard with determining the exact site boundaries (Bader and Grander 1989). The only description of the University of Louisville excavations is found in Bader and Granger's report (1989).

Apparently, the University of Louisville excavations noted "in situ features, numerous artifacts, a shell zone, and above average bone preservation of human interments in two very distinct horizons" occurred at KYANG (Bader and Granger 1989:IV-5). Cultural materials recovered at the site indicate that the upper zone was Lone Hill Phase and the lower zone was Old Clarksville Phase. Human burials are present on both zones and include males, females, and juveniles (Bader and Granger 1989). The full range of cultural components at KYANG includes Early Archaic through Early Woodland, based on diagnostic artifacts recovered. According to Bader and Granger, additional investigations of KYANG by University of Louisville in 1975 determined that the upper zone was nearly destroyed and an attempt to stabilize and preserve the site was made at that time (1989). After the entire surface of the site was examined and disturbed deposits were excavated, two hundred tons of sterile soil was spread over the site and planted with grass (Bader and Granger 1989).

In 1989, Bader and Granger examined KYANG to determine the boundary of cultural deposits and extent of previous disturbances. They describe the site as both a midden that lies on the natural knoll and a lithic scatter surrounding the midden. The southern and eastern limits of KYANG were destroyed by earth-moving activities in

1972 and road construction in the 1950s. However, Bader and Granger found that the northern and western portion of the site remained virtually in tact (1989). They were able to ascertain the probable limits of the site using aerial photography taken prior to site disturbance. They estimate that 55 percent of the site is still present, covering nearly 1.2 acres (Bader and Granger 1989). Bader and Granger also submitted a charcoal sample collected from a feature in the lower midden zone during the 1973 excavations for dating. The resulting date of cal 5768 BP places the lower shell midden component within the late Middle Archaic period.

The human skeletal materials recovered during excavations in the 1970s have also been examined for paleopathology (cf. Haskell et al. 1985). Of the 38 individuals recovered, three show signs of conflict or injury. One individual was found with a stemmed projectile point embedded in his chest (Haskell et al. 1985). Another male had suffered a severe injury to his jaw, but had survived and showed evidence of healing. The presence of Harris lines and defects in tooth enamel indicates that children and adults suffered from periods of malnutrition (Haskell et al. 1985). Vertebral osteoarthritis was also found in adults from KYANG. Burials contained grave goods such as bead bracelets, bear canine necklaces, engraved bone pines and atlatl weights (Haskell et al. 1985).

KYANG is very similar to Lone Hill with respect to its location on the landscape, nature of cultural deposits, and presence of human burials. Like Lone Hill, KYANG also includes deposits from both the Lone Hill and Old Clarksville Phases, suggesting that it was an important locale during both the Middle and Late Archaic periods. Deposits of mussel shell are less dense at these "inland" sites and are more often a thin, discontinuous layer. The 21 mussel species recovered are varieties that live in medium to large rivers (Janzen 2008). Janzen speculates that mollusks were brought to these inland sites by two means:

> They could have been carried there by people living along the Ohio River during their seasonal movement into the Wet Woods. The Falls of the Ohio is six miles north [of KYANG] and is the closest source for these species of mussels. Perhaps people walked to the river and collected them. Several people leaving at dawn could hike to the river and be back in the Wet Woods by early afternoon. We can speculate that perhaps such a trip was made so some diversity could be added to the diet (Janzen 2008:70).

Janzen (2008) also discusses probable sources for fish procurement in the Wet Woods using historic accounts of this environment. According to early settlers, fish were trapped in this wetland area after floodwaters receded from seasonal spring flooding of the Ohio River (Janzen 2008). Janzen speculates that these areas of high ground within the Wet Woods were utilized during the winter and spring, when flooding prevented occupation of the Ohio River floodbasin (Janzen 2008:77).

Minors Lane (15-Jf-36)

The Minors Lane site is a third large shell midden located in the Wet Woods of Jefferson County in Kentucky (see Figure 6.4). There is not a lot of data on this site, because it was destroyed in 1960 by the development of a housing subdivision. Janzen (2008) compiled information from avocational archaeologists and examined their collections to gain a picture for what the site was once like. He describes Minors Lane as "almost a carbon copy" of Lone Hill and KYANG. Cultural materials recovered at Minors Lane include: McWhinney Heavy Stemmed and Matanzas Side Notched hafted bifaces, groundstone axes, and quartz atlatl weights. Apparently, human burials were present at the site, but since there were no laws in place to protect them in the 1960s, the burials were not excavated by professional archaeologists and the development project was not halted. While there is a paucity of information about Minors Lane, it appears that it was similar to the other large Wet Wood sites and was utilized during the Lone Hill and Old Clarksville Phases.

Arrowhead Farm (20-JF-237)

The Arrowhead Farm site is located on the Mill Creek Bottom in southwestern Jefferson County, Kentucky (see Figure 6.4). This site was first discovered during archaeological survey conducted by the University of Louisville in 1971 for the Jefferson County Floodwall project (Chapman and Granger 1971). At that time, three small test pits were excavated at the site. These excavations determined the presence of shell midden deposits near the center of the site (Chapman and Granger 1971). This site was known by the locals as "arrowhead farm" because it was frequently visited for the purposes of collecting artifacts. Chapman and Granger (1971) estimated that the surface scatter of lithic materials and the associated midden covered nearly 5 acres at this site.

Two years after these initial investigations, Mocas and Smith acquired funding from the Jefferson County Fiscal Court for data collection prior to the construction of the Jefferson County Floodwall, which threatened to destroy the site (Mocas 1976). They conducted extensive excavations that included a 25 by 50 foot excavation block in the earthen midden area, and six 5 by 10 foot test pits in the shell midden portion of the site. In addition, several posthole auger tests were used to determine the extent of shell-bearing deposits (Mocas 1976).

Even within the dark midden soils, 56 features were identified during their excavations. Some features were superimposed onto other features, suggesting heavy reoccupation and reuse of the site. Most of the features were shallow circular or oval basins. The function and cultural affiliation could not be determined for most features. Those that could be determined were primarily refuse pits, dating to the Late Archaic, Early Woodland, or Late Woodland periods. Burial features, including a cremation pit, were also excavated (Mocas 1976). Unlike Lone Hill or KYANG, bone preservation at Arrowhead Farm was very poor. In several burials, teeth were the only analyzable bone material recovered (Mocas 1976). Red ocher was used in burials, and was also found in other features within the midden. The cultural affiliation of burials could not be determined, because any grave goods, such as scrapers and pestles, were non-diagnostic (Mocas 1976).

Ceramic materials were present in a low density at the site, with 162 sherds recovered. More than half of the fragments are limestone-tempered, but clay-tempered and quartz-sand-tempered pottery were also recovered (Mocas 1976). The majority of ceramic fragments were not attributable to cultural period, yet some Early and Late Woodland types could be identified. In addition, a radiocarbon date of 815+/-175 BP was produced from charcoal in a feature that contained pinched and cord-impressed quartz-sand-tempered pottery sherds (Mocas 1976:41). Lithic tools were extremely abundant at the site and include hafted projectile points, performs, bifaces, drills, scrapers and cores. The most common projectile point type is the Late Archaic stemmed Rowlett/McWhinney variety (Mocas 1976). Therefore, the Archaic period deposits at Arrowhead Farm most likely correspond to the Lone Hill phase.

Mocas reports that the burnt shells of black walnut and unidentified hickory nut species were found throughout the excavations. Several features may have been associated with nut processing and contained large quantities of burnt nutshell. Mocas (1976) speculates that the shells were used for fuel after the nutmeat was removed. Interpretation of faunal materials is limited, primarily due to the poor preservation of faunal remains. Mocas simply reports that, "evidence was present that the Late Archaic occupants exploited both large and small woodland game and riverine resources" (Mocas 1976:63). Mocas did not reconstruct seasonality from the floral and faunal remains. However, the site must have minimally been occupied in the late summer and fall, due to the presence of nut-processing features.

Shell deposits at Arrowhead Farm were heavily disturbed by agriculture and erosion. While the 1971 excavations determined there were intact shell deposits, these were not rediscovered in 1973. Rather, according to Mocas (1976), the shell-bearing layer of the midden was mostly eroded down-slope. Probably the most curious finding is that Mocas reports some of the shells in the midden deposits belong to a species found in the Gulf of Mexico, *Rangia cuneata* (Mocas 1976:65). In my opinion, this interpretation (made by Henry Hill) is dubious and the mussels likely belong to a species native to the Ohio River. Regardless of where the mussels were collected, the site is still extraordinary because, even in its disturbed state, shell deposits covered several hundred linear-feet of the floodplain ridge (Mocas 1976) and the numerous features and burials attest to the significance of this locale in prehistory.

Hornung (15-Jf-60)

The Hornung site is located at the confluence of the Salt and Ohio Rivers in the southwestern tip of Jefferson County in Kentucky (see Figure 6.4). Between 1970 and 1972 Janzen (1977) excavated 28, 5 by 5 foot units at the site. Unfortunately, very little has been published concerning these investigations. Janzen (1977) provides a brief description of the site and radiocarbon dates from his investigations. The Hornung site is a conspicuous mound feature that rises five feet above the floodplain and is approximately 110 feet long (Janzen 1977). Excavations on the mound revealed that the site was stratified and multicomponent. Early and Middle Woodland materials are present in a thin upper layer. Below the Woodland zone is Archaic period deposits that are an average of 42 inches deep. The mound fill was a dark midden with a heavy concentration of animal bone and human burials. Mussel shell comprises a smaller proportion of the site matrix at Hornung and is typically found in scattered concentrations (Janzen 1977). Janzen submitted numerous carbonized wood samples for radiocarbon dating. These samples span from cal 6165 BP – 4772 BP (Janzen 2008).

Janzen (1977) also conducted excavations off the mound to look for evidence of habitation. He was able to locate an Archaic period component that included several fire pits. Radiocarbon dates from two charcoal samples yielded late Middle Archaic dates of cal 5836 and 5823 BP. The dates collected from the shell mound and nearby habitation area suggest that Hornung was heavily utilized during the Lone Hill and Old Clarksville Phases.

Hoke (12-Hr-103)

The Hoke site is located in the New Boston bottom in Harrison County of Indiana (see Figure 6.4). This floodbasin is adjacent from the confluence of the Salt and Ohio Rivers, where Hornung is situated on the Kentucky site of the Ohio River. Hoke was first investigated by Janzen in 1972 and 1973. Janzen conducted surface survey and excavated eight 5 by 5 foot test units. He provided a brief description of his findings in an article from 1977. Apparently, cultural deposits were shallow and did not exceed 15 cm below surface. He submitted a sample of bone for radiocarbon dating, as charcoal was "sparse" (Janzen 1977). This bone sample produced a date of cal 5026 BP.

In 1980, Granger conducted deep testing of a portion of Hoke that was owned by the federal government for the Ohio River Lock and Dam 43. Approximately 65 percent of the site is located outside of this federally owned area and was not examined (Granger 1980). The remaining portion of the site was tested using machine-excavated trenches, placed along the terrace ridge. Granger's investigations recovered a wide range of stone tools spanning the Early Archaic through Early Woodland (Granger 1980). Of note to the Archaic period were stemmed projectile points (like Durst), notched projectile points (like Brewerton). Five cultural features were identified within the midden deposits. According to Granger, the features were from the Early and Late Archaic, as well as the Middle Woodland (Granger 1980).

Cultural deposits at the Hoke site include several strata. Granger described a thin Early Archaic horizon at the based of the deposits at roughly 1 meter below surface. The most significant portion of the site is a Late Archaic shell and earthen midden. Overlying the midden is a Early Woodland horizon that was badly disturbed. While Granger did not radiocarbon date any charcoal samples from Hoke, the artifact assemblage suggests that the SMA component was a Late Archaic midden and can be assigned to the Lone Hill phase. Neither Janzen (1977) nor Granger (1980) provide interpretations of seasonality from their investigations of Hoke.

Ferry Landing (12-Hr-4) and Miller (12-Hr-5)

Two SMA sites, Ferry Landing (12-Hr-4) and Miller (12-Hr-5), are located near Mauckport in Harrison County, Indiana (see Figure 6.4). Mauckport is well known in the Falls region for its high density of archaeological sites. Unfortunately, it is also a popular resort area that has seen much development in the past forty years. In addition, collectors have also been very active in this area. Consequently, Janzen was not able to excavate at Ferry Landing because the site had been severely looted in 1968 after collectors dug a fifty-foot trench through the site (Janzen 1977). From accounts relayed to Janzen, Ferry Landing may have had deposits as much as six feet deep with several layers of dense shell. Collectors also reported finding atlatl weights and hooks associated with human burials (Janzen 1977).

The Miller site had a similar fate and was almost completely destroyed by sand and gravel mining operations in the late 1960s (Janzen 2008). In 1970, Janzen discovered a remnant of the site that had not been destroyed and conducted limited excavations (Janzen 1977; 2008). Janzen placed four five by five foot units on the site. He found cultural deposits ranging from one and a half to three feet deep (Janzen 1977). He also profiled a bulldozer cut through the midden, which exposed a dark earthen midden overlying a shell lens. Hickory nutshell was recovered from the cultural midden deposits. In addition, Middle Archaic Matanzas hafted bifaces were also found. These points, along with a radiocarbon date of cal 5989 BP (Janzen 1977), suggest that this site is an Old Clarksville Phase occupation. Other artifacts recovered at Miller include: numerous utilized flakes, bone awls, various engraved bone tools, and a stone cup (Janzen 2008).

12-Hr-36

Site 12-Hr-36 was investigated by Gray and Pape Inc. in 1992 in advance of development for the River Valley Marina project (Baltz et al. 1992). This site is located on the Mauckport floodbasin near the Miller site (see Figure 6.4). Crews from Gray and Pape conducted surface survey and shovel testing at the site to determine the its boundaries. They determined that the bulk of the site was outside of the project area and only the western portion of the site could be impacted by the marina project.

Gray and Pape's crew recovered Early Archaic through Early Woodland varieties of hafted projectile points during surface survey (Baltz et al. 1992). Shovel testing determined that cultural deposits extended a maximum of 55 cm below surface in the main area of the site. The western portion of the site was excavated in by three 10 by 10 m blocks. Excavation of these units indicated that there was no cultural midden on this portion of the site. As a result of these findings, the marina developers agreed to use the site area for the placement of fill dirt and the site is currently protected.

Breeden (12-Hr-11)

The Breeden site is located at the western edge of the Falls region, in the New Amsterdam Bottom (see Figure 6.4). Systematic excavations at the Breeden site were conducted in 1966 by James Bellis of Indiana University (1968, 1981). The goal of Bellis' investigation was to assess the significance of the site, particularly since it appeared threatened by erosion. A total of seven 5 by 5 foot units were excavated at 1 or 0.5 foot levels. Bellis did not screen materials recovered from the shell midden portion of the site, but did screen the overlying and underlying zones.

Lithic materials recovered included a wide range of side-notched hafted bifaces such as Matanzas, Godar-Raddatz, Big Sandy, Brannon, and Salt River (Bellis 1981). These point varieties are typically affiliated with the Middle Archaic period. Late Archaic stemmed point varieties were far less common at this site, but were present in the upper shell midden deposits. Lithic materials were primarily manufactured from locally available Wyandotte chert, which occurs in nearby bluffs outcrops amd in eroded nodules. Other formal tools recovered during excavations include bannerstone fragments, a nutting stone, antler points, engraved bone, awls, and bone pins (Bellis 1981). In the zone overlying shell midden deposits, Early Woodland ceramics were recovered. Fire-cracked-rock comprised a significant portion of the cultural deposits at Breeden, although Bellis did not conduct volumetric sampling. Bellis submitted a charcoal sample taken from a depth of 1.38 m in the shell midden for radiocarbon dating. His sample returned a conventional date of cal 4769 BP.

The Breeden site has been heavily damaged by erosion and looting since Bellis' excavations. Figure 6.9 shows the beach immediately below Breeden littered with fire-cracked-rock, lithics, and bone from the site. The landowner, R. Fried, estimates that some 60 meters of the Breeden site have eroded away since Bellis' excavations (Burdin 2008). In August of 2005, I conducted limited investigations at the Breeden site in order to collect soil samples for palynological analysis (Surface-Evans 2006).

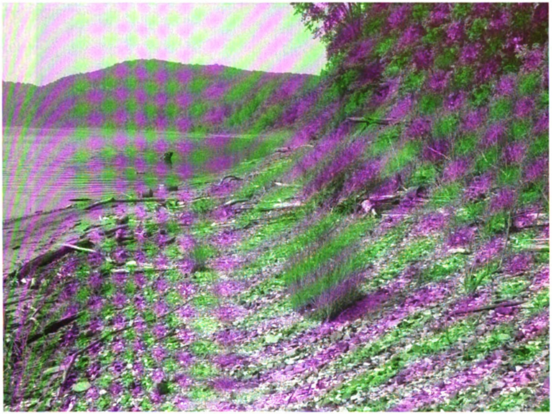


Figure 6.9. Photograph of the river beach below the Breeden Site, looking north. Note the high concentration of cultural debris. Photograph taken by the author, June 2005.

To reduce impact to the already damaged site, I prepared a portion of the eroded and exposed site in the river cut-bank to examine stratigraphy and collect pollen samples (Figure 6.10). Seven zones were noted in the profile. Cultural deposits were present between 0.31 to 1.5m below surface. Five subtle zones could be distinguished within these deposits based on soil texture, color, compaction, and the content and of cultural materials (Surface-Evans 2006). The upper 0.3 m of cultural deposits

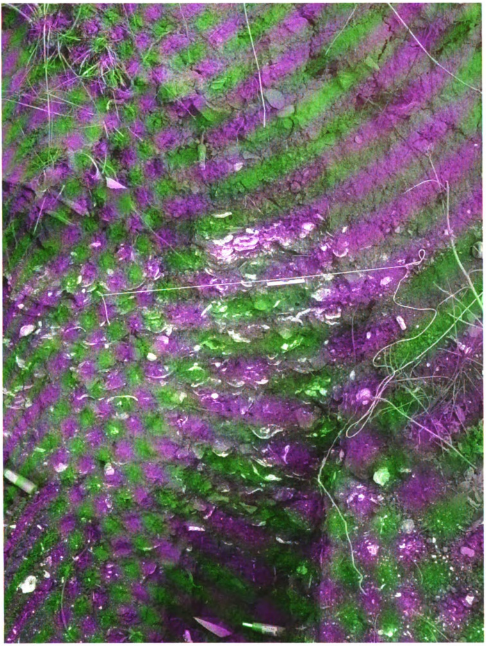


Figure 6.10. Photograph of profile prepared in the eroded riverbank at the Breeden site (12-Hr-11). Taken by the author, August 2005.

consisted of a shell-free earthen midden containing moderated charcoal and burnt rock fragments. Below this zone was an extremely dense and compact layer of mussel shell, only 0.09 m thick. Three additional zones of shell midden were present to a total depth of 1.5 m below surface. Shell content was highest in the upper zone and decreased with depth. The presence of four strata within the shell midden suggests a complex depositional history with multiple episodes of occupation (Surface-Evans 2006).

Six samples of charcoal were collected from the profile. Two of these samples, from within the shell midden deposits, were submitted for radiocarbon dating. One sample was collected at 0.88 m below surface. It returned a conventional radiocarbon date of cal 6111 BP (Surface-Evans 2006). A second sample, collected at 1.43 m below surface, produced a conventional date of 6174 BP (Surface-Evans 2006). These dates are significantly older than Bellis' and suggest that the site was repeatedly occupied by SMA peoples for at least a millennium. If datable materials are recovered from the upper non-shell midden or the lower portion of the shell midden, then this temporal range is likely to be extended. These dates also suggest that the rate of deposition was fairly high, with approximately 0.55 m of deposition between each of the two samples that were dated (Surface-Evans 2006).

In 2007, S. R. Burdin conducted excavations at the Breeden site for comparative analysis with materials excavated at the nearby Overflow Pond site (see below). His excavations support previous findings – that Breeden was occupied repeatedly during the Old Clarksville and Lone Hill phases. A 1 by 2 m unit was excavated to a depth of 1.52 m below surface on the floodplain ridge. According to Burdin (2008), cultural features were encountered at this depth and these features were excavated to a total depth of 2.03 m below surface, however, the base of cultural deposits was not reached. Cultural deposits encountered in the excavation unit were well stratified. From top to bottom of the unit, these strata included: rock midden, dark earthen midden, and four distinct shell midden strata. The shell midden deposits were encountered at 0.75 m below surface.

Eight cultural features were discerned during Brudin's excavations (2008). Most of these features appeared to be related to food preparation and were associated with the shell midden deposits at the site. Three radiocarbon dates were acquired from charcoal samples in and near the features. A date of cal 6417 BP came from charcoal collected in a volumetric sample collected between 1.14 and 1.24 m below surface (Burdin 2008). Charcoal from a Feature 14, between 1.62 and 1.72 m below surface, provided a date of cal 6180 BP (Burdin 2008). The age of this sample suggests that Feature 14 was intrusive into the midden deposits. A third charcoal sample from 1.52 – 1.62 m below surface dated to cal 6554 BP, which is the earliest radiocarbon date from a shell mound in the Falls region (Burdin 2008).

Artifacts in the shell midden deposits were extremely abundant and diverse (Burdin 2008). These included bone tools (such as awls, fishhooks, and pins), antler knapping tools, ground stone plummet or net sinker, a grinding slab, a wide range of Middle and Late Archaic side-notched and stemmed hafted bifaces, and hundreds of other formal and expedient lithic tools. Carbonized plant remains recovered from Breeden include hickory and oak nutshell and a variety of seeds from weed and fruit plants, such as grape (Bonzani 2008). According to Bonzani (2008), the grape seeds indicate that Breeden was occupied in late summer or early fall. The presence of hickory and oak nuts extends season of occupation possibly into winter, as these nuts ripen from August to December (Bonzani 2008).

Overflow Pond (12-Hr-12)

The Overflow Pond sites is located on the same floodbasin as Breeden. This site is not located on the Ohio River, but is situated along a cut-off meander of Indian Creek, called Overflow Pond. The Overflow pond site was first reported to the state in 1964 by John Dorwin. However, it remained virtually unknown to professional archaeologists and collectors for many decades. Consequently, Overflow Pond is the best preserved SMA site in the Falls Region. No professional investigations were conducted at Overflow Pond until 2007, when Burdin (2008) investigated the site during dissertation research. Burdin's project sought to 1) develop a detailed map of the surface of the site, 2) determine the integrity of cultural deposits, and 3) examine site organization and activities carried out at the site. He conducted a combination of pedestrian survey, coring, geophysical survey, and excavation at the Overflow Pond site.

The Overflow Pond site was estimated to cover some 60,000 square meters based on the distribution of artifacts and features identified in the surface and geophysical surveys (Burdin 2008). Burdin (2008) conducted auger test excavations over the site area to determine the depths of cultural deposits, which ranged from 0.50 to 0.95 m below surface. The deepest deposits were located in the center of the site. Within these deposits, a shell lens was identified at 0.60 to 0.80 m below the surface. Figure 6.11 shows the nature of the shell deposits at Overflow Pond.

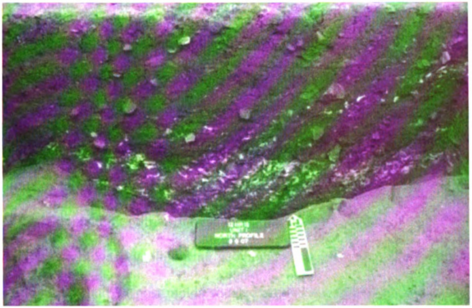


Figure 6.11. North profile of excavation unit 1, showing shell lens (Feature 15) in situ. Photograph used with permission from Burdin (2008).

A total area of 10 square meters was hand excavated (as one 2 by 2 m unit, two 1 by 2 m units, and two 1 by 1 m units) in several locations at the site. These units revealed that cultural deposits extended to between 0.50 and 0.6 m below surface (Burdin 2008). Early Archaic through Late Archaic components were found at the site, however, the Late Archaic component comprised the most extensive deposits. According to Burdin (2008), there is evidence for prehistoric mixing of the upper midden deposits at the site. Artifact densities were extremely high at the site, with more than 15,000 artifacts found in one 2 by 2 m excavation unit alone. Formal lithic tools, groundstone, and bone tools were all represented at the site. Botanical remains at Overflow pond suggest that this site was minimally occupied from July to December (Bonzani 2008). Seasonality was assessed from the presence of hickory nutshell, as well as huckleberry seeds. Non-domesticated chenopodium seeds were also recovered from this site, along with variety of other weedy seed plants (Bonzani 2008).

Three cultural features were identified by Burdin (2008) in test unit 1. Two of the features were hearths related to food preparation. These features contained abundant hickory nutshell, as well as faunal remains from deer, birds, and turtles. In the lower most strata, a large and unusual feature was encountered; feature 15 was a large and shallow basin containing primarily freshwater mussel shell (Burdin 2008). This feature was very large and was visible during geophysical survey. The portion of feature 15 exposed in unit 1, had 14 post molds situated around the outer edge of the feature. A charcoal sample from post mold 13 provided a date of cal 5722 BP (Burdin 2008). While the precise nature of feature 15 is unclear, it seems likely that this feature and the surrounding post molds are a late Middle or early Late Archaic structure of some kind (Burdin 2008).

According to Burdin (2008), Overflow Pond represents a slightly different adaptation than the nearby Breeden site. He argued that deposits at Overflow Pond indicate a shift from specialized subsistence procurement at the beginning of site occupation in the early Late Archaic, to a broad spectrum or generalized foraging strategy. Burdin also proposed that "based on the relatively short period during which stratified midden deposits accumulated, it also appears that occupational episodes were longer in duration and/or, more frequent" (2008:6-28). The detailed data provided by Burdin's excavations dispels the notion that SMA subsistence strategies were a monolithic entity. The stratified deposits at Overflow pond show evidence of changing procurement strategies, which also implies that land use strategies may change over time as well.

SUMMARY

Archaeological inquiry of the Middle and Late Archaic periods in the Falls Region has very early roots; however, it was not always consistent. The inconsistencies of site-level data and lack of extensive excavations, are two reasons that I chose to examine sites at a regional, spatial scale. Archaeological survey and excavation techniques have varied considerably over the years. Some Falls excavations were conducted with no screening and little attention to faunal or floral remains (eg. Bellis 1981), while others collected extensive volumetric samples for screening and flotation (eg. Burdin 2008; White 2004). Consequently, very little subsistence information is available for SMA sites and what does exist is largely not comparable. Yet, insights from several sites indicate 1) that many shell mound sites were minimally occupied from spring to late fall or early winter and 2) subsistence strategies changed and diversified over time time.

As mentioned previously, temporal control is lacking at most Falls SMA sites. Dated Archaic sites are the minority and most researchers heavily rely on projectile point typologies to assign sites to particular cultural periods or phases. Overall, however, it appears that SMA sites in the Falls Region are 1) Middle Archaic (Old Clarksville phase), 2) Late Archaic (Lone Hill phase), or 3) have both Middle and Late Archaic components. The largest SMA sites in the study region, such as Lone Hill, Dalhoff, Hornung, and Reid have both Old Clarksville and Lone Hill phase deposits and appear to have been preferred locales for settlement over several millennia.

Mortuary data is extremely minimal for the Falls sites. Burials have been reported at nearly one third (n=9) of the SMA sites. The majority of these sites are also known to be multicomponent, with cultural deposits spanning the Old Clarksville and Lone Hill Phases of the Middle and Late Archaic. Studies of the skeletal remains are even fewer (cf. Haskell et al. 1985; Lockhart and Schmidt 2007; Redman 1995). However, there is evidence for conflict and violence among this limited dataset.

Much of the archaeological research conducted in the Falls Region during the past forty years has been the result of CRM projects within the Ohio valley floodbasins. This has strongly skewed the representation of sites to the floodplain environments. In fact, little to no research has been conducted in the uplands, so our knowledge of this component of Middle to Late Archaic lifeways is slim. Research projects by Janzen (1971; 1972; 1977) and Granger (1980a) have attempted to examine regional patterns of Archaic subsistence and settlement, however, most survey work in the Falls region has been done in a piecemeal fashion. Survey bias, coupled with rampant site destruction (from erosion (see Chapters 4 and 5), looting, and modern development) also affect the representation of Middle to Late Archaic sites in the study region. Consequently, I cannot view my dataset as complete. Yet, given the size and prominence of shell middens, it is reasonable to assume that shell mound sites used for this study are representative of SMA utilization of the floodplain landforms.

CHAPTER 7

METHODOLOGY: A GIS STRATEGY FOR MODELING THE ARCHAIC CULTURAL LANDSCAPE

INTRODUCTION

The general question at the forefront of this research is *how does the structure of the landscape influence hunter-gatherer land use decisions*? More specifically, this research is concerned with testing the extent to which SMA peoples positioned these sites as logistic base camps. The primary goal is to develop a model to characterize Middle to Late Archaic land use decisions by reconstructing the SMA landscape. From ethnographic data and a landscape perspective, I expect that the spatial characteristics of shell mounds sites are indicative of social, economic, and cosmological aspects of Middle to Late Archaic lifeways, because human experiences are emplaced in the spaces they occupy. By examining the spatial characteristics of shell mound sites, it may be possible to understand some of the complex factors contributing to the SMA phenomenon in the central Ohio valley. This research utilizes both environmental and archaeological site data for the modeling universe. The spatial contexts of 29 SMA sites in the Ohio Falls region are examined with the aid of GIS as an exploratory and modeling tool.

The spatial characteristics of SMA sites can be examined in three different manners: 1) local context, 2) linear distance, and 3) cost-weighted distance. First, it is necessary to characterize the environmental contexts of site locales. In other words, to explore the question *what are the landscape characteristics of shell mound site locales*? Local context simply refers to the specific environmental conditions at the point in which the shell mound site is mapped. The second aspect of SMA modeling is to simulate possible patterns of interaction between shell mound sites and other points of interest in the landscape. This portion of the research examines the question *what is the relationship of SMA sites with other features of the landscape*? This question can be addressed with linear and cost-weighted distance measures. Linear distance is the straight-line distance between the shell mounds and various features of the landscape. Because linear distance is not a behaviorally based measure, it is also important to consider cost distance between the shell mound sites and landscape features. Cost distance models how the terrain, particularly slope, may have placed constraints on prehistoric travel and mobility. Both linear and cost-distance measures will be utilized in this study. Ethnographic expectations for hunter-gatherer behavior inform model assumptions, particularly with respect to distance modeling.

Before describing the specific methods of analysis in this study, it is necessary to discuss the data. I begin by defining spatial data and how spatial data are represented in GIS. Next I discuss my data sources and how these data were created. A significant portion of this research was devoted to collecting information to create spatial data layers of Ohio Falls shell mound sites. As I discuss the data, I also consider issues of data quality and other potential problems with the site dataset. After a thorough review of site forms, gray literature, publications, conducting limited field survey, and communicating with archaeologists working in the Falls Region, such as Anne Bader, Rick Burdin, Perry Harrell, and Don Janzen, I am confident that my site dataset includes a representative range of SMA sites for in study region.

After discussing how the data layers were collected and created, I will discuss methodologies of analysis. The first stage of analysis explores the question of local site context. The second question is examined by separate studies of linear distance and cost-distance relationships. Creating hypothetical models of interaction via cost-distance analysis was the most intensive part of this research project.

SPATIAL DATA AND RECONSTRUCTING THE SMA LANDSCAPE

Spatial Data

Spatial phenomena occupy space and can be visualized, explored, and modeled through spatial data analysis (Bailey and Gatrell 1995). In this study, the spatial phenomena of interest are shell mound sites and the various environmental features that comprise the study region. Within a GIS platform, real-world phenomena are represented in two different ways, vector and raster data models. The data format selected is dependent on the type of analysis being conducted (Bailey and Gatrell 1995).

Spatial data that can be considered discrete entities, such as points, lines, or areas, are represented as vector data (Bailey and Gatrell 1995; Burrough and McDonnell 1998). In the vector data model, real-world phenomena are symbolized as points, lines, and polygons, which are recorded as one or more coordinate x,y pairs[1] (Figure 7.1A) (Longley et al. 2001:189). There are drawbacks to this data-format. In particular, vectors require a lot of memory to store coordinate pairs for each feature, which also places limitations on analysis.

On the other hand, data can also exists as "fields" that vary continuously (Bailey and Gatrell 1995; Burrough and McDonnell 1998). Continuous fields are represented in

---

[1] In addition to the x and y dimensions, vertical (z) and temporal (m) dimensions may also be used to represent vector data.

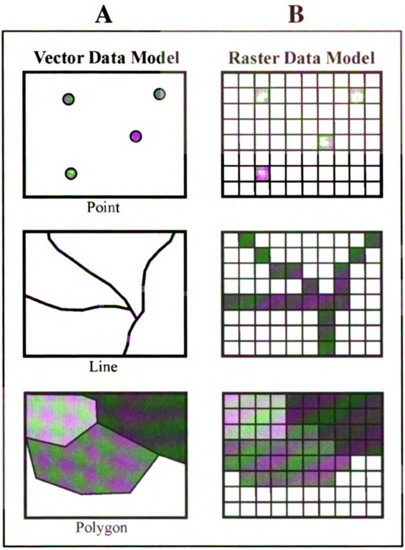


Figure 7.1. Illustration of how spatial features are represented in (A) vector and (B) raster data models.

GIS as a raster data format. "The raster data model uses an array of cells, or pixels" with values assigned to each pixel that represent real-world phenomena (Figure 7.1B) (Longley et al. 2001:187). While raster data is relatively easy to conduct analysis with, rasters also sacrifice some of the accuracy found in vectors. It is possible to transform vector data into raster data, and vice versa (see Figure 7.1).

In GIS, it is also possible to attach non-spatial attributes to spatial data. This is one of the features that make spatial analysis in GIS so productive (Bailey and Gatrell 1995). Both vector and raster data may have other non-spatial attributes connected to them. Non-spatial data may be viewed and accessed through the *Attribute Table* in GIS software such as ESRI's ArcMap. In creating the geographic SMA site data layer, numerous attributes were related to the spatial data. This will be discussed in more detail below.

Creating the SMA Site Layer

Archaeological sites can be represented as discrete points on the landscape or as polygon areas. In this study, sites are plotted as points in GIS using Universal Traverse Mercator (UTM) coordinates to situate them in space. Representing sites as points simplifies their real-world spatial attributes; however, this level of positional accuracy[2] is acceptable for the type of analysis conducted here because SMA sites are not extremely large nor do they cover multiple features of the landscape. However, before the site data could be entered into a GIS platform, it had to be collected and placed into a format for

[2] Because vector features in GIS are only representations of their real-world counterparts, it is recognized that there are differences between the "true" location and "recorded" location (Longley et al. 2001). Therefore, *accuracy* refers to how close a recorded location is to the real-world. The following provide detailed discussions of accuracy issues in spatial data (Burrough and McDonnell 1998:222) and errors in data sets (Kiedman and Shortridge 1998).

analysis. Unfortunately no inventory had ever been conducted of the SMA sites in the Falls Region and the study area lies within two different states: Indiana and Kentucky. Consequently, I had to conduct a thorough review of archaeological site records in both of these states before creating the site layer for GIS analysis. Figure 7.2 illustrates the work process conducted to create the SMA sites layer.

Over the course of several visits to the Indiana Department of Natural Resources Division of Historic Preservation and Archaeology (IDNR-DHPA) and the Kentucky Office of the State Archaeologist (KOSA) and Kentucky Heritage Council (KHC) I examined all of the site records for each county within the study area. I systematically reviewed all site forms and project reports to look for any mention of Archaic shell midden deposits. I also used regional summaries, such as Granger (1985), Granger et al. (1973), and Janzen (1971; 1972; 1978), to help identify SMA sites within the gray literature and direct my site inventory.

Identifying SMA sites within the thousands of reported sites for the Falls Region was complicated by several factors. First, while the modern site reporting form in Indiana had a field for "shell midden", the old site form did not. In addition, there was no such provision on any of the Kentucky site forms. Therefore, approximately a third of the actual SMA sites used for this study were not indicated as SMA sites on the site forms. To accurately identify SMA I relied on site descriptions in the gray literature and published articles. Unfortunately, my efforts were further complicated because information presented in reports was often contradictory. In some cases a site was referred to as a shell midden in one report, while another report stated that the site lacked a shell midden.

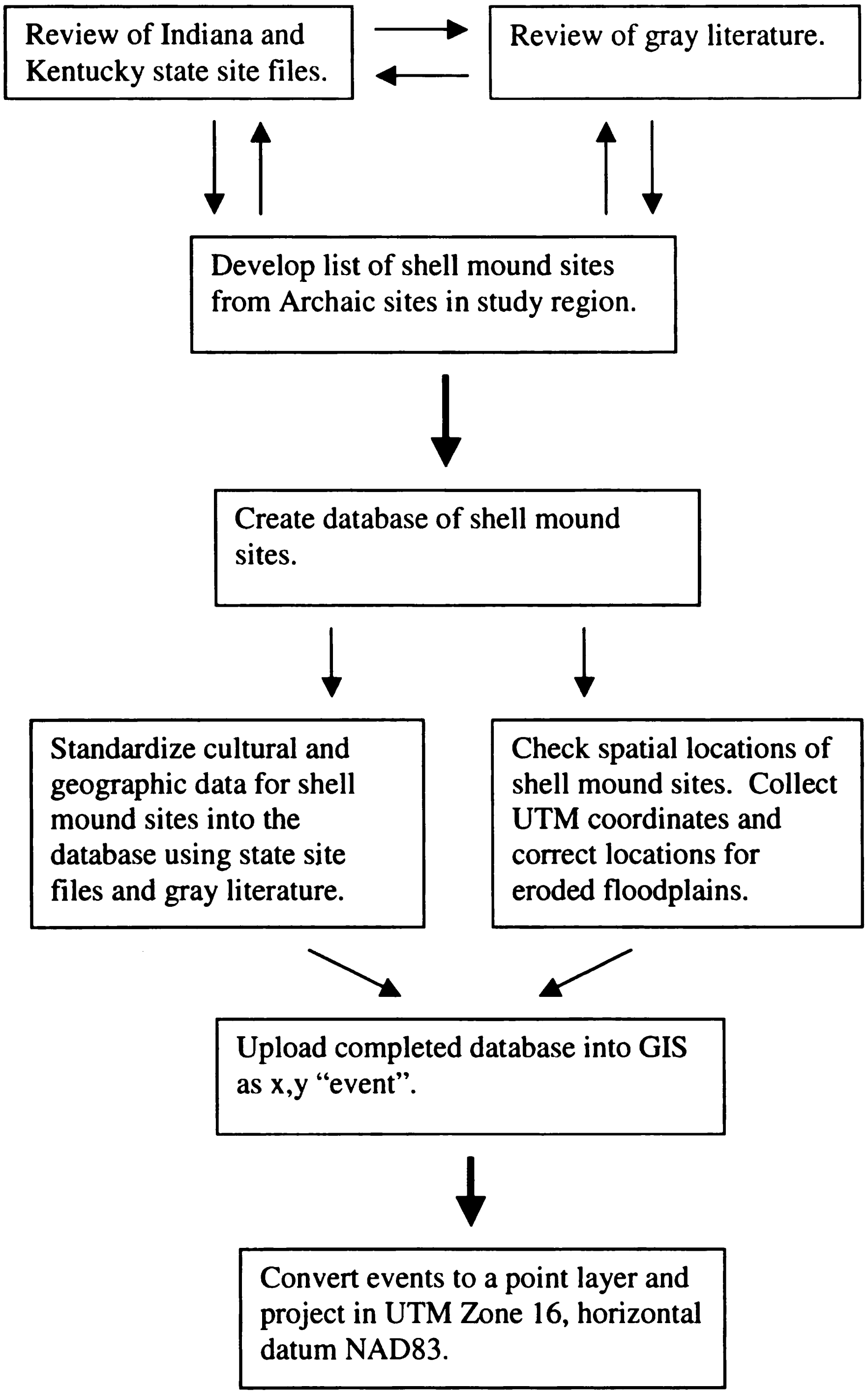


Figure 7.2. Flow chart illustrating steps in creating the archaeological site database and GIS layer.

