A GIS APPROACH TO UNDERSTANDING MISSISSIPPIAN SETTLEMENT PATTERNS IN THE CENTRAL ILLINOIS RIVER VALLEY

Kayla Jan Swoveland

Submitted to the faculty of the University Graduate School
in partial fulfillment of the requirements
for the degree
Master of Science
in the Department of Geography,
Indiana University

July 2020

Accepted by the Graduate Faculty of Indiana University, in partial fulfillment of the requirements for the degree of Master of Science.

Master's Thesis Committee

____
Jeffery Wilson, Ph.D., Chair

____
Jeremy Wilson, Ph.D.

____
Vijay Lulla, Ph.D.

ACKNOWLEDGEMENT

First and foremost I feel it is very important to thank my thesis chair, Dr. Jeff Wilson, for taking on my thesis and helping me through many challenges. You have been incredibly patient with me through the 3 years that it has taken me to get to this point. I also want to thank Dr. Vijay Lulla for all of his help, insights, and encouragement as I've worked toward this goal. Finally, Dr. Jeremy Wilson was integral in helping me craft this interdisciplinary project that merged two of my academic passions into one. I have been truly lucky in the help that I have gotten from all three of my committee members.

I also owe a huge thank you to my team at The Polis Center. Everyone has been so kind and helpful in letting me bounce ideas off them or helping me with technical issues or even just lending me some encouragement when I needed it most. My dearest friend Haley, you have been beyond essential in keeping me motivated and on task when I needed it. I cannot imagine how I could ever have gotten this far without you as my biggest cheerleader, thank you from the bottom of my heart!

Last but certainly not least, I owe an immense thank you to my family for their unwavering support. To my parents and siblings who never really understood why I'd ever want to do something like this, thank you for being proud of me no matter what. To my husband Joe, thank you for loving me unconditionally and believing in me especially when I didn't believe in myself.

Kayla Jan Swoveland

A GIS APPROACH TO UNDERSTANDING MISSISSIPPIAN SETTLEMENT PATTERNS IN THE CENTRAL ILLINOIS RIVER VALLEY

Geographic Information Science (GIS) technologies have helped to further the research of archaeologists almost since the inception of the field. Archaeologists have long made observations rooted in what would become GIS, but it wasn't until the early 21st century that science was able to back up these observations. From the seemingly simple task of organizing and storing spatial data to more robust statistical and spatial calculations, GIS has quickly become a valuable tool used by archeologists to better understand past populations. This research applied GIS to help understand the regional distribution of settlement locations from the Mississippian Period (AD 1050-1450) in the central Illinois River Valley (CIRV) of west-central Illinois. Settlement distribution was examined in two contexts, first in the context of larger, more "metropolitan" site placement in relation to smaller, more transitory sites. Secondly, site distribution was examined to see what, if any, pattern existed between site placement and a set of ecological factors. The results found that while smaller sites were prevalent around many of the larger sites, a few metropolitan sites did have a larger number of smaller sites surrounding them, supporting the idea of certain Mississippian sites serving as hubs. Additionally, it was demonstrated that several different types of GIS based analyses were particularly effective in helping to identify these patterns, thus solidifying and improving the role of GIS in the field of archaeology.

Jeffrey Wilson, Ph.D., Chair

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CIRV- Central Illinois River Valley

DEM- Digital Elevation Model

GIS- Geographic Information Science

GLU- Gnarly Landscape Utilities

LCD- Landcover Data

Introduction

Geographic information science (GIS) technologies have been used in archaeology for decades (Kintigh & Ammerman, 1982), but the integration of the two fields continues to grow, often focusing more on “methodological refinements rather than theoretical advances” (Arias, 2013, p.7). One of the more promising ways in which GIS is helping to further archaeological research is through the application of spatial pattern analysis. As Ebert (2004, p. 319) stated “…archaeology has always had a focus on the spatial dimension of human behavior” and GIS is now routinely used to store and examine spatial relationships in archaeological data. Spatial pattern analysis has been used in many different aspects of archaeological research, from examining the relationship between artifacts in a single structure to the distribution of buildings on a site, and regional patterns in site location (Wilson, Marcoux, & Koldehoff, 2006; Lock & Pouncett, 2017).

The purpose of this research is to examine the regional distribution of settlement locations from the Mississippian Period (AD 1050-1450) in the central Illinois River Valley (CIRV) of west-central Illinois. This research focused on two main goals, the first was to identify if any discernable spatial pattern existed between larger more metropolitan Mississippian sites, and those smaller subsidiary sites. This was examined through the use of GIS-based methods that have been previously used in the field of archaeology to examine spatial relationships of sites (Ducke & Kroefges, 2007). The second goal of this research was to examine the relationship of Mississippian sites to the natural environment of the CIRV. This relationship was examined using habitat connectivity software to not only to test the second goal, but to also examine if this software would be a practical option for archaeologists to use in future work.

The study area examined follows the Illinois River from modern-day Meredosia, Illinois in the south to Hennepin, Illinois in the north, spanning approximately 210 km of the larger Illinois River (Conrad, 1991). This area, characterized by a wide floodplain, backwater lakes, and abundant natural resources, was inhabited by Mississippian peoples from AD 1050 until the mid-1400s. While this area contained several fortified sites, the largest and most noteworthy of these is Lawrenz Gun Club (11CS4) which has been shown to be the longest inhabited Mississippian Site in the CIRV (Krus et al., 2019). Harns (1978; 1994) previously examined Mississippian settlement patterns in the CIRV, but without the use of the more advanced spatial technologies in use today.

Spatial pattern analysis in the context of this research paper, is defined as the process of using GIS-based technology to examine the spatial relationships of archaeological sites to each other and to the natural environments they exist in. This analysis approach has been recently used to examine settlement patterns in other locations and cultures in North America and abroad (e.g., Jones 2010, 2012; Milner & Chapiln 2010; Niknami, 2013). Results have shown correlations between ecological and cultural environments in site establishment in the upper Yadkin River Valley in North Carolina (Jones, 2012). Similarly, Niknami and colleagues (2012) found correlations between characteristics of the natural environment and site establishment in their study in Northwest Iran. Both studies demonstrated the ability to use GIS as a means to determine which factors, such as proximity to natural resources, elevation, or soil types, are favored over others.

Building on the research of Jones (2010, 2012) and Niknami and colleagues (2012), this research applied similar methods to Mississippian sites in the CIRV to evaluate whether similar insights could be attained. The specific focus of the research was to apply spatial pattern analysis methods to examine a set of quantifiable parameters that can potentially explain ecological influences on site selection for both larger and smaller Mississippian settlements in the CIRV. The distribution of smaller sites in relation to the larger villages was also examined. The goal was to evaluate why larger settlements appear where they do and whether a predictable pattern of subsidiary settlements could be discerned from extant databases using GIS analysis methods and applying them to the field of archaeology. The overall objective was to develop and apply a replicable methodology for assembling and analyzing archaeological site locations based on ecological variables in a GIS environment.

Identifying and integrating appropriate preexisting data on settlement locations is an important first step. In addition to the locations of settlements, both ecological and cultural data associated with these locations needs to be complied into a suitable format for storage and analysis in a GIS environment. The process of identifying and organizing site location data has required significant effort in previous case studies (e.g., Jones, 2010). An important resource that was integral to the current thesis research was the Illinois Inventory of Archaeological Sites, an online, ArcGIS database of known archaeological sites maintained by the Illinois State Museum. As illustrated in Figure 1, this database provides accurate spatial information on the areal extent of archaeological sites in Illinois.

Figure 1 Screenshot form Inventory of Illinois Archaeological Sites maintained by the Illinois State Museum. The red polygons represent all known archaeological sites in the vicinity of McKee Creek along the Pike and Brown County line in the CIRV.