Part of this confusion stems from the fact that SMA sites in the Falls Region vary considerably in size and structure (as in the Green River valley). Some sites have large prominent middens, while others contain only small lenses of mussel shell within an earthen midden. I cross-referenced descriptions in multiple site reports and only included sites for which there was clear evidence for a SMA occupation. For example, a description of the Arrowhead Farm site (15-Jf-237) by Granger et al. (1973:9) confirms it was an SMA site: "The artifact inventory and the presence of a shell mound [at Arrowhead Farm] indicate a Late Archaic cultural affiliation."

A second problem encountered while creating the SMA site dataset was the inconsistent and non-standardized information available in site forms and field reports. Site forms from Indiana and Kentucky recorded different information, and forms from different eras also varied in content. Thus, the data on site forms was largely not comparable or usable for my analysis. I standardized the site information whenever possible and created a database including the following variables: site number, site name, state, county, nearest modern town, USGS 7.5' Quadrangle map, UTM coordinates, topographic location, elevation, physiography, watershed, and comments (usually pertaining to diagnostic artifacts or National Register eligibility).

Site information presented in gray literature also varied. As discussed in Chapter 6, not all of the SMA sites in the Falls Region have been excavated. Data from excavations is highly irregular, due to differences in field procedures and methods over many decades. Consequently, I decided not to include excavation data in this study other than to 1) determine temporal components/phases at the site, or 2) help reconstruct geo-environmental contexts. Non-spatial data attributes recorded for shell mound sites in this study include: radiocarbon dates, relative dates (using artifact chronologies), temporal phase, any diagnostic lithic tools, subsistence remains, cultural features, presence of burials, and site stratigraphy. Many of these non-spatial characteristics of SMA sites are linked to the spatial locations in GIS by the attribute table. These data can be used to aid interpretation of the spatial analysis because it can provide estimates on the duration and intensity of occupation as well as the range of activities performed at these sites (cf. Binford 1980: 1982).

The third problem encountered was improper reporting of site spatial location. The location of sites is reported in UTM coordinates for both the state of Indiana and Kentucky. These coordinates were incorrect or missing for the majority of the sites identified as shell mounds. This was a significant problem, as the focus of this study is on reconstructing spatial contexts. Therefore, I devoted considerable amount of time to the data purity of spatial coordinates for each site. I used the mapped locations on paper USGS 7.5' Quadrangle maps on file at the IDNR-DHPA and KOSA to determine the UTM coordinates. During this process, all UTM coordinates were standardized to the NAD 83 datum[3]. In some cases the location of a site was altered slightly to account for situations where recent stream erosion had completely destroyed the floodplain landform on which a site was originally reported. Without moving these sites, they mapped in the Ohio River, rather than on land. I moved these sites out of the Ohio River and placed them on land, nearest to the original UTM coordinates. In addition to using USGS maps

---

[3] The National Geodetic Survey Glossary states that the NAD83 datum is a horizontal control datum that is based on 250,000 geographic points in North America, as well as satellite and remote sensing imagery (http://www.ngs.noaa.gov/CORS-Proxy/Glossary/xml/NGS_Glossary.xml). The NAD83 datum is currently the legal horizontal datum for the United States federal government.

to correct site locations, a field survey was conducted in an effort to relocate several sites that were reported as destroyed by river erosion. The survey is described in the following section.

Once corrected, the spatial locations of SMA sites are represented in GIS as point-data. Therefore, the site location coordinates were entered into a spreadsheet as UTM East and UTM North, along with the selected non-spatial attributes. The spreadsheet was imported in GIS as an x/y event-table. Once in GIS, I selected the appropriate spatial projection[4] system and horizontal datum[5] for the dataset, which is UTM Zone and NAD83, respectively. Next, the event-table was converted into a point layer and saved as a shape file. This final step creates a layer of the SMA sites (see Figure 7.2), which forms the cultural landscape to be analyzed in this study.

Field Survey and Site Location Correction

In June of 2005, I conducted limited field survey in the eastern portion of Clark County, Indiana with two specific goals (Figure 7.3). The first goal was to assess the mapped location of site 12-Cl-10 (Genuine Risk) and determine whether this site was completely destroyed by erosion. The second goal of the field survey was to examine the Ohio River bank between the towns of Westport and Owen in Indiana, approximately River Miles 580 to 585, to look for undocumented SMA sites. This portion of the Ohio

---

[4] The term p*rojection* is used in this dissertation to refer to corrections necessary to account for the curvature of the Earth's surface when displaying geographic features in a flat plane on a map. A map projection "transforms a position on the Earth's surface identified by latitude and longitude in to a position in Cartesian coordinates" (Longley et al. 2001). UTM uses multiple projections, which are broken into 60 zones to cover the entire face of the earth. This research is conducted in UTM Zone 16.

[5] In this dissertation the term *horizontal datum* refers to a point on the Earth's surface that has specific and known location. NAD83 is the North American Datum established in 1983 using geographic references, and satellite and remote sensing imagery. All data in this research are referenced to the NAD83 horizontal datum.

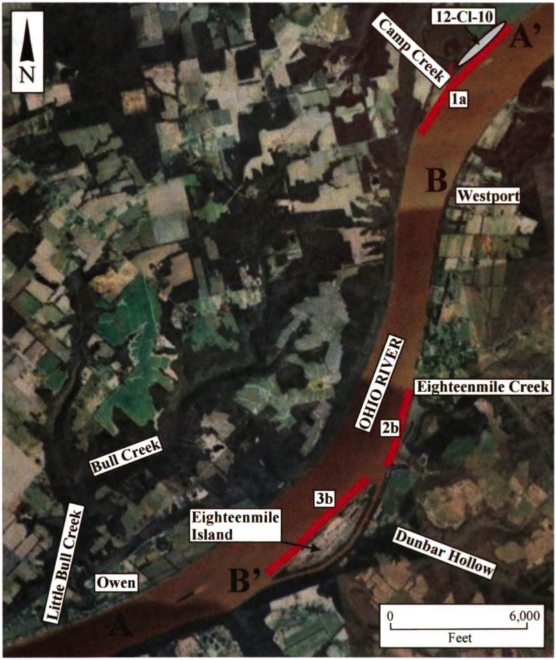


Figure 7.3. 2005 River Survey Area. Indiana riverbank survey area from A to A'. Kentucky riverbank survey area from B to B'. Red segments indicate areas where riverbank and beach were visually inspected through pedestrian survey. Aerial basemap downloaded from Google Earth, 2009. (In color)

valley lies immediately down river from 12-Cl-10 and 12-Cl-78, and was chosen for survey because it appeared to lack SMA sites or at least no SMA sites had been previously reported on these floodbasins. There are two large floodbasins in this portion of the river, as well as a former floodbasin that is now Eighteenmile Island. SMA sites were certainly possible on these landforms. Riverbank survey was conducted from a small boat. The field crew walked the beach and examined eroding cut-banks where possible.

Survey was conducted over two days. Perry Harrell, who was among a 1980 field crew that documented 12-Cl-10 (cf. Brinker et al. 1980), and Sean Evans accompanied me on the first day of survey. We examined the Indiana portion of the riverbank from the village of Owen (point A on Figure 7.3), upriver to the reported location of 12-Cl-10 in the Bethlehem Bottom (point A' on Figure 7.3). No SMA sites were visible in the eroded floodplain profiles or as midden debris on the river beaches. The Ohio River bank on the east and west sides of Camp Creek were examined by pedestrian survey for any visible remains of 12-Cl-10 (see Figure 7.3 segment 1a). As mentioned in Chapter 6, no evidence for SMA midden deposits was found in situ and it appears that 12-Cl-10 was destroyed by erosion and bank slumping. While we were at the presumed location of 12-Cl-10, a GPS unit was used to capture corrected UTM coordinates for the GIS analysis.

On the second day, Sean Evans and myself conducted survey of the Kentucky side of the Ohio River starting from West Port (point B on Figure 7.3) and heading down river just past Eighteenmile Island (point B' on Figure 7.3). The riverbank and beach were visually inspected by pedestrian survey between Eighteenmile Creek immediately west of Westport and Eighteenmile Island (segment 2b on Figure 7.3). The backchannel behind Eighteenmile Island was surveyed from the boat, as there was no beach to walk on. Pedestrian survey was conducted on the entire riverward side of the island (segment 3b on Figure 7.3). Both the eroding floodplain ridge and river beach were visually inspected. No archaeological sites or midden deposits were noted during this survey.

While the remains of 12-Cl-10 were not found during the field survey, no additional SMA sites were found either. These findings suggest that either 1) there were never additional SMA sites located on Owen and Westport floodbasins, or 2) that any SMA sites that were once in these areas were destroyed by erosion just like 12-Cl-10 on the Bethlehem Bottom, or 3) additional SMA sites in this portion of the study region may not have been located on the riverbank.

Regional Topographic and Environmental Data

A variety of environmental variables are necessary to reconstruct the natural landscape contexts of SMA sites for this research. Unlike the archaeological dataset, regional and national environmental datasets already exist and were created by a variety of private, federal, state, and local-governmental agencies. These datasets are widely available and accessible from online sources. One of the most reliable sources of environmental data for the United States is the U.S. Geological Survey Seamless Distribution Server (http://seamless.usgs.gov/). State-level geological surveys in Indiana[6] and Kentucky[7] also maintain online data clearinghouses. Both these national and state-level data sources were utilized for this study. While the environmental and

[6] Web source: http://129.79.145.7/arcims/statewide_mxd/download.html
[7] Web source: http://www.uky.edu/KGS/gis/kgs_gis.html

topographic data sources were preexisting, these data layers still required a degree of processing in order to use them for

analysis. Figure 7.4 illustrates the steps taken to prepare the topographic (Figure 7.4A) and environmental (Figure 7.4B) data for analysis.

Data acquired from the United States Geological Survey (USGS) included Digital Elevation Models (or DEMs) from the National Elevation Dataset (NED). This dataset is necessary in order to recreate the landscape topography and slope, which will be used to model cost-distances. According to the USGS, "the vertical accuracy [of NED] is basically +/- 7 to 15 meters" (http://ned.usgs.gov/Ned/faq.asp#NED). Vertical accuracy also depends on the original source and resolution of the data. NEDs are available at a variety of resolutions[8]. The highest resolution currently widely available is the so-called 10 meter or 1/3 arc-second NED. The level of topographic detail recorded in a 10 meter NED is equal to the USGS 7.5-minute topographic map series. DEMs of the NED are also available at resolutions of 30 meters and 90 meters; these correspond to 1 and 3 arc-seconds, respectively. A NED dataset at a resolution of 3 meters (1/9 arc-second) is currently being developed, but is not available for all regions of the country, including the study area.

The 10 meter NED data was downloaded[9] for this research area from the Seamless Server in three separate files. The first step in making these files usable for analysis was to combine them into one DEM through the *Mosaic to New Raster* function in the ArcMap toolbox (see Figure 7.4A). This function cooperates with Microsoft

[8] In this dissertation the term *resolution* is used to describe the size of the pixels that comprise a raster image.

[9] NED data are updated regularly, therefore it is important to note that the data used for this research were downloaded in 2004.

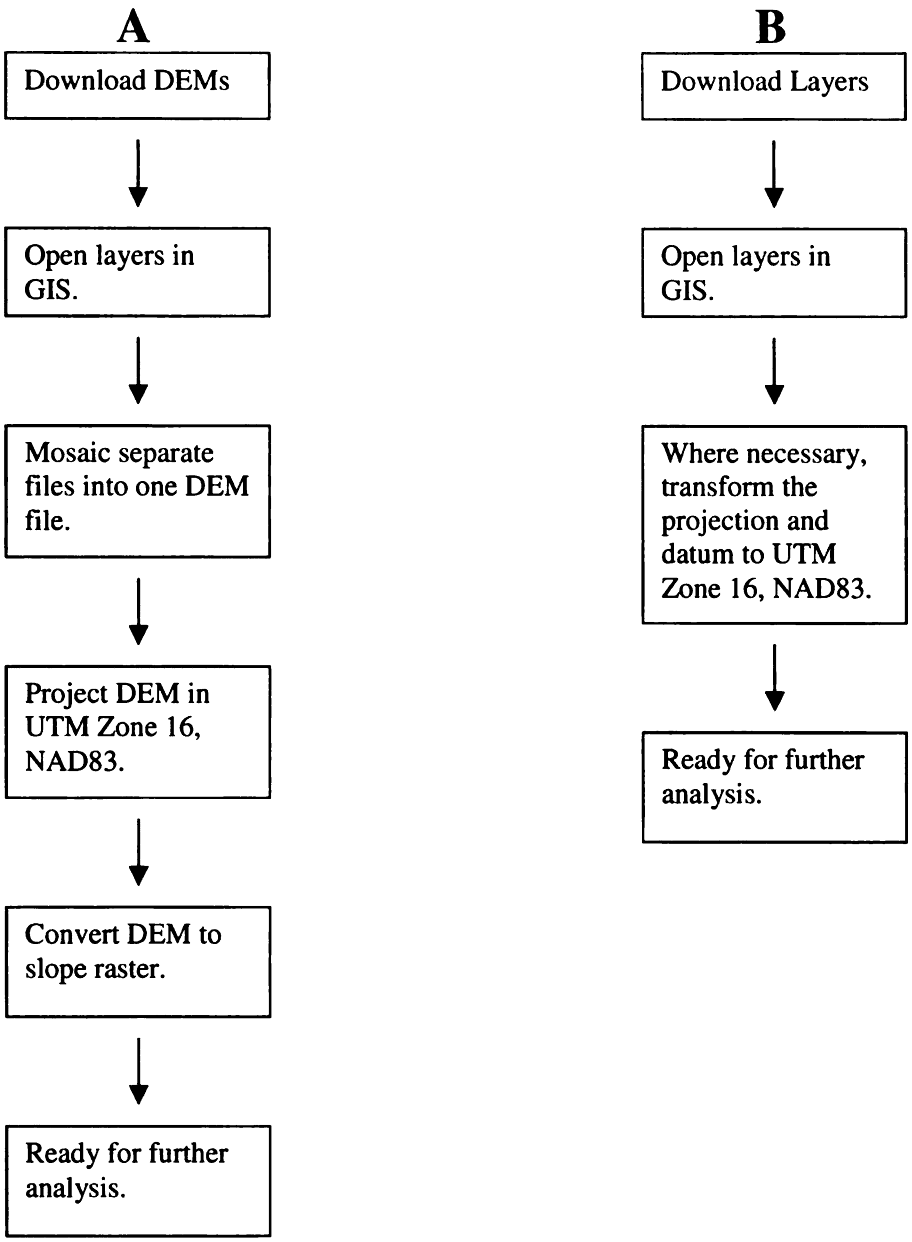


Figure 7.4. Flow charts illustrating data processing steps taken to prepare (A) topographic and (B) environmental data for analysis.

Access software to insert the new raster data in an empty database that I prepared with the name of the output file. The resulting DEM was a single seamless raster file for the region. NED data is download in the NAD83 horizontal datum; however, it does not have a projected coordinate system defined. I used the *Project Raster* function in the ArcMap toolbox to convert the mosaic DEM to Universal Traverse Mercator (UTM) Zone 16. Once these steps were completed (see Figure 7.4A), the DEM layer was ready for conducting cost-distance analysis, which I describe below in the next section.

A wide variety of environmental data are available from state-level geological surveys including: landforms, bedrock geology and outcrops, soils, karst features and springs, glacial geology, hydrology, wetlands, physiography, and tributary streams. Given the fact that mid-Holocene vegetation communities may have differed significantly from modern conditions, landcover was not a variable considered in this study. Future inquiry into local paleoclimate could help fill this gap (Surface-Evans 2006).

All of the environmental datasets used in this study were available in vector data format. A minimal amount of data processing was required, such as converting the map projection to UTM Zone 16 and converting to the NAD83 horizontal datum (see Figure 7.4B). Other than these minor adjustments to make all the data compatible in GIS, there were few technical problems affecting geo-environmental data collection and organization. The only problem encountered is that the States of Indiana and Kentucky have differing research priorities and maintain different types of datasets. For example, Indiana has datasets for glacial geology and cave density that are not available for the Kentucky portion of the study region. It is difficult to overcome these state-level differences in datasets. Consequently, it was necessary to limit my study to only those datasets that were common to both states.

It is important to note that the following caveat to using preexisting environmental layers and topographic DEM data layers: *these data are based on modern physiographic and environmental conditions.* Therefore, there are limitations to models derived from these environmental data because there have been geomorphic landscape changes in study area over the past 6,000 years. As discussed in Chapter 4 and 5, the Ohio River valley is a dynamic riverine environment that has been affected by a variety of geomorphic processes. Geoarchaeological studies have determined that some Middle Archaic period deposits were buried up to a meter or more in floodplain alluvium in the study area (cf. Bassett 1986; Boulding 1995, 1996; Russell 1996b; Surface-Evans 2002, 2005). Given this regional pattern, it is possible that the floodplain topography during the middle Holocene was slightly different than modern conditions. In addition, as noted above, in some cases the floodplain ridge was heavily eroded and sites are now located in the Ohio River. In these situations, site locations were altered slightly to account for these landscape changes. Consequently, fine-scale reconstructions are not appropriate for this study and my research is limited to regional-level modeling. In addition, any models derived from these data must be considered approximations of past conditions and human behavior.

GIS ANALYSIS

Reconstructing Local Site Contexts

Local site-level contexts were reconstructed by examining where sites occur in relation to various environmental variables, including: physiography, soils, watersheds, bedrock geology, landform, landform age. Once site locations and the various environmental layers were displayed in a GIS, I systematically examined each site with respect to these environmental variables (Figure 7.5). Table 7.1 shows the attributes for each environmental variable considered in this study. As mentioned above, variables were limited to data common to both Indiana and Kentucky. The environmental contexts for each site was recorded in a spreadsheet.

Table 7.1. Attributes of Environmental Variables

Variable	**Attributes**
Physiographic Province	Charlestown; Crawford; Mitchell; Muscatatuck; Norman
Watershed	Lower Ohio-Salt Rivers; Patoka-White Rivers
Soil Association	Corydon; Huntington; Lindside; Robertsville; Wellston; Wheeling; Zanesville
Bedrock Geology	Devonian; Devonian-Mississippian; Mississippian; Ordovician; Silurian
Landform Setting	Bottomland; Uplands
Floodplain Landform Age	Mid-Holocene; Wisconsin; n/a

Reconstructing Human Movement and SMA "Networks"

In order to examine issues of accessibility and movement within the study region, the second aspect of this research explores possible networks of connectivity between SMA sites and other features of the landscape. Measures of distance can be thought of in terms of either Euclidean/linear distance or cost-distance (Gorenflo and Bell 1991). Continuous or linear distance is measured "as the crow flies" through a landscape, while cost-distance considers characteristics of the landscape that may place constraints on movement. Both of these measures are considered in this study and the methodologies used to reconstruct them are described below.

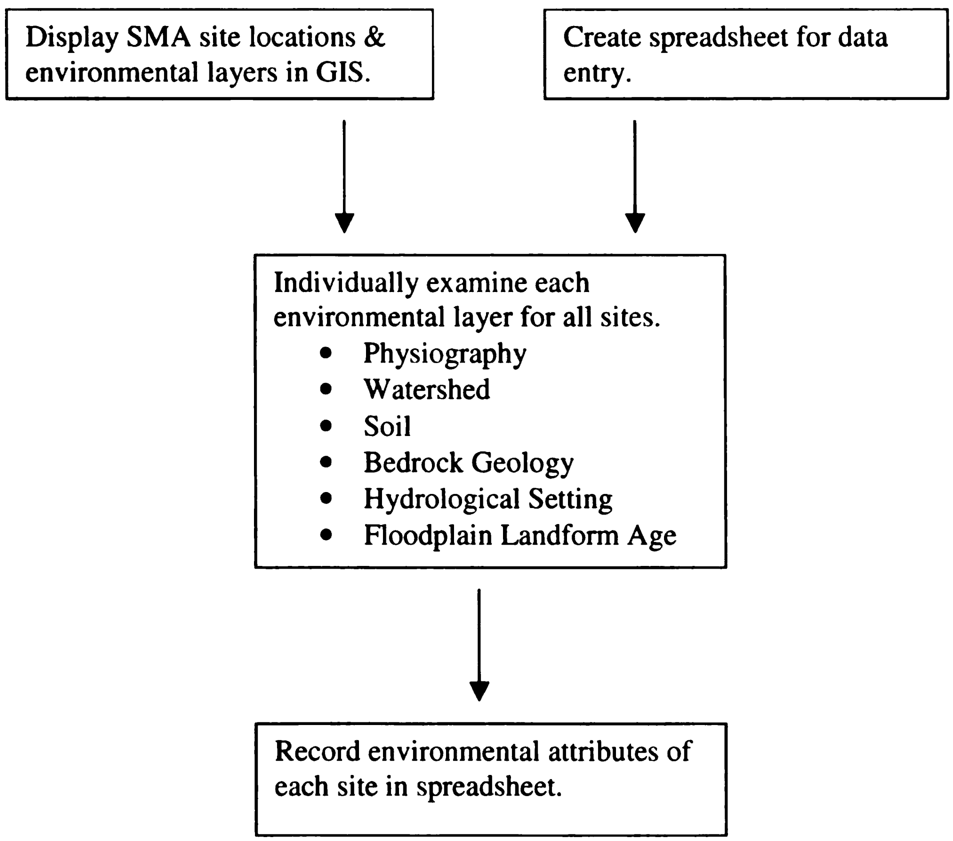


Figure 7.5. Flow chart of steps taken to reconstruct site-level environmental context.

Linear Distance

In a GIS platform, linear distance can be examined in several ways. The first method used in this research is a variation on catchment analysis. Vita-Finzi and Higgs (1970) applied catchment analysis in archaeology as a way to reconstruct how humans extract resources from their environment. Catchment studies are well established in archaeology and have been used for nearly forty years (cf. Boone 1987; Clarke 1977; Hodder and Orton 1979; Schermer and Tiffany 1985; Tiffany and Abbott 1982). More recently, GIS has also aided the examination of site catchments (eg. Hunt 1992). According to Hodder and Orton, "one of the most important aspects of site-catchment analysis is that it has focused attention on the micro-environment associated with a site" (1979:231). The basic assumption underlying catchment analysis is that human foraging or economic extraction is limited by various constraints; therefore, people are more likely to concentrate these activities in areas near settlements (Binford 1981; Hodder and Orton 1979; Vita-Finzi and Higgs 1970). The types of environmental features within a catchment area should be a reflection of the economy employed at that site (Hodder and Orton 1979). However, as Hodder and Orton (1979) caution, the environmental conditions within a catchment should only be considered an approximation of economy.

Typically, decisions regarding the size of catchment areas are informed by ethnographic research (Kelly 1995; Tiffany and Abbott 1982). For example, Tanaka (1980) reported that foragers in the Kalahari have an initial foraging radius of 1 to 2 km from a settlement. Among the Hadza, daily foraging is generally conducted within 5 km of a settlement (Vincent 1984). According to Kelly, "a 20- to 30- kilometer round trip appears to be the maximum distance hunter-gatherers will walk comfortably in a day"

(1995:133). Because ethnographically observed patterns of hunter-gatherer foraging distances vary under different circumstances, multiple catchment areas will be examined and compared in this research.

Methodologically, catchment areas may be modeled in GIS by creating concentric bands, known as buffers, around a site. Using the ArcMap *Buffer* tool, buffers are created for each site at a specified radius. For this research, catchment zones of 1 km, 5 km, and 25 km were created for each SMA site. The 1 km radius represents the resources within the immediate vicinity of the SMA site (Kelly 1995). The 5 km and 25 km catchments characterize a daily foraging radius, and a logistic foray, respectively (Kelly 1995). At each radius, all of the features that fell within the catchment were recorded in a spreadsheet. Figure 7.6A illustrates the steps to create site buffers and Figure 7.7 shows an example of catchment buffers around site 12-Cl-1 (Old Clarksville). The information recorded for each site-catchment provides a glimpse of the environmental diversity accessible within these selected areas.

The second methodology to examine linear distance relationships was to document the distance between SMA sites and specific points of interest on the landscape. Some of the landscape features that were examined this way include karst springs, other SMA sites, and tributary streams. The procedure to record distances was fairly simple (Figure 7.6B). First, a spreadsheet was created to record the distance (in meters) from each SMA site to the nearest spring, nearest other SMA site, and nearest stream. Then in GIS, the *measure* tool was used to determine the distance between SMA sites and these various features. These distance relationships were recorded in the spreadsheet.

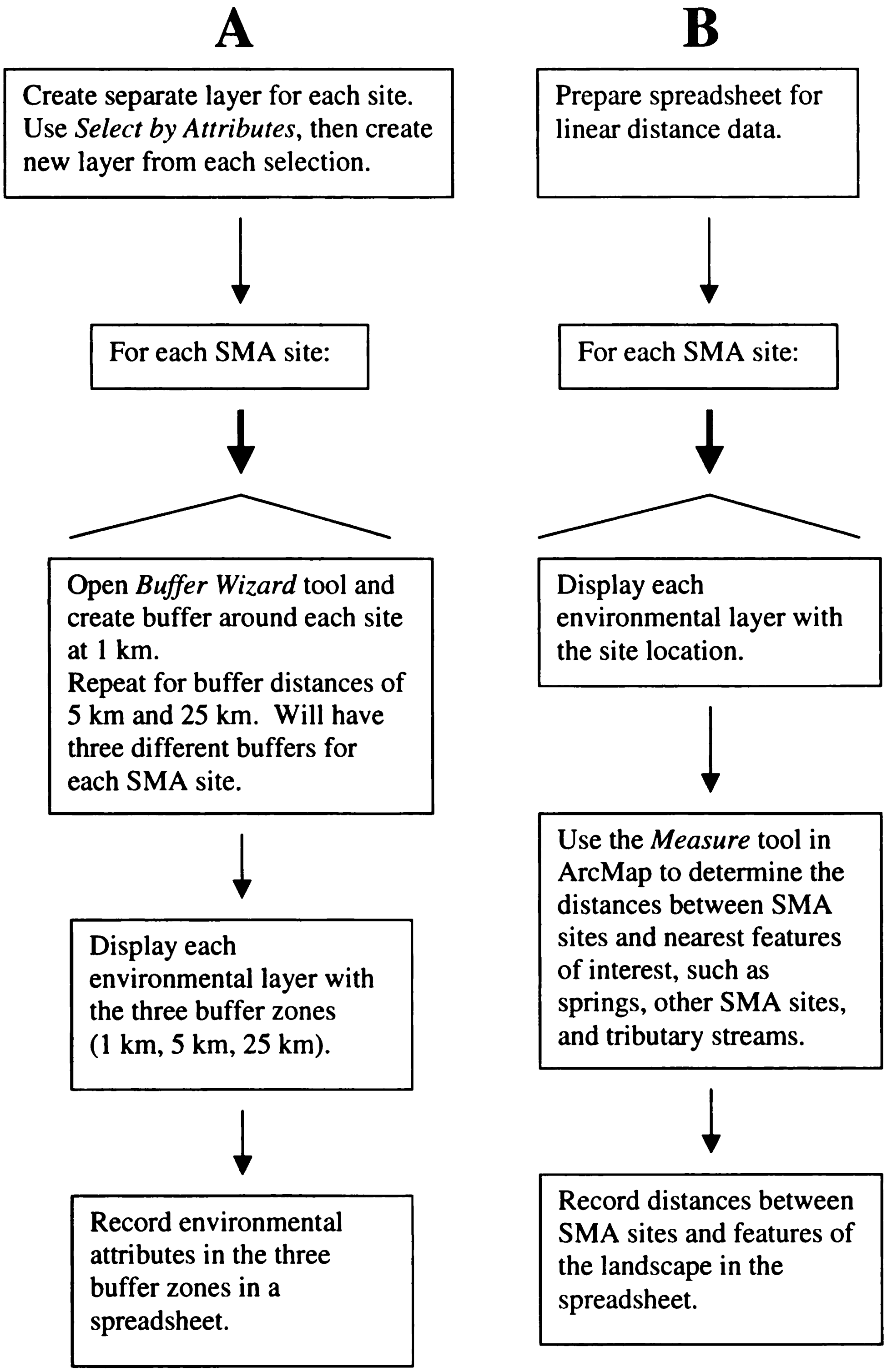


Figure 7.6. Flow chart showing (A) steps in conducting site-catchment analysis and (B) linear distances to features of the landscape.

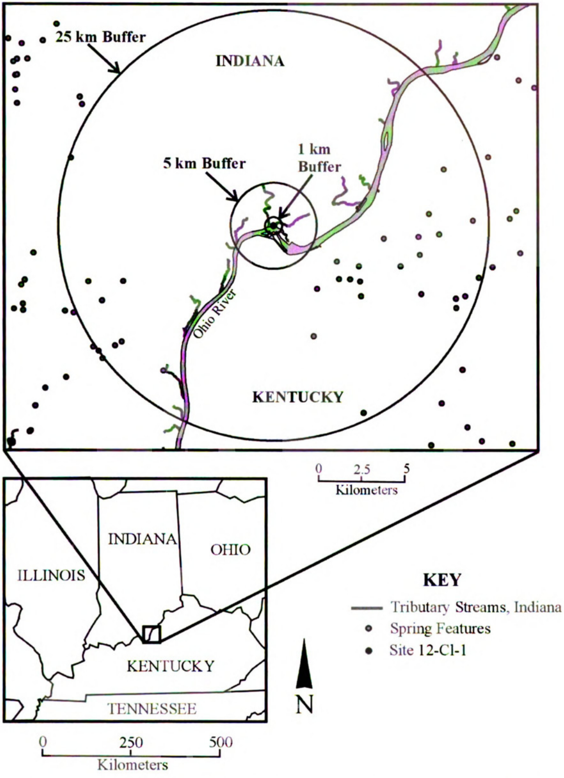


Figure 7.7. Example of concentric buffers around site 12-Cl-1. Shown with Indiana tributary stream features and spring features.

Cost-Distance: Creating Travel Pathways and Corridors

While linear distance is a useful way to examine the contexts of shell mounds, it is not a behaviorally based measure of distance and does not account for any environmental or cultural constraints on movement. Therefore, it is also important to also consider the costs of moving across the landscape between shell mounds and landscape features. Discrete or cost-distance is far more interesting in terms of human behavior, because it considers how human movement was restricted by terrain or other factors. Another benefit of this type of modeling is that moves beyond a static picture of the prehistoric landscape and explores human movement (Harris 2000). This is particularly, useful when studying hunter-gatherers, who occupy "mobile landscapes" (Boaz and Uleberg 2000:106).

The goals of the cost-distance modeling portion of my research are to:

1) Model hunter-gatherer movement within a landscape,
2) Predict the locations of other types of Archaic sites within the settlement system,
3) Explore potential relationships between sites to better understand the role of shell mounds within the Archaic settlement system and

Models of discrete distance are based on least-cost assumptions – that humans will limit energy expenditures while traveling in a rugged terrain. While there are many reasons that humans do not always chose to limit costs, this assumption is a heuristic device for modeling generalized expectations of regional patterns of movement. Cost-distance is calculated using the variables that constrain or place costs on movement. Terrain ruggedness is probably the most commonly used variable for estimating cost distance (cf. Bell and Lock 2000; Gorenflo and Bell 1991; Tobler 1979, 1993). To calculate cost-distance pathways using terrain, elevation data (in the form of DEMs) is converted mathematically to slope. The slope surface is then used to create a cost surface, also sometimes referred to as a "friction" surface. The cost surface is the basis for modeling hypothetical least-cost pathways between various destinations, in this case, SMA sites.

It is possible to incorporate numerous other variables into network modeling. Vegetation is one of the most common environmental variables considered in network models. The current lack of reliable paleoclimate data for the Ohio Falls region prevents the reconstruction of robust prehistoric vegetation models. Therefore, this study is primarily concerned with creating simulated networks using high-resolution terrain data and will not include vegetation as a cost-weighted variable. Cultural and physiological variables can also be used, such as carrying load or calorie consumption.

Typically, network analysis focuses on the structure, optimality, and accessibility of *existing* networks such as roadways. While network studies are prevalent in geography, they have been applied to limited archaeological contexts. Typically, archaeological applications of network analysis are conducted in situations where there is a record of past trails or road networks, such as Chaco Anasazi (e.g. Ebert and Hitchcock 1980; Kantner 1996) and Medieval Russian (e.g. Pitts 1965). Simulations of ancient networks for which there is no existing record, are even fewer. More recently, dissertation research by Parlsow (2006) modeled social interaction of Natufian hunter-gatherers in the Middle East. These simulations used low-resolution topographic data to create hypothetical networks of travel. White (2007) used a combination of known prehistoric trails and terrain to model patterns of interaction in the Western Papaguería portion of the North American Southwest. His research was based on high-resolution elevation data available from the United States Air Force.

All of these studies are concerned with modeling what may be termed a "pathway". Pathways are defined here as a way of modeling network connectivity that is a *single raster-cell* wide. Previous applications of least-cost modeling of prehistoric networks has centered on pathways. However, hypothetical pathways are strongly tied to the assumption that people *always* took the part of least resistance. Because it is unlikely that the SMA hunter-gatherer movement was this constrained within the landscape, this study also examines movement from an alternative perspective: cost-weighted corridors. While corridors are also based on least-cost assumptions, they model broader areas of potential accessibility and travel. Thus, cost-corridors incorporate more flexibility into hypothetical models of travel or movement than cost-paths. Corridors are modeled by adding the cost surfaces from an origin and destination together.

This least-cost modeling portion of this research is based on expectations of Archaic hunter-gatherer modes of travel and mobility (e.g. Kelly 1995). Archaic peoples would have traveled by foot and by small watercraft. Consequently, this research incorporates two different modeling scenarios. The first model considers how SMA peoples could have access different locales via the Ohio River, using small boats. The second model considers how SMA peoples would have walked to destinations in the Falls landscape.

While there is no single methodology for creating hypothetical pathways or corridors, there are several required data processing steps (Figure 7.8A). As mentioned above, topographic data must first be converted to slope values. The slope coverage was

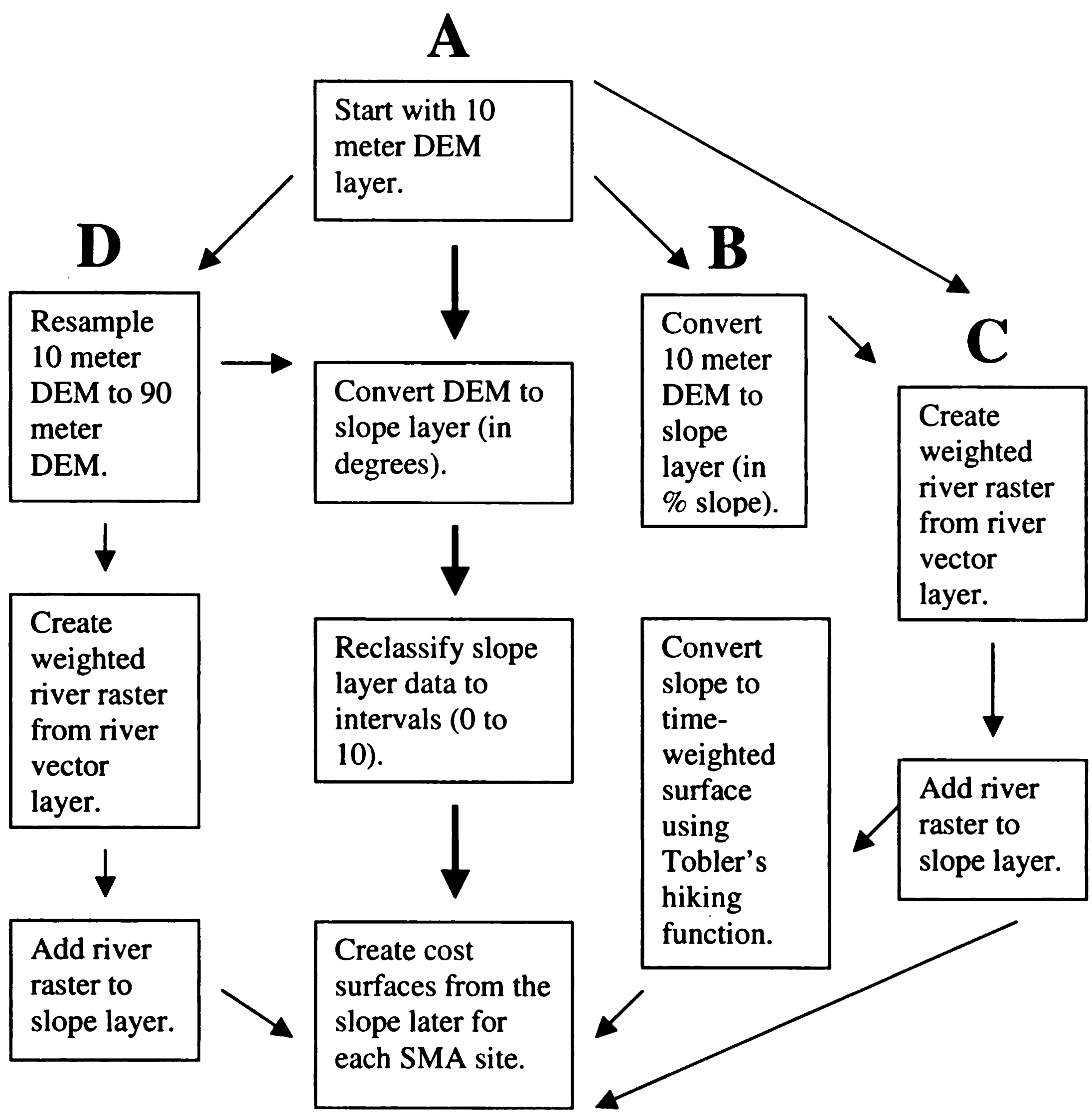


Figure 7.8. Flow chart illustrating data processing steps taking to convert (A) 10 meter DEMs to slope raster, cost raster, and over-land cost raster; (B-C) convert 10 meter DEM to cost surface using Tobler's hiking function, and (D) convert 10 meter DEM to 90 meter DEMs, slope, cost raster, and over-land cost raster.

created from the DEM data using the *Slope* function within the ArcMap *Spatial Analyst* extension (Figure 7.9). The resulting slope coverage was reclassified[10] as values between 1 and 8 (where 1 is no slope and 8 is vertical). These values were weighted using standard slope descriptions used by the USGS soil surveys (0 to 2 percent, 2 to 5 percent, 5 to 9 percent, 9 to 15 percent, 15 to 30 percent, 30 to 50 percent, and 50 to 75 percent). Slope provides a basis for calculating the costs of traversing a terrain. For example, a steep slope is much more difficult to traverse than a flat area.

The second step was to create costs surfaces from the slope data for selected points (all SMA sites) on the landscape (see Figure 7.7A). Cost can be calculated using build-in algorithms of the *Spatial Analyst* in ArcMap. According to the ESRI ArcMap documentation, "the Cost functions determine the shortest weighted distance (or accumulated travel cost) from each cell to the nearest cell in the set of source cells. The weighted distance functions apply distance in cost units, not in geographic units". The ArcMap cost-algorithm is an anisotropic model, which means that it is direction dependent. In other words, it does not assume that costs are identical in all directions, but instead may vary in different directions from the origin point (Bailey and Gatrell 1995). Cost-weighted surfaces are created with the *Cost Weighted Distance* function in *Spatial Analyst* (see Figure 7.8A). This function uses an origin point (SMA site) and a slope surface to create two layers: cost-direction and cost-raster (Figure 7.10). The cost-raster layer contains cells with the accumulative cost to the closest source cell.

[10] Using the *Reclassify* tool in the ArcMap *Spatial Analyst Tools*. The *Reclassify* tool allows one to change the values of raster cells.

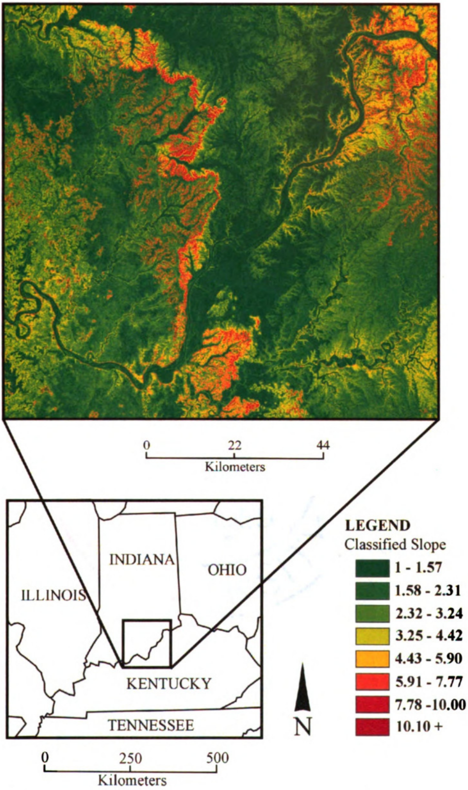


Figure 7.9. Resampled slope layer created from 10 meter DEM (In color).

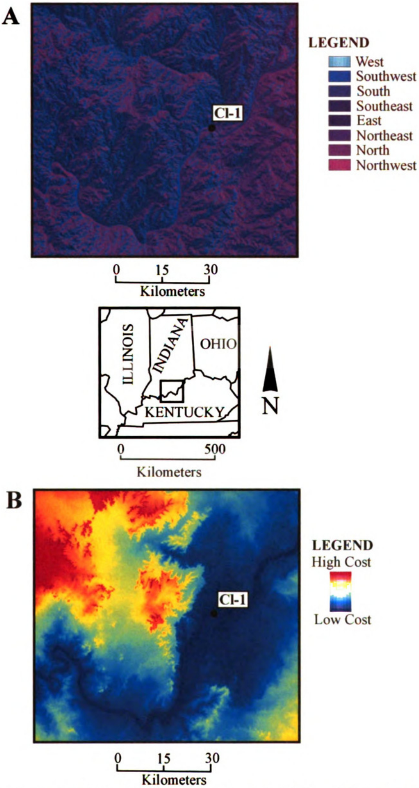


Figure 7.10. An Example of (A) Cost-direction and (B) Cost-Distance layers created for site 12-Cl-1 from slope layer (In color).

Other researchers (cf. Kantner 1996; Parlsow 2006) have also used the "hiking" algorithm developed by Tobbler (1991) to create a cost surface based on walking velocity. Tobler's "hiking" function is based on expectations for walking on hilly terrain and allows one to consider the costs of travel in terms of time. The equation is $W = 6 \exp\{-3.5 \text{ abs}(S + 0.05)\}$, where W is the walking velocity (in km per hour) and S is percent slope (Tobler 1993). To compare the results of the built-in ArcMap algorithm with Tobler's equation, I used his algorithm to model alternative cost surfaces for several sites. The hiking function requires two additional steps before creating a cost surface based on this algorithm (Figure 7.8B). First, I had to create a second slope surface in percent slope, rather than degrees. Second, because Tobler's model only considers foot travel, it was necessary to remove the Ohio River as a potential path of travel. To examine the costs of travel over land, I developed a plan for removing the Ohio River from the modeling universe (Figure 7.8C).

A vector layer of the Ohio River was converted to a raster layer using the *Convert Features to Raster* function in ArcMap *Spatial Analyst* (Figure 7.11). This created a raster layer where the Ohio River had a value of 1 and all other cells in the grid had a value of 0. The next step was to reclassify the river-raster to impose an artificially high cost to the river, which has the effect of removing the river as a potential area of travel. Using the *Reclassify* function in ArcMap, a value of 10 was imposed on the river cells in the raster. Lastly, the river raster was added to the slope layer of the study area using the *Raster Calculator* in ArcMap *Spatial Analyst*.

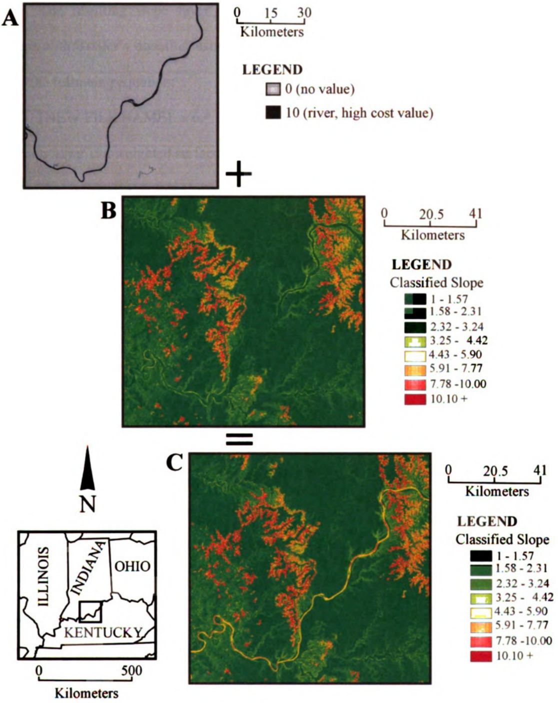


Figure 7.11. Demonstration of how (A) river raster and (B) slope are added together to create (C) a slope surface where the river is heavily weighted (In color).

The resulting slope layer was mathematically converted to a cost-weighted surface with Tobler's equation using the *Raster Calculator* in ArcMap *Spatial Analyst* using the following equation:

[NEW FILE NAME] = 6 * Exp(Abs(([SLOPE FILE] / 100) + 0.05) * -3.5)

This new layer is a weighted surface that is inversely related to terrain ruggedness (Figure 7.12). That is, areas with low slope have a higher walking velocity, while areas with high slope have a low walking velocity. The maximum walking velocity possible in this model is roughly 5 km per hour. The hiking function layer was then converted to cost layers for several sites, using the same method described above for the standard slope layer (see Figure 7.8).

While the Shell Mound Archaic certainly traveled in canoes on the Ohio River, it was important to consider travel exclusively by foot because this was most likely the primary method for travel. Because the least-cost modeling with the Ohio River will prevent over-land pathways from being modeled, I used the same steps outlined above to remove the river from the slope layer used with Tobler's algorithm to remove the river in the original slope layer. The new "over-land" slope surface was used to create a second set of cost surfaces for SMA sites. Figure 7.13 illustrates that the resulting upland cost surfaces are substantially different from the cost surface models with the river included.

Originally, this research was to be conducted exclusively with the 10 meter resolution DEMs. However, several problems were encountered with this dataset that necessitated a change in research design. First, the 10 meter model was so detailed that modern features such as highways and bridges, create "artifacts" in the model (Figure 7.14). DEM artifacts are features in the elevation model that do not accurately relfect the

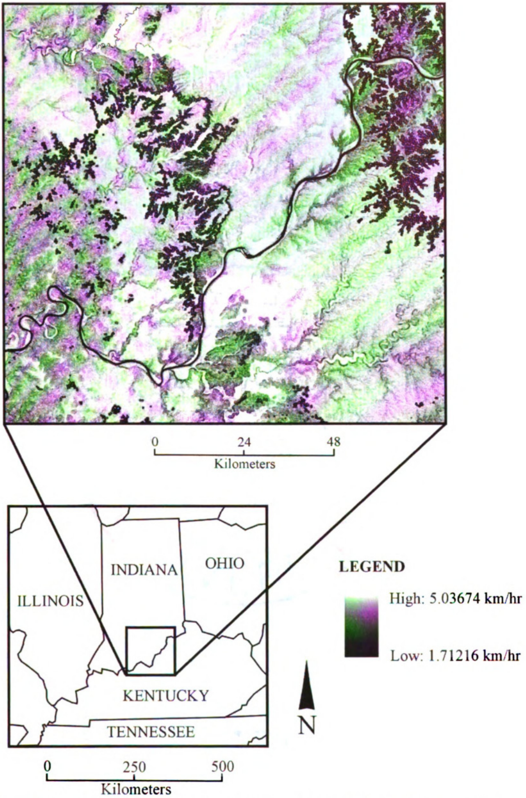


Figure 7.12. Travel time-weighted surface created from Tobler's Hiking function.

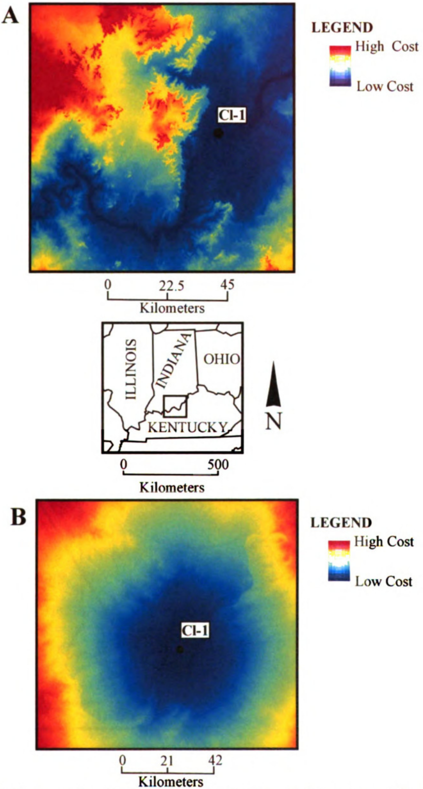


Figure 7.13. Examples of (A) river travel and (B) over-land cost rasters for 12-Cl-1 (In color).

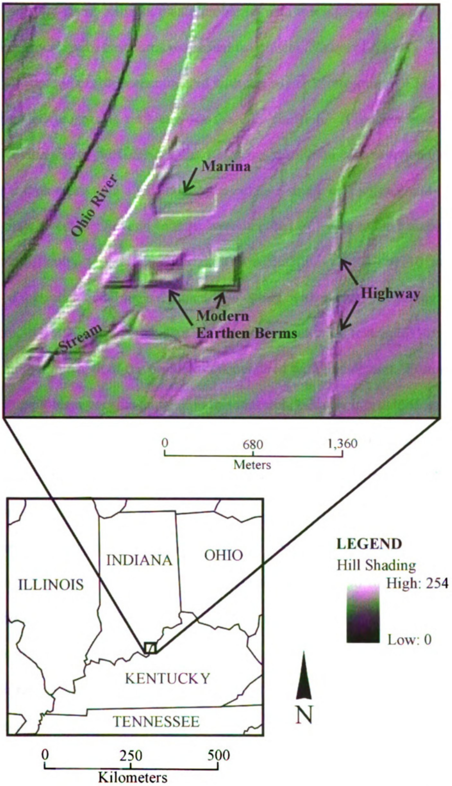


Figure 7.14. Examples of several artifacts present in the 10 meter DEM (hillshaded) in Jefferson County, Kentucky.

natural terrain. These artifacts create problems with a least-cost analysis, because they will affect any slope or cost surfaces created from them (Shortridge 2001).

The second problem encountered with the 10 meter resolution DEMs was that this data presented processing problems for the GIS platform. It quickly became apparent that calculating cost surfaces at the 10 meter resolution was overloading ArcMap, because it took more than a half hour to calculate a single cost surface and often caused the program to crash. Several months were devoted to trying to find ways around this technical difficulty. After much trial, it was determined that the 10 meter DEMs contained too much detail for a regional-level study, with current computing capabilities. Therefore, the 10 meter NED data of the study area was resampled to a 90 meter resolution to solve both of the problems encountered with this dataset. Fortunately, what started as a problem became an asset to this research, because it provided an opportunity to observe how resolution affects network modeling (presented in Chapter 8).

The 10 meter DEM data was resampled in ArcMap using the *Resample* command under the *Raster, Data Management Tools*. I chose the bilinear[11] interpolation technique to convert the 10 meter raster cells to 90 meters. Once this step was complete, the same processing steps described above were conducted with the 90 meter dataset to create slope and cost surfaces (see Figure 7.8C). Cost surfaces were created for every shell mound site in the research area at the 90 meter spatial resolution and selected sites at the 10 meter resolution. Surprisingly, the 10 meter and 90 meter resolution cost surfaces do not appear to differ substantially (Figure 7.15).

[11] *Bilinear interpolation* uses the value of the four nearest input cell centers to determine the value on the output raster. The new value for the output cell is a weighted average of these four values, adjusted to account for their distance from the center of the output cell (ESRI ArcMap Help Database).

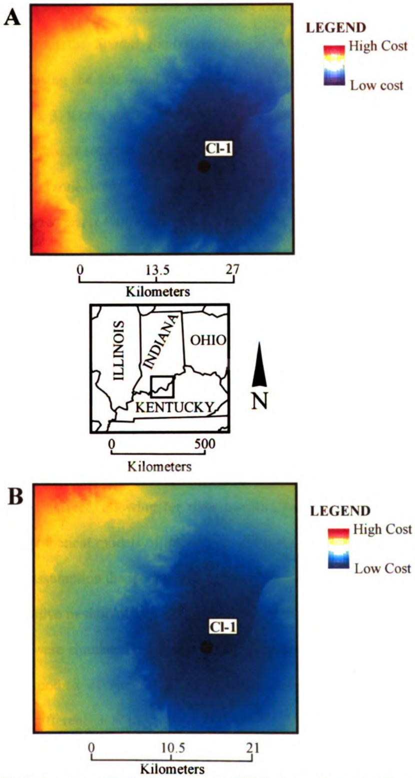


Figure 7.15. Comparison of (A) 10 meter and (B) 90 meter cost rasters (over-land) for site 12-Cl-1 (In color).

Hypothetical travel paths between sites were calculated using the built-in *Shortest Path* algorithm from the *Spatial Analyst* toolbar in ArcMap (Figure 7.16A). This algorithm is run using the following information: 1) a destination site and 2) the cost surface of that site, 3) a cost surface for the site of origin, and 4) the type of path to be calculated (in this case, I selected "for each cell", which calculates the least cost path for each cell in each zone using the cost rasters). According to the ESRI ArcMap documentation, the *Shortest Path* calculates a path that "is one cell wide, travels from the destination to the source, and is guaranteed to be the cheapest route relative to the cost units defined by the original cost raster that was input into the weighted-distance function".

Least-cost travel paths were calculated between all shell mound site in the project area at the 90 meter resolution and for selected sites in the 10 meter resolution. The same calculations were also done for the over-land cost models. Figure 7.17 illustrates examples of cost pathways from site Cl-1 and all other SMA sites in the study area (using the 90 meter cost surface, allowing for river travel). As mentioned previously, these pathways are hypothetical models of interaction and movement between SMA sites that are based on the assumption that people will follow the path of least-resistance.

An alternative method of modeling movement in a landscape is through corridor*s*. Travel corridors were simulated using the *Corridor* function in the *Distance* tools in the Spatial Analyst toolbox of ArcGIS. The corridor function essentially adds the cost surfaces of two different sites to create a combined cost surface. The ESRI ArcMap documentation describes that the *Corridor* function creates a raster where each cell is

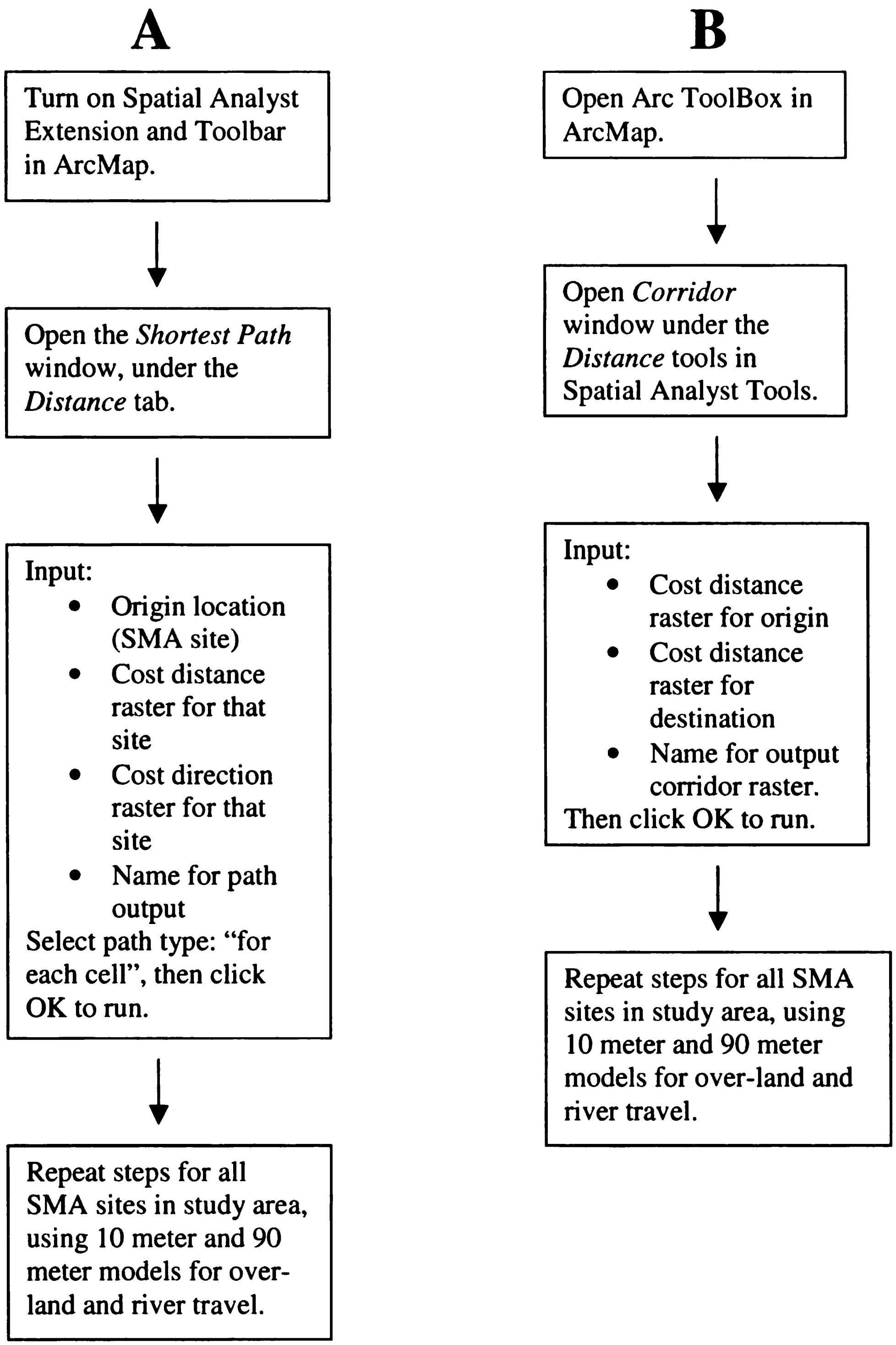


Figure 7.16. Flow charts illustrating steps to create (A) pathways and (B) corridors.

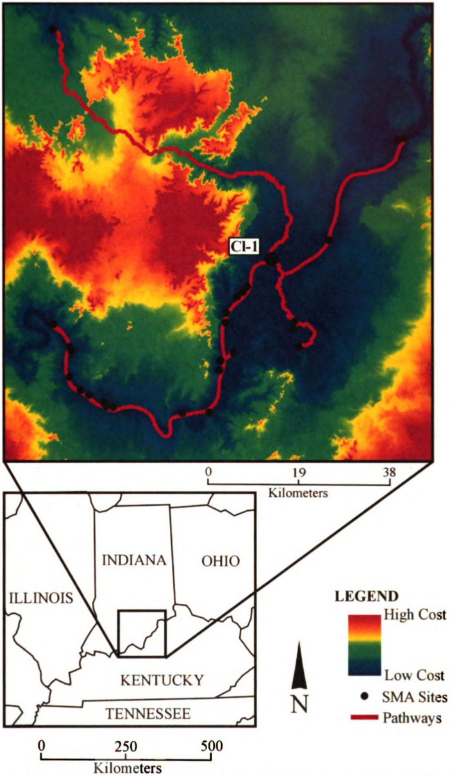


Figure 7.17. Example of hypothetical travel pathways between site 12-Cl-1 and all other SMA sites in the study area. Shown with the 12-Cl-1 90 meter cost surface. (In color)

"the sum of the cost distances (accumulative costs) for two input accumulative cost rasters is calculated...The output raster identifies not a single least-cost path between the two sources but identifies the range of accumulative costs between the sources." In other words, the output raster shows the total sum of all costs between two locations. A cost-corridor calculates cost for the entire region, rather than a single pathway (Figure 7.18). The advantage of this method is that it takes into account the fact that people seldom travel a defined least-cost path. Additionally, cost corridors model relative accessibility of a region, rather than between two specific locales. Also, corridors visually display routes that are nearly as good as the least-cost pathways and the viewer can clearly see other potential areas of travel.

The steps taken to create hypothetical travel corridors are shown in Figure 7.16B. Within the *Corridor* window, the following information is entered to create the corridor model: 1) cost raster for point of origin, 2) cost raster for destination, and 3) name of the new output corridor raster. Figure 7.18 demonstrates this process for sites 12-Cl-1 and 12-Hr-11 (using the 90 meter upland costs surfaces). The resulting output shows the costs of terrain, as considered from both sites. The "corridor" shows areas of high and low accessibility in the landscape.

SPATIAL STATISTICS

Several spatial statistics were applied in this research to examine the distribution of shell mound sites. These methods include Kernel density estimation[12] (KDE) and several statistics commonly known as Nearest Neighbor tests. KDE is used to explore

---

[12] Kernel Estimation was developed to smooth histogram plots, however, it can also be applied to estimate density or intensity of spatial point data (Bailey and Gatrell 1995:84; Beardah and Baxter 1996).

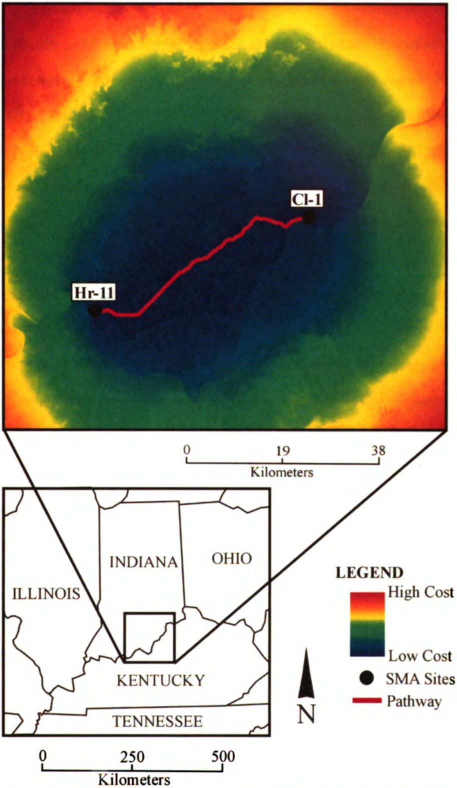


Figure 7.18. Example of over-land cost corridor between site 12-Cl-1 and 12-Hr-11, also shown with least-cost pathway (in red) for comparison. (In color)

variation at different scales by changing the degree of smoothing, referred to as bandwidth (Bailey and Gatrell 1995). KDE can identify first order[13] spatial properties to determine whether the intensity of points varies throughout a study region (Bailey and Gatrell 1995). I conducted KDE in two different ways in order to understand site patterning 1) along the Ohio River and 2) in the region as a whole. The first strategy was to examine the density of SMA sites along the Ohio River. SMA sites were plotted using their location in *river miles* for this step. I first recorded the river mile at each SMA site location in a spreadsheet. Then I prepared frequency tables for the data at several different bandwidths or intervals: 4 miles (6.437 km), 6 miles (9.656 km), and 12 miles (19.312 km).

The second type of KDE analysis was undertaken in GIS, using the spatial coordinates of all SMA sites in the study region. In ArcMap the *Density* function in the *Spatial Analyst* Toolbar "calculates a magnitude per unit area from point features using a kernel function to fit a smoothly tapered surface to each point" (ArcMap Help documentation). In this function the *Search Radius* (or bandwidth) and *Output cell size* are specified. The resulting output layer visually displays the density of SMA sites throughout the study area. Both the linear and regional KDE strategies work on the same principles.

Nearest Neighbor analysis is commonly used to determine whether there are second order[14] spatial properties to a distribution of points. In other words nearest neighbor statistics examine whether points clustered or dispersed and what the distances are between points (Bailey and Gatrell 1995). Two spatial statistics were used: K-

---

[13] First-order patterning refers to a large-scale trend or gradient in variation (Bailey and Gatrell 1995).

[14] A point distribution has second-order patterning when the data are clustered (correlated) or regular (dispersed) (Bailey and Gatrell 1995).

function and L-function. The advantage of the K-function over other nearest neighbor techniques is that it allows both small- and large-scale patterns to be examined (Bailey and Gatrell 1995). The K-function is expressed as the following equation: $\lambda K(h) = E(\#(\text{events within distance h of an arbitrary event}))$. Where λ is the intensity or "mean number of events per unit area, assumed constant throughout [region] R" (Bailey and Gatrell 199:92), # is the "number of", and E( ) is the expectation operator. A full discussion of how the K-function is calculated is presented by Bailey and Gatrell (1995).

The L-function was used to determine the scale of the clusters observed in the KDE and K-function tests. The L-function is a transformation of the K-function to essentially straighten the plot. The equation and assumptions of the L-function are discussed by Bailey and Gatrell (1995). The smoothing effect of the Lhat plot makes it easier to see the scale of spatial clustering. The results of the K- and L-function analysis indicates that SMA sites in the study regional are indeed clustered and that clustering occurs at several scales. The results and interpretations of the patterns are discussed further in Chapter 8.

SUMMARY OF METHODS

In this chapter, I reviewed the steps taken to 1) create a GIS layer of SMA sites, 2) select and download preexisting environmental and topographic GIS data layers, 3) reconstruct site-level contexts, 4) examine linear and cost distance relationships between SMA sites and features of the landscape, and 5) conduct spatial statistical analysis of the site distribution. The methods described here utilize ERSI ArcMap software for modeling the ancient SMA landscape. This research explores the spatial contexts of SMA sites in four different ways.

First, site-level contexts will be reconstructed using environmental layers, such as physiography and soil. Second, linear distance relationships will be examined using catchment analysis. In GIS, site-catchments were created by developing buffers at 1-, 5-, and 25 km around each site. These catchment zones were selected based on ethnographic data on hunter-gatherer land use patterns (cf. Kelly 1995). Third, cost-weighted modeling will be employed in an effort to better understand how topographic constraints affected movement and accessibility within the study area. While the concept of least-cost modeling is not new to archaeology, their application to modeling movement within the landscape is relatively new. Fourth, the spatial statistics used in this research help identify first and second order patterning within the SMA site distribution.

Very few researchers have used least-cost modeling to reconstruct ancient pathways or trails in the landscape. This research also modeled travel corridors, which is a method for exploring regional movement that has not been used by other archaeologists. The cost-weighted models developed in this study are hypothetical – that is, they are theoretical trails or areas of accessibility based on the assumption that humans have a tendency to take the path of least resistance. In Chapter 8, I will discuss the results of local-site and linear distance analyses portion of this research. Chapter 9 provides a discussion of the results of cost-weighted modeling.

CHAPTER 8

RESULTS AND DISCUSSION OF LOCAL SITE CONTEXTS AND LINEAR DISTANCES

"*Hill*...a hasty word for a thing that has stood here ever since this part of the world was shaped."

J. J. R. Tolkien, *The Two Towers*

INTRODUCTION

Shell mounds are distinctive sites on the landscape –some are even "hills" formed by the daily living of generations of people. These sites were formed through many years of repeated occupation at particular locales. This chapter presents the results analysis to 1) reconstruct the position of SMA sites in their landscape contexts, and 2) examine linear distance relationships between SMA sites and features of the landscape. These results are presented in several sections. First I discuss site-level variables recorded at SMA sites. Next, I discuss the results of catchment analysis. In the process of exploring the catchment data, I also conducted cluster analysis of the SMA sites.

SITE-LEVEL CONTEXT

The first step in this research was to examine site-level contexts. The question guiding this research was *what are the landscape characteristics of shell mound site locales?* This step was aimed at looking for common features that might be shared by SMA sites or for regional patterns in site placement. Table 8.1 summarizes data for site level variables. Several patterns emerge at the site level.

Table 8.1. Summary of Site-Level Context					
Site No.	**Physiography**	**Soil Association**	**Soil Landform/ Setting**	**Hydrological Setting**	**Bedrock Geology**
12-Cl-1	Charlestown	Wheeling-Elkinsville-Vincennes	Terraces, Bottomlands	Bottomlands	Devonian-Mississippian
12-Cl-10	Muscatatuck	Wheeling-Elkinsville-Vincennes	Terraces, Bottomlands	Bottomlands	Ordovician
12-Cl-3	Charlestown	Wheeling-Elkinsville-Vincennes	Terraces, Bottomlands	Bottomlands	Devonian
12-Cl-78	Muscatatuck	Corydon-Caneyville-Gilpin	Stony Uplands	Uplands	Ordovician
12-Fl-1	Charlestown	Wheeling-Elkinsville-Vincennes	Terraces, Bottomlands	Bottomlands	Devonian-Mississippian
12-Fl-13	Charlestown	Wheeling-Elkinsville-Vincennes	Terraces, Bottomlands	Bottomlands	Devonian-Mississippian
12-Fl-46	Charlestown	Wheeling-Elkinsville-Vincennes	Terraces, Bottomlands	Bottomlands	Devonian-Mississippian
12-Fl-73	Norman	Wheeling-Elkinsville-Vincennes	Terraces, Bottomlands	Bottomlands	Mississippian
12-Hr-103	Mitchell	Huntington-Nework-Woodmere	Floodplains, Terraces	Bottomlands	Mississippian
12-Hr-11	Crawford	Huntington-Nework-Woodmere	Floodplains, Terraces	Bottomlands	Mississippian
12-Hr-113	Mitchell	Wheeling-Elkinsville-Vincennes	Terraces, Bottomlands	Bottomlands	Mississippian
12-Hr-12	Crawford	Huntington-Nework-Woodmere	Floodplains, Terraces	Bottomlands	Mississippian
12-Hr-13	Crawford	Corydon-Caneyville-Gilpin	Stony Uplands	Uplands	Mississippian
12-Hr-3	Mitchell	Huntington-Nework-Woodmere	Floodplains, Terraces	Bottomlands	Mississippian
12-Hr-36	Mitchell	Huntington-Nework-Woodmere	Floodplains, Terraces	Bottomlands	Mississippian
12-Hr-4	Mitchell	Huntington-Nework-Woodmere	Floodplains, Terraces	Bottomlands	Mississippian

Table 8.1. Continued.

12-Hr-6	Crawford	Huntington-Nework-Woodmere	Floodplains, Terraces	Bottomlands	Mississippian
12-Hr-9	Crawford	Huntington-Nework-Woodmere	Floodplains, Terraces	Bottomlands	Mississippian
12-Hr-96	Mitchell	Huntington-Nework-Woodmere	Floodplains, Terraces	Bottomlands	Mississippian
12-Ws-30	Norman	Wellston-Berks-Gilpin	Shallow Loess, Uplands	Uplands	Mississippian
15-Cl-58	Outer Bluegrass	Huntington-Nework-Woodmere	Floodplains, Terraces	Bottomlands	Ordovician
15-Hr-115	Mitchell	Wheeling-Elkinsville-Vincennes	Terraces, Bottomlands	Bottomlands	Mississippian
12-Hr-5	Mitchell	Huntington-Nework-Woodmere	Floodplains, Terraces	Bottomlands	Mississippian
15-Jf-10	Outer Bluegrass	Robertsville Silt loam	Unknown	Uplands	Devonian/ Mississippian
15-Jf-217	Outer Bluegrass	Wheeling-Elkinsville-Vincennes	Terraces, Bottomlands	Bottomlands	Mississippian
15-Jf-237	Outer Bluegrass	Lindside silt loam	Unknown	Bottomlands	Mississippian
15-Jf-267	Outer Bluegrass	Captina silt loam	Unknown	Uplands	Devonian
15-Jf-36	Outer Bluegrass	Zanesville Silt Loam	Uplands/toe slope	Uplands	Mississippian
15-Jf-60	Mitchell	Huntington-Nework-Woodmere	Floodplains, Terraces	Bottomlands	Mississippian
15-Jf-92	Outer Bluegrass	Wheeling-Elkinsville-Vincennes	Terraces, Bottomlands	Bottomlands	Silurian

Not surprisingly, 90 percent (n=26) of the SMA sites are found in floodplain or lowland contexts. All of the sites are located in the Ohio River watershed, except for one site located in the northern portion of the study area on the White River (Figure 8.1). The vast majority (72 percent, n=21) of the sites in the Falls region are located on a floodplain

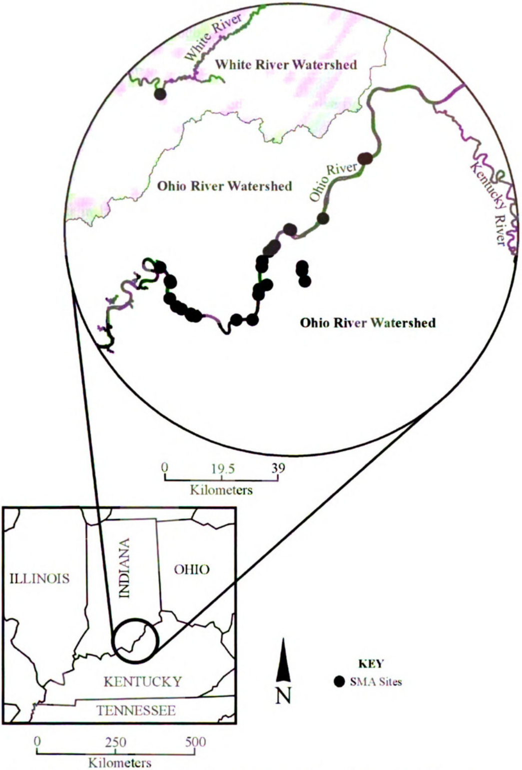


Figure 8.1. Location of SMA sites with respect to the Ohio and Salt River watersheds.

immediately adjacent to the Ohio or White Rivers. Soil types also support a preference for site placement on a floodbasin. Nearly 76 percent (n=22) of sites are located on Huntington-Newark-Woodmere or Wheeling-Elkinsville-Vincennes soil associations. Huntington soils are poorly developed soils on active floodplains and Wheeling soils are typical of terrace landforms (Robbins 1975).

Three sites, Lone Hill (15-Jf-10), Minors Lane (15-Jf-36), and KYANG 15-Jf-267), occur in land, away from the Ohio River. These sites are located in an area of Jefferson County, Kentucky, called the "Wet Woods". Three other sites (12-Ws-30, 12-Cl-78, and 12-Hr-13) are on a bluff overlooking the Ohio and White Rivers, rather than a floodplain landform. Clearly, the six sites situated away from the river or overlooking the river, must have required greater energy to carry mussel shells to these locales.

SMA sites in the study region tend to cluster in two different physiographic zones, Muscatatuck Plateau and Mitchell Plain (Figure 8.2). These two physiographic provinces are probably the richest and most diverse out of the seven provinces that comprise the study region (cf. Gray 2000). A little over a quarter (n=8) of the sites are located in the Muscatatuck (also called Outer Bluegrass) zone. This physiographic zone is in the glacial landscape and covers most of Jefferson County, Kentucky and the northeastern portion of Clark County, Indiana. Plant communities in the Muscatatuck varied considerably. Mesophytic forest, which included several nut-bearing species such as black walnut, red oak, and shagbark hickory, were found in the ravines and stream valleys. Pockets of wetlands could be found in the uplands due to a perched water table or springs. In Indiana, the Muscatatuck offers outcrops of Laurel and Jeffersonville chert (see Figure 8.2). Muldraugh chert can be found in outcrops along the western edge of the

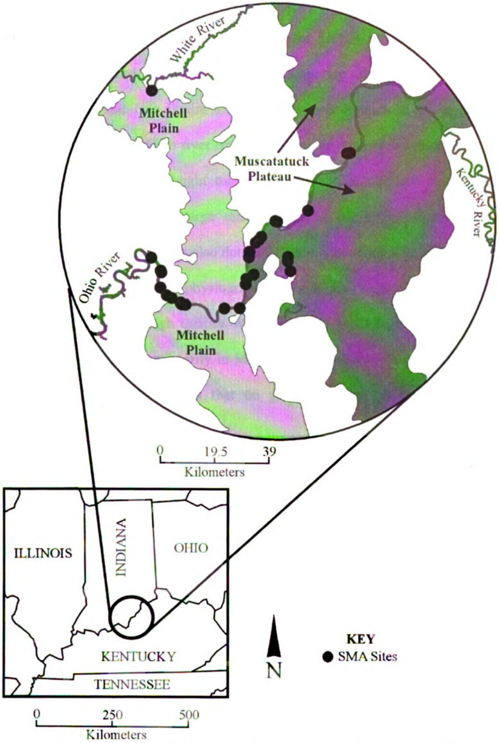


Figure 8.2. Location of SMA sites with respect to the Muscatatuck Plateau and Mitchell Plain physiographic zones.

Muscatatuck/Outer Bluegrass region of Kentucky. All of these features would have made this physiographic zone a desirable area for Archaic settlement.

Over a third (n=10) of the SMA sites are clustered in the Mitchell Plain physiographic zone (see Figure 8.2). This zone is located in the un-glaciated karstic portion of the region, down river from the Falls. Vegetation in this region is a mosaic of grassland, shrubs, and drought tolerant trees, such as hickory and black, white, or chestnut oak. Small and large mammals prefer the edge-habitats in these mosaic landscapes. Wetland settings also dotted the landscape at karst springs and sinkholes. In addition, the Mitchell Plain physiographic zone is also located in proximity to bedrock outcrops that contain high quality Wyandotte and Muldraugh cherts (see Figure 8.2). These cherts are found primarily in Mississippian bedrock. An examination of bedrock and SMA sites, demonstrates that 66 percent (n=19) of the sites are located on Mississippian bedrock.