Literature Review

Background

Mississippians had a vast and intricate cultural history, but the aspects most important to this thesis include their emergence in the CIRV, their subsequent growth, including the development of larger villages, and their eventual decline as part of a larger, macro-regional phenomenon known as the "Vacant Quarter" (Milner and Chaplin, 2010). Mississippian sites and settlements began to appear in the CIRV during the 11th century, shortly after the rise of Cahokia and other centers in the American Bottom circa A.D. 1050. Near the confluence of the Spoon and Illinois Rivers, the Eveland site and Dickson Mounds have yielded significant evidence for the incorporation of Mississippian lifeways by local Late Woodland populations in what is referred to as the "Spoon River" Mississippian tradition (Wilson, 2010; Harn, 1994 p. 11). Current research suggests that Mississippian emergence in this area was at least partially the result of migration from Cahokia and the American Bottom, located just outside of modern-day St. Louis (Harn, 1994; Wilson, Bardolph, Esarey, & Wilson 2020), though bio-distance studies suggest most CIRV Mississippians were native to the Illinois Valley (Steadman, 1998, 2001; Hatch 2015). Cahokia was the largest prehistoric settlement in North America by AD 1050-1100 and had influences across the Midwest and greater Southeast, including distant ceremonial centers in the upper Mississippi River Valley (Pauketat et al, 2015). Archaeological evidence from the CIRV shows a blending of Cahokian practices, like shell-tempered pottery, with local Late Woodland practices, leading researchers to believe that Cahokia migrants or emissaries (i.e., early Mississippians) blended with and indoctrinated peoples native to the study region (Harn, 1994; Bardolph, 2014; Wilson, Delaney, & Millhouse, 2017).

The mark of Mississippian settlement, so to speak, was the evidence of shell-tempered pottery, wall-trench construction, maize subsistence, and later “temple towns,” among other iconographic and ideological constructs (Wilson, 2012; Harn, 1994). Mississippians relied heavily on maize, thus the fertile soils of the CIRV were an important resource that supported development of settlements and a swidden farming lifestyle supplemented with local cultivated and wild resources (VanDerwarker et al., 2013). Harn (1994, p.5) describes the CIRV as being “…segregated from the river’s upper and lower sections not only on the basis of geographic location, but also because of differences in topography, hydrology, flora, and fauna.” While Mississippians still relied on hunting and fishing, their talents in agriculture distinguish them from the preceding cultures, enabling larger populations to live in more finite settlements. Harn (1994, p.12) found that “four major soil associations suitable for prehistoric horticulture occur within the region,” which were a key resource that enabled Mississippians to be self-sufficient farming-based based peoples.

The majority of Mississippian sites were established near the Illinois River’s western bluff edge with a few exceptions in the floodplain and colluvium-derived terraces (Conrad, 1991). Harn (1994, p.15) speculates as to a scenario that may have influenced the settlement distribution, stating that sites in the CIRV were “…distributed non-randomly, and their locations were influenced in descending order of importance by access to favorable biotic zones, water sources, landforms, and soil types.” Thus bluff-top sites would have been favorable based on several of Harn’s assumptions.

Proximity to major water sources was a common feature among all larger sites, termed “towns” by Harn (1994). He identifies six towns along the CIRV that would have operated as central hubs for the surrounding smaller settlements including Hildemeyer, Kingston Lake, Larson, Crable, Lawrenz Gun Club, and Walsh (Harn, 1994). Major sites were central to what Harn (1994, p.23) describes as “settlements,” which are defined as “individual areas of habitation that include towns, primary villages, intermediate settlements, and smaller subsidiary sites.” These settlements, while consistent in overall cultural traits at a regional level, would at times retain unique characteristics that would slightly differentiate them from neighboring settlements. Harn speculated that physical distance between settlements drove these differences as opposed to intentional efforts of individuality. Though often viewed together, the major Mississippian towns of the CIRV did not all flourish at the same time; in fact, Harn (1994, p. 23) states that there are “significant time differences represented by the occupations of the various population centers.”

While not classified as a town, but a smaller “primary village,” Orendorf has the earliest radiocarbon dates among the major sites in the CIRV dating to around AD 1105 to 1180 (Harn, 1994; Wilson, Melton, & VanDerwarker, 2018). The last large village during the Mississippian Period in the CIRV was Crable, dating around AD 1400 (Harn, 1994). It is the unique topography and soil composition that appears to have made the CIRV a successful place for Mississippians to prosper. Mississippians lived and thrived in the CIRV until around AD 1450 when they began to abandon the towns and villages in the area. While speculation exists as to why Mississippians left the CIRV, such as encroaching foreign tribes, unfavorable climatological conditions, and/or European contact, there appears to be no one reason, but a combination of several factors (Bird, Wilson, Gilhooly III, Steinman, & Stamps 2017).

History of Settlement Pattern Analysis

Harn (1994) reviewed much of his previous work and that of other researchers in order to develop an overall understanding of Mississippian settlement patterns in the CIRV. This summary emphasized the influence of the natural environment in shaping settlement patterns. Specifically, landform and water resources were identified as the most influential variables in site selection. In addition, Harn (1994, p.13) argued that "natural zones and their associated vegetation" may have played a more direct role in site selection than previously considered. This is evident along the western floodplain and bluffs (west of the Illinois River), where there is a heavier concentration of upland and riparian forest along tributary streams, creeks, and rivers. Sites on the eastern side of the river show a concentration in relation to "loess bluffs and upland and bottomland forest" (Harn 1994, p. 13).

Harn is perhaps one of the most relied upon sources for information on Mississippians in the CIRV and, as such, many of his assumptions and conclusions about settlement patterns have been influential. However, technological resources (including analytical tools, methods, and spatial data) that enable examination of Harn's theories in more detail have become increasingly accessible and provide an opportunity to examine the importance of ecological factors on settlement patterns in an empirical, GIS-based framework.

Schroeder (2004) has also offered some general observations about the Mississippian settlement patterns. Her work focused on late pre-contact societies across the mid-continental United States, thus including the CIRV. She noted that new GIS technologies have improved researchers' abilities to handle larger data sets, making regional settlement analyses more accessible. The ability of GIS to organize data gathered on archaeological sites is not without limitations, primarily in the sense that it is only as accurate as the data gathered.

One of the biggest hurdles that Schroeder (2004) mentioned is gaps or biases in site discoveries. Many archaeological sites in CIRV have been documented thanks to the presence of noticeable mounds or surface scatters of archaeological materials in plowed fields. Meanwhile, other areas and sites have been discovered across the midcontinent in advance of modern development, often following highway or pipeline surveys (Schroeder, 2004). Schroeder (2004, p. 323) stressed that "…care must be taken when drawing inference from or evaluating GIS analyses of data that have highly variable collection histories." She discussed general Mississippian settlement patterns noting that they were primarily "…composed of multiple communities of varying sizes" (Schroeder, 2004 p. 324). The majority of Mississippian sites were smaller and organized around one larger site with earthworks and potentially fortifications. There was also a tendency to build defensive palisade walls around larger sites.

Milner (Milner, Chaplin, & Zavodny, 2013) finds that skeletal evidence points towards a significant increase in remains discovered with projectile points embedded within them along with other types of trauma. This would indicate an increase in hostilities among different groups of Mississippians, which he speculates may be the reason that certain sites began to put up defensible palisade walls, thus becoming population centers for other smaller sites to aggregate around. The natural environment would have played an important role in this scenario, necessitating that the surrounding area would have to support a much larger population nucleation and, therefore, enhance risk in times of resource shortfalls. While these individual features were noticed on a site-to-site basis, it was through the use of GIS that researchers like Milner and others, were able to recognize larger regional trends.