To examine association between SMA sites and physiographic province, I conducted a Chi-square goodness of fit test[1] for the following hypotheses:

H_1 = Physiography has an influence on site placement.
Ho = Physiography has no influence on site placement.

The null hypothesis states that sites are equally likely to occur in all physiographic zones. Chi-square value for physiography is 5.31, with 4 degrees of freedom, this value is not significant at the 0.05 probability level. Therefore, the null cannot be rejected for physiography.

[1] The equation for the Chi Square one sample statistic is: $\mathbf{X^2 = Sum ((O - E)^\wedge 2 /E)}$, where **O** is observed data and **E** is the expected values.

Because sites appear to cluster in physiographic zones that also contain chert resources that are found within bedrock of specific ages, I also conducted a Chi-square goodness of fit for bedrock geology type.

H_1 = Bedrock geology has an influence on site placement.
Ho = Bedrock geology has no influence on site placement.

In the case of bedrock geology, the Chi-square value is 39.10, with 4 degrees of freedom. This Chi-square value is significant at greater than the 0.005 probability level and the null can be rejected. This means that bedrock geology has some influence on site placement. It is possible that this is due to the high quality cherts, such as Wyandotte and Muldraugh, which outcrop in Mississippian aged bedrock.

Due to the unexpected results of the Chi square for SMA sites and physiographic zone, I looked for another method to reexamine the data. An alternative Chi-square test described by Hodder and Orton (1979) allows associations between sites and the *area* of environmental variables such as soil type, vegetation type, physiography, and geology. Hodder and Orton state that "if a particular land type has a certain percentage of land area, under the null hypothesis we would expect it to have the same percentage of sites" (1979:225). Given the spatial approach to this modified version of Chi-square, I decided to re-examine physiography and bedrock geology in this methodology[2].

Using the Hodder and Orton test, the null hypothesis for physiography (Ho=Physiography has no influence on site placement) is rejected. The Chi-square value is 190.03, which is significant at greater than the 0.005 probability level. The Hodder and Orton method suggests that physiography is a significant factor in site placement,

[2] The Chi square method described by Hodder and Orton (1979:224-225) uses the same basic equation as the Chi square goodness of fit, but uses the percentage of the total area covered by land type to calculate expected values. The expected values are calculated with the following equation: $r = N(a/A)$, where N is the number of sites, A is the total land area, and a is the land area for each type.

unlike the standard goodness of fit Chi-square. Given the fact that the Hodder and Orton method determines expected values weighted by land type area, I feel that this method is more accurate. A standard Chi-square test assumes that expected values are the same in each land type, regardless of its size or area. I also conducted the Hodder and Orton test with bedrock geology. The null hypothesis for bedrock geology (Bedrock geology has no influence on site placement) was rejected. The Chi-square value was 111.56, which is significant at greater than the 0.005 probability level.

Nearly two-thirds of the SMA sites are located in the driftless or karst portion of the Falls region (Figure 8.3). The karst area of the study region lies west and down river from the Falls. The Ohio River channel narrows in this area and the floodbasins tend to be smaller than their glaciated counterparts. Geoarchaeological research in the region suggests that floodbasins downriver from the Falls may have had different geomorphic histories from upriver floodbasins (cf. Boulding 1993; Stafford 1995). In particular, the Ohio River channel appears to have been more stable during the Holocene and vertical accretion was the dominant process, rather than lateral migration of the river channel (Boulding 1993). It is possible that sites are preferentially located in the karst portion of the valley because the floodplain landforms were less likely to be inundated. Alternatively, modern erosion of the floodplain ridge is exaggerated downriver from the Falls due to the High-Lift Navigational Locks and Dams at the Falls. Consequently, SMA sites may simply be more visible in this portion of the valley because they have been exposed by erosion.

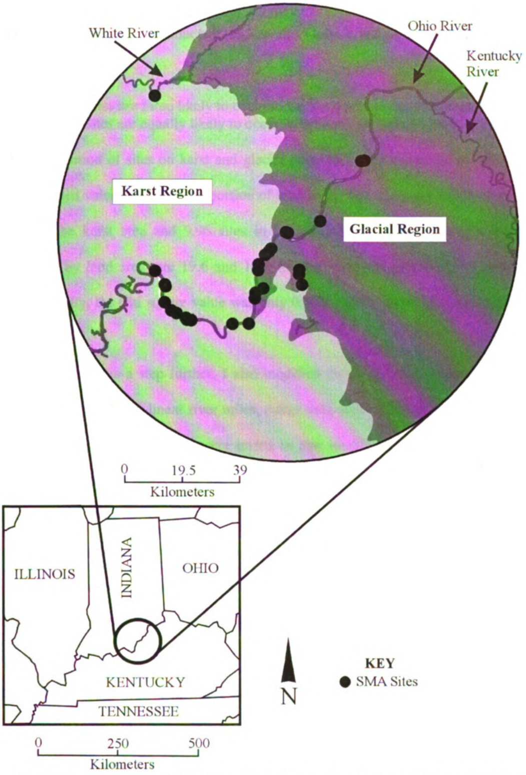


Figure 8.3. Location of SMA sites with respect to the glacial and karst portions of the project area.

To explore whether or not the distribution of sites in the karst region of the study area was significant, I conducted Hodder and Orton's weighted Chi-square test. The hypotheses are:

H_1 = Sites are more likely to occur in the karst area of the Falls region.
Ho = Sites are equally likely to occur in the karst and glacial areas of the region.

The distribution of sites on karst and glacial portions of the region almost perfectly fits the expected values based on proportion of land area. The observed distribution is 19.03 sites in the karst area and 9.96 sites in the glacial area. The expected site values, weighted by land area, are 19.6 and 10.3 for the karst and glacial areas, respectively. Consequently, the Chi square value was only 0.165 and the null hypothesis could not be rejected.

Taking this a step further, I also modified the Hodder and Orton area-weighted Chi square to consider linear river miles, rather than area. The same hypotheses used in the area-weighted Chi square were tested in this manner. I tried this additional Chi square test, because SMA sites are obviously more likely to occur along the river than another portion of the study region. Approximately 55 percent of the riverfront in the project area is in the karst sub-region and 45 percent is in the glacial sub-region. The observed and expected values did not differ very much and the resulting Chi square value was only 0.919, which is not significant. Therefore, the null could not be rejected in this test either.

The results of the Chi-square test for glacial versus karst portions of the study area are quite unexpected because the division between the glacial and karst regions appears visually pronounced (see Figure 8.3). Since the differences in distribution of SMA sites between the eastern and western portion of the study area cannot be explained by whether or not it was glaciated alternative explanations must be considered. Both physiographic zone and bedrock geology are significant factors in site placement, based on the above Chi-square tests. It is possible that the observed differences between east and west have more to do with differences in the *structure of resources*, than the actual distribution of SMA sites. Four physiographic regions intersect within the western portion of the study area, increasing access to varied plant, animal, and lithic resources in the western portion of the project area.

LINEAR DISTANCES

The second aspect of the research was to explore the question *what is the linear relationship of SMA sites with other features of the landscape*? As Kelly points out, "if we were to track an individual's movements, we would find that the majority of the time he or she spent moving was...in logistic forays to hunt or to gather plant food" (1995:130). Therefore, the goal of this portion of the research was to examine patterns of interaction and resource extraction from SMA sites. Linear movement was investigated through a combination of catchment analysis and linear distance measurements from SMA sites to features on the landscape. Linear distance relationships were examined between SMA sites and variables such as karst springs, tributary streams, and other SMA sites (Table 8.2). Variables including physiographic zones, bedrock outcrops and geology, karst springs, and other SMA sites, were examined for the site-catchment analysis at radii of 1 km (Table 8.3), 5 km (Table 8.4), and 25 km.

Table 8.2. Linear Distances between SMA Sites and Features on the Landscape					
Site No.	**Distance to Spring Feature (m)**	**Distance to Tributary (m)**	**Tributary Name**	**Distance to nearest SMA Site (m)**	**Nearest SMA Site**
12-Cl-1	8422	316	Mill Creek	728	12-Cl-3
12-Cl-10	5824	360	Camp Creek	728	12-Cl-1
12-Cl-3	7752	412	Mill Creek	1118	12-Cl-78
12-Cl-78	5433	800	Camp Creek	1118	12-Cl-10
12-Fl-1	10408	1004	French Creek	1562	12-Fl-46
12-Fl-13	10210	2282	French Creek	1421	12-Fl-46
12-Fl-46	11007	921	French Creek	1421	12-Fl-13
12-Fl-73	6363	1788	Knob Creek	2102	15-Jf-237
12-Hr-103	4084	2655	Mosquito Creek	5700	15-Jf-60
12-Hr-11	2505	1334	Indian Creek	671	12-Hr-12
12-Hr-113	6744	400	unnammed	2022	12-Fl-13
12-Hr-115	5008	1118	unnammed	2022	15-Jf-237
12-Hr-12	1835	848	Indian Creek	671	12-Hr-11
12-Hr-13	1166	223	Potato Run	5800	12-Hr-11
12-Hr-3	412	1923	Buck Creek	1513	12-Hr-4
12-Hr-36	2435	400	Buck Creek	224	12-Hr-5
12-Hr-4	1923	412	Buck Creek	640	12-Hr-36
12-Hr-5	2416	608	Buck Creek	224	12-Hr-36
12-Hr-6	1746	4604	Lick Creek	1923	12-Hr-96
12-Hr-9	300	3337	unnammed	3687	12-Hr-6
12-Hr-96	1526	2701	Lick Creek	1923	12-Hr-6
12-Ws-30	3201	990	Clifty Creek	61100	12-Hr-13
15-Jf-10	1900	n/a	n/a	1500	15-Jf-267
15-Jf-217	5608	183	Mill Creek	3176	12-Hr-115
15-Jf-237	4669	1646	Mill Creek	2102	12-Fl-73
15-Jf-267	400	n/a	n/a	1500	15-Jf-10
15-Jf-36	5805	n/a	n/a	3832	15-Jf-10
15-Jf-60	5700	262	Salt River	5700	12-Hr-103
15-Jf-92	5333	1022	Harrods Creek	12150	12-Cl-3
MEAN	**4781.8**	**1664.8**		**7077.8**	

Table 8.3. Counts of Features within 1 km Site-Catchments				
	1 KM			
Site #	Physiography	Bedrock Geology	Karst Springs	SMA Sites
12-Cl-10	1	2	0	0
12-Cl-78	1	2	0	0
15-Jf-92	1	1	0	0
12-Cl-3	2	2	0	1
12-Cl-1	2	2	0	1
12-Fl-13	1	1	0	0
12-Fl-46	1	1	0	0
12-Fl-1	1	2	0	0
12-Fl-73	2	1	0	0
15-Jf-237	2	1	0	0
12-Hr-115	2	1	0	0
15-Jf-217	1	1	0	0
12-Hr-113	2	1	0	0
15-Jf-60	2	1	0	0
2-Hr-103	1	1	0	0
12-Hr-3	1	1	1	0
12-Hr-4	1	1	0	2
12-Hr-5	1	1	0	2
12-Hr-36	1	1	0	2
12-Hr-96	2	1	0	0
12-Hr-6	1	1	0	0
12-Hr-9	2	1	0	0
12-Hr-12	1	1	0	1
12-Hr-11	1	1	0	1
12-Hr-13	1	1	0	0
15-Jf-10	1	1	0	0
15-Jf-267	1	1	1	0
15-Jf-36	2	1	0	0
12-Ws-30	2	1	0	0
TOTAL	**40**	**34**	**2**	**10**
Mean	**1.37**	**1.172**	**0.069**	**0.345**
Mode	**1**	**1**	**0**	**0**

Table 8.4. Counts of Features within 5 km Site-Catchments				
	5 KM			
Site No.	Physiography	Bedrock Geology	Karst Springs	SMA Sites
12-Cl-1	3	4	0	2
12-Cl-10	2	3	0	0
12-Cl-3	2	4	0	2
12-Cl-78	2	3	0	0
12-Fl-1	4	2	0	3
12-Fl-13	3	2	0	2
12-Fl-46	3	2	0	2
12-Fl-73	4	2	0	2
12-Hr-11	1	1	8	2
12-Hr-113	3	1	0	2
12-Hr-115	3	1	0	1
12-Hr-12	1	1	8	2
12-Hr-13	1	1	8	0
12-Hr-3	2	1	7	3
12-Hr-36	2	1	8	6
12-Hr-4	2	1	7	6
12-Hr-5	2	1	8	6
12-Hr-6	2	1	7	3
12-Hr-9	2	1	4	4
12-Hr-96	2	1	4	4
12-Ws-30	2	1	6	0
15-Jf-10	2	3	1	2
15-Jf-217	3	2	0	2
15-Jf-237	4	2	1	1
15-Jf-267	2	3	1	2
15-Jf-36	2	3	0	1
15-Jf-60	3	1	0	0
15-Jf-92	2	3	0	0
2-Hr-103	2	1	3	0
TOTAL	**68**	**53**	**81**	**60**
Mean	**2.34**	**1.82**	**2.79**	**2.06**
Mode	**2**	**1**	**0**	**2**

1 km

to the

Appro

physi

two s

radiu

varie

landi

Whi

river

land

km

maj

zona

acce

to th

Far

of

phy

Pro

SM

1 km and 5 km Site-Catchments

The diversity of resources in the 1 km buffer is relatively limited, when compared to the 5 and 25 km catchments, but still contains a wide range of resources for some sites. Approximately 38 percent (n=11) of the SMA sites had access to more than one physiographic zone. Six SMA sites (20 percent) were within 1 km of each other. Only two sites had access to a spring feature within the 1 km catchment. The 1 km catchment radius appears to primarily summarize the local site conditions and does not include a variety of landscape zones or features. Rather, the 1 km catchment includes access to the landform on which the SMA sites are located. The 1 km buffer also includes Ohio or White Rivers for 90 percent (n=26) of SMA sites, which indicates a need for access to riverine resources.

At the 5 km foraging radius, it appears that SMA sites are situated in the landscape to take advantage of a wide range of resources. Kelly (1995) proposes that a 5 km daily foraging radius is common for hunter-gatherers in temperate forests. The majority (90 percent, n=26) of the SMA sites have access to multiple physiographic zones within a 5 km buffer of the site. Over one third of the SMA sites (n=9) have access to 3 or more physiographic zones within a 5 km catchment area. Sites with access to the greatest diversity of physiographic zones, such as Reid (12-Fl-1) and Arrowhead Farm (15-Jf-237), are located immediately downriver from the Falls, near the intersection of the Charlestown Hills, Outer Bluegrass, Norman Upland, and Mitchell Plain physiographic zones (Figure 8.4). Sites with access to the fewest physiographic provinces (12-Hr-11, 12-Hr-12, and 12-Hr-13) are located in the western edge of the SMA site distribution.

As discussed in Chapter 4, physiographic zones in the Falls region can be thought of as slightly different habitats that offer a variety of different food resources. Numerous small mammal species would have been present in these environments. The positioning of shell mound sites within the daily foraging distance of multiple physiographic zones, suggests that Archaic peoples were maximizing their access to the resource potential of the Falls region. This result supports the interpretation of SMA sites as seasonally occupied residential camps, at minimum. SMA sites may have been occupied longer term.

While SMA sites were expected to be near the Ohio or White Rivers, it was unexpected that they would also occur near tributary streams (Figure 8.4). All but 3 SMA sites (90 percent, n=26) are located within 5 km of a tributary stream and 45 percent (n=13) are located within 1 km of a tributary. Most sites are also in very close proximity to a tributary stream of the Ohio or White Rivers, with an average distance of only 1.7 km (see Table 8.2). The confluence of streams with the Ohio River may have produced shoal habitats for shellfish (Morey and Crothers 1998), as well as nutrient rich waters that attracted fish spawning. Alternatively, these streambeds may have provided access to the uplands, as a natural incision into the rugged upland. Therefore, site placement near a tributary could have been a strategy to aid travel between lowland and upland contexts, an issue that will be explored further in the cost-distance portion of this research. Three sites (Lone Hill (15-Jf-10), Minors Lane (15-Jf-36), and KYANG (15-Jf-267)) are located more than 5 km from a tributary stream. The reason that these three sites are not near a stream or river becomes clear upon examining their relationship with karst springs.

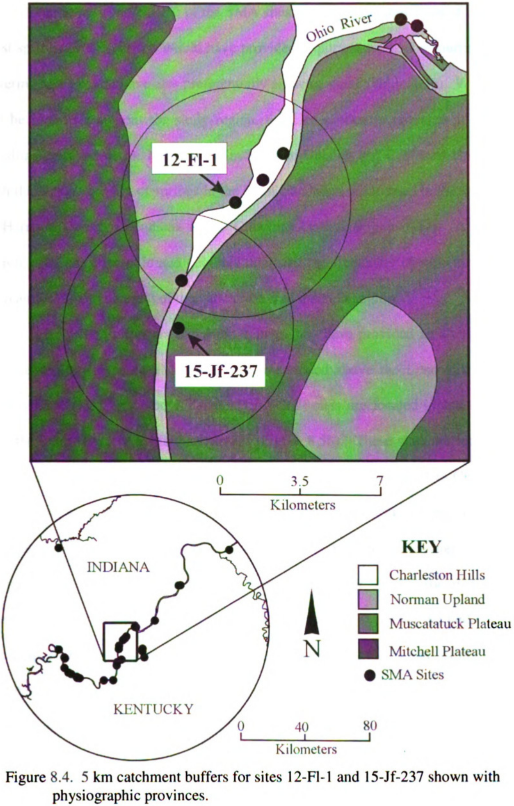


Figure 8.4. 5 km catchment buffers for sites 12-Fl-1 and 15-Jf-237 shown with physiographic provinces.

A little over half (n=15) of the SMA sites are located within 5 km of one or more karst springs. Karst springs would have provided important wetland resources and these watering holes would have also preferentially attracted game (Gray 2000). While springs can be found throughout the study region, they are especially prevalent in the karstic physiographic provinces: Mitchell Plain, Norman Upland, and Crawford Upland. Sites with the highest density of springs in the 5 km catchment are located in the western edge of Harrison County in Indiana in the Crawford Upland (Figure 8.5a). Although this region lacks physiographic and geologic diversity, the frequency of springs would have been an asset for settlement of the karst portion of the Falls region.

In addition, it appears that karst springs may have provided an alternative, non-riverine setting for some SMA sites. As mentioned above the Lone Hill (15-Jf-10), Minors Lane (15-Jf-36), and KYANG (15-Jf-267) sites are located inland and are not near the Ohio River or a tributary stream (Figure 8.5b). These sites are located in the "Wet Woods" region of Jefferson County in Kentucky. As described in Chapter 6, the Wet Woods was an extensive area of wetlands with karst springs, rather than flowing streams. For the three SMA sites located in the Wet Woods, the average distance to a spring is only 2.7 km, compared to the mean distance of 4.8 km for all SMA sites. Interestingly, all three of these sites have cultural deposits that span the Old Clarksville and Lone Hill phases of the Middle and Late Archaic periods (as well as the Early and Middle Woodland periods). Evidently, the resources at these wetland spring environments were rich enough for SMA peoples to repeatedly use these locales for many generations.

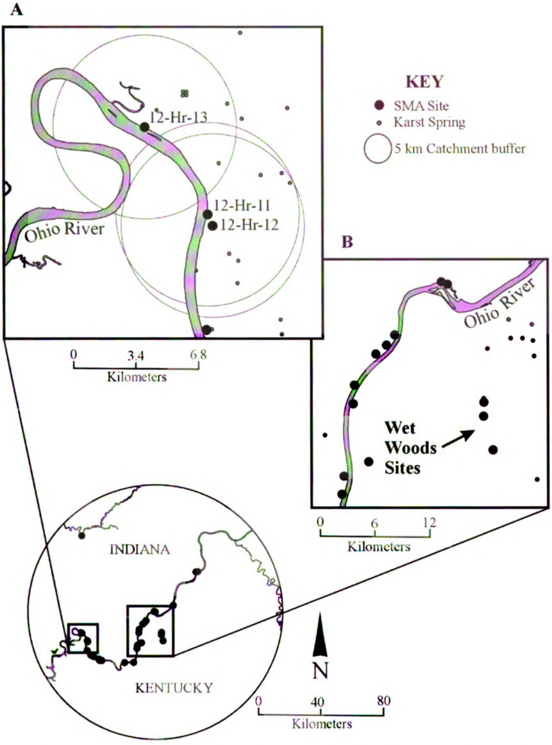


Figure 8.5. A) Close-up of 12-Hr-11, 12, and 13 in relationship to karst springs. B) Close-up of Wet Woods sites (15-Jf-10, 15-Jf-36, 15-Jf-267) in relationship to karst springs.

bedro

depos

1994

bedro

not p

preva

deep

acqui

bedr

bedr

may

for b

man

SM

in T

The

for

loc

do

the

At the 5 km foraging radius, 45 percent (n=13) of SMA sites have access to bedrock of different ages. Various chert types are available in the different bedrock deposits. Wyandotte and Muldraugh cherts are found in Mississippian bedrock (Cantin 1994). Allen's Creek chert occurs in Devonian bedrock. Ordovician and Silurian bedrock contain Laurel and Jeffersonville cherts, respectively (Cantin 1994). Bedrock is not present at the surface in all areas and neither are chert deposits. Outcrops are prevalent in the western karstic landscape, where the solum is thin. Glacial deposits deeply bury bedrock in the eastern portion of the project area. Surface geology was acquired for Indiana, but not available for Kentucky. Using this data, the proximity of bedrock outcrops to SMA sites was examined for Indiana only. The average distance to bedrock outcrops from SMA sites is 4.7 km for the Indiana data. These outcrops may or may not have contained chert deposits, but they suggest that SMA peoples had an affinity for bedrock outcrops. Chert resources were essential for hunting, food processing, and many daily activities in Archaic lifeways.

The last variable examined in terms of linear distance is the distance between SMA sites. The distance to each nearest neighboring SMA site in the study area is listed in Table 8.2. SMA sites are as little as 0.22 km and as much as 61.1 km from each other. The average distance to the nearest SMA site is 9.7 km, which is nearly double the 5 km foraging radius. The mean site distance is slightly skewed by site 12-Ws-30, which is located on the outskirts of the project area and is more than 61 km from another documented SMA site. Omitting this site from the mean distance calculations reduces the mean distance between SMA sites to only 2.9 km. Seventy-six percent (n=22) of

SMA sites have at least one other SMA site within the 5 km buffer radius. Of these sites, 86 percent (n=19) have multiple SMA sites within 5 km.

The close proximity of SMA sites to each other is rather surprising because a foraging-radius model (Kelly 1995) proposes that there is a direct relationship between the distance of residential camp moves and the length of occupation at each residential camp. This pattern is related to the manner in which resources become increasingly scarce immediately surrounding a residential locale over time. Eventually, the amount of energy required to forage for food and resources from a residential camp becomes greater than the amount of calories acquired from foraging (Kelly 1995). Therefore, one might expect a greater distance is between SMA sites if they represent residential camps.

Kernel Density Estimation and Cluster Analysis

In order to examine the spacing and density of SMA sites, I conducted kernel density estimation (KDE). As mentioned in Chapter 7, KDE is an exploratory technique where various bandwidths can be used on the data to examine the degree of smoothing to isolate "hot spots" within a distribution (Bailey and Gatrell 1995). I conducted KDE in two different ways 1) a linear analysis of sites along the Ohio River and 2) a regional analysis of all sites in the study area.

For the linear KDE of sites along the Ohio River, I examined bandwidths of 4 miles (6.437 km), 6 miles (9.656 km), and 12 miles (19.312 km). The frequency tables for each bandwidth are shown in Table 8.5. These frequencies were plotted in graphs to view the degree of smoothing and to assess the density of sites at different scales. Figure 8.6 compares each bandwidth. Three clusters or "hot spots" of SMA sites appear at the

Table 8.5. Frequency Table for Linear Kernel Density Analysis of SMA Sites Along the Ohio River

4 Mile Bandwidth		6 Mile Bandwidth		12 Mile Bandwidth	
River Mile	Frequency	River Mile	Frequency	River Mile	Frequency
662-659	1	662-655	1	662-649	1
658	2	656	2	650	5
654	0	650	3	638	4
650	2	644	4	626	2
646	5	638	0	614	6
642	0	632	1	602	4
638	0	626	1	590	1
634	0	620	3	578	2
630	1	614	3		
626	1	608	2		
622	3	602	2		
618	2	596	1		
614	3	590	0		
610	2	584	0		
606	2	578	2		
602	0				
598	1				
594	0				
590	0				
586	0				
582	0				
578	2				

12 mile (19.312 km) bandwidth interval. Two of the clusters contain a large number of sites, while the third cluster is quite small. The division between the largest two clusters occur just west of the Hoke site (12-Hr-103), which lies approximately 27 river miles downriver from the Falls near river mile 630 (see Figure 8.6). All the sites downriver from river mile 630 form one cluster and the sites upriver form a second cluster. The third cluster occurs at the eastern edge of Clark County, with two sites in the Bethlehem

Bottom near river mile 578. This smaller cluster is approximately 36 river miles upriver from the center of the next closest cluster. The western cluster is approximately 40 river miles from the center of the downriver cluster.

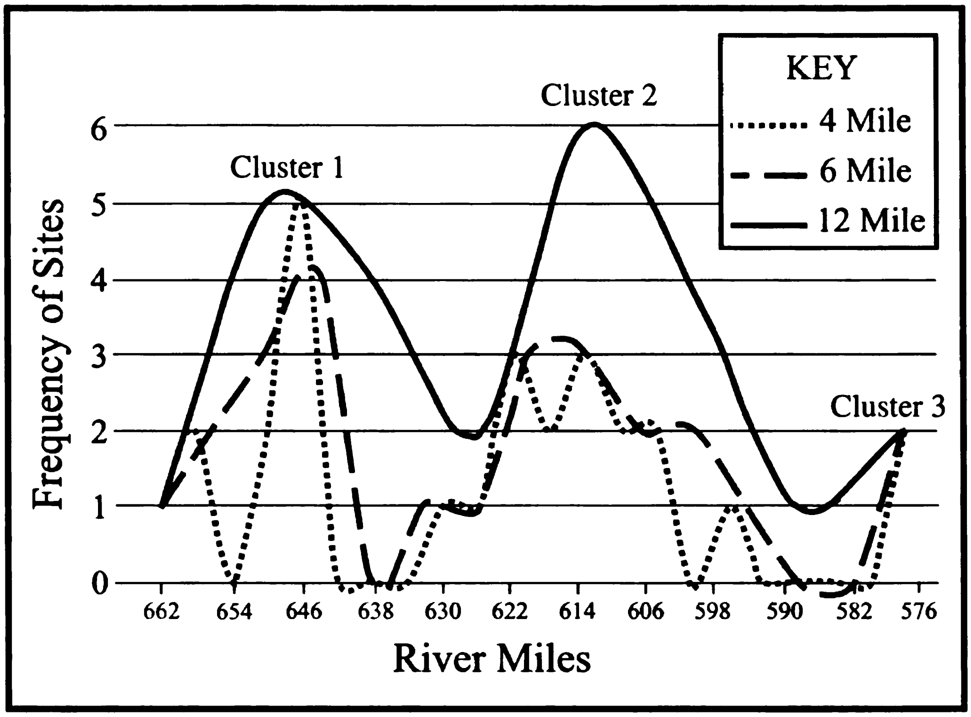


Figure 8.6. KDE frequency charts at intervals of 4, 6, and 12 miles.

The KDE clusters can also be visually observed in GIS using the *Density* function in the *Spatial Analyst* Toolbar. The resulting output layers visually display the density of SMA sites throughout the study area (Figure 8.7). Darker shading indicates a higher density of sites, while the lighter shade indicates a low density. Clusters are not clearly visible at the 4 mile (6.437 km) bandwidth, but are very distinct at the 12 mile (19.312 km) bandwidth (see Figure 8.7), much like the KDE of sites along the Ohio River. The two larger clusters are present in the western and central portion of the valley. The central cluster encompasses the three SMA sites in the Wet Woods

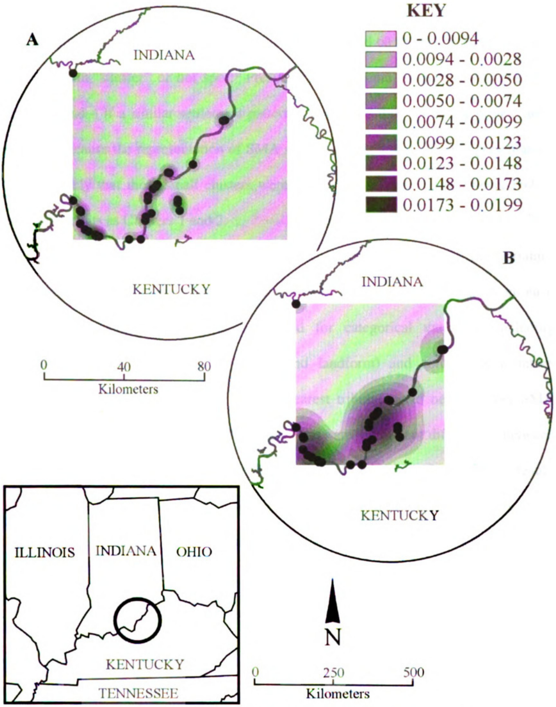


Figure 8.7. KDE results for A) 4 mile bandwidth and B) 12 mile bandwidth.

region of Jefferson County, Kentucky (see Figure 8.7). Further upriver, one small cluster occurs in Clark County, Indiana. The lone site documented on the White River (12-Ws-30) is a fourth "cluster" or hot spot. Presumably, additional SMA sites occur within Clusters 3 and 4 if a similar settlement pattern was utilized throughout the project area. However, because the representation of SMA sites is assumed to be fairly representative, it is also likely that these small clusters were not as heavily utilized and never had as many settlements as Clusters 1 and 2.

Once site clusters were delineated, it was possible to compare the variables between clusters to examine what conditions may set Clusters 1 and 2 apart from each other. A one-way ANOVA was conducted for categorical variables (including physiography, bedrock geology, soil type, and landform) and continuous variables (including linear distance to nearest spring, nearest tributary, and nearest other SMA site). The results of the ANOVA indicate that there are significant differences between the site clusters for spring distance, physiography, and bedrock geology. These result, shown in Table 8.6, seem consistent with the differences observed between sites at the local-level and in the 5 km catchment areas. Because of differences in the nature of physiography, geology, and springs between the eastern and western portions of the project area, it makes sense that these variables would be different between the two clusters. The fact that the difference in landscape structure coincides with the division of the two primary site clusters is significant because it suggests that there is a relationship between Archaic land use patterns and the configuration of the landscape.

Table 8.6. ANOVA by Site Clusters

		Sum of Squares	df	Mean Square	F	Sig.
Spring Distance	Between Groups	1.30E+08	1	1.30E+08	23.53	**0.00**
	Within Groups	1.32E+08	24	5503829.7		
	Total	2.62E+08	25			
Tributary Distance	Between Groups	4741200.39	1	4741200.4	3.726	0.065
	Within Groups	3.05E+07	24	1272528.3		
	Total	3.53E+07	25			
Site Distance	Between Groups	1.00E+07	1	1.00E+07	1.589	0.22
	Within Groups	1.51E+08	24	6303871.9		
	Total	1.61E+08	25			
Physiography	Between Groups	31.154	1	31.154	31.82	**0.00**
	Within Groups	23.5	24	0.979		
	Total	54.654	25			
Bedrock Geology	Between Groups	6.154	1	6.154	4.615	0.042
	Within Groups	32	24	1.333		
	Total	38.154	25			
Soil Type	Between Groups	0.278	1	0.278	0.074	0.788
	Within Groups	90.338	24	3.764		
	Total	90.615	25			
Landform	Between Groups	2.124	1	2.124	1.384	0.251
	Within Groups	36.838	24	1.535		
	Total	38.962	25			

statis

used

stron

plot

The

mod

F

To explore the nature and scale of the site clusters further, I conducted two spatial statistical tests: Khat and Lhat-h. Scripts available for the statistical package R, were used to conduct Khat for the SMA sites in the study area. The results of the Khat test strongly indicates that sites in the Falls region are clustered. Figure 8.8 shows the Khat plot of SMA sites compared to the expected plot for complete spatial randomness (CSR). The Khat for the Falls SMA site data is substantially greater than that for the CSR model, which indicates that the data are indeed clustered.

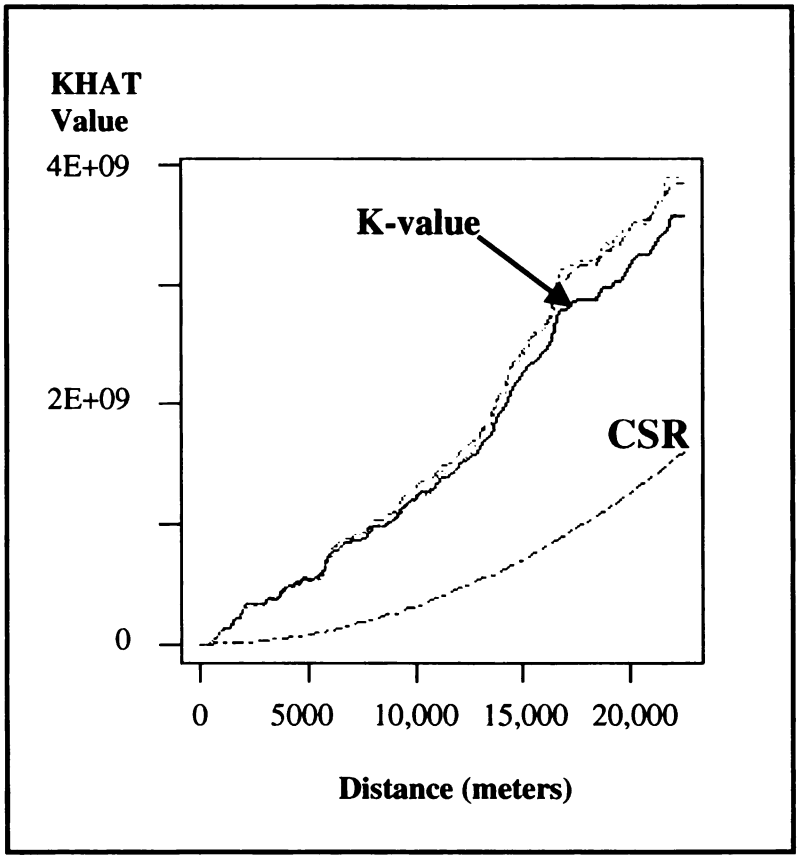


Figure 8.8. Khat plot of SMA sites in the Falls region. Distance shown in meters. Note the difference between the CSR model and the SMA site patterning.

Lhat-h was conducted using script in the spatial statistical program R. The Lhat-h test produced a similar result to Khat, but indicates the distances at which clustering occurs (Figure 8.9). Sites appear to cluster at three scales, at approximately 2.5 km, 7 km, and 17.5 km apart. At the 2.5 km cluster distance are the multiple SMA sites established in the same floodbasin, which was repeatedly used over several generations. These small clusters suggest that some locales were so important that several settlements were established through time in the same general area. The 7 km cluster distance may include groupings of sites on several floodbasins. These clusters may have developed with residential moves during seasonal rounds. Because many freshwater mollusk species take between 6 and 12 years to reach reproductive maturity (Thorp and Covich 1991), it is possible that communities varied the location of their summer camps up or down river, in order to allow shellfish populations to replenish at particular locales. Incidentally, the 7 km cluster distance is nearly the same as the 4 mile cluster distance used in the KDE analysis. The 17.5 km cluster distance could represent the annual range of a corporate group (Binford 1981; Vita-Finzi and Higgs 1970). This cluster distance is roughly equivalent to the clusters identified at the 12 mile (19.312 km) bandwidth, because a bandwidth of 17.5 km also produces two main clusters that are separated at the Hoke site (12-Hr-103) (see Figure 8.7).

Temporal data can help to clarify the nature of these various cluster scales. Few of the Falls SMA sites are securely dated; however, 24 sites can be assigned to a cultural phase based on 1) formal lithic tool typologies or 2) radiocarbon dates. Table 8.7 is a list of SMA sites organized by the 12 mile (19.312 km) kernel clusters. Clusters 1 and 2 are the

respo

the largest and located in the western and central portions of the project area, respectively. Cluster 3 is composed of two sites on the eastern edge of the project area.

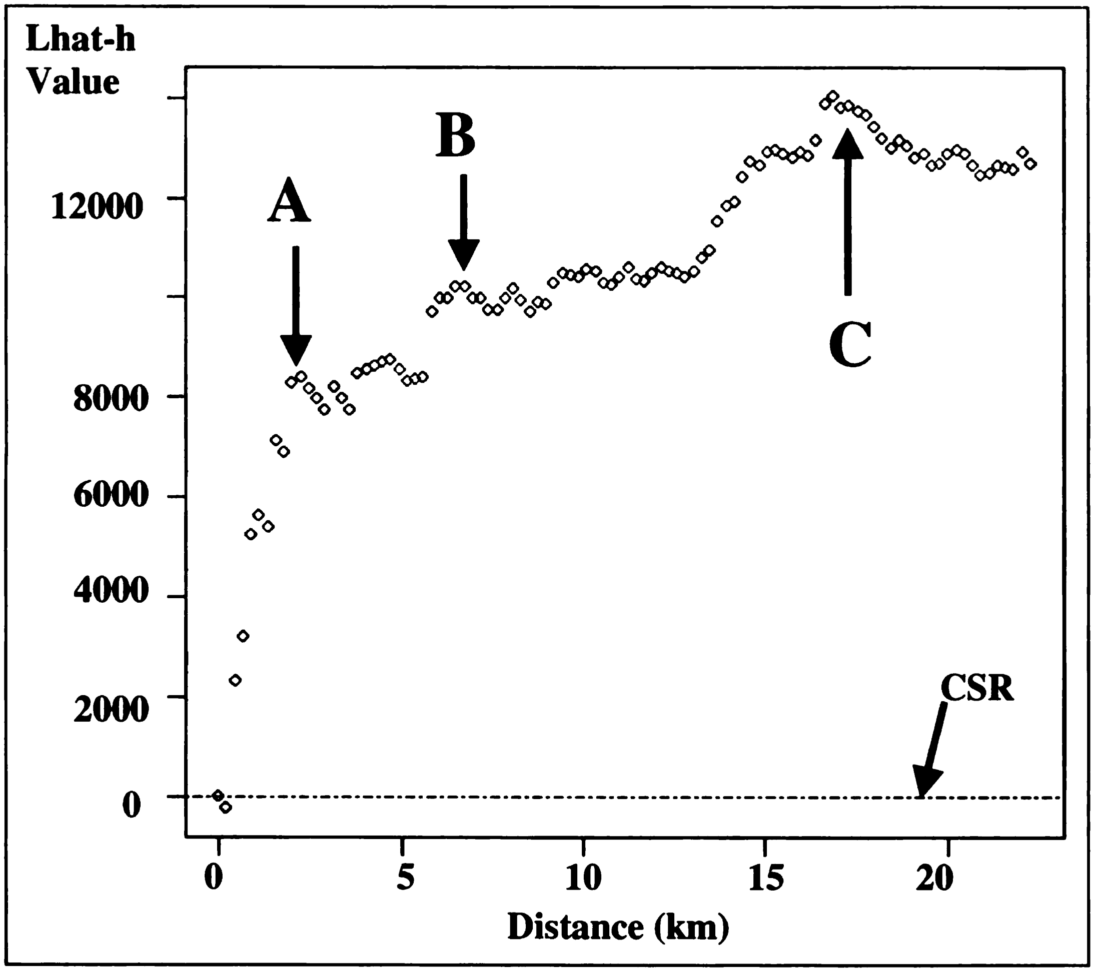


Figure 8.9. Lhat-h plot of SMA sites in the Falls region. Distance shown in meters. Note spikes at A) 2.5 km, B) 7 km, and C) 17.5 km, indicating the presence of clusters at these distances.

Both the large clusters have at least one single-component Old Clarksville phase site and single-component Lone Hill phase site. Several multi-component sites, with both Old Clarksville and Lone Hill Phase deposits, are found in Clusters 1 and 2. The two sites in Cluster 3 have both Old Clarksville and Lone Hill phase deposits. Because sites from each SMA phase can be found in the clusters, it appears that each of these areas were used by the SMA peoples throughout their occupation of the Falls Region.

Table 8.7. List of sites sorted by 12 mile kernel cluster and cultural phase

Site No.	Kernel Cluster #	Cultural Phase	River Mile
12-Hr-13	1	unknown	662
12-Hr-6	1	unknown	651
12-Hr-96	1	unknown	650
12-Hr-3	1	Old Clarksville	646
12-Hr-4	1	Old Clarksville	647
12-Hr-36	1	Lone Hill	647.5
12-Hr-5	1	Lone Hill	647.5
12-Hr-12	1	Lone Hill	657.3
12-Hr-9	1	Old Clark. & Lone Hill	653.6
12-Hr-11	1	Old Clark. & Lone Hill	657.6
15-Hr-115	2	unknown	622.6
15-Jf-92	2	unknown	596.3
12-Hr-103	2	Old Clarksville	633
12-Hr-113	2	Old Clarksville	624
12-Cl-3	2	Lone Hill	606
12-Fl-73	2	Lone Hill	616.3
15-Jf-217	2	Lone Hill	623
15-Jf-237	2	Lone Hill	617.75
12-Fl-13	2	Old Clark. & Lone Hill	611.8
12-Cl-1	2	Old Clark. & Lone Hill	606.25
12-Fl-1	2	Old Clark. & Lone Hill	614
12-Fl-46	2	Old Clark. & Lone Hill	613
15-Jf-10	2	Old Clark. & Lone Hill	n/a
15-Jf-267	2	Old Clark. & Lone Hill	n/a
15-Jf-36	2	Old Clark. & Lone Hill	n/a
15-Jf-60	2	Old Clark. & Lone Hill	629.75
12-Cl-78	3	Old Clark. & Lone Hill	579
12-Cl-10	3	Old Clark. & Lone Hill	578.5

Table 8.8 shows SMA sites grouped by the 4 mile (6.437 km) clusters. At this scale or bandwidth, there are 13 clusters from west to east along the Ohio River. Most of these clusters have a site that spans both the Old Clarksville and Lone Hill phases, or they have different sites for each phase. In either case, it appears that 77 percent (n=10) of the clusters were utilized the entire duration of SMA occupation of the Falls region.

Table 8.8. List of sites by 4 mile kernel cluster and cultural phase

Site No.	Kernel Cluster #	Cultural Phase	River Mile
12-Hr-13	1	unknown	662
12-Hr-12	2	Lone Hill	657.3
12-Hr-11	2	Old Clark. & Lone Hill	657.6
12-Hr-6	3	unknown	651
12-Hr-9	3	Old Clark. & Lone Hill	653.6
12-Hr-96	4	unknown	650
12-Hr-4	4	Old Clarksville	647
12-Hr-36	4	Lone Hill	647.5
12-Hr-5	4	Lone Hill	647.5
12-Hr-3	5	Old Clarksville	646
12-Hr-103	6	Old Clarksville	633
15-Jf-60	7	Old Clark. & Lone Hill	629.75
15-Hr-115	8	unknown	622.6
12-Hr-113	8	Old Clarksville	624
15-Jf-217	8	Lone Hill	623
12-Fl-73	9	Lone Hill	616.3
15-Jf-237	9	Lone Hill	617.75
12-Fl-13	10	Old Clark. & Lone Hill	611.8
12-Fl-46	10	Old Clark. & Lone Hill	613
12-Fl-1	10	Old Clark. & Lone Hill	614
12-Cl-3	11	Lone Hill	606
12-Cl-1	11	Old Clark. & Lone Hill	606.25
15-Jf-92	12	unknown	596.3
12-Cl-10	13	Old Clark. & Lone Hill	578.5
12-Cl-78	13	Old Clark. & Lone Hill	579

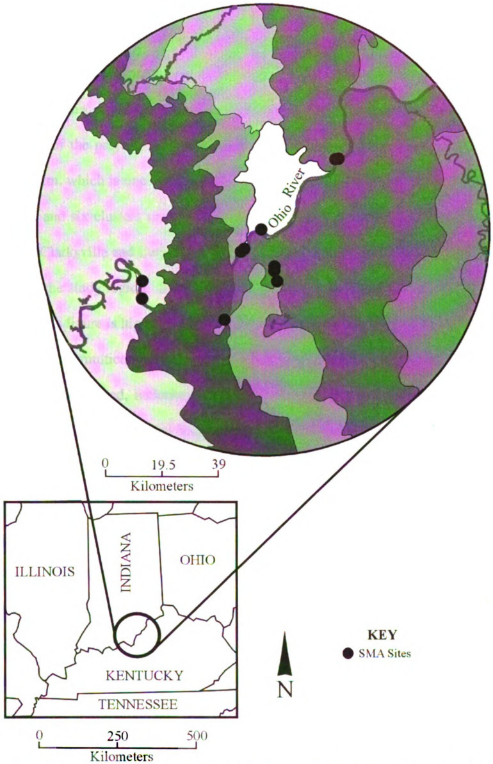


Figure 8.10. Locations of Multicomponent SMA sites shown with physiographic regions.

Looking more specifically at the distribution of identified multicomponent sites in the Falls landscape, it appears that these sites have a strong tendency for the center of the project area (Figure 8.10). I conducted KDE analysis of only multicomponent sites to illustrate these clusters (Figure 8.11). At the at the 12 mile (19.312 km) bandwidth, three site clusters are discernable: a central cluster and two small clusters on eastern and western edges of the project area (see Figures 8.10 and 8.11a). When the bandwidth is reduced to 7 km, which is one of the cluster distances identified with the Lhat-h analysis, between five and six clusters are visible (see Figure 8.11b). Multicomponent sites (that span the Old Clarksville and Lone Hill phases) comprise at least 41 percent (n=12) of the SMA sites in the study region. Since not all of the SMA sites have been excavated, it is possible that this figure is higher.

I compared multicomponent and single-component sites using ANOVA. Several variables were considered, including 1) counts of physiographic zones, geological bed rock units, karst springs, and other SMA sites accessible within the 5 km catchment areas and 2) linear distances to points of interest on the landscape, such as springs, tributary streams, and other SMA sites. Table 8.9 is the ANOVA results for mean counts of physiographic zones, bedrock geology types, karst springs, and other SMA sites accessible in the 5 km catchment zones. Table 8.10 is the ANOVA results for mean linear distances to the nearest karst spring, tributary stream, and other SMA site.

The results of the mean counts ANOVA indicate that there is a significant difference between multi- and single-component sites for bedrock and springs (see Table 8.9). On average, multicomponent sites have access between 2.5 and 3 types of bedrock, while single component sites have access to less than 1.5 types of bedrock.

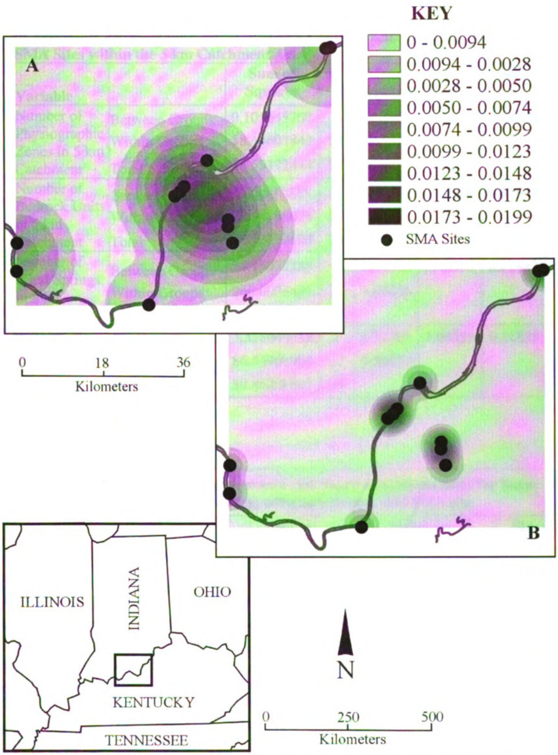


Figure 8.11. KDE results for multicomponent sites at A) 19 km bandwidth and B) 7 km bandwidth

Table 8.9. ANOVA of Multicomponent and Single-component Sites for counts of Accessible Physiography Zones, Bedrock Geology, Karst Springs, and other SMA Sites within the 5 km Catchment Area						
Variable		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Number of Physiographic Zones in 5 km Catchment	Between Groups	0.105645707	1	0.10565	0.15464	0.69723
	Within Groups	18.44607843	27	0.68319		
	Total	18.55172414	28			
Number of Bedrock Units in 5 km Catchment	Between Groups	5.23597025	1	5.23597	6.17289	**0.01947**
	Within Groups	22.90196078	27	0.84822		
	Total	28.13793103	28			
Number of Karst Springs in 5 km Catchment	Between Groups	54.15077755	1	54.1508	5.48398	**0.02682**
	Within Groups	266.6078431	27	9.87436		
	Total	320.7586207	28			
Number of SMA Sites in 5 km Catchment	Between Groups	3.313049358	1	3.31305	1.03355	0.31835
	Within Groups	86.54901961	27	3.20552		
	Total	89.86206897	28			

Table 8.10. ANOVA of Multicomponent and Single-component Sites for linear distances to the nearest karst spring, tributary stream, and SMA site						
Variable		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Distance to nearest karst spring	Between Groups	2.8E+07	1	2.8E+07	3.19277	**0.0852**
	Within Groups	2.4E+08	27	8808103		
	Total	2.7E+08	28			
Distance to nearest tributary stream	Between Groups	72010	1	72010	0.05695	0.81342
	Within Groups	3E+07	24	1264534		
	Total	3E+07	25			
Distance to nearest SMA site	Between Groups	1.2E+08	1	1.2E+08	0.97144	0.33307
	Within Groups	3.4E+09	27	1.2E+08		
	Total	3.5E+09	28			

Multicomponent sites have access to fewer springs (only 1.2 within 5 km), compared to 3.9 per 5 km for single-component sites. The simplest explanation for these two differences is that multicomponent sites occur more often in the glaciated portion of the project area, where access to diverse bedrock is highest and access to springs is lower. A total of 7 sites are located in glacial physiographic provinces, and 5 are located in karst.

These findings further substantiate the observed distribution of multicomponent sites in the landscape; that most multicomponent sites are located in the central portion of the study area, where karst springs are not as abundant but multiple geologic units are accessible. On the other hand, most of the single component sites are located in the karst region, which has high accessibility to springs and low accessibility to different bedrock units. In essence, multicomponent sites have an inverse relationship to geology and karst springs, when compared to single component sites. The results of ANOVA for linear distance variables, shows a significant difference between multi- and single-component sites in terms of distance to nearest karst spring (see Table 8.10). These results further support the above findings. Therefore, the observed differences between multi- and single-component sites appear to have more to do with regional differences in the distribution of karst springs and bedrock geology units, rather than actual differences in how SMA peoples positioned their sites with respect to these variables.

It is telling that the largest and most reused SMA sites occur in the center of the region. The glacial and karst landscapes intersect in the center, thus the greatest diversity of physiography also occurs here. Likewise, the Falls itself was a rich riverine environment for SMA peoples.

25 km Site-Catchments

Within the 25 km site-catchment areas (Table 8.11), several patterns are notable. First, there are an average of 3.8 physiographic provinces accessible to SMA sites. Six sites (12-Fl-13, 12-Fl-73, 15-Jf-217, 15-Jf-237, 12-Hr-113, and 12-Hr-115) have access to up to 5 physiographic provinces in the 25 km catchment. These sites are located near the center of the study region, along a stretch of the Ohio River that flows nearly due north-south. This area is near the confluence of the Muscatatuck, Charlestown Hills, Norman Upland, and Mitchell Plain physiographic zones. Not surprisingly, these sites also tend to have access to more physiographic zones than average at the 5 km catchment as well. SMA sites with access to the fewest physiographic zones include, Breeden (12-Hr-11), Overflow Pond (12-Hr-12), and 12- Hr-13. These sites are located on the western edge of the site distribution, within the Crawford Upland, and have access to only 2 physiographic provinces within the 25 km catchment. Breeden and Overflow pond are both large shell middens with Old Clarksville and Lone Hill phase deposits. It may seem counter-intuitive that such significant SMA sites have low accessibility to multiple physiographic zones; however, these sites are located near a large backwater pond and an extremely prolific source of Wyandotte chert. These two significant resources may have been a strong draw to this locale.

Overall, access to different units of bedrock geology is fairly high, with an average of 3.3 bedrock sources accessible in the 25 km catchment. The structure of bedrock geology in the region allows sites in the eastern portion to have access to as many as 5 different bedrock sources. Conversely, the western portion of the project area has a much lower access to bedrock of different ages. For example, the four sites in the

Table 8.11. Counts of Features within 25 km Site-Catchments				
	25 KM			
Site No.	Physiography	Bedrock Geology	Karst Springs	SMA Sites
12-Cl-1	4	5	29	9
12-Cl-10	3	5	18	1
12-Cl-3	4	5	29	9
12-Cl-78	3	5	18	1
12-Fl-1	4	4	39	13
12-Fl-13	4	4	34	13
12-Fl-46	5	4	35	13
12-Fl-73	5	4	44	14
12-Hr-11	2	2	109	8
12-Hr-113	5	4	59	14
12-Hr-115	5	4	56	15
12-Hr-12	2	2	110	9
12-Hr-13	2	2	116	9
12-Hr-3	4	1	111	13
12-Hr-36	4	1	116	11
12-Hr-4	4	1	113	14
12-Hr-5	4	1	117	15
12-Hr-6	3	2	70	10
12-Hr-9	3	2	120	10
12-Hr-96	3	2	113	10
12-Ws-30	4	1	79	0
15-Jf-10	4	5	37	14
15-Jf-217	5	5	44	14
15-Jf-237	5	4	46	14
15-Jf-267	4	5	37	13
15-Jf-36	4	5	37	14
15-Jf-60	4	4	70	12
15-Jf-92	4	5	35	8
2-Hr-103	4	3	82	13
TOTAL	111	97	1923	313
Mean	3.82758621	3.34482759	66.3103448	10.7931034
Mode	4	5	37	14

Mauckport Bottom of Harrison County, Indiana have access to only Mississippian bedrock in the 25 km catchment (Figure 8.12). While these sites may not have had access to different bedrock outcrops, they were located near well-known quarry locales for Wyandotte and Muldraugh cherts (see Figure 8.12).

As mentioned previously, the regional distribution of karst springs is inversely related to the diversity of bedrock geology. SMA sites in the eastern portion of the region have access to an average of 35 springs in a 25 km catchment. The average number of springs in 25 km for sites in the western half of the project area is 103 springs, nearly three times the eastern portion of the project area. The division between the eastern and western portions of the project area, based on accessibility to karst springs, appears to occur down river from the Falls between the Hornung site (15-Jf-60) and 12-Hr-3. This is roughly the same area in which the two large site clusters could be differentiated in the KDE analysis.

The average number of SMA sites accessible within a 25 km catchment is 10.4. However, some sites such as 12-Cl-10, 12-Cl-78, and 12-Ws-30 appear quite isolated. These sites, which are located near the edge of the Falls region, have 1 or less SMA sites in their 25 km catchment (Figure 8.13a). The sites with the highest number of other SMA sites within a 25 km catchment occur near the center of the project area, just down river from the Falls. Site 12-Fl-13 and all sites down river to 12-Hr-5, have an average of 12.8 sites within their 25 km catchment area (Figure 8.13b).

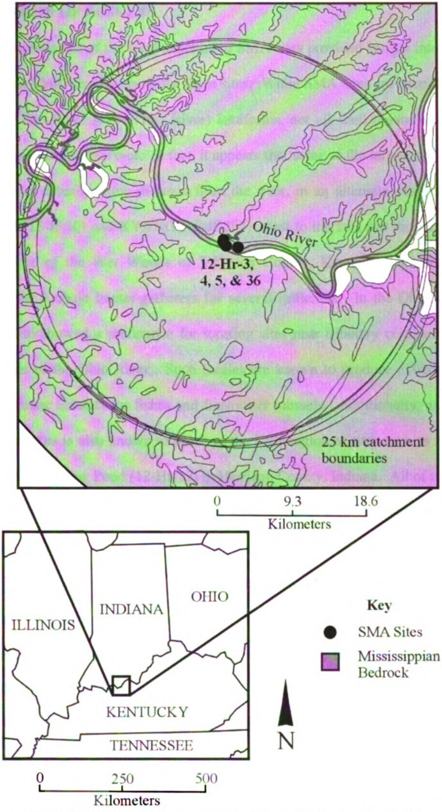


Figure 8.12. SMA sites with access to only Mississippian bedrock geology.

DISCUSSION OF RESULTS

Examination of the local contexts of SMA sites provided insight into the types of locales that SMA peoples chose for these sites. While SMA sites are strongly associated with the Ohio River (and White River) landforms, not all shell mound sites are found immediately next to the river. In fact, it appears that some of the largest and most reused locales were actually some distance from the river, in an alternate context. Sites like Lone Hill (15-Jf-10) and KYANG (15-Jf-267) attest to the fact that the wetland springs and marshes of the Wet Woods of Jefferson County, Kentucky provided significant resources to Archaic hunter-gatherers for several millennia. In the Ohio valley, SMA peoples also showed a preference for locating sites near tributary confluences on large floodbasins of the Ohio River. Such locales are known to produce extremely rich and diverse aquatic habitats for fishes and freshwater mussels. Additionally, exploitation of backwater lakes is also known to occur in the Falls region at sites such as Breeden (12-Hr-11) and Overflow Pond (12-Hr-12) in Harrison County, Indiana. All of these contexts fit the expectation that SMA peoples are placing these sites in highly productive and diverse environments.

The pattern of combined riverine and wetland procurement observed in the project area has many parallels elsewhere in the midcontinent (cf. Anderson 1996; Brown and Vierra 1983; Emerson et al. 1986; Jefferies and Lynch 1983; Lovis 1986; Stafford et al. 2000; Styles 1986; Styles and Ahler 2000). Notable among them is the Koster Site in the lower Illinois River valley. At Koster, Middle and Late Archaic peoples heavily targeted resources in the Illinois River and backwater lakes and marshes in the floodbasin (Styles 1986). Throughout the Midwest and Southeast, Archaic

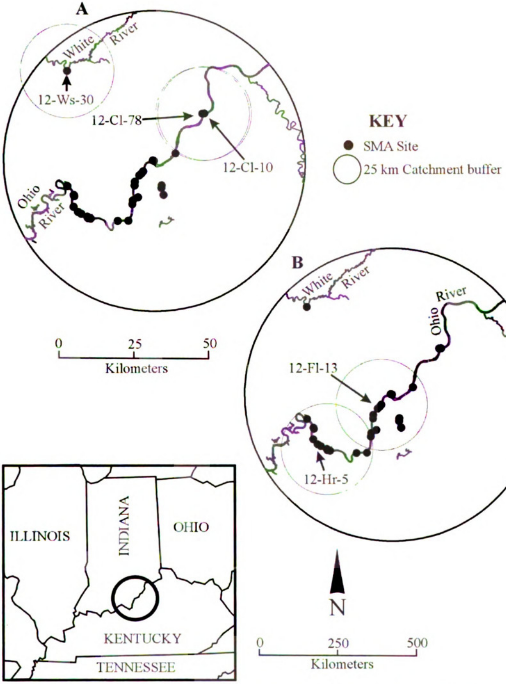


Figure 8.13. A) SMA sites with 1 or less other sites within the 25 km catchment, and B) SMA sites with the highest density of other sites within the 25 km catchment.

peoples revisited particularly productive locales, creating large and sometimes stratified middens.

Linear-distance models of accessibility were created through catchment analysis. In this analysis, variables such as physiography and bedrock geology were used as proxy measures for diversity of food resources and diversity of chert/lithic resource, respectively. The number of different physiographic zones and bedrock types, as well as the total number of karst springs and other SMA sites within a given catchment radius was tallied for each site. I expected that SMA sites should be located in areas with high resource diversity, particularly at the 5 km and 15 km catchment radii.

The results of the 1 km catchment analysis, indicates that this catchment scale summarizes local site contexts and does not indicate that SMA sites are necessarily located in settings with diverse resources. At the 5 km catchment radius, which approximates a daily foraging radius for hunter-gatherers (eg. Kelly 1995), SMA sites favor areas with high access to different physiographic zones. The relationship of SMA sites to bedrock geology and karst springs is not as clear cut. Due to regional differences in the structure of the landscape, karst springs and bedrock geology are inversely related; that is, sites with high access to different bedrock types and low access to karst springs, and visa versa. This pattern was observed for both the 5 and 25 km catchment distances. The geographic differences in bedrock and springs generally mirror the glacial/karst division in the study region. SMA sites in the Falls region are almost equally likely to occur in either the karst or the glacial landscape. Because the karst region is proportionally larger (in both area and length of riverfront), there are proportionally more SMA sites in this sub-region. It appears, therefore, that both the glacial and karst landscapes offer significant resources to SMA peoples, even if the specific resources differed.

Overall, it appears that SMA sites are indeed situated in areas with high resource abundance and diversity. It is telling that shell mounds are located within the daily foraging radius of resources such as chert-bearing bedrock outcrops, karst springs, tributary streams, and other SMA sites. These characteristics can facilitate activities pertaining to subsistence, tool manufacturing, and communication with other communities within the region. The fact that SMA sites are positioned near clusters of resources fits Binford's (1980) expectations for residential camps within a logistic collector economy. Consequently, the Falls data is consistent with the late Middle to Late Archaic shift towards a collector economy observed elsewhere in the Eastern Woodlands (cf. Brown and Vierra 1983; Jefferies et al. 2005; Phillips and Brown 1983; Price and Brown 1985; Stafford 2004). These findings indicate that shell mounds do have economic significance within Archaic lifeways outside of shellfish procurement.

Linear distances between SMA sites were also examined in this study. The results of this research indicate that SMA sites are highly accessible to each other. An average of 2.6 sites could be accessed within the 5 km catchment area. Sites immediately down river from the Falls tended to have the greatest access to other SMA sites by virtue of their central location. The spatial association between shell mounds suggests that these sites may have had more than just economic significance in Archaic lifeways.

Shell mound sites within the Falls region demonstrate spatial clustering at several scales. It is difficult to determine the precise nature of these spatial relationships. Certainly there are economic relationships between sites; perhaps clusters of shell mounds represent seasonal or annual moves in a logistic mobility pattern, particularly at the 17.5 km scale (cf. Janzen 1977). These clusters could also indicate social and political links between different 'tribal' lineages within the Falls region. Perhaps the 2.5 km level of clustering is indicative of patches or territories maintained by corporate groups over many generations (cf. Crothers 1999). Multiple shell mound sites developed over time as these locales were repeated occupied throughout the Middle and Late Archaic. The 7 km clusters could indicate medium-term changes in the locales of settlements in order to ensure a rebound of shellfish populations. No doubt the reasons for these different clusters are extremely varied and complex.

Analysis of the relationship between site clusters and the temporal span of sites indicates that the large-scale (17.5 km) clusters were utilized roughly the same intensity throughout the Middle and Late Archaic periods. In other words, SMA peoples chose the same landscape features throughout the SMA utilization of the Falls region. Multicomponent sites tended to cluster towards the center of the project area, where environmental diversity was greatest, and accessibility between sites was also highest.

While the results of the linear distance models provide significant information concerning the positioning of SMA sites in the Falls landscape, linear distance measures have several significant limitations. First, linear models are simplistic and do not account for the fact that topography and landscape structure place constraints on human movement. Consequently, it is not valid to assume that all areas within a 5 km catchment, for example, would have the same degree of accessibility. Second, traditional catchment studies examine a circular area and do not consider how features, such as a river, may influence the direction and route of travel. Given the proximity of most SMA sites to the Ohio River, resource exploitation and travel may have followed the corridor of the Ohio valley. Cost-distance modeling provides a means for overcoming the shortcomings of catchment analysis and allows movement to be modeled on the structure of the landscape. The results of cost-distance modeling are presented in Chapter 9.

CHAPTER 9

RESULTS AND DISCUSSION OF COST-DISTANCE MODELING

"The Road goes ever on and on, down from the door where it began.
Now far ahead the Road has gone, and I must follow, if I can,
Pursuing it with eager feet, until it joins some larger way
Where many paths and errands meet."
And whither then? I cannot say."
- J. J. R. Tolkien, *Fellowship of the Ring*

INTRODUCTION

To borrow a line from Tolkien, shell mounds can be thought of as places "where many paths and errands meet" for the SMA peoples. This chapter discusses how SMA peoples moved to and from shell mound sites. The models discussed here are hypothetical and are based on least-cost assumptions to provide a generalized picture of travel. The aim of these models is to understand movement and interaction between SMA sites and features of the landscape. The question at the heart of this portion of the research was *in what way does the structure of the landscape influence movement and interaction between SMA sites*? This question was explored by conducting cost-distance analysis based on the terrain slope.

Several different types of models were developed. As discussed in Chapter 7, both travel pathways and corridors were modeled in order to consider the constraints of the landscape. I compare and contrast models created for hypothetical travel using the river- and overland methods. Modeling was also conducted at two different resolutions and I discuss the impact of resolution on modeling results. The results of analysis are discussed separately for the 10 and 90 meter resolutions and for the overland and riverine travel models. Another other aspects of this study was to compare the Tobler hiking algorithm with built-in least-cost algorithms in ArcGIS.

RIVER-TRAVEL MODELS

90 Meter Resolution Paths and Corridors

The river-travel models clearly demonstrate that utilizing the Ohio River was one potential mode of travel in the project area. River-travel path and corridor models shows a *strong* preference for the Ohio River to travel between shell mound sites in floodplain contexts (Figure 9.1). There is considerable redundancy in the hypothetical travel paths and corridors between sites in the river-travel models. In fact, the path models are nearly identical for all sites. Figure 9.1 shows the hypothetical travel pathways and corridors for the Old Clarksville site (12-Cl-1) to all other SMA sites in the study area. The paths (shown as a dashed line in Figure 9.1) follow the Ohio River and the corridors (blue low-cost portions of the cost-corridor surface in Figure 9.1) are confined to the river and adjoining lowlands. The reason that there is so much similarity between paths is because the majority (86%, n = 25) of the shell mounds are located near the Ohio River. There is little change in elevation within floodbasins, so traveling to the river is very low-cost for sites within lowland contexts. This means that nearly all of the shell mound sites in the project area would have been easily accessible from the river. The very nature of these sites – as large mounds of shellfish and refuse – also would have made them visible (and possibly detected by smell) from the river as well.

The river-travel models assume that SMA peoples had access to watercraft for regional travel. Consequently, river-travel models are rather limited in scope. This mode of travel allows relatively easy access to other floodbasins within the Ohio valley, but does not improve access to upland ecosystems. SMA and non-shell bearing Archaic base camps located in the floodbasins would have been accessible using the river-travel

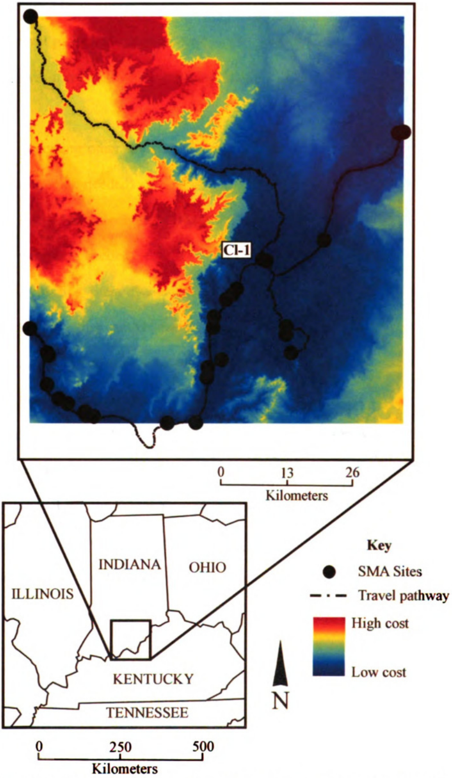


Figure 9.1. 90 m resolution model of cost-corridors and cost-pathways from site 12-Cl-1 and all other SMA sites in the study region. (In color)

paths/corridors. Locales away from the Ohio River were not accessible in the river-travel model, as travel paths and corridors tend to be restricted to the lowlands. However, the lowland or river-travel pathways may have been possible mode of travel for the following situations:

1) Accessing other areas of the same floodbasin, for gathering or hunting (no watercraft needed)
2) Accessing resources at the riverbank, such as shellfishing or fishing (no watercraft needed)
3) Accessing other floodbasins up- or down-river, for hunting, gathering, or visiting other camps (watercraft needed)
4) Accessing riverine resources, such as fish and waterfowl, up- and down-river (watercraft needed)

One site, 12-Ws-30, is located in the White River basin in the northern portion of the project area. There is no direct route to this site via tributary streams (other than a lengthy journey down the White River to the Wabash and then up the Ohio River), so the resulting travel paths to 12-Ws-30 provided a glimpse of what travel through the uplands might look like (Figure 9.2). The route to 12-Ws-30 follows along the Ohio River to the Falls, where it then takes Silver Creek north into the Charlestown Hills (see Figure 9.2). Then the route crosses the Knobstone escarpment into the Norman Upland via Muddy Fork. From there it continues across the Mitchell Plain to the site.

The three SMA sites (15-Jf-10, 36, & 267) located in the Wet Woods of Jefferson County, Kentucky, have been traditionally considered "upland" shell mound sites

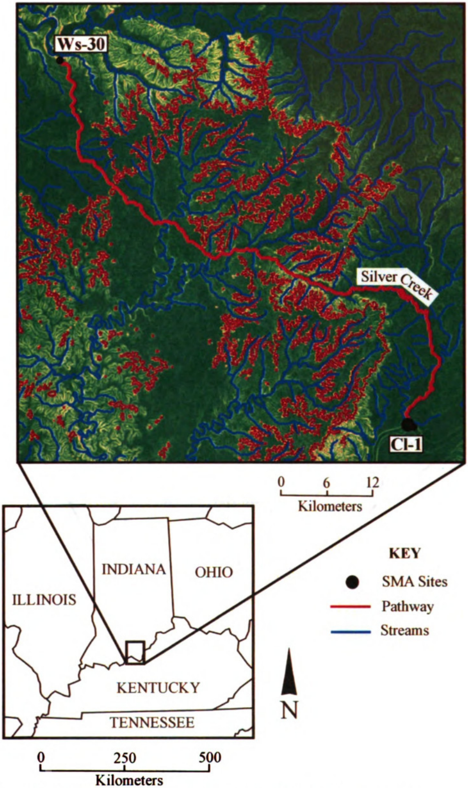


Figure 9.2. Pathway (red) from 12-Cl-1 to 12-Ws-30. Shown on 10 m slope surface. (In color)

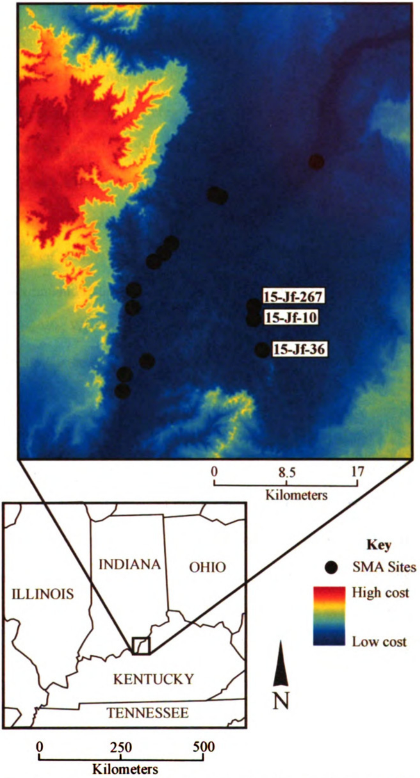


Figure 9.3. Close-up of Wet Woods sites, showing 90 m resolution corridor models.
(In color)

(Bader and Granger 1989; Burnett 1963; Granger et al. 1973) (Figure 9.3). However, the cost-corridor and travel paths clearly indicate that these so-called upland areas are actually easily accessible from the Ohio River lowlands (see Figure 9.3). Previous geoarchaeological studies of this area indicate that this area is an extensive lacustrine deposit created by a period of Pleistocene impoundment of the Ohio River (Gray 1984). Consequently, the landforms that comprise the Wet Woods are not substantially different in elevation from the floodbasin landforms near the Ohio River. In fact, the Wet Woods area can be viewed as an extension of the large Louisville bottomland to the north and the Mill Creek bottomland to the west. The corridors developed for the river-travel model all indicate that the Wet Woods sites were relatively accessible from all the SMA sites in the Ohio River valley in the study area.

10 Meter Resolution Paths and Corridors

I originally anticipated significant differences in the path models between the resolutions. In particular, I expected that the 90 m model would not have enough data to accurately model human movement in the landscape. Surprisingly, the 10 m resolution model is not considerably different from the 90 m model. The simulated travel paths primarily follow the Ohio River in both resolutions. The only variation between the resolution models occurs when the paths leave the river. For example, Figure 9.4 shows a comparison between the 90 m and 10 m results between 12-Cl-1 and the Wet Woods sites of Jefferson County, Kentucky. The 90 m paths (dashed line) are shorter than the 10 m paths (solid line). These results may be due to the fact that the 10 m resolution data is actually too detailed for the path modeling. Modern "artifacts" such as highways and city

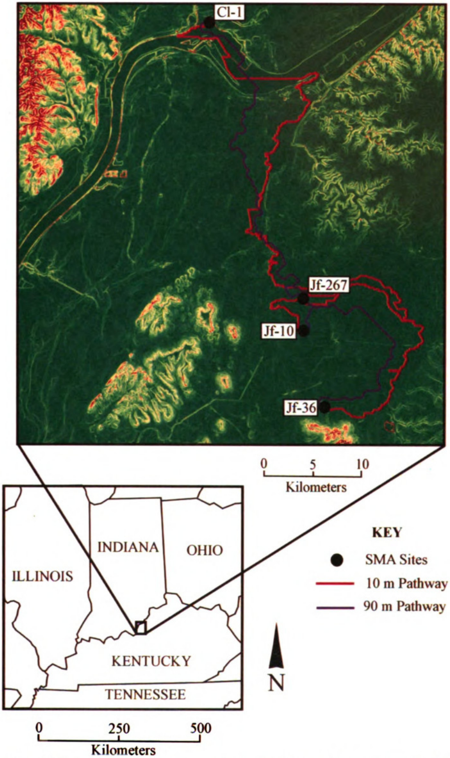


Figure 9.4. Comparison of 10 m river paths (red) and 90 m river paths (purple) between 12-Cl-1 and Wet Woods sites (15-Jf-10, 36, & 267). Shown on 10 m slope surface. (In color)

bloc

mod

the

slop

top

res

mo

Co

co

Tr

ha

pr

w

in

t

l

y

f

s

v

blocks disrupt the natural topography of the terrain and affect the results of path modeling. This is particularly evident in Jefferson County, which has been impacted by the city of Louisville. The terrain artifacts of modern features do not appear in the 90 m slope surface (see Figure 9.4). The lower resolution effectively smoothes out the topographic variation created by modern man-made features. Consequently, the lower resolution has an advantage over the higher resolution, particularly in areas where modern structures may cause DEM "artifacts".

Considerations in River-Travel Models

There are several factors not considered in the simulation of river-travel paths and corridors. First, these models do not account for the flow direction of the Ohio River. Travel from east to west in the project area, following river currents downstream would have been easier and faster than going upstream. A second factor not examined is the presence of the rapids at the Falls. From early historic accounts, travel through the Falls was possible the majority of the year, but periods of high or low water may have made it impossible to safely navigate (Powell 1999).

It is unclear how much the Falls would have created a barrier to travel between the eastern and western portions of the project area. If Ohio River water levels were lowered during the mid-Holocene coincident with the Middle to Late Archaic periods, as Marquardt and Watson (2005b) propose for the Green River and Styles (1986) suggests for the Illinois River, then it is possible that the Falls was not navigable in a canoe or small boat during SMA times. However, given the portable nature of Native American watercraft, it is likely that portages around the Falls were possible and were conducted in prehistoric times. While the Falls may have presented difficulty for traveling up and down river, it may have conversely aided movement between the north and south sides of the Ohio River. Seasonal low water at the Falls would have eased access between the northern and southern sides of the Ohio River, as Archaic peoples would have been able to walk across the exposed bedrock.

OVERLAND MODELS

10 m and 90 m Travel Paths

The results of the overland travel paths are significantly different from the river-travel models. Figure 9.5 shows 90 m resolution overland travel paths (shown as dashed-lines) and corridors (shown as blue areas) from 12-Cl-1 to all other sites. The paths between sites tend to follow tributary streams into the uplands and then along ridge tops and bluffs. Travel paths often took advantage of broad floodbasins of the Ohio River, where present.