Methodological Review

While authors like Harn (1994) previously assessed settlement pattern characteristics in relation to environmental factors in the CIRV, it is only recently, since the early 2000s, that GIS technology has been used to examine and test general assumptions with empirically based methods and competing models. One of the biggest factors in this change to more robust analysis methods being used has to do with new data being available. It was not until the mid-2000's that the data moved from being paper based recordings into a GIS framework, thus allowing researchers more opportunities to look at the data in more detail. Given that the integration of GIS-based spatial pattern analysis in archaeological research is a relatively new and developing area, there are no widely acknowledged standards for associating environmental variables with settlement locations. A few recent examples in the literature include Jones's (2012) work in the North Carolina Piedmont and Niknami's (2012) work in the Northwest of Iran.

Jones (2012) examined the relationship between site size, location, and the ecological environment through a process of first collecting and categorizing data and then through the application of discriminant function analysis to produce definitive ranges of influence for ecological variables. Thirty sites which were compared to two sets of 30 random points. A total of 16 environmental variables were examined as potential predictors of settlement site selection. Discriminant function analysis was applied to both the sites and two control groups in order to examine the statistical significance of each variable. Results indicated that the sites differed from random based on “flatter land at the location, less visibility from the river, lower average solar radiation within the catchment, longer distances from overland trails, and longer distances from tributaries” (Jones 2012, p. 179). While some of these are in fact ecological variables, they shed light into cultural practices of the time. Based on the information Jones gathered and information gathered from other studies, a general trend appears of dominant groups of peoples “positioning themselves on the landscape to control transportation routes” (Jones, 2012 p. 186). This is an intriguing hypothesis that mirrors previous observations by Harn (1994) for the Mississippian Period in the CIRV that was examined in the current research project.

Niknami (2012) examined the distribution of archaeological sites in northwestern Iran using an approach similar to that of Jones (2012). His study focused on describing spatial characteristics of settlement patterns using GIS-based analysis methods, including point density, distance, and some 3D analysis. Niknami determined that four environmental factors were integral to the settlement patterns observed in this particular area. Those factors were, in order of importance, proximity to the main water source in the valley, elevation above sea level (asl), degree of slope, and proximity to main transportation routes (Niknami, 2012). Over half the sites were found within 50 m of rivers and, of the remaining, none were farther away than 350 m. Results indicated that 67% of the sites in the area were located within the lower bounds of the elevation between 1000-2000 meters asl. Topography also played an important factor in site establishment. Niknami found that 72% of sites examined in the area were found on land that was between 0 and 2 degrees slope (Niknami, 2012). Another significant environmental factor was that 72% of sites could be found within 500 to 1000 m of main transportation routes.

While past researchers like Harn (1994) and Schroeder (2004) provide insight from an archaeological perspective about the variables that explain the general patterns in Mississippian settlements, the goal of the current research was to explore the potential to use GIS methods to examine the spatial and ecological patterns in more thematic detail. While no widely acknowledged standards to perform these types of analyses in archeological research have been formalized, archaeologists have certainly been using GIS to perform these types of analyses for years. Additionally, comparable areas of spatial analysis methods may be applicable to furthering the practice in the field of archaeology. The fields of landscape ecology and ecological modeling use spatial analysis methods to associate environmental characteristics with site locations. These methods can potentially be applicable in archaeological contexts. While prehistoric settlement pattern analysis is not directly comparable to ecological modeling, the two fields of study have many similarities and, as such, examining the adaptability some of the techniques that have proved useful in the field of ecology opens an opportunity to better understand Mississippian settlement patterns.

Circuit theory has been applied to look at connectivity in chemical, neural, economic, and social networks. It is most often used in the study of ecology and habitat modeling (Beier 2011, Dickson 2019, Diniz 2019). Previous work done by Doyle and Snell (1984) and Chandra and colleagues (1996) showed that there is a relationship between resistance in electrical circuits and random walks. The mathematical concept of random walks states that each movement by a walker is independent of the steps previous (Dickson, 2019). It is most commonly used when discussing stock market prices, or, as is more applicable to this research, the foraging habits of animal species. The concept of random walks as it applies to circuit theory and movement is that each movement from cell to cell or node to node is independent of the last. Dickson et at (2019, p. xx) states that "Circuit theory's basis in random-walk theory results in an implicit assumption that individuals moving across a landscape have no knowledge of relative resistance beyond their immediate surroundings…" This encompasses another of the potential limitations of using this approach, the unspoken assumption that an individual would have no historical knowledge of the area and thus would move, in theory, only based on the resistance of the landscape and other natural factors. The reality of movement and settlement when examining a human species is that past experiences and encounters would impact where a population moved and settled.

One goal of the current research was to examine if this could be applied to understanding settlement patterns. McRae et al. point out additional short comings with this approach, one of which is that the resistors are isotropic, meaning the resistance to current flows the same in both directions. In other words, the concept can only be used to examine movement that is the same in either direction. Take the example of a cell that represents a sloped area. The cost of movement down the slope would be less than it would be to move up the slope because it's easier to walk down a hill than up it. As it stands, the current model does not have a way to encompass that difference, it treats the movement up or down the slope as the same cost.

Either of these limitations could pose hindrances in using the theory to examine settlement patterns and migration given the deliberateness of human decisions. In the case of looking at Mississippians in the CIRV, the limitation of movement being the same in either direction might not pose much of a hindrance. The area is relatively flat, so movement would most likely have similar “cost” in either direction, unlike an area dominated by mountains where it might have been harder to move up the mountain than down. The limitation of independent steps could also impact this particular study. Mississippians presumably would have remembered past experiences with particular locations or types of landscape and would presumably have used those memories to influence their choice of routes and locales for habitation. Overall, the concept of circuit theory has potential application in prehistoric settlement pattern analysis as a whole. Tarkhnishvili et al (2016) used the tool Circuitscape to study and ultimately presume that landscape complexity was the factor in the genetic assimilation of early humans in the Caucasus mountain range in Africa. Their work, based in circuit theory, was able to examine ecological factors and their impact on the peoples of this area. While much GIS-based work has been done in examining Mississippian settlement patterns, it would appear that very little of that has been based in circuit theory. This concept offers the ability to examine the landscape as a whole with multiple factors, to see what, if any, impact that had on Mississippian settlements.

Methodology

Data collection and preparation was the first step in this project. Archaeological site data from the Illinois Inventory of Archaeological sites was requested from Dr. Michael Wiant, former Director of the Illinois State Museum (ISM). The Museum's database contains information on all archaeological sites documented in Illinois. As a result, the request made to the ISM was to obtain only information on sites pertinent to this study (i.e., Mississippian sites within the CIRV). From north to south, counties with relevant sites included in the analysis were Putnam, Marshall, Peoria, Woodford, Tazwell, Fulton, Mason, Schuyler, Cass, Brown and Morgan. Pike, Scott, Greene, Calhoun and Jersey counties, which are typically associated with the lower Illinois River valley, were excluded from the analysis for several reasons such as the difference in physical geography of these counties and the fact that they are associated with a different study region. The requested data were exported from the Illinois Inventory of Archaeological sites as polygon files that contained site dimensions and basic ecological data. Sites were then classified into two categories based on size, with larger sites containing platform mounds and/or recognizable defenses (i.e. palisade walls) considered as major settlements (n = 13), and smaller sites void of any noticeable defense considered as villages, hamlets, farmsteads, or resource extraction sites (n = 384). A database of 140 radiocarbon dates for Mississippian sites in the CIRV from the Department of Anthropology at Indiana University-Purdue University Indianapolis was used to assign date ranges for the larger sites within the study area (e.g., Orendorf, Larson, Lawrenz Gun Club).

Other data gathered from freely-accessible sources included a 10-by-10 m digital elevation model (DEM) of the State of Illinois, hydrology data detailing major rivers and streams obtained from the USDA, and landcover data from the 1800s obtained from the Illinois Natural History Survey. The goal of this phase of the thesis was to gather potentially relevant ecological data to examine settlement patterns during the Mississippian Period in the CIRV.

The analytic portion of the research tested methods adapted from the work of Jones (2012) and Niknami (2012) as described above. The results of applying these methods to Mississippian sites within the CIRV produced a set of descriptive statistics about the ecological characteristics of settlements. The ecological variables examined included proximity to water, soil type, proximity to hardwood growth, and proximity to nearest transportation route.