There are some differences between the 10 m and 90 m resolutions in the overland pathways (Figure 9.6, and see Figure 9.5). The 90 m data was "smoothed" to such an extent that paths often have straight segments (see Figure 9.5). This means that the 90 m cost surfaces had large areas where the cost-values were the same. This appears to happen in areas with relatively little relief or change in slope. The 10 m model appears to preserve more topographic variation. Overall, however, the paths created by both resolutions were remarkably similar. Differences between paths were largely due to the 90 m resolution missing some detail in low relief areas. For example, the Charlestown Hills portion of the path to 12-Ws-30 varies between the 10 m and 90 m resolutions

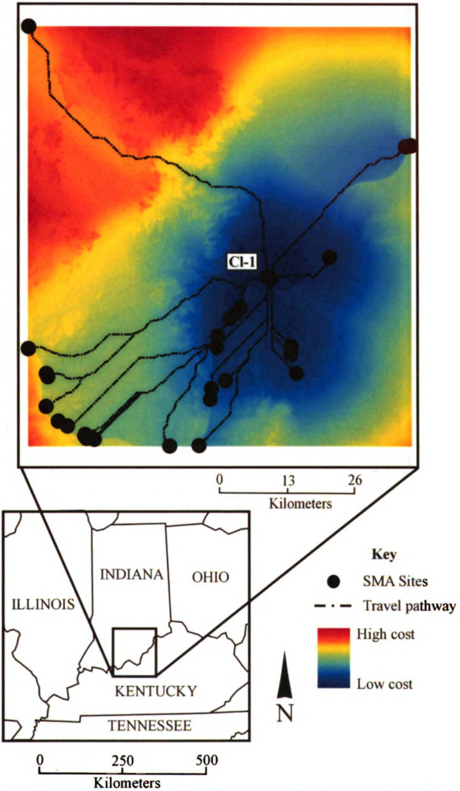


Figure 9.5. 90 m resolution overland travel pathway and corridor from 12-Cl-1 to all other SMA sites. (In color)

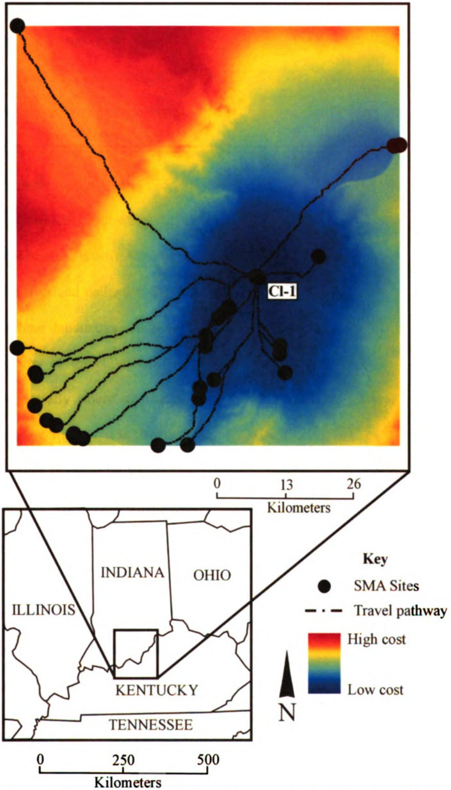


Figure 9.6. 10 m resolution overland travel pathway and corridor from 12-Cl-1 to all other SMA sites. (In color)

(Figure 9.7). The 90 m resolution pathway follows Silver Creek north through the Charleston Hills and then uses the Muddy Fork valley to ascend the Knobstone escarpment and gain access to the Norman Upland. Alternatively, the 10 m resolution pathway heads west from the Old Clarksville site (12-Cl-1) and climbs the Knobstone Escarpment at a small stream called Fall Run. Once in the Norman Upland, the pathway heads northwest to site 12-Ws-30. With some personal experience with the ruggedness of the Knobstone Escarpment, the 90 m model actually seems more appropriate than the 10 m model because it provides a more reasonable path up the Knobstone.

The overland pathways frequently intersect each other. This may be due to the fact that some landmarks, such as the Knobstone Escarpment, place constraints on possible paths of travel. Consequently, there were limited ways of traversing this obstacle (generally where streams cut through the bedrock). Given the constraints of traveling in the uplands, it is likely that there are undocumented base camps and resource extraction sites in the areas where travel paths frequently converged. Upland settlement patterns during the Middle-Late Archaic is poorly documented and understood in the Falls region, primarily due to a lack of survey in these areas. Therefore, the hypothetical travel paths may help predict areas for future investigation. Figure 9.8 highlights several areas that have a high potential for Middle to Late Archaic period sites, based on where pathways frequently intersect in the 90 m resolution model. Possible site locales highlighted in Figure 9.8 have five or more pathway intersections.

To test whether this method is a good predictor of site location, I acquired the spatial locations of all documented Archaic period sites in Jefferson County, Kentucky. This portion of the project area was chosen because it is probably the best surveyed

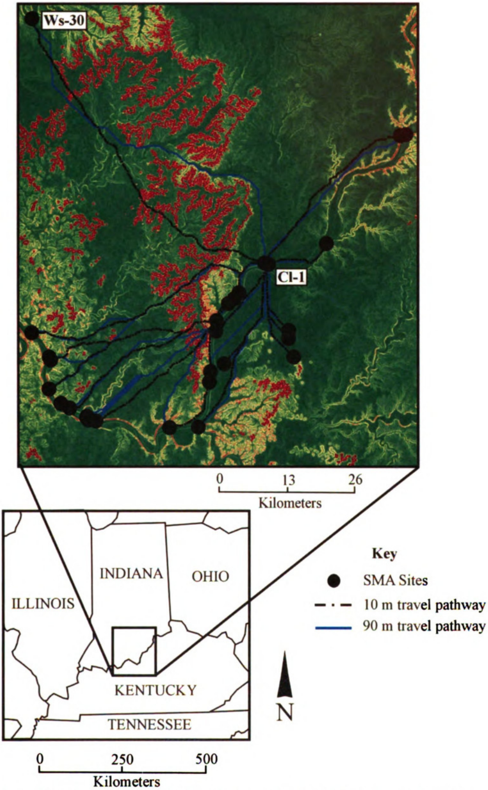


Figure 9.7. Comparison of 10 m and 90 m overland travel pathways from site 12-Cl-1 to all other SMA sites. Shown on 90 m slope basemap. (In color)

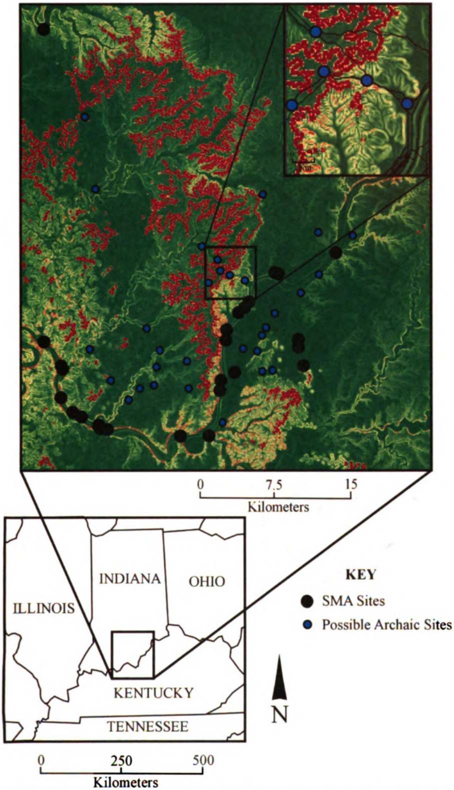


Figure 9.8. Possible Archaic site locales determined by pathway intersections, shown on 90 m slope. (In color)

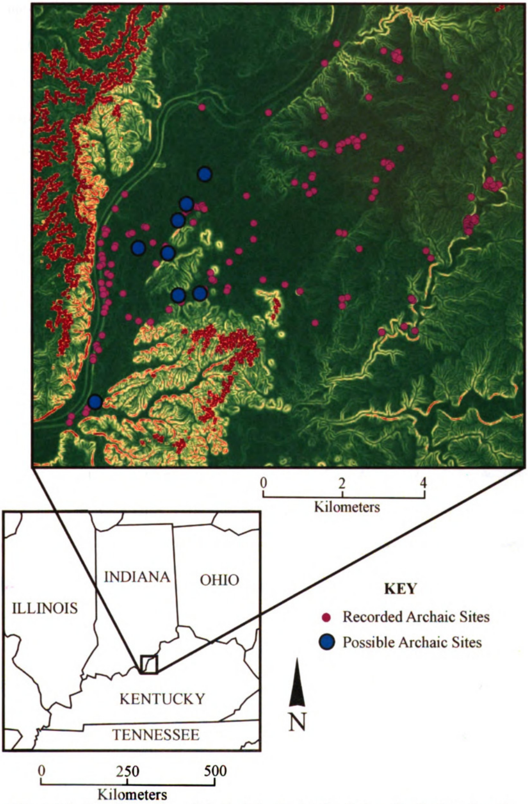


Figure 9.9. Locations of possible Archaic site locales that predict the location of actual Archaic sites in Jefferson County, Kentucky. (In color)

county of the Falls region. Additionally, the Kentucky Office of the State Archaeologist already had this site data compiled in a GIS database. Figure 9.9 shows the locations of actual documented Archaic sites and corresponding proposed site locations based on my model. The correlation between actual and predicted site locations is quite high. Seventy percent (n=7) of the ten potential site locales in Jefferson County, actually contain identified Archaic sites. While not all Archaic period sites are identified by this method, it does suggests that pathway intersections can be used to predict the locations of other Archaic sites within the settlement landscape. The potential site locales identified elsewhere in the study region may be the starting point for archaeological survey to document additional Archaic sites.

Another interesting aspect of the overland travel paths is that there are often many sites accessible along a path from one site to another. Sites located in the middle of the Falls region, particularly the Floyd County sites, are frequently accessed by paths connecting east to west (Figure 9.10). For example, the Reid site (12-Fl-1) is accessed by travel paths between other SMA sites in the project area 51 times. The high degree of accessibility is partly due to the sites' central location, but also due to local topography. This area of Floyd County has the steep bluff of the Knobstone Escarpment, which restricts travel to the west of the Floyd County sites. Interestingly, this area is also well known for high-quality outcrops of Muldraugh chert (Cantin 1994). Consequently, the Floyd County sites may have been established in order to access or control this important resource. Despite their central location and proximity to the Falls, the Old Clarksville and Clark's Point sites (12-Cl-1 and 12-Cl-3), are not nearly as accessible as the Floyd County sites in the upland pathway models. This pattern may be due to the fact that these

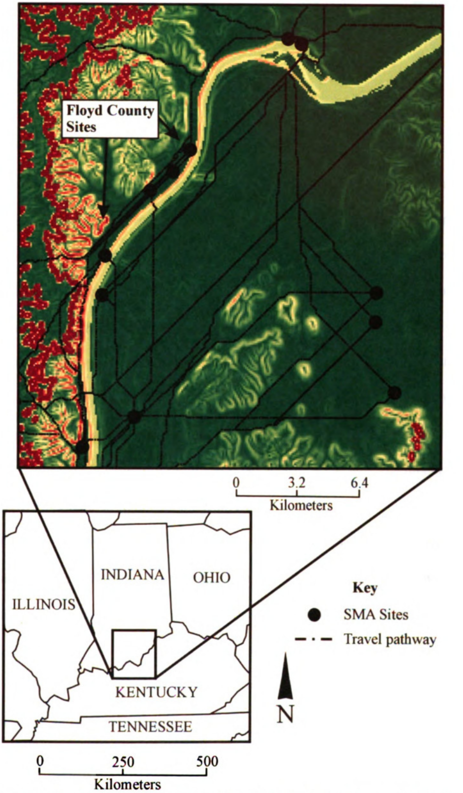


Figure 9.10. Close up of Floyd County, Indiana SMA sites, showing pathways that intersect these sites. Shown on 90 m slope. (In color)

sites are located in a broad expanse of the Ohio River floodbasin, where travel is not as restricted.

10 m and 90 m Travel Corridors

Travel corridors are in some ways more informative than paths, because they better approximate how hunter-gatherers move in the landscape. Rather than taking a single path, hunter-gatherers often deviate slightly from an idealized path in order to access resources, take advantage of scenic views, or visit economically or socially important locales. The overland corridor models have a very different appearance than the river-models. Rather than being confined to a narrow area within the Ohio valley, the upland corridors are broad areas of potential travel. For example, Figure 9.11 shows the overland 90m corridor model for the Old Clarksville site (12-Cl-1). The upland corridor models demonstrate that without the Ohio River as a potential route of travel, movement in the falls landscape is generally radial; in other words, a *circular catchment area does closely approximate the area accessible from a site.*

The upland-travel corridors encompass wide areas of potential travel. This is significant because variation between the 10 m and 90 m travel paths, are encompassed by the corridor models. In order to compare the 10 m and 90 m corridor models, the corridor rasters were converted into a data format that could be examined statistically. By selecting a portion of the cost corridor, it was possible to determine the area within these corridors and use this data for statistical analysis. Additionally, this process also created a sort of cost-catchment that could be compared with the standard site-catchments. The lowest 10-percent of cost seemed to be a good estimate of what was

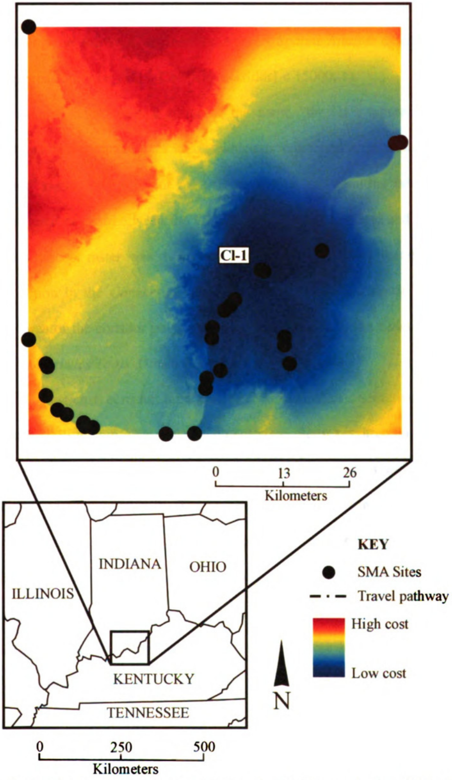


Figure 9.11. 90 m resolution cost corridor for site 12-Cl-1 to all other SMA sites. (In color)

reasonable for people to traverse on a daily basis. The 10-percent cost threshold was calculated using the *Raster Calculator* in ArcGIS *Spatial Analyst* extension, with the following expression: [thr_cl1] = Con([cl1_corridor] < 15000, 1).

This equation produces a raster of the name "thr_cl1", where the lowest 10 percent of cost has a value of "15000", which is converted to a value of 1 for the "cl1_corridor" raster. As you can see in Figure 9.12, the resulting raster defines the lowest 10 percent of cost between the Old Clarksville site (12-Cl-1) and all other SMA sites. The new cost raster was then converted to a feature layer using the *Raster to Polygon* function in the *Conversion Tools* of ArcGIS. Once converted to a polygon feature, the area of the corridor polygon can be calculated with the *Calculate Areas* tool in the *Spatial Statistics Tools, Utilities*.

The lowest-cost corridor area can be considered an alternative way to view resource accessibility from a circular catchment area. Sites, resource patches, and other features of the landscape that lie within the corridor area polygon are more accessible than landscape features outside it. The major difference between these corridors and a circular-catchment area is that the corridors take into account the cost of moving through the landscape. Table 9.1 summarizes the corridor areas for each site at the 10 m and 90 m resolutions. The average area of the 10 m corridors and 90 m corridors is 71,093 square meters and 70,460 square meters, respectively. These averages appear remarkably similar to the average area within a circular 5 km catchment, which is 78,446 square meters.

A two-sample T-test was used to compare the means of the 10 m and 90 m corridor models with the following hypotheses:

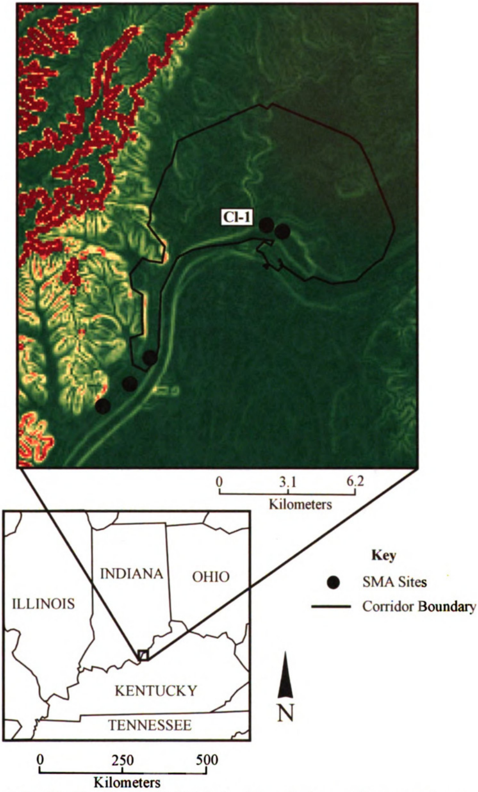


Figure 9.12. Corridor for site 12-Cl-1 derived from the lowest 10 percent of cost. Basemap is 90 m resolution slope. (In color)

Tha

equ

Wh

sar

ver

no

co

the

Th

H

t=

co

H_1 = There is a difference in the mean area for the 10 m and 90 m resolution corridors.

Ho = There is no difference in the mean area for the 10 m and 90 m resolution corridors.

The two-sample T-test compares the mean area of the 10 m and 90 m models using the equation:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{(SD_1\text{^}2/n_1) + (SD_2\text{^}2/n_2)}}$$

Where x and x_2 are the averages of each sample, *SD* is the standard deviation of each sample, and *n* is the number of observations for each sample. The resulting t-value is very small 0.547 and not significant. This means that the 10 m and 90 m resolutions are not significantly different in area.

Because the area of a 5 km catchment is roughly similar to the 10 m and 90 m corridor area. A two-sample T-test was also conducted between the 1) 10 m corridor and the 5 km catchment areas and 2) 90 m corridor and 5 km catchment areas.

H_1 = There is a difference in the mean area for the 10 m corridors and 5 km catchment areas.

H_2 = There is a difference in the mean area for the 90 m corridors and 5 km catchment areas.

Ho = There is no difference in the mean area for the 10 m (or 90 m) resolution corridors and 5 km catchment areas.

The result of the first T-test for the 10 m corridors is t=1.187, which is not significant. However, the test of 90 m corridor area and 5 km catchment area produced a result of t=1.453, which is significant at the 0.05 probability level. Therefore, it appears that the corridor areas produced by the 10 m resolution model are not equivalent to the 5 km

Table 9.1. Comparison of 10 % corridor areas (in square m) for 10 m and 90 m over-land models		
Site No.	**90m Model**	**10m Model**
12-Cl-1	63250.831	69484.048
12-Cl-10	44677.623	46097.982
12-Cl-3	59324.97	65168.154
12-Cl-78	54397.575	55920.722
12-Fl-1	61726.57	66725.56
12-Fl-13	58654.534	61510
12-Fl-46	53909.687	64367.185
12-Fl-73	61750.171	70056.216
12-Hr-103	47463.832	42297.661
12-Hr-11	56024.275	52686.806
12-Hr-113	68084.074	70836.208
12-Hr-115	75576.62	78311.922
12-Hr-12	58090.463	53156.093
12-Hr-13	14314.735	9230.957
12-Hr-3	69071.89	60028.492
12-Hr-36	70246.113	64843.955
12-Hr-4	69157.248	61145.668
12-Hr-5	70815.508	64492.833
12-Hr-6	71158.905	68679.271
12-Hr-9	64962.14	62550.483
12-Hr-96	69509.23	68816.429
12-Ws-30	34722.954	24214.122
15-Jf-10	141015.753	151079.351
15-Jf-217	112579.99	114466.048
15-Jf-237	96929.515	104655.932
15-Jf-267	137400.045	147333.211
15-Jf-36	142582.636	150970.176
15-Jf-60	61974.721	64100.859
15-Jf-92	53970.128	48457.789
MEAN	70460.09434	71092.55631
Standard Deviation	30141.31067	33970.8813
Coef of Var	2.337658608	2.092749837

catchment areas, but the 90 m resolution corridors are equivalent to the 5 km catchment areas.

To further compare the 5 km catchment area and the corridor areas, variables such as access to physiographic zones, bedrock geology, karst springs, and other SMA sites were tabulated for corridors at each resolution (Table 9.2). The data complied in Table 9.2 was compared with the 5 km catchment tally in Table 8.4 using a two-sample T-test. The following hypotheses were evaluated:

> H_1 = There is a difference in the mean number if physiographic provinces (geological units, springs, or other SMA sites) within the 10 m corridors and 5 km catchment areas.
>
> H_2 = There is a difference in the mean number if physiographic provinces (geological units, springs, or other SMA sites) within the 90 m corridors and 5 km catchment areas.
>
> Ho = There is no difference in the mean number if physiographic provinces (geological units, springs, or other SMA sites) in the 10 m (or 90 m) resolution corridors and 5 km catchment areas.

The results of the T-test are shown in Table 9.3. There is no significant difference in the average number of physiographic, bedrock geology, and spring features in the 5 km catchment areas compared with the corridor areas. However, there is a significant difference in the number of other SMA sites that are accessible in the 5 km catchment, compared to the corridors. On average, the corridor areas access more SMA sites than the 5 km catchment area. This is due to the fact that the corridors give preference to travel in the lowland floodplains where most SMA sites are located. For example, the 10 m corridor for site 12-Hr-9 contains 7 SMA sites, and the 5 km catchment only contains 1 other SMA site (Figure 9.13). Therefore, while corridor modeling does not provide a

Table 9.2. Counts of Features within 10 and 90 m Corridor Areas								
	90m Corridor Area				10m Corridor Area			
Site No.	Physio-graphy	Bedrock Geology	Karst Springs	SMA Sites	Physio-graphy	Bedrock Geology	Karst Springs	SMA Sites
12-Cl-1	3	4	0	2	3	4	0	3
12-Cl-10	2	3	0	1	2	3	0	1
12-Cl-3	3	4	0	1	3	4	0	2
12-Cl-78	2	3	0	1	2	3	0	1
12-Fl-1	4	2	0	4	4	2	0	4
12-Fl-13	3	3	0	5	4	3	0	5
12-Fl-46	4	3	0	4	4	3	0	5
12-Fl-73	4	2	0	4	4	2	0	5
12-Hr-103	3	1	1	1	3	1	1	1
12-Hr-11	1	1	7	3	1	1	7	3
12-Hr-113	3	1	0	2	3	1	0	2
12-Hr-115	3	1	0	3	3	1	0	3
12-Hr-12	1	1	8	3	1	1	7	3
12-Hr-13	1	1	5	0	1	1	5	0
12-Hr-3	2	1	6	5	2	1	6	6
12-Hr-36	2	1	4	6	2	1	6	6
12-Hr-4	2	1	5	6	2	1	8	6
12-Hr-5	2	1	3	6	2	1	6	6
12-Hr-6	2	1	9	8	2	1	6	8
12-Hr-9	2	1	8	7	2	1	8	7
12-Hr-96	2	1	6	6	2	1	5	6
12-Ws-30	2	1	9	0	2	1	7	0
15-Jf-10	2	3	1	2	2	3	1	2
15-Jf-217	3	2	0	4	4	2	0	4
15-Jf-237	4	3	0	6	4	3	0	6
15-Jf-267	2	3	2	2	2	3	2	2
15-Jf-36	2	3	2	2	2	3	2	2
15-Jf-60	3	1	0	3	3	1	0	3
15-Jf-92	1	2	1	0	1	2	1	0
TOTAL	70	55	77	97	72	55	78	102
Mean	**2.41379**	**1.89655**	**2.65517**	**3.34483**	**2.48276**	**1.89655**	**2.68966**	**3.5172**
Mode	**2**	**1**	**0**	**1 & 4**	**2**	**1**	**0**	**6**
StDev	**0.90701**	**1.04693**	**3.23238**	**2.25635**	**0.98636**	**1.04693**	**3.10648**	**2.2775**

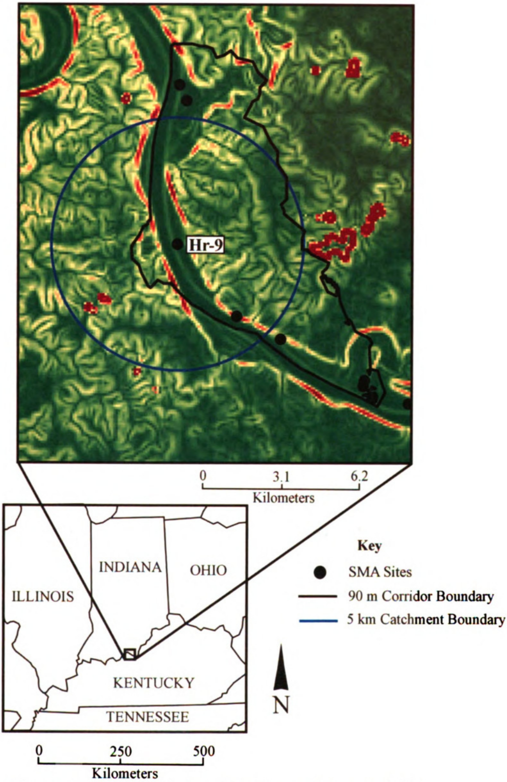


Figure 9.13. Comparison of SMA sites within 90 m corridor area and 5 km catchment area for site 12-Hr-9. (In color)

Table 9.3. T-tests of landscape features for 5 km catchments and corridors				
		t	df	Sig (2-tailed)
Pair 1	Physiography: 5km catchment & 10m corridor	-1	28	0.326
Pair 2	Physiography: 5km catchment & 90m corridor	-1.684	28	0.103
Pair 3	Geology: 5km catchment & 10m corridor	-1	28	0.326
Pair 4	Geology: 5km catchment & 90m corridor	-1	28	0.326
Pair 5	Springs: 5km catchment & 10m corridor	0.414	28	0.682
Pair 6	Springs: 5km catchment & 90m corridor	0.394	28	0.696
Pair 7	SMA sites: 5km catchment & 10m corridor	-4.625	28	**0**
Pair 8	SMA sites: 5km catchment & 90m corridor	-5.192	28	**0**

different view of accessibility for resources or environmental feature, it does provide a different model of accessibility between SMA locales.

RESULTS OF TOBLER-FUNCTION PATHWAYS AND CORRIDORS

As discussed in Chapter 7, some researchers (cf. Gorenflo and Bell 1991; Kantner 1996; Parlsow 2006) have used the "hiking" algorithm developed by Geographer, Waldo Tobler (1993), to create prehistoric cost-pathways. Due to the methodological focus of this research, it was important to test whether Tobler's algorithm produced significantly different model results from the built-in GIS algorithm. Hypothetical travel pathways and corridors were developed for all the SMA sites in the study region using the Tobler Algorithm (using the 90 m resolution DEM). The results of these pathways and corridors were compared with the overland corridors derived from the built-in ArcGIS least-cost algorithm (at both 90 and 10 m resolutions).

The pathway models developed from the Tobler hiking function differ from the pathways made with the standard ArcGIS algorithm. Figure 9.14 shows pathways from site 12-Cl-1 to all other SMA sites for both the Tobler (in red) and 90 m overland (in blue) models. The pathways generated from the Tobler algorithm behave quite differently from the ArcGIS derived pathways. In particular, even though the Ohio River was weighted in order to prevent "walking" travel down the river, the Tobler pathways frequently follow the river. Another problem with the Tobler pathways is that they do not appear to appropriately weight the cost of traveling up the Knobstone escarpment. In fact, the Tobler model climbs the Knobstone escarpment in very steep areas to create a shorter pathway, rather than finding a slightly longer, but easier way over the Knobs. For example, the Tobler model creates a pathway from site 12-Cl-1 to 12-Ws-30 that cuts across numerous steep valleys and ravines (see Figure 9.14), which is contrary to expectations and rather counter-intuitive for a "terrain" based model. Another way that the Tobler pathways differ is that they show a slightly greater preference for traveling along ridge tops than the ArcGIS algorithm.

Overall, the results of the Tobler pathways are surprising and disappointing. I expected that the pathways produced by the different algorithms would be roughly comparable. However, the Tobler algorithm appears less intuitive and is more likely to generate pathways that are, in reality, too difficult to traverse. While Tobler's algorithm may be useful for some landscapes, it does not appear to provide a more accurate model of human movement for the Falls region. The results of this portion of the study suggests

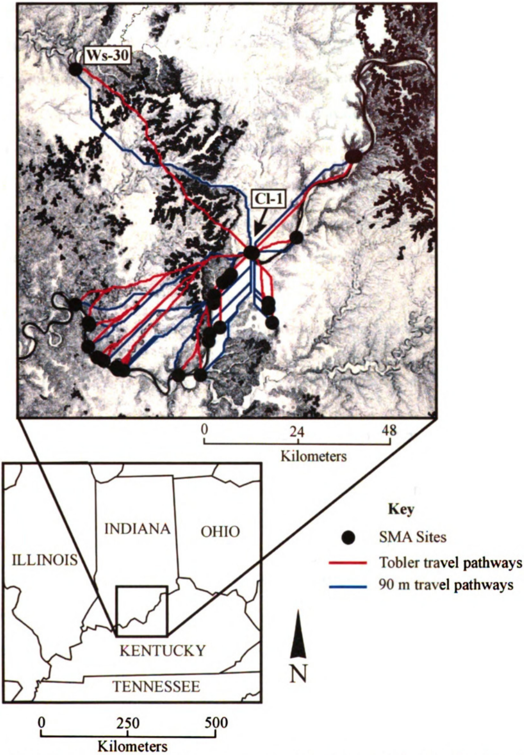


Figure 9.14. Comparison of travel pathways derived from Tobler algorithm (in red) and ArcGIS algorithm at the 90 m resolution (in blue) for site 12-Cl-1 to all other SMA sites in the study region. Shown on Tobler slope surface. (In color)

that researchers should chose a least-cost algorithm carefully and examine the model output to evaluated whether it produces pathway models that are logical for their archaeological culture and the landscape in which it is situated.

Corridors generated from the Tobler hiking function were also compared with the 90 m and 10 m resolution corridors developed with the built-in algorithm. The total area of the corridor polygon created from the lowest 10 percent of the cost was compiled for the Tobler data (Table 9.4). The average area of the Tobler-generated corridors is larger than either the 90 or 10 m resolution models (see Table 9.4). T-tests were conducted with the area data for the following hypotheses:

H_1 = There is a difference in the mean area for the 5 km catchments and Tobler corridor areas.

H_2 = There is a difference in the mean area for the 10 m corridors and Tobler corridor areas.

H_3 = There is a difference in the mean area for the 90 m corridors and Tobler corridor areas.

Ho = There is no difference in the mean area for the 10 m (or 90 m) resolution corridors and Tobler corridor areas.

The T-test results are shown in Table 9.5. The area of corridors generated by the Tobler function are significantly different (at the 0.001 level) than the area of corridors generated with the GIS algorithm or the area of the 5 km catchments. Therefore, it appears that the corridors generated by the Tobler models are not comparable to the ArcGIS algorithm models, in terms of area.

While these results may seem problematic, there are several reasons why the corridor area produced by these models would differ so significantly. First, the algorithm in ArcGIS produces a corridor model that provides a "cost" estimate. Tobler's algorithm,

Table 9.4. Comparison of Tobler Corridor Areas with 90 m and 10 m Corridor Areas			
Site No.	**90m Model**	**10m Model**	**Tobler Area**
12-Cl-1	54397.575	55920.722	49879.314
12-Cl-10	63250.831	69484.048	63204.199
12-Cl-3	61750.171	70056.216	132839.851
12-Cl-78	44677.623	46097.982	47010.021
12-Fl-1	53909.687	64367.185	100196.442
12-Fl-13	61726.57	66725.56	97664.653
12-Fl-46	58654.534	61510	101121.377
12-Fl-73	47463.832	42297.661	63095.304
12-Hr-103	69071.89	60028.492	121208.828
12-Hr-11	141015.753	151079.351	84388.997
12-Hr-113	14314.735	9230.957	96291.508
12-Hr-115	75576.62	78311.922	139925.41
12-Hr-12	112579.99	114466.048	118419.823
12-Hr-13	96929.515	104655.932	143241.148
12-Hr-3	70246.113	64843.955	131148.127
12-Hr-36	71158.905	68679.271	174244.696
12-Hr-4	69157.248	61145.668	129363.209
12-Hr-5	70815.508	64492.833	130489.213
12-Hr-6	34722.954	24214.122	27270.167
12-Hr-9	64962.14	62550.483	173688.174
12-Hr-96	69509.23	68816.429	166718.126
15-Jf-10	137400.045	147333.211	79326.022
15-Jf-217	58090.463	53156.093	141305.711
15-Jf-237	68084.074	70836.208	140681.474
15-Jf-267	142582.636	150970.176	91187.302
15-Jf-36	61974.721	64100.859	88501.549
15-Jf-60	56024.275	52686.806	140302.015
15-Jf-92	59324.97	65168.154	77294.715
12-Ws-30	53970.128	48457.789	65098.414
TOTAL	**2043342.74**	**2061684.13**	**3115105.789**
MEAN	**70460.0943**	**71092.5563**	**107417.441**

however, produces a corridor model that is a measure of "time". The second and related issue is that the lowest 10 percent of the Tobler corridors does not measure the same thing as the lowest 10 percent of the ArcGIS derived corridors. Consequently, it is not surprising that the areas differ. In other words, the distribution of the Tobler costs is different because there is a larger proportion of cells within the 10 percent. Third, in Chapter 7, I described that Tobler's hiking algorithm requires that slope surface used to create the cost surface be in percent slope, rather than degrees slope. These two differences in the assumptions and requirements of the Tobler function are likely to cause additional differences between the two types of models.

Table 9.5. T-tests of the lowest 10 percent area of Tobler and ArcGIS algorithm corridors

		Mean	**Std. Deviation**	**Std. Error Mean**	**t**	**df**	**Sig. (2-tailed)**
Pair 1	Tobler area v. 5 km Catchment area	28971	39114.1	7263.3	3.989	28	**0**
Pair 2	Tobler area V. 10 m Resolution area	36324.9	48955.2	9090.75	3.996	28	**0**
Pair 3	Tobler area V. 90 m Resolution area	36957.3	45991.8	8540.46	4.327	28	**0**

The Tobler corridors were also compared to the 10 m and 90 m resolution corridors in terms of accessibility to landscape features. Table 9.6. lists the counts of features accessible within the lowest 10 percent of the Tobler corridors for each SMA site. T-tests were conducted on each of the variables listed in Table 9.6 for the Tobler corridors, 90 m corridors, 10 m corridors, and 5 km catchment areas for these hypotheses:

> H_1 = There is a difference in the mean number if physiographic provinces (geological units, springs, or other SMA sites) within the 5 km catchment and Tobler corridor areas.
>
> H_2 = There is a difference in the mean number if physiographic provinces (geological units, springs, or other SMA sites) within the 10 m corridor and Tobler corridor areas.
>
> H_3 = There is a difference in the mean number if physiographic provinces (geological units, springs, or other SMA sites) within the 90 m corridor and Tobler corridor areas.
>
> Ho = There is no difference in the mean number if physiographic provinces (geological units, springs, or other SMA sites) in the 10 m (or 90 m) resolution corridors and Tobler corridor areas.

The results of the T-tests are shown in Table 9.7. There is a significant difference in the number of springs and other SMA sites with the Tobler corridor areas and all three other areas modeled (5 km catchment, 10 m and 90 m corridors). Because the Tobler corridor areas tend to be larger than the other three areas, more sites and springs are accessible within the Tobler model. Figure 9.15 shows an example of how the Tobler corridor area includes more sites than the 90 m corridor area for SMA site 12-Hr-9.

Similarly, the Tobler corridors also have higher access to spring features (Figure 9.16), particularly for sites in the western, karstic portion of the project area. These results indicate that the Tobler algorithm models greater accessibility to both springs and other SMA sites. However, the parameters for this accessibility are questionable. Upon examining the boundary of the Tobler corridor, the corridor does not appear to adequately weigh the cost of traveling across particular features of the landscape. In Figures 9.15 and 9.16, the boundaries of the Tobler corridor crosses the Ohio River, as well as steep hills. These results are similar to the problems found in the pathway models derived from the Tobler algorithm.

Table 9.6. Counts of Features within Tobler Corridor Areas

Site No.	Physiography	Bedrock Geology	Karst Springs	SMA Sites
12-Cl-1	2	4	0	2
12-Cl-10	2	3	1	1
12-Cl-3	2	4	0	2
12-Cl-78	2	3	1	1
12-Fl-1	4	2	0	4
12-Fl-13	4	3	0	6
12-Fl-46	4	3	0	6
12-Fl-73	4	2	1	7
12-Hr-11	2	1	19	5
12-Hr-113	4	1	1	5
12-Hr-115	4	2	1	5
12-Hr-12	2	1	21	5
12-Hr-13	1	1	14	3
12-Hr-3	2	1	13	6
12-Hr-36	2	1	14	6
12-Hr-4	2	1	13	6
12-Hr-5	2	1	14	6
12-Hr-6	2	1	16	9
12-Hr-9	2	1	18	9
12-Hr-96	2	1	17	8
12-Ws-30	2	1	7	0
15-Jf-10	2	3	1	2
15-Jf-217	4	2	1	4
15-Jf-237	4	1	2	7
15-Jf-267	2	3	1	2
15-Jf-36	2	3	1	2
15-Jf-60	3	1	0	3
15-Jf-92	2	4	0	0
2-Hr-103	3	1	1	2
TOTAL	**75**	**56**	**178**	**124**
Mean	**2.586206897**	**1.9310345**	**6.137931**	**4.27586**

Table 9.7. T-Test Results for Counts of Physiography, Geology, Springs, and SMA Sites within Tobler corridor areas compared to 10 m corridor areas, 90 m corridor areas, and 5 km catchments.				
		t	**df**	**Sig. (2-tailed)**
Pair 1	Physiography: Tobler v. 5 km Catchment	-2.544	28	**0.017**
Pair 2	Physiography: Tobler v. 10 m	-1.140	28	0.264
Pair 3	Physiography: Tobler v. 90 m	-1.722	28	0.096
Pair 4	Geology: Tobler v. 5 km Catchment	-1.361	28	0.184
Pair 5	Geology: Tobler v. 10 m	-0.328	28	0.745
Pair 6	Geology: Tobler v. 90 m	-0.328	28	0.745
Pair 7	Springs: Tobler v. 5 km Catchment	-3.876	28	**0.001**
Pair 8	Springs: Tobler v. 10 m	-3.899	28	**0.001**
Pair 9	Springs: Tobler v. 90 m	-3.854	28	**0.001**
Pair 10	SMA Sites: Tobler v. 5 km Catchment	-5.975	28	**0.000**
Pair 11	SMA Sites: Tobler v. 10 m	-3.863	28	**0.001**
Pair 12	SMA Sites: Tobler v. 90 m	-4.700	28	**0.000**

Tobler's hiking function overly "smooths" costly features of the Falls landscape. One cannot gain a sense of how difficult it is to travel in the landscape by just looking at a slope surface in GIS. I cannot stress enough the ruggedness of the Falls landscape and the fact that Ohio River floodbasins are separated from the uplands by bluffs more than 200 feet high in many places (Figure 9.17). Even today, there are few roads in and out of the Ohio River lowlands. The Tobler pathway and corridor models trivialize these topographic constraints. Therefore, while the corridors derived from the built-in ArcGIS algorithm are smaller and model reduced accessibility, they appear to "fit" the landscape constraints of the Falls region better than the corridors developed from Tobler's hiking function.