Three analytical techniques were evaluated. Two methods, Thiessen Polygons and Near Analysis, are more commonly used in the field of archaeology (Maschner 1996). The third approach used habitat and resistance theories based on electrical circuit theory and is still being tested in the archaeological world (Tarkhnishvili, Gavashelishvili, Murtskhvaladze, & Latsuzbaia, 2016). Thiessen Polygons are created by drawing boundaries between points which represent that location which is equidistant from each point. This process continues, creating a two-dimensional space(s) representing all the area that is closest to the point at the center of the polygon. Thiessen Polygons were created from the 13 major sites (Buckeye Bend, Crab Tree, Crable, Emmons, Fandel, Hildemeyer, Kingston Lakes, Larson, Lawrenz, Orendorf, Star Bridge, Vandeventer, Walsh). The extent of the polygons was limited to the boundaries of the 12

CIRV counties. The 384 smaller sites, converted from polygons to points, were then associated with a major site based on the Thiessen polygon they occurred in. Four sites were located on Thiessen polygon boundary lines were manually assigned to one polygon or the other based on a visual assessment of the original site boundary. Sites were then exported into separate feature classes including an attribute identifying which Thiessen polygon to which they belonged.

The second analysis method used the Near tool in ArcMap to measure the distance between the 13 major sites and the 384 subsidiary sites in the CIRV. The major and subsidiary sites were separated into those east and west of the Illinois River. It was assumed that Illinois River would have been used as a major transportation route, but perhaps not crossed frequently as a part of Mississippian's normal day-to-day activities. The Near tool was used to assign each subsidiary site to the major site it was closest to on either side of the Illinois River. This created a set of subsidiary sites grouped with a major site and a basis on which to compare commonalties between the "community" groups.

The third and final set of analyses examined the relationship between site distribution and the habitability and resistance ranking of the surrounding environment using circuit theory. Circuitscape is a connectivity analysis software commonly used in ecology. One tool within this analysis package is the Gnarly Landscape Utilities (GLU), which can be used to develop habitat and resistance maps in the Circuitscape software. The input layers used to create habitat and resistance variables were the historic landcover dataset (LCD), a raster layer representing distance to the Illinois River, and a raster layer indicating the distance to the nearest tributary of the Illinois River. Since the

GLU tool needs all layers to have same spatial resolution, all the raster layers were set at 10 x 10 m spatial resolution, consistent with the original DEM data for the area.

The Resistance and Habitat Calculator tool determines the suitability of a cell based on the resistance values of all the variables at that particular location. To accomplish this, resistance scores were assigned to each class in each layer. The resistance score of a class represents the level of unsuitability for habitation. For example, a water landcover class would have a resistance score of 0 in a model of suitability for an aquatic species. Conversely, the resistance score of dry, barren landcover would be 100, indicating that the landscape is not at all a suitable for the aquatic species. There are no broadly accepted standards for resistance scores. Within a given discipline, resistance scores are either experimentally applied or based on previous research and consensus. The reliance on resistance values to indicate suitability of habitat stems from this tool's basis in electrical circuit theory.

The Resistance and Habitat Calculator tool can use both continuous and categorical variables. However, since it is widely used for habitat modeling, most continuous variables are converted into categorical variables so that similarly grouped classes can be aggregated spatially into larger contiguous areas representing favorable habitats for the species. The tool provides a way to include many variables into habitat modeling, but it requires the data to be organized in a particular way.

Habitat values and resistance scores were organized in an Excel sheet with the following columns: Data Layer, Class ID, Habitat Value, Resistance, and ExpandCells (Table 1). The Excel sheet can also contain other optional variables, but the above variables are required. Documentation for the GLU tool that explains this process in detail is available in McRae (2013).

Table 1 Sample GLU Excel Table

Data Layer	ID	Class Description	Source	Habitat Value	Resistance	ExpandCells
LCD	1	Prairie	Historic Landcover data set from the 1800s	0.8	0	0
LCD	3	Water/River		0.0	70	0
LCD	4	Forest		0.7	20	0

In order to create a data set that could be easily used with the GLU tool, distance from the Illinois River was calculated at 500-meter increments up to 10 kilometers. By consulting with Dr. Jeremy Wilson, a subject matter expert Mississippian cultural practices, it was determined that 5 km would have been the average daily “commute” Mississippians would have made for everyday resources, such as water or wood for fuel. Distances beyond 5 km would have required more effort and most likely would not have been part of daily activities. As such, those areas within 5 km of the rivers were ranked as the lowest resistance and highest habitability.

The historic Landcover dataset originally contained 27 different land cover classes but was reclassified into 26 different classes for this study. The classifications of wetland and wet prairie were combined for the purpose of running the tool as they would have had the same resistance and habitat values. Habitat and resistance values were assigned to each reclassified land cover value. The “Expand Cells” column was not used on the initial run. Assigning a value here would tell the tool whether all features in a layer should be expanded by a given number of cells before combining with other layers. Values in the habitat and resistance columns are assigned by the user and, as such, results can vary based on input data. The values used in the current study were assigned by working with Dr. Wilson who used historical knowledge of the area and functionality of Mississippians to help determine the appropriate weight of different variables. The full table of weights can be found in Appendix A.

The model was run within ArcMap 10.5 using the Resistance and Habitat Calculator tool box. All default options were used, with the exception of the resistance values. The tool automatically takes the maximum values of all input layers for a given cell as the final resistance value. There are, however, other options, such as sum or minimum. After using all the options available for extracting the resistance value, it was determined that the sum option best represented the study area. According to McRae (2013), using the sum acknowledges that effects of different layers can be cumulative. By using the maximum option, the river layers dominated the results, thus placing a higher importance on access to water than what was judged to be reasonable. Using the sum of weights appeared to create a more reasonable output that incorporated important variables from each of the input layers.

The output results allowed for examination of the range of cell values around the 13 major sites. A 5 km buffer was generated around each major site to examine how the landscape both on and around the major sites ranked using the GLU tool. After these buffers were created, the raster output from the GLU tool was clipped to the 5 km major site buffers. Then the raster to point tool was used within ArcMap to convert each of the cells from the raster, along with their resistance value, to a point. From this point, it was possible to select all of the points within each major site buffer and summarize the information. For this process, the data was examined in ArcPro using the Summarize function. This generated a histogram summarizing the point values. From there, the data were copied into Excel and percentage of total coverage area was calculated for each resistance group in each major site. This allowed examination of the most prominent resistance group within each major site’s 5 km buffer. The assumption was that, because these sties show in the archaeological record as being important epicenters to the Mississippian populations in the area, they should have a high majority of low resistance cells in their coverage areas.

Results and Discussion

Before expanding on the results, it is important to note a few drawbacks to the three experimental analytical approaches used in this thesis. First and foremost, the input data used for terrain information is dated several hundred years after the Mississippian Period. Using modern DEMs to generate the analysis might not yield the most accurate representation of the AD 1100 topography and hydrology, which was a key component, but it is the best available data. Modern political boundaries were used as a method of bounding the CIRV because this allowed for equal comparison of the space across all three methods. Finally, there is always the consideration of sampling biases in looking at archaeological sites. The study area examined, while heavily studied and excavated, still has areas that have been subject to more excavations than others. Table 2 details the number of sites found in each of the CIRV counties, showing that Fulton County has the most discovered sites. As such, any spatial patterns revealed by these three analyses could change as more sites are discovered in other counties of the CIRV.