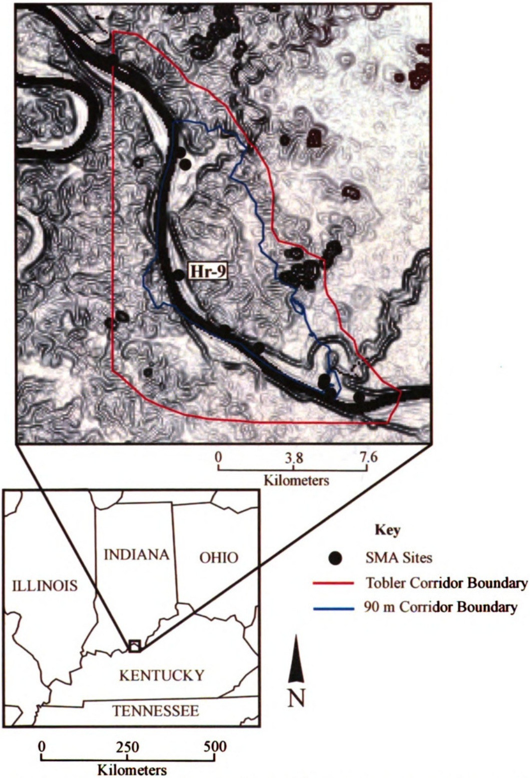


Figure 9.15. Comparison of sites within the Tobler (in red) and 90 m (in blue) corridor areas for site 12-Hr-9. (In color)

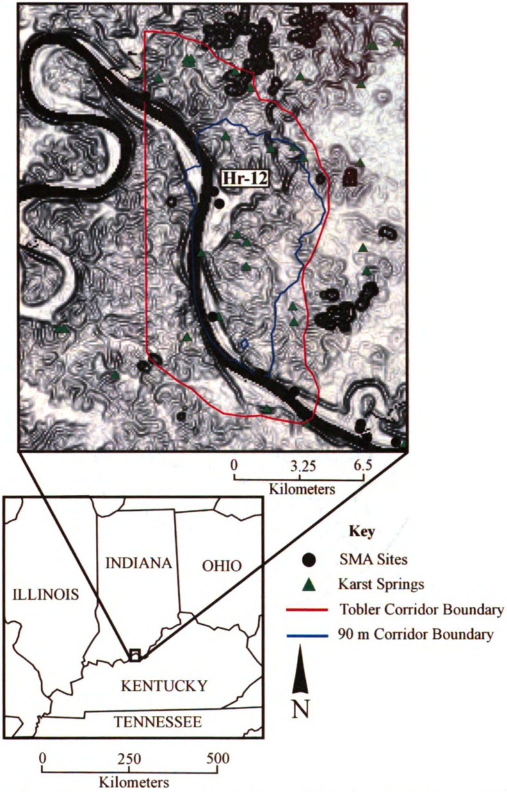


Figure 9.16. Comparison of springs within the Tobler (in red) and 90 m (in blue) corridor areas for site 12-Hr-12. (In color)

Figure 9.17. Photograph looking south on Camp Creek Road showing steep bluffs between the uplands and the Bethlehem Bottom. Immediately left (east) of Camp Creek Road is a cliff. Google Earth (2009) image shows the location of photograph with respect to local topography. Photograph taken by the author, March 2000. (In color)

DISCUSSION OF RESULTS

So what can the hypothetical models of movement and interaction tell us about Shell Mound Archaic settlement and socio-economic systems? There are several insights to be gained from the results of corridor and trail modeling. First, contrary to expectations, the 10m and 90m resolutions were not significantly different from each other in the river-travel models. The 10m resolution models did provide slightly more detail over-land pathways. However, in some cases, the 10 m resolution introduced modern "artifacts" such as city blocks and interstate highways, which skewed the path models. The 10 m and 90 m resolution models produce corridors of similar area, derived from the lowest 10 percent of the corridor cost surface. In terms accessibility to various features of the landscape (i.e. physiographic zones, bedrock geology units, karst springs, and other SMA sites) the 10 m and 90 m corridor models are not significantly different.

Second, it is apparent that the network of hunter-gatherer movement in the Falls region can be either characterized as linear (in the case of the river-corridors) or somewhat radial (in the case of the upland corridors) depending on the mode of travel. This finding is significant, because it demonstrates that it is important to consider how features of the landscape influence movement, communication, and resource extraction in a region. While circular catchment areas can approximate accessibility to economic resources, they are a poor approximation of access to other SMA sites in the settlement system.

Third, some sites are highly accessible due to a combination of their location and local topography. The accessibility of certain sites may not be accidental, particularly when considering their proximity to other resources. Crothers (1999) argued that the

Green River shell mounds were "established because of their proximity to rich resources, and that hunter-gatherers exercised rights of exclusive access". If a similar model can be applied to the Falls region, then one should expect a correlation between shell mound location and resource accessibility. The local-context and distance-relationships between SMA sites and variables such as physiography, geology, and springs, suggests that there is a relationship between SMA site location and resources. That is, SMA sites appeared to be positioned in the landscape in a way that makes them accessible from each other, as well as providing access to diverse resources.

Fourth, the hypothetical pathways and corridors developed from Tobler's hiking function were expected to be comparable with the built-in algorithms in ArcGIS. However, comparison of these modeling techniques shows that there are significant differences. In particular, Tobler's model overly-smooth the terrain in the study region.

Each of these results and how they relate to the research questions guiding this research will be discussed further in Chapter 10.

CHAPTER 10

CONCLUSIONS AND FUTURE DIRECTIONS

"A truly useful predictive model, from both a management and a research perspective, is one that puts human use of the area into its environmental contexts" (Church et al. 2000:146)

This dissertation reconstructed the SMA landscape of the Ohio Falls region in order to place SMA sites within their broader environmental and social contexts. This research used a spatial approach in order to move beyond the problem of site-level variability, which has led to multiple interpretations of the role SMA sites had within Middle to Late Archaic lifeways. In particular, this dissertation tests whether the assumption that SMA sites are "positioned" as residential base camps is valid. The results of this study suggest that SMA peoples did practice a strategy to increase access to diverse and highly productive resources. However, the relationship of SMA sites to their cultural and environmental contexts is far more complex than simple attraction to desirable resources. For example, the Ohio Falls SMA sites show evidence of clustering at various scales. Additionally, SMA sites in this study do not appear to be associated with one "type" of resource setting. Rather, long-term SMA occupations occurred in several locales with different environmental configurations in the study region.

The Ohio Falls case study is the first to explicitly reconstruct a regional SMA landscape. As such it provides valuable behavioral insights on SMA land use decisions, as well as methodological insights on how to model hunter-gatherer landscapes. The SMA site dataset used in this study was collected from previously documented or investigated sites. As described in Chapter 6, the nature of this site data made it unsuitable for synthesis or comparison at the site-level. Very few of the SMA sites were excavated by professional archaeologists and the quality of data collection is not consistent for those that were. An additional problem with the site dataset in this study is the issue of sampling and potential site bias. In Chapter 5 I discussed geomorphological changes in the Ohio River valley that may have affected the representation of SMA sites. The other issue with the Falls SMA dataset relates to uneven survey and reporting of archaeological sites.

However, I argue that the sample of SMA sites used in this research can be considered representative of SMA settlement patterns, given that 1) geomorphological changes in the Ohio valley do not appear to have a significant impact on Middle to Late Archaic deposits and 2) these sites are so prominent on the landscape that it is unlikely that any significant shell mounds have gone undocumented over the past two hundred years of Euroamerican settlement in the Falls region. Regardless of these deficiencies with the site dataset, the methods used in this research demonstrate that even datasets with poor excavation data can garner useful conclusions about SMA lifeways.

REVIEW OF RESEARCH QUESTIONS AND RESULTS

Several questions guided this reconstruction of the Ohio Falls SMA landscape. The first question, *are there common spatial characteristics shared by SMA locales,* was focused on the site-level contexts. Expectations derived from hunter-gatherer theory predict that SMA sites should not be randomly placed on the landscape. If shell mound sites were residential base camps, then SMA peoples would have had a preference to settle in proximity to multiple, productive sources of procurement and subsistence resources. Local site contexts were reconstructed by recording environmental variables such as physiography, landform, soil association, bedrock geology, and hydrological setting at each SMA site in the study area. The results of this analysis demonstrate that SMA peoples in the Falls region had a preference for floodbasins near particularly rich physiographic regions, specifically the Muscatatuck Plateau and Mitchell Plain. However, not all sites are found in this context. Significant, multicomponent SMA sites also occur near inland wetlands and springs in the Wet Woods of Jefferson County, Kentucky. Apparently, SMA peoples also viewed these inland wetlands as highly desirable settings and reused them over the entire duration of the SMA tradition.

The second question, *what is the relationship of SMA sites to other features of the landscape*, examined the types and quantity of resource zones accessible from SMA sites. Within this portion of the research I also addressed the methodological question, *what is the best method and scale of analysis for modeling accessibility?* I expected that SMA sites would conform to expectations for residential base camps (ie. access to multiple resource zones within a daily foraging radius). Resource accessibility was modeled through 1) standard site-catchment analysis at three radii (1 km, 5 km, and 25 km) and 2) cost-weighted mobility modeling. Catchment analysis was conducted at three scales, determined by ethnographic expectations for hunter-gatherer land use. The 1 km catchment approximates the immediate conditions surrounding SMA sites and did not provide much more information than provided by the site-level reconstruction of contexts. The most significant findings are that over a third of the shell mounds had access to more than one physiographic zone and 20 percent had access to another shell mound locale within the 1 km catchment radius. Additionally, all but two SMA sites in the Falls region had access to a stream, river, or karst spring within the 1 km catchment.

A 5 km catchment was considered in this research because it approximates a hunter-gatherer's daily foraging radius (Kelly 1995). This means that SMA hunter-gatherers would have conducted most of their foraging, hunting, and fishing within this catchment area. The results of this portion of the research help to refine our understanding of the conditions that SMA peoples preferred for settlement. While all SMA sites clearly indicate a preference for access to aquatic resources, the most utilized locales had access to the most productive aquatic settings. Specifically, the largest, multicomponent sites occur in three settings: 1) on floodbasins near the intersection of multiple physiographic zones, 2) inland near karst springs and wetlands, and 3) on floodbasins near backwater lakes or tributary confluences with marshes. Each of these landscape contexts is distinct, yet all of them fit the expectation that SMA peoples are locating their base camps to access multiple, abundant resources.

The 25 km catchment is generally considered the maximum distance that hunter-gatherers will walk in a day for logistic forays (Kelly 1995). Although it is unlikely that SMA hunter-gatherers frequently traveled this distance (cf. Kelly 1995:133), I considered this catchment radius to gain a sense of the diversity of resources that could possibly be accessed at this distance. On average, accessibility to other SMA sites, karst springs, different physiographic zones, and bedrock types was very high. Due to the structure of the Falls landscape, SMA sites in the eastern portion of the project area were more likely to have access to diverse types of bedrock, while SMA sites in the western portion of the project area were more likely to have access to karst springs.

As an alternative to simple catchment analysis, I also conducted cost-weighted modeling of accessibility using corridor analysis. A cost-weighted "corridor" is a model of the cost to walk from a shell mound site to any specified point within the study region. Cost was determined by the constraints of terrain ruggedness as measured by slope (ie. change in elevation over a given distance). The goal of this portion of the research was to determine whether a model based on landscape constraints would provide a different and presumably more accurate picture of how Archaic peoples viewed and utilized their landscape. I expected that the cost-corridor models would differ from the catchments in terms of the quantity of resources accessible. Cost-corridors were developed using the built-in ArcGIS algorithm from terrain slope at two resolutions: 10 m and 90 m. An area of accessibility was modeled by creating a polygon from the lowest 10 percent of the cost-corridor surface for each SMA site. A T-test determined that the area of the selected 10 m cost-corridor was not significantly different than the area within a 5 km catchment, however the 90 m corridor had a significantly different area at the 0.05 probability level.

While the 10 m corridor and 5 km catchments were fairly similar in terms of area, the shape of the corridors and catchments differed. The cost-corridor boundaries followed constraints of the landscape, such as the Ohio River and edges of bluffs. Surprisingly, the difference between corridor and catchment shape produced no significant difference on the quantity of physiographic zones, bedrock types, or karst springs accessible from sites. Differences did arise between corridors and catchments when considering accessibility to other SMA sites. Cost-corridors contained approximately 60 percent more SMA sites on average than the 5 km catchments, even though the catchments cover an average of 7000 square meters of additional area. This means that SMA sites are highly accessible to each other. This accessibility is partly due to their common location within the Ohio River lowlands. It also indicates that simple catchments based on linear distances from a site do not accurately summarize all aspects of a settlement landscape, particularly with regard to the relationship between sites.

The third question evaluated in this research was *what is the spatial relationship of shell mound sites to each other?* The fourth question, *how do the SMA site clusters differ from one another*, builds upon the third question. These questions sought to further explore the patterns observed during the previous portion of the study, which indicated that SMA peoples did not place sites randomly in the Falls landscape. Kernel density estimation (KDE) and nearest-neighbor statistics were used to identify spatial clusters within the SMA site distribution.

KDE analysis identified two major clusters of sites, plus two smaller site clusters. One of the major clusters was located near the Falls of the Ohio, at the center of the project area. Based on what was learned during the catchment and corridor analysis, we know that the area surrounding the Falls has the highest geomorphic and environmental diversity in the study region. Four physiographic zones converge immediately downriver from the Falls. Additionally, this area is at the interface between the glaciated and karstic portions of the region. The second major cluster occurs roughly 40 river miles downriver from the falls. This portion of the study region has less physiographic and geologic diversity, but is rich in wetland springs and chert outcrops. ANOVA tests indicate that there are indeed significant differences in the environmental setting of the two major site clusters.

Nearest-neighbor (Khat and Lhat-h) analysis further supported the finding that SMA sites in the Falls region demonstrate spatial attraction or clustering. The results of the L-function test indicate that SMA sites cluster at several spatial scales in the study area. Specifically, SMA sites cluster at 2.5 km, 7 km, and 17.5 km intervals. Interpretation of what these clusters mean in terms of SMA land use decisions are difficult without more detailed site excavation data and radiocarbon dates. Therefore all the explanations offered here are tentative.

It appears that the 2.5 km clusters may represent single floodbasins, where multiple sites developed over the course of the SMA tradition. The presence of numerous shell mounds in particular areas may be indicative of long-term and repeated use of certain locales. Thus, the 2.5 km clusters may be viewed as long-term settlement areas. From a research perspective, all shell mound sites within a floodplain locale should be examined together to better understand long-term settlement patterns.

Sites within the 2.5 km clusters are unlikely to be occupied contemporaneously. While it is impossible to test this without radiocarbon date ranges for all of the sites in the study region, where radiocarbon dates are present at sites such as Breeden (12-Hr-11) and Overflow Pond (12-Hr-12) in the New Amsterdam bottom, it appears that these two locales were used at different times. Breeden was occupied periodically throughout the Middle and early Late Archaic periods, while Overflow Pond dates to the Late Archaic.

Information on mollusk life-cycles indicates that the 7 km clusters may be related to an Archaic strategy to allow shell fish populations at particular floodbasins to rebound after intensive collection (Reidhead 1981; Thorp and Covich 1991). Hunter-gatherer ethnographic literature tells us that they had an intimate knowledge of their resource base and were unlikely to completely exhaust a resource (cf. Bettinger 1991; Binford 2001; Kelly 1995). Thus, SMA hunter-gatherers may have shifted the location of their shellfishing activities to a nearby floodbasin in order to prevent resource depletion.

Most of the SMA sites in the study region can be, at the very least, assigned to a phase: Old Clarksville or Lone Hill. From this crude temporal distinction, it appears that 77 percent of the 7 km clusters (n=10 of 13 total clusters) were occupied at least periodically through both phases. Again, without greater temporal control on durations and periodicity of site occupations, it is impossible to determine whether the above interpretation is probable or to make an estimate of the frequency of proposed shifts in settlement. Mollusk biology can, however, provide some indication of the temporal scale. Some common freshwater mollusk species in the Ohio valley require a decade in order to reach reproductive maturity (Thorp and Covich 1991). Therefore, these fluctuations in settlement likely occurred at the scale of a decade or more, rather than years or seasons.

Lastly, SMA sites also cluster at the 17.5 km scale, which corresponds to the 4 (12 mile bandwidth) clusters identified in the KDE analysis. As discussed above, the two largest clusters are located in different settings within the study area. Due to the significant diversity in the geo-environmental contexts of these clusters, it is possible that they represent settlement changes within an annual round of residential mobility. Comparison of the temporal phases present in each of the clusters located along the Ohio River indicates that all of these areas were utilized throughout the Middle and Late Archaic periods. However, multicomponent sites occur more frequently in the central cluster, near the Falls.

Zedeno (1997) and Tacon (1999) both propose that striking geographic features often become socialized and gain both cosmological and political importance. Therefore, it is not surprising that the vicinity near the Ohio Falls has a higher site density than the rest of the region. This area may have served as both a natural and cultural boundary and the two main site clusters could represent distinct use areas for different corporate groups. Though without more information from site excavations, it is impossible to assess whether there was evidence of multiple groups or lineages occupying the Falls region during the SMA tradition.

The fifth question considered in this research is can hypothetical cost-weighted pathways between SMA sites predict locations of non-shell sites within the Middle to Late Archaic settlement system? The pathways developed in this study are based on the same terrain data and assumption – that topography places limits on human movement – as cost-weighted corridors. Pathways were developed for both river and overland travel scenarios. The resulting pathways can be viewed as hypothetical networks of connectivity between SMA sites, which indicate approximate routes taken by hunter-gatherers in canoes or on foot. These pathways should not be taken as literal trails, but as indications where potential paths of travel could have existed based on the difficulty of traversing the terrain. It is also important to note that the hypothetical pathways between SMA sites were only modeled between sites, not to destinations outside of the project area.

One of the reasons for conducting this type of modeling was to identify possible "high-traffic" areas, or locales that were frequently accessible between SMA sites, in order to predict the locations of non-shell mound Middle to Late Archaic sites.

Specifically, I was most interested in the possible locations of Archaic sites in the uplands, where little systematic archaeological survey has been conducted. Due to topographic constraints in the Falls landscape, the hypothetical pathways frequently used the same routes into the uplands. As discussed in Chapter 9, numerous Archaic site locales were predicted in the Falls region, based on the intersection of multiple pathways.

To test whether pathway intersections predicted site locations, I compared the possible site locations with known sites documented in a portion of the study area. Archaeological site records for Jefferson County, Kentucky provided the comparative data. While pathway intersections did not predict the location of all Archaic sites in Jefferson County, particularly beyond the SMA site distribution, there were correlations between predicted and actual site locations. The results of this portion of the research suggest that this method could help target future survey efforts to find Middle to Late Archaic period sites in the uplands.

The sixth question evaluated is *to what extent does high resolution data improve cost-weighted models of accessibility from SMA sites in the Falls region?* As mentioned above, cost-weighted modeling was conducted at two resolutions. Initially, the research plan was to conduct all analysis using the 10 m resolution National Elevation topographic dataset. However, numerous technical problems were encountered when conducting regional-level analysis of this high-resolution dataset. Consequently, the 10 m data was resampled to create a coarser-grain 90 m resolution layer of topography. I expected that the high-resolution data would be superior to the coarse-grained resolution when modeling prehistoric cost-pathways and corridors. Specifically, I anticipated that the low-resolution data would not adequately represent the topography of the Falls landscape and therefore, would not create suitable pathway and corridor models.

Comparison of the 10 m and 90 m cost-corridors was conducted through comparative statistics. A T-test of the mean area within 10 m and 90 m corridors determined that there is no significant difference between the corridor models produced by the different resolutions. Pathways for the 10 m and 90 m models were visually compared to consider how they traveled over the landscape. In particular, I was interested in whether 1) there were considerable differences between the pathways modeled at each resolution, 2) the 10 m and 90 m hypothetical models made sense based on the Falls terrain, and 3) there was evidence of pathway error introduced by "artifacts" in the Digital Elevation Models (DEM) on which the cost-surfaces were based. Surprisingly, there were not significant differences in the 10 m and 90 m paths. Generally speaking, differences in the specific paths occurred where terrain was relatively low-relief, which indicates that either pathway could have been potential routes of travel for SMA peoples.

In a few cases, there were some differences in how the 10 m and 90 m pathway models crossed steep terrain, such as the Knobstone escarpment. While these differences cannot be quantified, it appears that the lower resolution provides a more perceptive model of pathway travel. For example, the 90 m pathways tended to make a path into the uplands where a stream valley had incised steep bluffs, while the 10 m pathways were more likely to climb straight up a bluff. The result is that 90 m pathways were often longer, but less difficult than the 10 m pathways. The observed differences between the 10 m and 90 m pathways is likely due to the fact that the lower resolution cost-surface is "smoother" in low-relief areas. The effect of having less topographic variation in the low-relief areas is that the 90 m pathways were not as constrained. Thus, the 90 m paths were free to seek out easier routes over steep slopes. Another benefit of the lower resolution data is that artifacts of modern landscape modification (ie. highways and river levees) were smoothed out. On the other hand, the 10 m resolution pathways were frequently affected by DEM artifacts, particularly in the Louisville area of Jefferson County, Kentucky.

Overall, differences between the 10 m and 90 m resolution pathways were minimal, but where they exist, the 90 m pathways appear to "fit" the landscape better. Corridor models were not significantly different at the 10 m and 90 m resolutions. This research determined that high-resolution topographic data is not a requirement for pathway or corridor modeling for regional-scale archaeological reconstructions – at least for landscapes with relatively significant topographic variation, such as the Falls region.

The seventh and final question was *how does the Tobler hiking function pathways and corridors differ from overland pathways and corridors developed with the built-in least-cost ArcGIS algorithm?* I expected that hypothetical pathways and corridors developed using the Tobler function would not be significantly different that those made from the built-in algorithm. The same qualitative and quantitative methods used to compare the different resolution pathways and corridor models was used to compare the Tobler and built-in models. The Tobler and built-in modeling techniques do not appear to create similar models of accessibility and interconnectivity.

The Tobler pathways behaved differently than the built-in algorithm in several ways. First, the Tobler pathways were much more likely to climbs steep bluffs and slopes in order to reduce the total length of the path. Second, the Tobler pathways frequently followed the course of the Ohio River, even though the river was assigned a high cost-weight in order to prevent this from happening. Third, Tobler pathways were much more likely to follow ridgelines than valleys, once in upland contexts. In sum, the pathways developed from Tobler's hiking function tend to underestimate the topographic constraints in the project area. Overall, the Tobler pathways do not appear to be as good of a "fit" for the Falls landscape as those derived from the built-in algorithm.

T-tests of Tobler corridor area and the area of 90 m and 10 m corridors, indicate that the Tobler corridors are significantly different that the built-in corridors. Additionally, T-test results comparing the accessibility to landscape features (such as physiography, geology, springs, and other SMA sites) within Tobler and built-in corridors, indicated that the Tobler corridors contain significantly more springs and SMA sites. The results of the accessibility T-test are not unexpected, given the fact that the Tobler corridors are significantly larger in area. More problematic is the fact that Tobler corridors do not appear to appropriately weigh the difficulty of walking over steep terrain. These results draw attention to the importance of comparing and carefully selecting algorithms for least-cost modeling in archaeological contexts. While Tobler's hiking function does not appear to be the best method for modeling movement in the Falls region, it is possible that it is more suitable for landscapes with a different scale of local relief.

SIGNIFICANT CONTRIBUTIONS

This dissertation research contributes 1) new insights into how SMA peoples viewed their landscape and 2) new approaches with which to examine hunter-gatherer adaptations.

Contributions to SMA Archaeology

This dissertation determined that SMA sites are indeed positioned with respect to resource accessibility and diversity. As Goldstein noted for Woodland effigy mounds, shell mound sites are placed to "emphasize certain rich resources" (Goldstein 1995:113). Not surprisingly, accessibility to water, in the form of rivers, streams, wetlands, or karst springs, was an important factor in site placement. However, Falls SMA peoples chose several different types of "high access" locales that were not always associated with the Ohio River. Accessibility to diverse geo-environmental and physiographic settings was an important factor to SMA peoples. This research also determined that there is a relationship between desirable environmental contexts and the intensity and duration of site use. In fact, the sites with the longest-term reuse and reoccupation occurred near the center of the Falls region, where resource diversity was greatest. This pattern provides an explanation for why SMA sites differ in their size, content, structure, and duration of use. The results of this research support the interpretation that SMA sites were base camps within an increasingly sedentary logistic collector economy.

The land use decisions made by SMA peoples resulted in a clustered distribution of shell mound sites at several geographic (and possibly temporal) scales. While there is not enough excavated data from the Falls SMA sites to clarify what these clusters represent, they suggest that SMA peoples had a complex relationship with the landscape. The socio-political role of SMA remains largely obscure; yet, it is significant to note that the multicomponent sites with large, stratified deposits are more likely to contain burials in the Falls region than non-stratified, single-component sites. The presence of mortuary activities at these multicomponent sites certainly indicates increased social significance of these locales within the SMA landscape. Thus it appears that sites with the greatest economic importance also developed social significance among the SMA peoples. These findings support Crothers' (1999) position, as well as the views recently expressed by Marquardt and Watson (2005b) in their volume on the Green River SMA:

> ...that Middle Holocene peoples were drawn to the same locations again and again – locations that offered reliable access to nutritious resources, such as nuts, deer, mollusks, and fish. As family groups gathered in such places year after year, they must have expended energy communally in the creation of facilities...fostering an identification with the landscape. This was undoubtedly reinforced upon death of community members, when the dead were buried in the accumulating midden-mounds near an important source of sustenance for the living (Marquardt and Watson 2005b:638-39).

Long-term reuse of key locales, along with burial of deceased family members, may indicate that the people who used them viewed these locations as both economically and socially significant. Through time some shell mounds, particularly those with access to high resource abundance and diversity, shifted from economically important sites to significant loci of cultural memory.

Methodological Contributions to Hunter-Gatherer Studies

Examination of the spatial aspects of prehistory has a long tradition in archaeology (cf. Clarke 1977; Willey 1953). This research can be viewed as a culmination in a trajectory to unite theory and method into a cohesive "spatial" approach.

Here, landscape archaeology provides the theoretical platform and Geographic Information Science (GIS) provides the methodological platform or "toolbox". The theoretical and methodological approaches used in this research are not new, in the strictest sense. However, this particular application of landscape and GIS to the SMA tradition is. Three methodological insights can be gained from this dissertation research.

First and foremost the suite of GIS techniques utilized in this research allowed me to make use of a previously unusable dataset. The archaeological data of SMA sites in the Falls region are of such poor and disparate quality that they could not be synthesized and interpreted in a meaningful way at the regional-scale. However, this research demonstrates that it is possible to make significant insights into prehistoric lifeways, even with datasets that were previously considered inadequate for research. The caveat, collecting and standardizing data for this type of analysis, still is relatively time-consuming and difficult. The good news is that these difficulties are well worth the time and energy invested. Therefore, the results of this research provide impetus for reexamination of "unusable" datasets in other regions.

Second, this research employed an alternative method to site-catchment analysis to reconstruct resource accessibility of SMA site locales. The specific method used was based in a least-cost modeling technique known as corridor analysis. This type of analysis considers the constraints of a landscape to create a representation of how people could have exploited a region, in terms of cost. Topography was the variable used to calculate cost in this dissertation; however, additional environmental and cultural variables can be used to "weight" areas or points on the landscape. Corridor analysis and site-catchments were compared in this study. This research determined that the SMA settlement landscape was not adequately described by simple site-catchments. The corridor models provided a better representation of accessibility to other SMA sites in the Falls region. The chief benefit of modeling corridors over site-catchments is that the former technique is a better depiction of the "real-world" conditions facing prehistoric peoples. The more our archaeological models conform to actual conditions, the more improved our resulting interpretations of these models will be.

The third methodological insight from this research is that least-cost pathway modeling provides a means for predicting site locations. In the study region, there was a correlation between intensely traveled or "high-access" areas, as determined by the intersection of multiple hypothetical pathways, and Archaic period sites. Predictive models are based on the assumption that some portions of a landscape are more likely to contain archaeological deposits than others. Generally, archaeologists identify "high-potential" areas based on environmental characteristics. For example, prehistoric peoples tend to settle on dry land near water. This study demonstrates that hypothetical pathways of human travel or movement can also contribute to predicting site locations. Therefore, if a portion of a prehistoric settlement landscape is relatively well documented, like the SMA sites in this study, then it may be possible to identify survey areas for additional sites within the settlement landscape. This means that archaeologists have one more tool to aid identification of "high-potential" areas for archaeological survey.

REMAINING QUESTIONS AND FUTURE DIRECTIONS

Some aspects of this research were relatively simplistic due to the limitations of the data available. For example, this research relied only on the distribution of SMA sites and did not include any other sites within the Middle to Late Archaic settlement system. One of the reasons for this omission is that no systematic surveys have yet been conducted in the upland portions of the project area. Therefore, a substantial portion of the Archaic landscape is currently absent. An important and necessary step for future research is to conduct archaeological survey in each of the different environmental settings and physiographic zones of the Falls region. As discussed above, this research demonstrated that one of the benefits of hypothetical least-cost pathway modeling is that it has some power to predict the location of other Archaic sites. The results of this portion of the research can help target areas for survey and further investigation. Thus, the models presented in this dissertation can be refined with additional non-shell mound site data.

Another issue that prevents further interpretation of the results gathered here, is the fact that few sites in the Falls region have been excavated in any detail. Specific data needed to help make sense of the observed site clusters include:

1) Radiocarbon dates to assess the temporal period, duration and frequency of site reuse,
2) Stratigraphic reconstructions of midden deposits to determine the intensity and frequency of occupations,
3) Botanical and faunal remains to assess the seasonality of occupations and look for evidence of long-term change in subsistence patterns,

4) Diagnostic and formal tools, such as hafted bifaces, atlatl weights, and bone pins, to look for indications of differentiation into corporate social groups or lineages, and

5) Human burials to provide information on mortuary treatment, exchange networks, and socio-political identities.

These data, along with the spatial contexts reconstructed in this research, should provide a nuanced picture of the SMA landscape in the Falls region. Recent work by Burdin (2008) at the Breeden and Overflow Pond sites puts us one step closer toward attaining these goals. Additional detailed excavation should be conducted at remaining shell mound sites in the Falls region to get a full sense of the regional variation in SMA sites. An attempt should also be made to look for remnants of "destroyed" sites and investigate damaged SMA sites before they are lost.

A third pursuit for future research is to gather local climatological and ecological data to reconstruct prehistoric vegetation and biomass. This dissertation research relied primarily on topography/slope to conduct least-cost modeling. If detailed paleo-ecological information was available, these models could be refined to include land cover, as well as botanical productivity and resource patches. Surface-Evans (2006) and Burdin (2008) have collected pollen cores at the Overflow Pond and Breeden sites for such purposes. Pollen data is an excellent indicator of prehistoric vegetation, which can in turn be used to estimate biomass or resource productivity. Any plans for archaeological excavation of SMA sites should include the collection of such data for paleoenvironmental reconstruction.

Lastly, the methods used in this dissertation should be tested with data in other regions to determine their effectiveness. The research presented here is just one case study. The specific methods and techniques used herein have broad applications for those conducting landscape reconstructions in general. For example, just as catchment analysis has been widely used in archaeology, corridor modeling has applications for societies including small-scale hunter-gatherers and state-level agriculturalists. More specifically, cost-weighted pathway modeling is particularly useful for hunter-gatherer studies with no documented roadways or trails, because this technique can identify intense zones of travel and possibly predict the locations of additional sites within the settlement system.

With regard to SMA studies, the theoretical questions and methods used in this dissertation to reconstruct the Middle to Late Archaic landscape in the Falls should also be carried out in other regions to ascertain whether the patterns observed also occurred elsewhere. Given the degree of regional variation in the SMA tradition, I expect that other regions will differ in some of the specifics. However, similarities in the social and environmental configuration of the SMA landscapes of other regions should exist if SMA sites are fulfilling similar roles in Archaic lifeways. What makes this study so powerful is that it provides a means to compare regions and place SMA site variation into contexts for anthropological interpretation.

Bibliography

Alcock, S. E.

1993 *Graecia Capta: The Landscapes of Roman Greece*. Cambridge University Press, Cambridge.

Allen, K. M. S., S. W. Green, and E. B. Zubrow (editor)

1990 *Interpreting Space: GIS and Archaeology*. Taylor and Francis, London.

Anderson, D. G.

1996 Approaches to Modeling Regional Settlement in the Archaic Period Southeast. In *Archaeology of the Mid-Holocene Southeast*, edited by K. E. Sassaman, and David G. Anderson, pp. 157-176. University Press of Florida, Gainesville.

2001 Climate and Culture Change in Prehistoric and Early Historic Eastern North America. Archaeology of Eastern North America 29:143-186.

Anderson, D. G., and C. J. Gillam

2000 Paleoindian Colonization of the Americas: Implications from an Examination of Physiography, Demography, and Artifacts. *American Antiquity* 65(1):43-66.

Angst

1998 Archaeological Salvage Excavations at the Reid Site 12Fl-1 Floyd County, Indiana. Ball State University - ARM.

Anschuetz, K. F., Richard H. Wilshusen, and Cherie L. Scheick

2001 An Archaeology of Landscapes: Perspectives and Directions. *Journal of Archaeological Research* 9(2):157-192?

Anslinger, C. M.

1996 The Archaic Period in the Falls of the Ohio Region of Kentucky, pp. 21. Cultural Resource Analysts, Inc.

Bader, A. T.

2004 The Meyer Site: An Inadvertent Discovery in Spencer County, Indiana. *Currents of Change* 2(1):17-29.

Bader, A. T., and Joseph E. Granger

1989 Recent Archaeological Investigations on the Kentucky Air National Guard Site (15Jf267) Jefferson County, Kentucky. Granger Consultants.

Bailey, T., C., and Anthony C. Gatrell

1995 *Interactive Spatial Data Analysis*. Prentice Hall, Essex.

Baltz, C. J., W. K. Pape, J. H. Schulderein, E. J. Harris, S. E. Kozarek, and E. H. Tuttle

1992 Phase I and II Archaeological Investigations at the Proposed River Valley Marina Near Maukport, Harrison County, Indiana. Gray and Pape.

Bassett, J. L.

1986 Geomorphological History of the CMC Floodplain. In *Final Report on the Phase III Mitigation of the Clark Maritime Archaeological District, Clark County, Indiana*, edited by E. Sieber, and A. Ottensen, pp. 17-41. Resource Analysts, Inc., Bloomington.

Bell, J. A.

1994 Interpretation and Testability in Theories about Prehistoric Thinking. In *The Ancient Mind: Elements of Cognitive Archaeology*, edited by C. Renfrew, and E. B. Zubrow, pp. 15-21. Cambridge University Press, Cambridge.

Bell, T., and G. Lock

2000 Topographic and cultural influences on walking the ridgeway in later prehistoric times. In *Beyond the Map: Archaeology and Spatial Technologies*, edited by G. Lock, pp. 85-100. NATO Science Series A: Life Sciences. vol. 321. IOS Press, Amsterdam.

Bellis, J. O.

1968 An Appraisal of the Archaeological Resources of the Lafayette and Patoka Reservoirs and a Report of the Test Excavation Conducted at Site Hr 11 in Harrison County, Indiana. Indiana University.

1981 Test Excavations at the Breeden Site 12-Hr-11, In Harrison County, Indiana. *Proceedings of the Indiana Academy of Science* 91:78-92.

Bender, B.

1985 Emergent Tribal Formations in the American Midcontinent. *American Antiquity* 50(1):52-62.

1992 Theorizing Landscapes, and the Prehistoric Landscapes of Stonehenge. *Man* 27(4):735-755.

2002 Time and Landscape. *Current Anthropology* 43(Supplement):S103-112.

Benz, B. J., Jane Stone, and C. A. Bergman

1997 Emergency Archaeological Excavations at 12Fl1 in Floyd County, Indiana. Cultural Resources Program - 3/D Environmental.

Bettinger, R. L.

1991 *Hunter-gatherers: Archaeological and Evolutionary Theory*. Interdisciplinary Contributions to Archaeology. Plenum Press, New York.

Binford, L. R.

1980 Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45(1):4-20.

1982 The Archaeology of Place. *Journal of Anthropological Archaeology* 1:5-34.

2001 *Constructing Frames of Reference: An Analytical Method for Archaeological Theory Building Using Hunter-Gatherer and Environmental Data*. University of California Press, Berkeley.

Boaz, J., and E. Uleberg

2000 Quantifying the non-quantifiable: studying hunter-gatherer landscapes. In *Beyond the Map: Archaeology and Spatial Technologies*, edited by G. Lock, pp. 101-115. NATO Science Series A: Life Sciences. vol. 321. IOS Press, Amsterdam.

Bonzani, R. M.

2002 Botanical Analysis for Site 12-Fl-73, Indiana. In *An Archaeological Assessment of Site 12-Fl-73 in Floyd County, Indiana*, edited by S. R. Burdin, pp. 113-116. University of Kentucky, Department of Anthropology, Lexington.

2008 Botanical Analysis for the Breeden (12Hr11) and Overflow Pond (12Hr12) Sites. In *Archaeological Investigations of the Overflow Pond Area in Harrison County, Indiana: The 2007 Survey and Excavations at the Breeden (12Hr11) and Overflow Pond (12Hr12) Sites*, edited by S. R. Burdin, pp. A1-A12. University of Kentucky, Department of Anthropology, Lexington.

Boone, J. L.

1987 Defining and Measuring Midden Catchment. *American Antiquity* 52(2):336-345.

Borden, W.

1874 Report of a Geological Survey of Clark and Floyd Counties, Indiana, pp. 184-186. Indiana Geological Survey, Indianapolis.

Boulding, J. R.

1993 Geomorphology and Soils of the Ohio River Flood Plain South of New Albany, Floyd County, Indiana, with Special Reference to the Paddy's West Substation. In *Archaeological Investigations at the Paddy's West Substation*

Floyd County, Indiana, edited by E. E. Smith, and S. Mocas. Glenn A. Black Laboratory of Archaeology, Indiana University. Report of Investigations 93-8.

1995 Geomorphology and Geoarchaeology of the Swan's Lansing Site (12Hr304) on the Ohio River, Harrison County, Indiana. In *Archaeological Subsurface Investigations at the Swan's Lansing Site (12Hr304), Harrison County, Indiana*, edited by S. T. Mocas, and Edward E. Smith, pp. 25-46. Glenn A. Black Laboratory of Archaeology, Reports of Investigations 95-36, Bloomington.

1996 Pedoarchaeological Investigations of Sites 12Cl81, 12Cl77 and 12Cl425, Bethlehem Bottoms, Clark County, Indiana. In *Phase 3 Archaeological Data Recovery from a Portion of Site 12Cl81 and Geomorphological Investigations in the E. T. Slider Permit Area (ID #199201279), Near Bethlehem, Clark County, Indiana*, edited by Edward E. Smith, and Stephen T. Mocas. vol. ROI 96-33. Indiana University - GBL.

Bradley, R.

1993 *Altering the Earth: The Origins of Monuments in Britain and Continental Europe*. Society of Antiquities of Scotland.

1996 Ruined Buildings, Ruined Stones: Enclosures, Tombs, and Natural Places in the Neolithic of South-west England. *World Archaeology* 30(1):13-22.

Brand, L.

1934 Some Notes on the Pleistocene History of the Cincinnati Region. *The Ohio Journal of Science* 34(2):67-85.

Brinker, R., Perry Harrell, Sandy Jones, and Cheryl A. Munson

1980 Archaeological Reconnaissance of the Initial Work Stages at a Sand and Gravel Pit, Ohio River Mile 578, Clark County, Indiana. Glen A. Black Laboratory of Archaeology, Indiana University.

Brown, J. A., and R. K. Vierra

1983 What Happened in the Middle Archaic? Introduction to an Ecological Approach to Koster Site Archaeology. In *Archaic Hunters and Gatherers in the American Midwest*, edited by J. Phillips, and J. Brown, pp. 165-196. Academic Press, New York.