Table 2 Count of Mississippian Sites per County in CIRV

County Name	Number of Sites in County
Fulton	157
Peoria	63
Brown	33
Cass	30
Mason	27
Schuyler	24
Tazewell	17
Marshall	12
Woodford	12
Putnam	9

The first analysis method used was Thiessen Polygons. This approach created a set of 13 polygons used to represent potential "community boundaries" of the 13 major sites based solely on Euclidean distance. An overlay analysis was used to assign each of the 384 smaller sites to one of the major sites. The major site community with the most sites assigned to it was Orendorf, which had 72 smaller sites contained within its Thiessen polygon as shown in Figures 2 and 3. Interestingly, the Orendorf Theissen polygon lies in the very center of the CIRV.

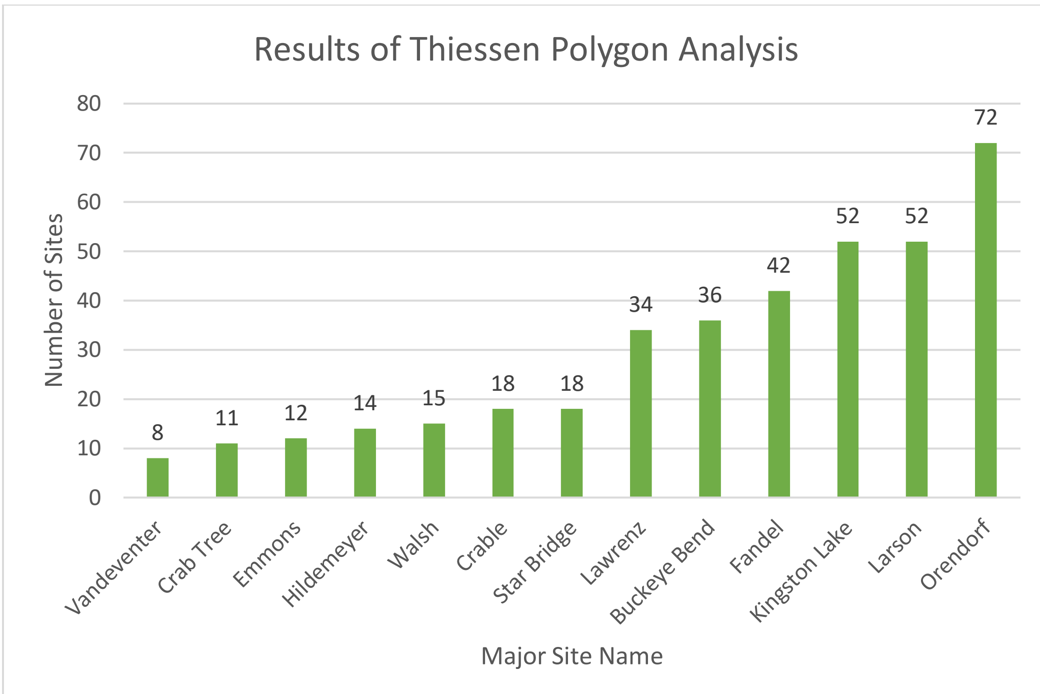

Figure 2 Results of Thiessen Polygon Analysis

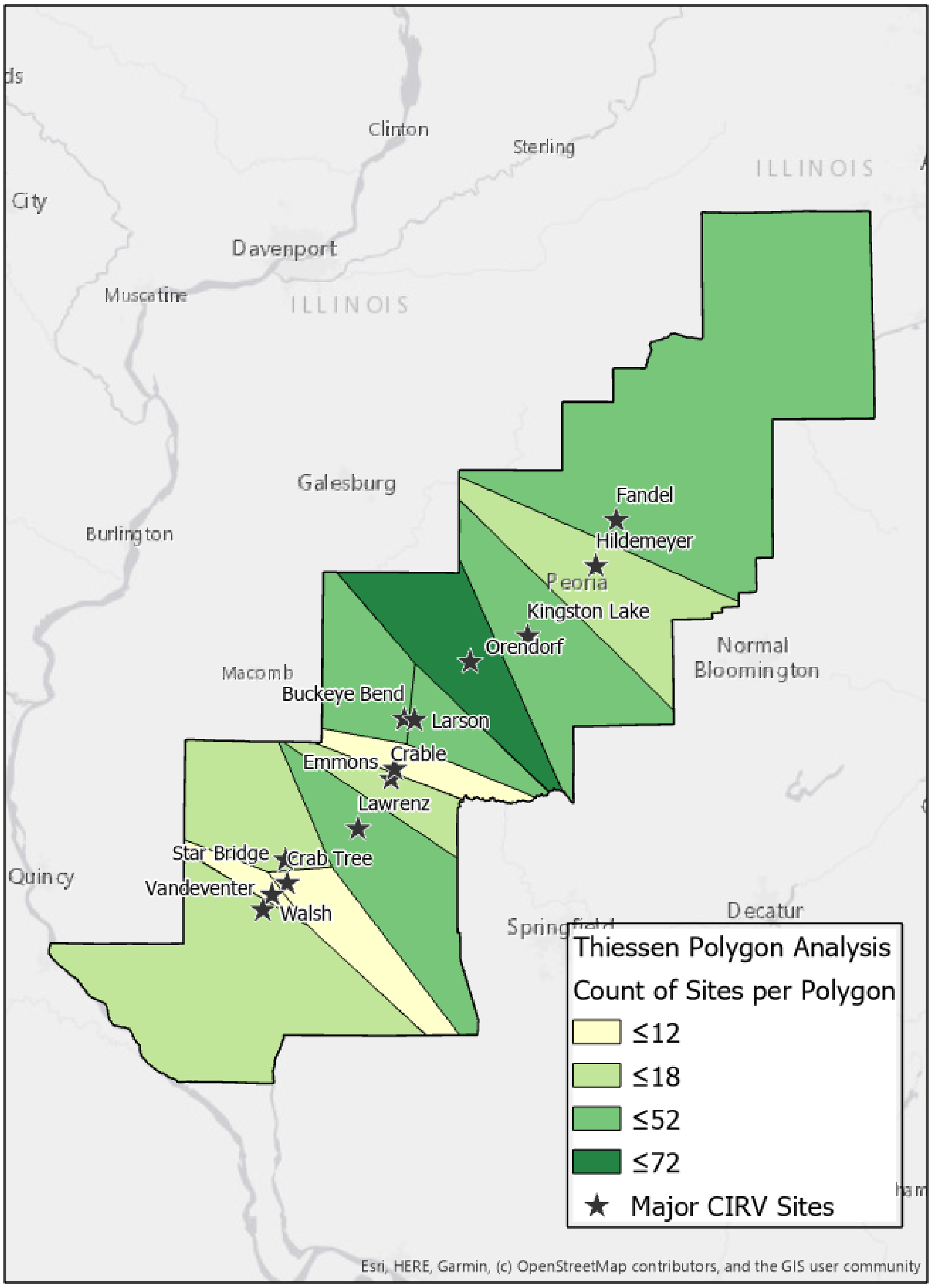

Figure 3 Thiessen Polygon Results. Thiessen polygons were generated using major the 13 CIRV sites. Counts of sites per polygon indicate the number of smaller sites in each Thiessen polygons (total number of sites, 384)

The next analysis method used the Near Analysis function in ArcMap. Before running this tool, both the smaller and major sites were separated into those east and west of the Illinois River. While the Illinois River was a major transportation corridor, it also presented a barrier for which crossing may not have been a part of everyday village life. The divide was done to see how it affected the distribution of the smaller sites in comparison to the larger sites. Near analysis uses the same concept as Thiessen polygons by examining the Euclidian distance between different objects. This approach assigned each of the 384 smaller sites to one of the 13 major sites. The Kingston Lake community was assigned the highest number of smaller sites, 70 in total, which are depicted in Figure 4 below.

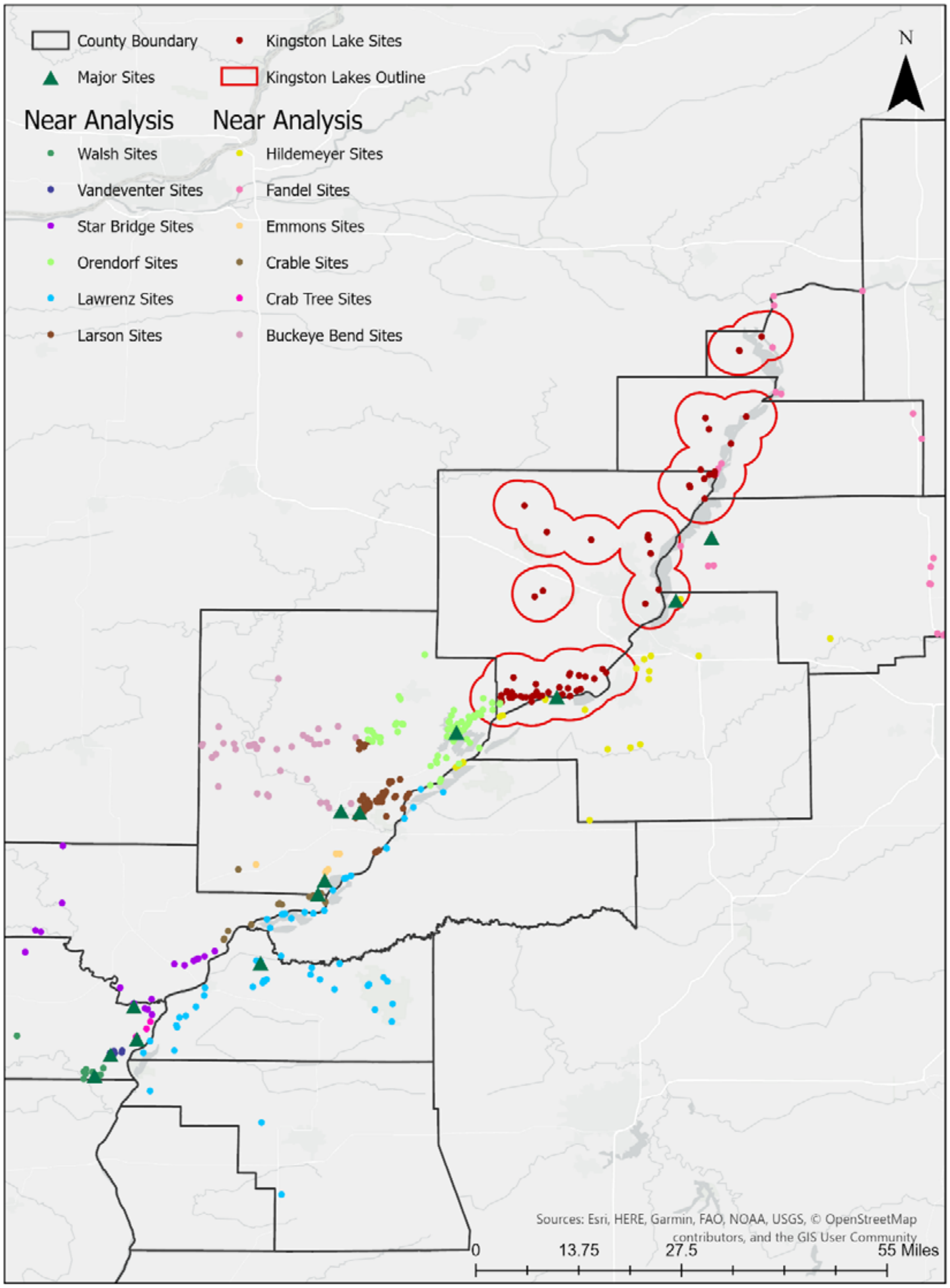

Figure 4 Near Analysis Results

Figure 5 shows the difference in number of sites per community group based on the two different analysis types. In general, most of the larger sites were associated with at or near the same number of sites using both methods. Some of the notable exceptions to that can be seen in the graph. Kingston Lake had just over 50 sites using the Thiessen Polygon approach but jumped to 70 sites using the Near analysis. This site also happens to be the northern most site located on the western side of the Illinois River.

Another notable difference between the two analysis methods is Lawrenz. This site in located on the eastern side of the river, right in the middle of the study area. When using the Near analysis, and drawing the Illinois River as a hard boundary, Lawrenz jumped to having the 3rd most assigned sites. While both of the analysis methods used the same underlying concept of Euclidian distance to assign smaller sites to a larger site, the Near analysis and inclusion of the Illinois River as a hard boundary through the study area impacted the spread of smaller sites to the larger sites.

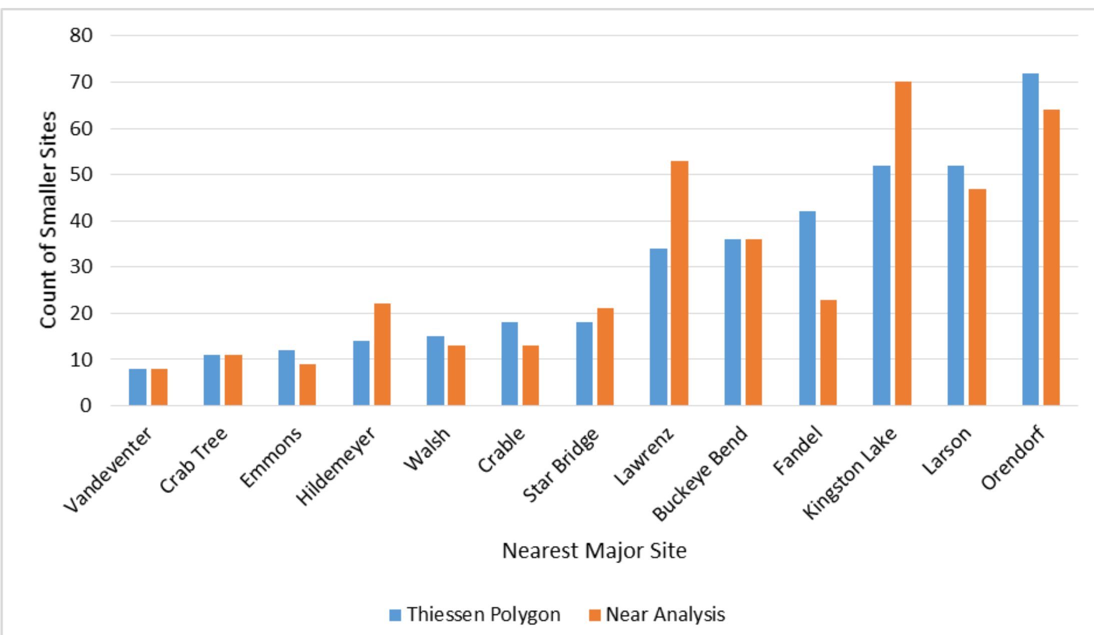

Figure 5 Thiessen Polygons Vs. Near Analysis

The final analysis used the GLU tool to generate a habitability layer to compare to actual site placement. After running the GLU tool, the output was examined with the location of the 384 known Mississippian sites in the area. Using the extract value tool, a value from the resistance raster was assigned to each site point. The highest resistance values reported from the tool was a score of 90 with the lowest scores being under 1. In looking at the histogram, generated within ArcGIS Pro, of the resistance results for CIRV sites, the mean resistance score was 23 (Figure 6). The majority of CIRV sites had a resistance value below the mean score, with a small percentage of sites having resistance scores above that. As such, a score of 23 was then considered to be the mid to low range of resistance scores