Buikstra, J., and D. Charles

1999 Centering the Ancestors: Cemeteries, Mounds, and Sacred Landscapes of the Ancient North American Midcontinent. In *Archaeologies of Landscape: Contemporary Perspectives*, edited by W. Ashmore, and A. Knapp, pp. 201-228. Blackwell Publishers, Malden.

Burdin, S. R.
1998 *The Archaeology of the Falls Area of the Ohio River Valley: Paleoindian and Archaic Periods (12,000 - 2,750 BP)*, unpublished manuscript on file with the Department of Anthropology, Indiana University Southeast.

2002 An Archaeological Assessment of Site 12Fl-73 in Floyd County, Indiana. University of Kentucky, Department of Anthropology, Lexington.

2004 *Interaction, Exchange, and Politics Among Hunter-Gatherers in the Midcontinent- Evidence from the Lower Ohio River Valley: Bannerstone Use from 6500 to 3000 B.P.* MS Thesis, On File at the Department of Anthropology, University of Kentucky, Lexington.

2008 *Archaeological Investigations of the Overflow Pond Area in Harrison County, Indiana: The 2007 Survey and Excavations at the Breeden (12Hr11) and Overflow Pond (12Hr12) Sites.* University of Kentucky, Department of Anthropology, Lexington.

Burnett, R.
1963 Lone Hill. *Central States Archaeological Journal* 10:84-90.

Burrough, P., and R. McDonnell
1998 *Principles of Geographical Information Systems.* Spatial Information Systems and Geostatistics. Oxford University Press, Oxford.

Butzer, K.
1990 A Human Ecosystem Framework for Archaeology. In *The Ecosystem Approach in Anthropology: From Concept to Practice*, edited by E. F. Moran, pp. 91-130. University of Michigan Press, Ann Arbor.

1996 Ecology in the Long View: Settlement Histories, Agrosystem Strategies, and Ecological Performance. *Journal of Field Archaeology* 23:141-150.

Campbell, R. K.
1997 Limestone Ledges and "Crawfish Flats": The Bluegrass Natural Region. In *The Natural Heritage of Indiana*, edited by M. T. Jackson, pp. 161-166. Indiana University Press, Bloomington.

Cantin, M.
1994 *Provenience, Description, and Archaeological Use of Selected Cherts in Indiana.* Indiana State University.

Carlson, D. L.
1979 *Hunter-gatherer Mobility Strategies: An Example from the Koster Site in the Lower Illinois Valley.*, Unpublished PhD. Dissertation, Department of Anthropology, Northwestern University, Evanston.

Carmichael, D. L.
1990 GIS Predictive Modeling of Prehistoric Site Distributions in Central Montana. In *Interpreting Space: GIS and Archaeology*, edited by K. M. S. Allen, S. W. Green, and E. B. Zubrow, pp. 216-225. Talyor and Francis, London.

Carr, L., and N. S. Shaler
1876 *On the Prehistoric Remains of Kentucky*. Memoirs of the Geological Survey of Kentucky. Kentucky Geological Survey, Frankfort.

Chapman, L. N., and Joseph Granger
1971 An Archaeological Survey of the Southwest Jefferson County, Kentucky Local Flood Protection Project. University of Louisville.

Charles, D. K., and J. E. Buikstra
1983 Archaic Mortuary Sites in the Central Mississippi Drainage: Distribution, Structure, and Behavioral Implications. In *Archaic Hunter-Gatherers in the American Midwest*, edited by J. L. Phillips, and James A. Brown, pp. 117-145. Academic Press, New York.

Church, T., R. Brandon, and G. R. Burgett
2000 GIS Applications in Archaeology: Method in Search of Theory. In *Practical Applications of GIS for Archaeologists: A Predictive Modeling Kit*, edited by K. Wescott, and J. Brandon, pp. 135-155. Taylor and Francis, London.

Claassen, C.
1986 Shellfishing Seasons in the Prehistoric Southeastern United States. *American Antiquity* 51(1):21-37.

1996 A Consideration of the Social Organization of the Shell Mound Archaic. In *Archaeology of the Mid-Holocene Southeast*, edited by K. E. Sassaman, and David G. Anderson, pp. 235-258. University of Florida Press, Gainsville.

2005 An Analytical Study of Shellfish from the DeWeese Mound, Kentucky. In *Archaeology of the Middle Green River Region, Kentucky*, edited by W. H. Marquardt, and P. J. Watson. Institute of Archaeology and Paleoenvironmental Studies. Monograph No. 5. Florida Museum of Natural History, University of Florida, Gainesville.

Clark, J. G. D.
1975 *The Earlier Stone Age Settlements of Scandinavia*. Cambridge University Press, Cambridge.

Clarke, D. L.
1977 Spatial Information in Archaeology. In *Spatial Archaeology*, edited by D. Clarke, pp. 1-32. Academic Press, New York.

Coffee, G.
1958 Major Glacial Drainage Changes in Ohio. *The Ohio Journal of Science* 58(1):43-49.

Collins, M. B. (editor)
1979 *Excavations at Four Archaic Sites in the Lower Ohio Valley Jefferson County, Kentucky*. 2 vols. University of Kentucky, Department of Anthropology, Occasional Papers in Anthropology 1, Lexington.

Colvin, G. H.
2003 Cannel Coal - Origin, Recognition, Distribution and Use in Ohio. *Ohio Archaeologist* 53(3):4-8.

Cosgrove, D. E.
1984 *Social Formation and Symbolic Landscape*. University of Wisconsin Press, Madison.

Cowin, V. L.
1999 Cannel Coal Pendants: Types and Distribution. *North American Archaeologist* 20(3):239-262.

Cox, E. T.
1879 *Eighth, Ninth, and Tenth Annual Reports of the Geological Survey of Indiana*. Indianapolis Journal Company, Indianapolis.

Crawford, G. W.
1982 Late Archaic Plant Remains from West-Central Kentucky: A Summary. *Midcontinental Journal of Archaeology* 7(2):205-224.

2005 Plant Remains from Carlston Annis (1972, 1974), Bowles, and Peter Cave. In *Archaeology of the Middle Green River Region, Kentucky*, edited by W. H. Marquardt, and P. J. Watson. Institute of Archaeology and Paleoenvironmental Studies. Monograph No. 5. Florida Museum of Natural History, University of Florida, Gainesville.

Crothers, G. M.
1999 *Prehistoric Hunters and Gatherers, and the Archaic Period Green River Shell Middens of Western Kentucky*. Ph.D., Washington University.

2005 Vertebrate Fauna from the Carlston Annis Site. In *Archaeology of the Middle Green River Region, Kentucky*, edited by W. H. Marquardt, and P. J. Watson. Institute of Archaeology and Paleoenvironmental Studies. Monograph No. 5. Florida Museum of Natural History, University of Florida, Gainesville.

Dennel, R.
1983 *European Economic Prehistory: A New Approach*. Academic Press, New York.

Dovey, K.
1985 The Quest for Authenticity and the Replication of Environmental Meaning. In *Dwelling, Place, and Environment: Towards and Phenomenology of Person and World*, edited by D. Seamon, and R. Mugerauer, pp. 33-50. Kluwer Academic Publishers, Boston.

Duerkson, K., and C. Bergman
1995 Phase I Archaeological Survey of a Proposed 50 Acre Sand and Gravel Quarry in Floyd County, Indiana.

Dye, D. H.
1996 Riverine Adaptation in the Midsouth. In *Of Caves and Shell Mounds*, edited by K. C. Carstens, and P. J. Watson, pp. 140-158. University of Alabama Press, Tuscaloosa.

Ebert, J. I., and R. K. Hitchcock
1980 Locational Modeling in the Analysis of the Prehistoric Roadway System at and around Chaco Canyon, New Mexico. In *Cultural Resource Remote Sensing*, edited by T. R. Lyons, and F. J. Mathien, pp. 167-207. National Park Service, Washington DC.

Edmonds, M. R.
1999 *Ancestral Geographies of the Neolithic: Landscapes, Monuments, and Memory*. Routledge, New York.

Emerson, T., D. McElrath, and J. Williams
1986 Patterns of Hunter-Gatherer Mobility and Sedentism During the Archaic Period in the American Bottom. In *Foraging, Collecting, and Harvesting: Archaic Period Subsistence and Settlement in the Eastern Woodlands*, edited by S. W. Neusius, pp. 247-274. Southern Illinois University at Carbondale, Center for Archaeological Investigations, Occasional Paper No. 6, Carbondale.

Erickson, C. L.
1999 Neo-environmental Determinism and Agrarian 'Collapse' in Andean Prehistory. *Antiquity* 73(10):634-642.

Feld, S.
1996 Waterfalls of Song: An Acoustemology of Place Resounding in Bosavi, Papua New Guinea. In *Senses of Place*, edited by S. Feld, and K. Basso, pp. 91-136. School of American Research Press, Sante Fe.

Fenneman, N.
1914 Preglacial Miami and Kentucky Rivers. *Geological Society of American Bulletin* 25:85.

Fisher, C. T., and T. L. Thurston
1999 Special Section: Dynamic Landscapes and Socio-political processes: the topography and anthropogenic environments in global perspective. *Antiquity* 73(10):630-632.

Ford
1882 *History of the Ohio Falls Cities and Their Counties* 1 & 2. L. A. William & Co., Cleveland.

Fowke, G.
1925 The Genesis of the Ohio River. *Proceedings of the Indiana Academy of Science* 34:81-102.

Frasher, G., and D. Fishbaugh
1986 *Alluviation of the Ohio River Valley near Evansville, Indiana and Its Effect on the Distribution of Sand and Gravel in the Area.* Indiana Geological Survey Special Report 36, Bloomington.

Funkhouser, W. D., and W. S. Webb
1932 Archaeological Survey of Kentucky. vol. II. University of Kentucky, Reports in Archaeology and Anthropology, Lexington.

Goldstein, L.
1995 Landscapes as Mortuary Practices: A Case for Regional Perspectives. In *Regional Approaches for Mortuary Analysis*, edited by L. A. Beck, pp. 101-121. Plenum Press, New York.

Gorenflo, L. J., and Thomas L. Bell
1991 Network Analysis and the Study of Past Regional Organization. In *Ancient Road Networks and Settlement Hierarchies in the New World*, edited by C. D. Trombold. Cambridge University Press, Cambridge.

Granger, J.

1976 *A Preliminary Regional Research Design for Jefferson County, Kentucky*. Archaeological Survey, University of Louisville, Louisville.

1980 *The Prehistoric Cultural Resources of Lock and Dam 43, Harrison County, Indiana*. United States Army Corps of Engineers, Louisville.

1988 Late/Terminal Archaic Settlement in the Falls of the Ohio River Region of Kentucky: An Examination of Components, Phases, and Clusters. In *Paleoindian and Archaic Research in Kentucky*, edited by C. D. Hockensmith, D. Pollack, and T. N. Sanders, pp. 153-204. Kentucky Heritage Council, Frankfort.

Granger, J. E., and Ann T. Bader

1991 Guthrie Beach Archaeology: Archaic and Woodland Settlement Variation on Floodplain and Upland in Jefferson County, Kentucky. In *Studies in Kentucky Archaeology*, edited by C. D. Hockensmith, pp. 27-44. Kentucky Heritage Council, Frankfort.

Granger, J. E., B. J. McGraw, & D. E. Janzen

1973 *A Reconnaissance and Evaluation of "Known" Prehistoric Sites in the Falls of the Ohio Region.* Archaeological Survey, University of Louisville, Louisville.

Gray, H. H.

1979 Summary and Discussion of the Geologic Data. In *Excavations at Four Archaic Sties in the Lower Ohio Valley, Jefferson County, Kentucky*, edited by M. B. Collins, pp. 883-899. 2 vols. University of Kentucky, Department of Anthropology, Occasional Papers in Anthropology 1., Lexington.

1984 Archaeological Sedimentology of Overbank and Silt Deposition on the Floodplain of the Ohio River Near Louisville, Kentucky. *Journal of Archaeological Science* 11:421-223.

1997 The View from the Window: Physiography. In *The Natural Heritage of Indiana*, edited by M. T. Jackson, pp. 28-44. Indiana University Press, Bloomington.

2000 *Physiographic Divisions of Indiana*. Special Report 61. Indiana Geological Survey, Bloomington.

Guernsey, E. Y.

1939 Relationships Among Various Clark County Sites. *Proceedings of the Indiana Academy of Science* 48:27-32.

1942 The Culture Sequence of the Ohio Falls Sites. *Proceedings of the Indiana Academy of Science* 51:60-67.

Hammett, J. E.

1992 The Shapes of Adaptation: Historical Ecology of Anthropogenic Landscapes in the Southeastern United States. *Landscape Ecology* 7(2):121-135.

Harris, T.

2000 Moving GIS: Exploring Movement within Prehistoric Cultural Landscapes using GIS. In *Beyond the Map: Archaeology and Spatial Technologies*, edited by G. Lock, pp. 116-123. NATO Science Series A: Life Sciences. vol. 321. IOS Press, Amsterdam.

Haskell, B., R. Arm, J. Stroop, and J. Shaunessey

1985 The Role of the Dentist in Archaeological Investigation: An Unusual Facial Fracture with Healing Occurring 3,000 Years Ago. *Quintessence International* 1:95-101.

Haywood, N.

1995 A Phase 1c Subsurface Archaeological Reconnaissance for the Proposed 50 Acre Sand and Gravel Quarry in Floyd County, Indiana. Cultural Resources Program - 3/D Environmental.

Hensely, C.

1988 *The Green River Archaeological Study Preliminary Report: Phase I.* Manuscript on file, Kentucky Heritage Council, Frankfort.

1991 The Green River Archaeological Study. In *Studies in Kentucky Archaeology*, edited by C. D. Hockensmith, pp. 11-26. Kentucky Heritage Council, Frankfort.

1994 *The Archaic Settlement System of the Middle Green River Valley, Kentucky*, Washington University.

Hodder, I., & Clive Orton

1979 *Spatial Analysis in Archaeology.* New Studies in Archaeology. Cambridge University Press, Cambridge.

Holiday, V. (editor)

1997 *Soils in Archaeology: Landscape Evolution and Human Occupation.* Smithsonian Institution Press, Washington.

Homoya, M. A.
1997 Land of the Cliff Dwellers: The Shawnee Hills Natural Region. In *The Natural Heritage of Indiana*, edited by M. T. Jackson, pp. 172-176. Indiana University Press, Bloomington.

Homoya, M. A., and H. Huffman
1997 Sinks, Slopes, and Stony Disposition: The Highland Rim Natural Region. In *The Natural Heritage of Indiana*, edited by M. T. Jackson, pp. 167-171. Indiana University Press, Bloomington.

Hood, E.
1996 Social Relations and Cultural Landscapes. In *Landscape Archaeology*, edited by Yamin, and Methany, pp. 121-146. University of Tennessee Press, Knoxville.

Hunt, E.
1992 Upgrading Site-Catchment Analysis with the Use of GIS: Investigating the Settlement Patterns of Horticulturalists. *World Archaeology* 24(2):283-309.

Ingold, T.
1993 The Temporality of the Landscape. *World Archaeology* 25(2):152-174.

2000 *The Perception of the Environment: Essays in Livelihood, Dwelling, and Skill.* Routledge, London.

Janzen, D. E.
1971 Excavations at the Falls of the Ohio River Region. Paper presented at the Kentucky Archaeological Association.

1972 Archaeological Investigations in Louisville and Vicinity: A Historical Sketch. *The Filson Club Quarterly* 46(4):305-321.

1977 An Examination of Late Archaic Development in the Falls of the Ohio River Area. In *Anthropological Papers, Museum of Anthropology No. 61*, edited by C. Cleland, pp. 123-143. University of Michigan, Ann Arbor.

2008 *Unearthing the Past: The Archaeology of the Falls of the Ohio River Region*. Butler Books, Louisville.

Jefferies, R.
1988 Archaic Period Research in Kentucky: Past Accomplishments and Future Directions. In *Paleoindian and Archaic Research in Kentucky*, edited by C. D. Hockensmith, D. Pollack, and T. N. Sanders, pp. 85-126. Kentucky Heritage Council, Frankfort.

1996a Hunters and Gatherers After the Ice Age. In *Kentucky Archaeology*, edited by B. Lewis. Kentucky University Press, Lexington.

1996b The Emergence of Long-Distance Exchange Networks in the Southeastern United States. In *Archaeology of the Mid-Holocene Southeast*, edited by K. E. Sassaman, and David G. Anderson, pp. 222-234. University of Florida Press, Gainesville.

1997 Middle Archaic Bone Pins: Evidence of Mid-Holocene Regional Scale Social Groups in the Southern Midwest. *American Antiquity* 62(3):464-487.

Jefferies, R., and B. Lynch
1983 Dimensions of Middle Archaic Cultural Adaptations at the Black Earth Site, Saline County, Illinois. In *Archaic Hunters and Gatherers in the American Midwest*, edited by J. L. Phillips, and James A. Brown, pp. 299-322. Academic Press, New York.

Jefferies, R., V. Thompson, and G. Milner
2005 Archaic Hunter-Gatherer Landscape Use in West-Central Kentucky. *Journal of Field Archaeology* 30(1):3-23.

Jochim, M.
1998 *A Hunter-Gatherer Landscape: Southwest German in the Late Paleolithic and Mesolithic*. Interdisciplinary Contributions to Archaeology, Plenum Press, New York.

Justice, N. D.
1995 *Stone Age Spear and Arrow Points of the Midcontinental and Eastern United States: A Modern Survey and Reference*. Indiana University Press, Bloomington.

Kantner, J.
1996 An Evaluation of Chaco Anasazi Roadways. Paper presented at the 61st Society for American Archaeology, New Orleans.

Kelly, R. L.
1992 Mobility/Sedentism: Concepts, Archaeological Measures, and Effects. *Annual Review of Anthropology* 21:43-66.

1995 *The Foraging Spectrum: Diversity in Hunter-gatherer Lifeways*. Smithsonian Institution Press, Washington.

Kiedman C. and A. Shortridge
1998 GIS: Do you know where your errors are? *EMIS Tech* 2(1).

Kent, S., and H. Vierich
1989 The Myth of Ecological Determinism - Anticipated Mobility and Site Spatial Organization. In *Farmers as Hunters: The Implications of Sedentism*, edited by S. Kent, pp. 96-139. Cambridge University Press, Cambridge.

Kuna, M., and D. Adelsbergerova
1995 Prehistoric Location Preferences: An Application of GIS to the Vinorsky Potok Project, Bohemia, the Czech Republic. In *Archaeology and Geographical Information Systems: A European Perspective*, edited by G. Lock, and Voran Stancic, pp. 117-139. Taylor and Francis, London.

Kus, S.
1983 The Social Dimension of Space: Dimensioning the Cosmological and the Quòtidian. In *Archaeological Theories and Hammers*, edited by J. A. Moore, and A. S. Keene, pp. 277-297. Academic Press, New York.

Lockhart, R. A., and C. Schmidt
2007 Evidence of Decapitation and 'trophy-taking' during the Late Archaic in Southern Indiana. Paper presented at the Seventy-Sixth Annual Meeting of the American Association of Physical Anthropologists, Philadelphia.

Longley, P., M. Goodchild., D. Maguire, and D. Rhind
2001 *Geographic Information Systems Science*. John Wiley & Sons, Chichester.

Lovis, W. A.
1986 Environmental Periodicity, Buffering, and the Archaic Adaptations of the Saginaw Valley of Michigan. In *Foraging, Collecting, and Harvesting: Archaic Period Subsistence and Settlement in the Eastern Woodlands*, edited by S. W. Neusius, pp. 99-116. Southern Illinois University at Carbondale, Center for Archaeological Investigations, Occasional Paper No. 6, Carbondale.

Mandel, R. (editor)
2000 *Geoarchaeology in the Great Plains*. University of Oklahoma Press, Norman.

Marquardt, W. H.
1985 Complexity and Scale in the Study of Fisher-Gatherer-Hunters: An Example from the Eastern United States, edited by T. D. Price, and J. A. Brown, pp. 59-98. Academic Press, Orlando.

Marquardt, W. H., and P. J. Watson (editor)
2005a *Archaeology of the Middle Green River Region, Kentucky*. Institute of Archaeology and Paleoenvironmental Studies. Monograph No. 5. Florida Museum of Natural History, University of Florida, Gainesville.

2005b The Green River Shell Mound Archaic: Conclusions. In *Archaeology of the Middle Green River Region, Kentucky*, edited by W. H. Marquardt, and P. J. Watson, pp. 629-648. Institute of Archaeology and Paleoenvironmental Studies. Monograph No. 5. Florida Museum of Natural History, University of Florida, Gainesville.

Marquardt, W. H., and Patty J. Watson
1983 The Shell Mound Archaic of Western Kentucky. In *Archaic Hunters and Gatherers in the American Midwest*, edited by J. L. Phillips, and James A. Brown, pp. 323-339. Academic Press, New York.

Martin, P. S.
1973 The Discovery of America. *Science* 179:969-974.

Maslowski, R. F., C. M. Niquette, and D. M. Wingfield
1995 The Kentucky, Ohio, and West Virginia Radiocarbon Database. *West Virginia Archaeologist* 47:1-2.

May, J.
2005 An Exploratory Quantification of Midden Constituents to Detect Archaeological Strata at the Carlston Annis Site, 15Bt5. In *Archaeology of the Middle Green River Region, Kentucky*, edited by Marquardt, W. H., and P. J. Watson, pp. 167-181. Institute of Archaeology and Paleoenvironmental Studies. Monograph No. 5. Florida Museum of Natural History, University of Florida, Gainesville.

McBride, J. D. E.
2000 *The Baker Site and the Late Middle Archaic Period in the Green River Region of West Central Kentucky.* Masters, University of Kentucky.

McGlade, J.
1995 Archaeology and the Ecodynamics of Human-modified Landscapes. *Antiquity* 69:113-132.

McGrath, K., A. Bader, and D. Janzen
2005 Further Clarifications of Matanzas and McWhinney Projectile Points in the Falls of the Ohio Area. Paper presented at the Falls of the Ohio Archaeological Society Lithic Conference, Louisville, Kentucky.

McPherson, A.
1993 *Indian Names in Indiana*. The Blasted Works, Monticello.

Mocas, S.
1976 *Excavations at Arrowhead Farm (15Jf237).* University of Louisville Archaeological Survey, Louisville.

Mocas, S., and E. Smith
1994 An Archaeological Surface and Subsurface Reconnaissance of the Proposed E. T. Slider Permit Area Near Bethlehem, Clark County, Indiana. Indiana University - Glenn Black Laboratory of Archaeology.

Mocas, S. T., and Edward E. Smith
1995 *Archaeological Subsurface Investigations at the Swan's Lansing Site (12Hr304), Harrison County, Indiana.* Glenn A. Black Laboratory of Archaeology. Reports of Investigations 95-36, Bloomington.

Monaghan, G. W., and W. A. Lovis
2005 *Modeling Archaeological Site Burial in Southern Michigan: A Geoarchaeological Synthesis.* Environmental Research Series No. 1, Michigan Department of Transportation. Michigan State University Press, East Lansing.

Moore, C. B.
1916 Some Aboriginal Sites on the Green River, Kentucky. *Journal of the Academy of Sciences of Philadelphia* 25:907-926.

Morey, D. F., and G. M. Crothers
1998 Clearing up Clouded Waters: Paleoenvironmental Analysis of Freshwater Mussel Assemblages from the Green River Shell Middens, Western Kentucky. *Journal of Archaeological Science* 25:907-926.

Munson, C. A., and T. G. Cook
1980 Chronology of the Excavated Sites: Radiocarbon Dates, Cultural Components, and Stratigraphy. In *Archaeological Salvage Excavations at Patoka Lake, Indiana: Prehistoric Occupations of the Upper Patoka River Valley*, edited by C. A. Munson, pp. 468-503. Glenn A. Black Laboratory of Archaeology, Indiana University, Bloomington.

Munson, P. J., and C. A. Munson
1990 *The Prehistoric and Early Historic Archaeology of Wyandotte Cave and Other Caves in Southern Indiana.* Prehistoric Research Series VII(1). Indiana Historical Society, Indianapolis.

Parmalee, P. W., and W. E. Klippel
1974 Freshwater Mussels as a Prehistoric Food Resource. *American Antiquity* 39(3):421-434.

Parslow, C.
2006 *Social Interaction in the Prehistoric Natufian: Generating an Interactive Agency Model Using GIS.* unpublished Ph.D. Dissertation, University of Toronto, Toronto.

Petty, R., and M. Jackson
1966 Plant Communities. In *Natural Features of Indiana*, edited by A. Lindsey, pp. 264-296. Indiana Academy of Science, Indianapolis.

Phillips, J. L., and James A. Brown (editor)
1983 *Archaic Hunter-Gatherers in the American Midwest.* Academic Press, Inc.

Pitts, F.
1965 A Graph-Theoretic Approach to Historical Geography. *The Professional Geographer* 17:15-20.

Powell, R. L.
1999 *Geology of the Falls of the Ohio River.* Circular 10. Indiana Geological Survey, Bloomington.

Price, T. D., and James A. Brown (editor)
1985 *Prehistoric Hunter-Gatherers: The Emergence of Cultural Complexity.* Academic Press, Orlando.

Rapp, G., and C. Hill
1998 *Geoarchaeology: The Earth-Science Approach to Archaeological Interpretation.* Yale University Press, New Haven.

Ray, L.
1957 Two Significant New Exposures of Pleistocene Deposits Along the Ohio River Valley in Kentucky. *Journal of Geology* 65(5):542-545.

1960 *Significance of Loess Deposits along the Ohio River Valley.* United States Geological Survey Professional Paper 400-B.

1963 *Quaternary Events along the Unglaciated Lower Ohio River Valley.* United States Geological Survey Professional Paper 475-B.

1974 *Geomorphology and Quaternary Geology of the Glaciated Ohio River Valley.* United States Geological Survey Professional Paper 826.

Redman, K.
1995 *Analysis of Human Skeletal Material from the Lone Hill Site (15Jf10) Jefferson County, Kentucky.* Unpublished manuscript held at ARCS, Inc., Louisville.

Reidhead, V. A.

1981 *A Linear Programming Model of Prehistoric Subsistence Optimization: A Southeastern Indiana Example.* Prehistory Research Series VI(1). Indiana Historical Society, Indianapolis.

Richards, C.

1996 Henges and Water. *Journal of Material Culture* 1(3):313-335.

Robbins, J. M.

1975 *Soil Survey of Harrison County, Indiana.* United States Department of Agriculture Soil Conservation Service.

Rothschild, N. A.

1979 Mortuary Behavior and Social Organization at Indian Knoll and Dickson Mounds. *American Antiquity* 44:658-675.

Russell, E.

1996a Geomorphology of the Bethlehem Bottoms and the Potential for Buried Deposits in the Floodplain. In *Phase 1 Archaeological Surface Reconnaissance within the Proposed Nugent Sand and Gravel Extraction Area, Near Bethlehem, Clark County, Indiana*, edited by Stephen T. Mocas, and Edward E. Smith. vol. ROI 96-38. Indiana University - GBL.

1996b *Geoarchaeological Investigations of Ohio River Terrace Deposits Near Bethlehem, Indiana*, Indiana University.

Sassaman, K. E.

2008 The New Archaic, it ain't what it used to be. *The SAA Archaeological Record, Special Issue: The New Archaic.* November 2008:6-8.

Sauer, C. O.

1944 A Geographical Sketch of Early Man in America. *Geographical Review* 34:543-554.

Savage, S. H.

1990a GIS in Archaeological Research. In *Interpreting Space: GIS and Archaeology*, edited by K. M. S. Allen, S. W. Green, and E. B. Zubrow, pp. 22-32. Taylor and Francis, London.

1990b Modeling the Late Archaic Social Landscape. In *Interpreting Space: GIS and Archaeology*, edited by K. M. S. Allen, S. W. Green, and E. B. Zubrow, pp. 330-355. Taylor and Francis, London.

Schackleton, N. J., and N.D. Obdyke
1976 Oxygen isotope and paleomagnetic stratigraphy of Pacific Coree v28-239, Late Pliocene to Latest Pleistocene. *Geological Society of America Memoir 145.*

Schermer, S., and J. Tiffany
1985 Environmental Variables as Factors in Site Location: An Example from the Upper Midwest. *Midcontinental Journal of Archaeology* 10(2):215-240.

Schiffer, M. B.
1987 *Formation Processes of the Archaeological Record.* University of Utah Press, Salt Lake City.

Seeman, M.
1975 The Prehistoric Chert Quarries and Workshops of Harrison County, Indiana. *Indiana Archaeological Bulletin* 1:47-61.

Shortridge, A.
2001 Characterizing Uncertainty in Digital Elevation Models. In *Spatial Uncertainty in Ecology: Implications for Remote Sensing and GIS Applications*, edited by C.T. Hunsaker, M. Goodchild, M. Friedl, and M. Case, pp. 238-257. Springer, New York.

Smith, B. D.
1987 The Independent Domestication of Indigenous Seed-Bearing Plants in Eastern North America. In *Emergent Horticultural Economies of the Eastern Woodlands*, edited by W. F. Keegan. Center for Archaeological Investigations, Occasional Paper No. 7, Southern Illinois University, Carbondale.

Smith, E., and Mocas, S.
1993 Archaeological Investigations of the Paddy's West Substation Floyd County, Indiana. Indiana University, Glen Black Labratory of Archaeology.

Smith, E., and S. R. Burdin, S. L. Surface
1999 *Executive Summary: Phase 2 Archaeological Subsurface Reconnaissance and Testing of Sites with Portions of the Proposed Nugent Sand Company Sand and Gravel Extraction Area near Bethlehem, Clark County, Indiana.* Report of Investigations 99-6, Indiana University-Purdue University at Fort Wayne Archaeological Survey, Fort Wayne.

Stafford, C. R.

1995 *Geoarchaeology in the Knob Creek-Ohio River Confluence Area: The Thompson Engineering Development, Harrison County, Indiana*. Indiana State University Anthropology Laboratory, Technical Report 26, Terre Haute.

2004 Modeling Soil-geomorphic Associations and Archaic Stratigraphic Sequences in the Lower Ohio River Valley. *Journal of Archaeological Science* 31:1053-1067.

Stafford, C. R., and M. Cantin

2005 Archaic Period Chronology in the Hill Country of Southern Indiana. In *Urbana Conference on the Archaic Societies of the Midcontinent*, Champaign-Urbana, Illinois.

Stafford, C. R., and S. D. Creasman

2002 The Hidden Record: Late Holocene Landscapes and Settlement Archaeology in the Lower Ohio River Valley. *Geoarchaeology* 17(2):117-140.

Stafford, C. R., R. Richards, and C. Anslinger

2000 Bluegrass Fauna and Changes in Middle Holocene Hunter-Gatherer Foraging in the Southern Midwest. *American Antiquity* 65(2):317-336.

Stein, J. K.

1980 *Geoarchaeology of the Green River Shell Mounds, Kentucky*, University of Minnesota.

1992 *Deciphering a Shell Midden*. Academic Press, Inc., San Diego.

2005 Environment of the Green River Sites. In *Archaeology of the Middle Green River Region, Kentucky*, edited by Marquardt, W. H., and P. J. Watson, pp. 19-40. Institute of Archaeology and Paleoenvironmental Studies. Monograph No. 5. Florida Museum of Natural History, University of Florida, Gainesville.

Straw, W.

1958 The Upper Alluvial Terrace Along the Ohio River Valley in South-Central Indiana. *Proceedings of the Indiana Academy of Science* 77:231-235.

Styles, B., and S. Ahler

2000 Changing Perspectives on the Archaic: Contributions from Modoc Rock Shelter. In *Mounds, Modoc, and Mesoamerica: Papers in Honor of Melvin L. Fowler*, edited by S. Ahler, pp. 25-38. Illinois State Museum Scientific Papers, Volume 28, Springfield.

Styles, B. W.
1986 Aquatic Exploitation in the Lower Illinois River Valley: The Role of Paleoecological Change. In *Foraging, Collecting, and Harvesting: Archaic Period Subsistence and Settlement in the Eastern Woodlands*, edited by S. W. Neusius, pp. 145-174. Center for Archaeological Investigations, Southern Illinois University, Occasional Paper 6.

Surface-Evans, S.
2002 Geoarchaeology of the Nugent East Area. In *Final Report of Investigations of the Nugent East Area*, edited by A. White, pp. 209-221. Report of Investigations 206. Indiana University-Purdue University at Fort Wayne Archaeological Survey, Fort Wayne.

2005 *Surface and Subsurface Archaeological Reconnaissance of the Floodplain Portion of the Lucas Tract, Clark County, Indiana.* Report of Investigations 420. Indiana University-Purdue University at Fort Wayne Archaeological Survey, Fort Wayne.

2006 *Report of Pollen Collection from the Breeden Shell Midden (12-Hr-11) and Overflow Pond, Harrison, County, Indiana.* Michigan State University, East Lansing.

Tacon, P.
1999 Identifying Ancient Sacred Landscapes in Australia: From Physical to Sacred. In *Archaeologies of Landscape: Contemporary Perspectives*, edited by W. Ashmore and A. B. Knapp. Blackwell Publishers, Malden.

Tanaka, J.
1980 *The San Hunter-Gatherers of the Kalahari: A Study of Ecological Anthropology.* University of Tokyo Press, Tokyo.

Thomas, S. W., and E. H. Conner
1971 The Falls of the Ohio River and Its Environs: The Journals of Increase Allen Lapham for 1827-1830. *The Filson Club Quarterly* 45(1):5-403.

Thorp, J., and A. Covich
1991 *Ecology and Classification of North American Freshwater Invertebrates.* Academic Press, San Diego.

Thurston, T. L.
1999 The Knowable, the Doable, and the Undiscussed: Tradition, Submission, and 'Becoming' of Rural Landscapes in Denmark's Iron Age. *Antiquity* 73(10):661-671.

Tiffany, J., and L. Abbott
1982 Site-Catchment Analysis: Applications to Iowa Archaeology. *Journal of Field Archaeology* 9(3):313-322.

Tight, W.
1903 *Drainage Modifications in Southeastern Ohio and adjacent parts of West Virginia and Kentucky*. United States Geological Survey Professional Paper 13.

Tilley, C.
1994 *A Phenomenology of Landscape: Places, Paths, and Monuments*. Berg Publishers, Oxford.

Tobler, W.
1979 Smooth Pycnophylactic Interpolation for Geographic Regions. *Journal of American Statistical Association* 74(367):519-536.

1993 Three Presentations on Geographical Analysis and Modeling. In *Technical Report 93-1*. National Center for Geographic Information and Analysis, University of California, Santa Barbara.

Tuan, Y.-F.
1977 *Space and Place: The Perspective of Experience*. University of Minnesota Press, Minneapolis.

1979 Thought and Landscape: The Eye and the Mind's Eye. In *The Interpretation of Ordinary Landscapes: Geographical Essays*, edited by D. W. Meinig, pp. 89-102. Oxford University Press, Oxford.

Veatch, A.
1898 Notes on the Ohio Valley in Southern Indiana. *Journal of Geology* 6:257-272.

Vincent, A.
1984 Plant Foods in Savanna Environments: A Preliminary Report of Tubers Eaten by the Hadza of Northern Tanzania. *World Archaeology* 17:131-147.

Vita-Finzi, C., and E. S. Higgs
1970 Prehistoric Economy in the Mount Carmel Area of Palestine: Site Catchment Analysis. *Proceedings of the Prehistoric Society* 36:1-37.

Wandsnider, L.
1987 Landscape Element Configuration, Lifespace, and Occupational History: Ethnoarchaeological Observations and Archaeological Applications.

In *Surface Archaeology*, edited by A. S. III, pp. 21-42. University of New Mexico Press, Albuquerque.

1992 The Spatial Dimension of Time. In *Space, Time, and Archaeological Landscapes*, edited by J. Rossignol, and L. Wandsnider, pp. 257-284. Plenum Press, New York.

Warren, R. E.
1990 Predictive Modeling of Archaeological Site Location: A Case Study in the Midwest. In *Interpreting Space: GIS and Archaeology*, edited by K. M. S. Allen, S. W. Green, and E. B. Zubrow, pp. 201-215. Taylor and Francis, London.

Waters, M.
1992 *Principles of Geoarchaeology: A North American Perspective*. University of Arizona Press, Tucson.

Watson, P. J.
1996 Of Caves and Shell Mounds in West-Central Kentucky. In *Of Caves and Shell Mounds*, edited by K. C. Carstens, and P. J. Watson, pp. 159-164. University of Alabama Press, Tuscaloosa.

Watson, P. J., and W. H. Marquardt
2005 The Shell Mound Archaeological Project: Chronology of Fieldwork. In *Archaeology of the Middle Green River Region, Kentucky*, edited by W. H. Marquardt, and P. J. Watson, pp. 13-18. Institute of Archaeology and Paleoenvironmental Studies. Monograph No. 5. Florida Museum of Natural History, University of Florida, Gainesville.

Wayne, W.
1952 Pleistocene Evolution of the Ohio and Wabash Valleys. *Journal of Geology* 60(6):575-585.

Webb, W. S.
1946 Indian Knoll, Site Oh 2, Ohio County, Kentucky. vol. IV. University of Kentucky, Reports in Anthropology and Archaeology, Lexington.

1950 The Read Shell Midden: Site 10, Butler County, Kentucky. vol. VII. University of Kentucky, Reports in Anthropology, Lexington.

Wheatley, D., and M. Gillings
2002 *Spatial Technology and Archaeology: The Archaeological Applications of GIS*. Taylor and Francis, London.

White, A.
2003 The Late Archaic Component of the Miles Site, Clark County, Indiana. *Proceedings of the Indiana Academy of Science* 112(2):117-131.

2004 Excavations at the Clark's Point Site (12-Cl-3), Clark County, Indiana. Report of Investigations 302. IPFW Archaeological Survey. Indiana University-Purdue University at Fort Wayne, Fort Wayne.

White, D. A.
2007 *Transportation, Integration, and Facilitation: Prehistoric Trail Networks of the Western Papagueria*, Unpublished PhD. Dissertation, Department of Anthropology, University of Colorado.

Willey, G. R.
1953 *Prehistoric Settlement Patterns in the Viru Valley*. Bulletin 155. Smithsonian Institution, Bureau of American Ethnology, Washington D.C.

Winters, H. D.
1969 The Riverton Culture: A Second Millennium Occupation in the Central Wabash Valley. In *Illinois State Museum Report of Investigations, No. 13*, Springfield, Illinois.

Wobst, H. M.
1974 Boundary Conditions for Paleolithic Social Systems. *American Antiquity* 39(2):147-178.

Zedeno, M. N.
1997 Landscapes, Land Use, and the History of Territory Formation: An Example from the Puebloan Southwest. *Journal of Archaeological Method and Theory* 4(1):67-103.

Zubrow, E. B.
1990 Modeling and Prediction with Geographic Information Systems: A Demographic Example from Prehistoric and Historic New York. In *Interpreting Space: GIS and Archaeology*, edited by K. M. S. Allen, S. W. Green, and E. B. Zubrow, pp. 307-318. Talyor and Francis, London.

1994 Knowledge and the Representation of Archaeology: A Cognitive Example Using GIS. In *The Ancient Mind: Elements of Cognitive Archaeology*, edited by C. Renfrew and E. B. Zubrow, pp. 107-118. Cambridge University Press, Cambridge.