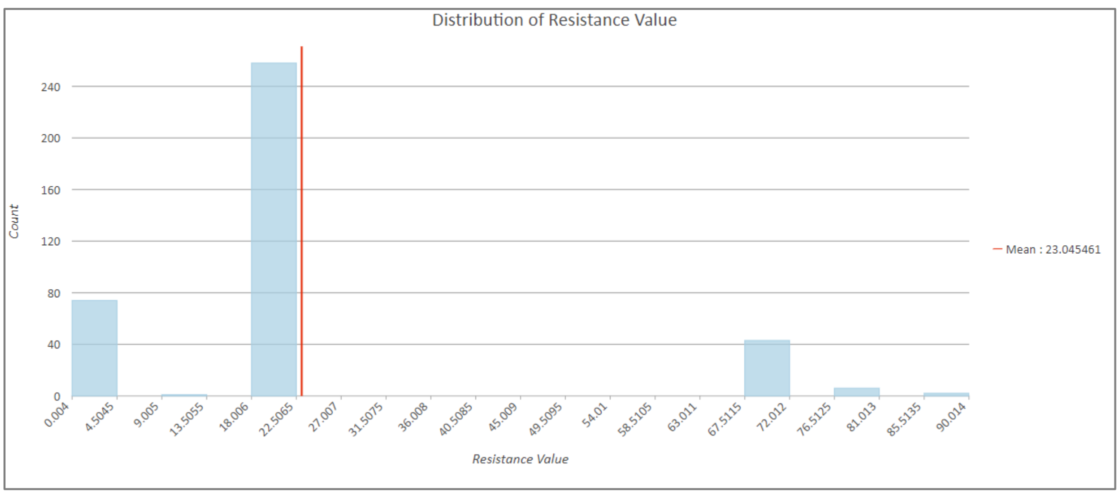

Figure 6 Summary Statistics of CIRV Site's Resistance Values

The majority of the CIRV sites, 259, had resistance values between 20 and 50, which for the purposes of this research, were considered medium resistance. Of those 259 sites, 106 had a resistance value between 20 and 30, which was the lower end of the medium ranking. Seventy-four sites scored a resistance value of below 20, which was considered a low resistance value. Of those 74 low ranked sites, 39 had a resistance value of less than 5, which would be considered a very low resistance score. The final group, those sites scoring a resistance value of 50 or above, totaled 51.

.

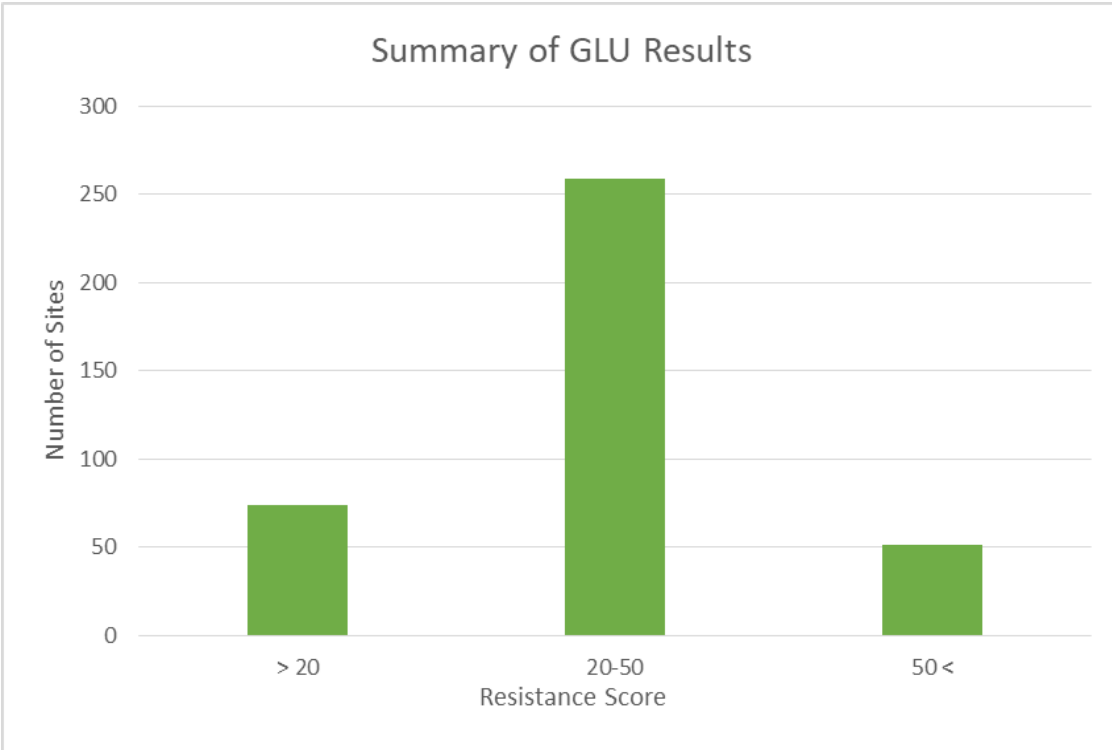

Figure 7 GLU Results

These results, shown in Figure 7, indicate the majority of sites had moderate resistance values (at or below 30). Some settlements did fall in areas ranked as higher resistance, a combination of a landcover classification ranked unfavorable for habitat (like swamp or marsh) and not within a favorable proximity to water. When examined on a map, with the exception of one, these sites all fall along the modern boundaries of the Illinois River. This would indicate distance from water as a dominate influence in the modeling results. A more detailed graph of the distribution of resistance values among the CIRV sites can be found in the Appendix, Figure A-11.

Many of the sites ranked with low resistance (a score of less than 20) fell along tributaries of the Illinois River. These areas along the tributaries are prime locations for settlements as the soils were favorable for growing crops. These areas were also primarily within walking distance of hardwood growth that would have needed to build settlements and gather fuel. Another reason areas along the tributaries may have been more popular, as opposed to areas directly adjacent to the Illinois River, has to do with defensibility. Being set away from the main thoroughfare that was the Illinois River afforded settlements and extra level of protection from potentially combative peoples traveling on the river, while still providing access to water and transportation. This same pattern of settling near to major waterways but not too close, was observed in Mississippian settlements in the Carolinas by Jones (2012). Jones found that Mississippians in that area created settlements that were within walking distance of major waterways, but were hidden from them by the surrounding landscape. This, as is assumed in the case of CIRV Mississippians, was an intentional decision to allow Mississippians access to the rivers while still maintaining some security in case of attack.

Figure 8 maps the results from the GLU tool, while Figures 9 & 10 show close-ups of the results for clarity. Those areas shown on the map in red represent values of high resistance, i.e., areas mapped by the tool to be less favorable for settlements. Those areas shown in green represent values of low resistance, i.e., areas mapped by the tool to be more favorable for settlements.

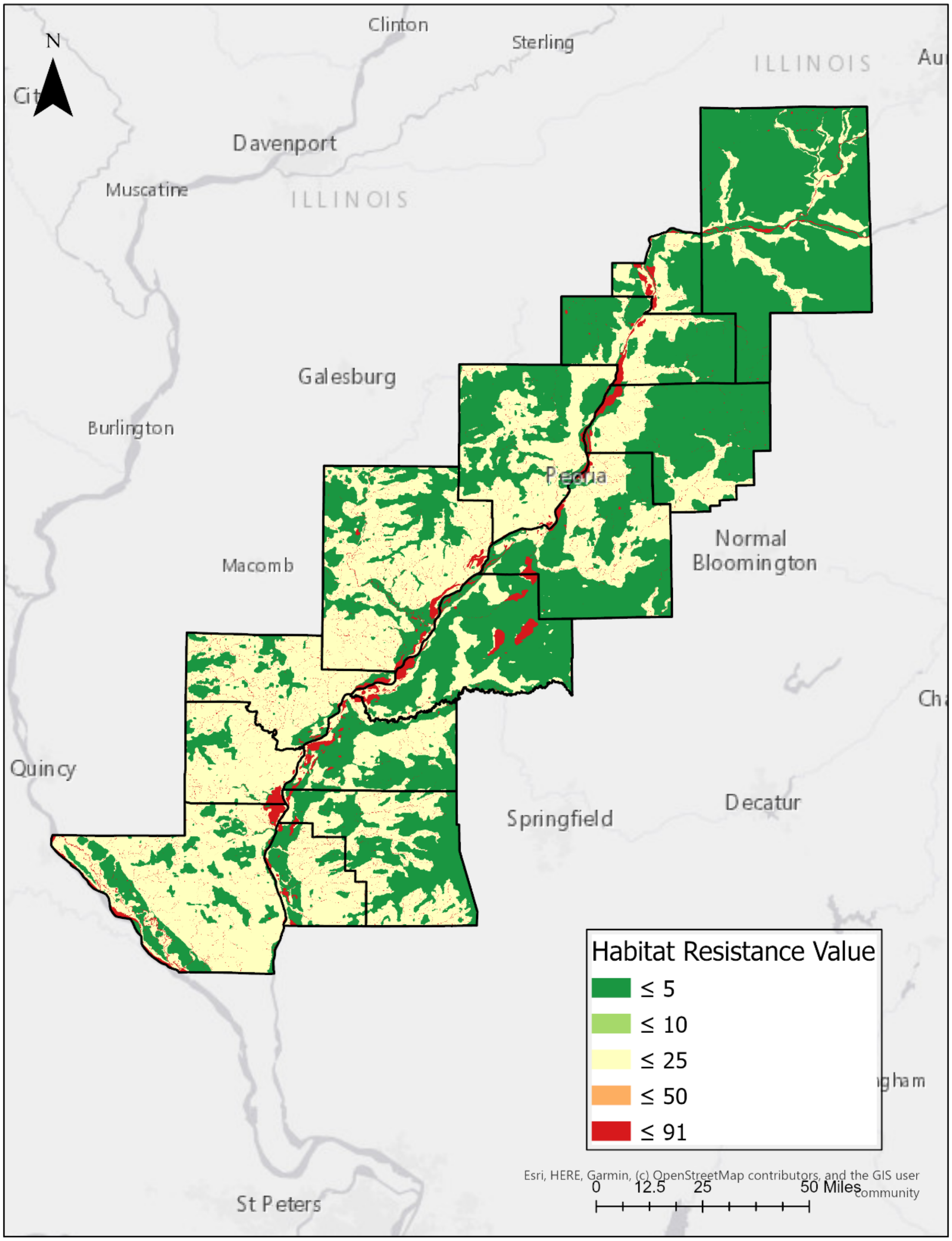

Figure 8 Habitat Resistance Results from GLU Tool with Major Sites

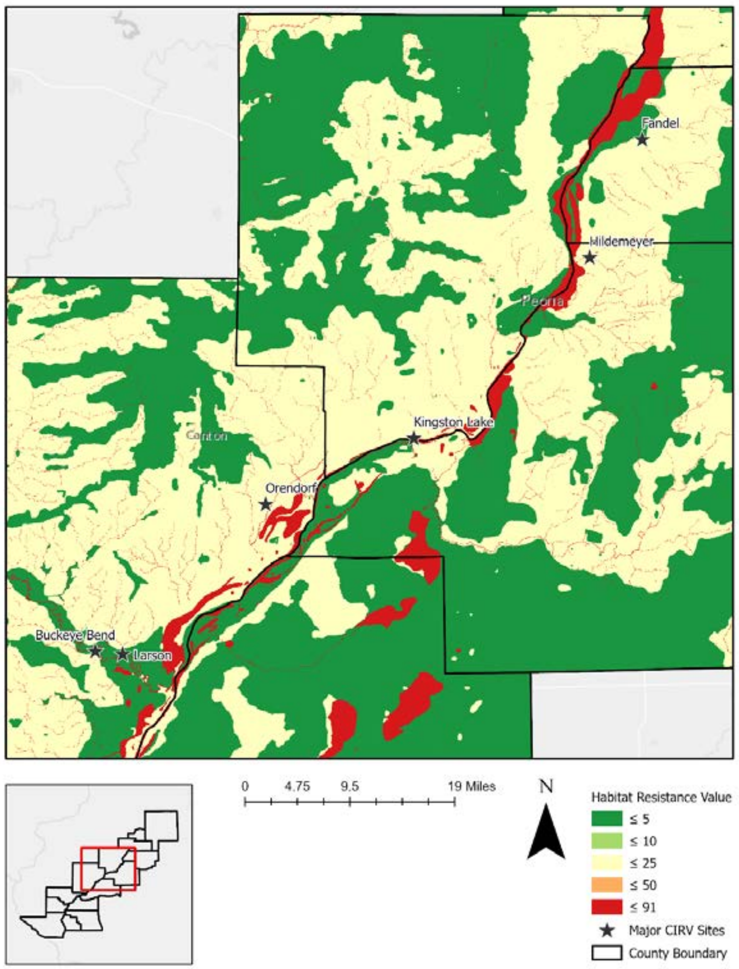

Figure 9 GLU Results Zoomed In: Northern

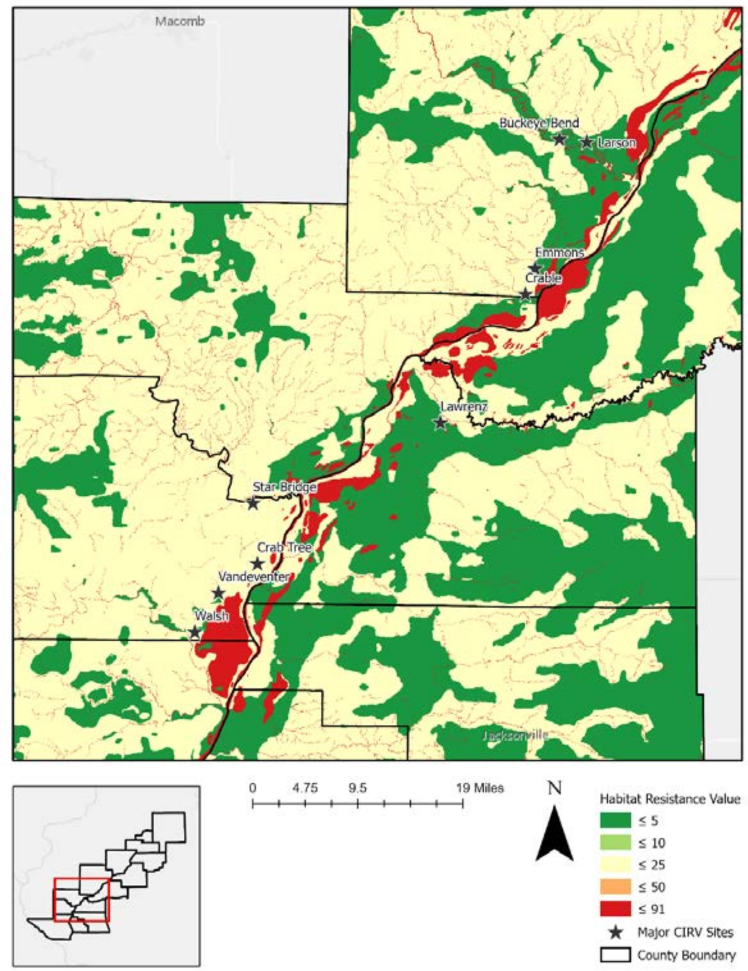

Figure 10 GLU Results Zoomed In: Southern

In general, those areas on the map that ranked highest in resistance correspond with the location of either the Illinois River or one of its many tributaries. While proximity to water was a desirable factor in Mississippian site selection, the water itself would not have been a suitable settlement location. It is also important to remember that the age of each of these datasets is not necessarily the same. For example, the hydrology dataset from USGS is from 2017, while the report date ranges on the archaeological sites go back as far as the 1930s. This could cause some sites to appear within the boundaries of the river, when in fact, it could simply be a large gap in time between when the different datasets were gathered. Without more detailed historical data, this is a limitation when examining prehistoric landscapes that cannot be avoided.

Many of the areas represented in the orange or tan were too far away from one of the major water bodies. Additionally, much of the areas represented in tan were identified as forest in the historic landcover dataset. While forested areas were assumed to have been desired for resource acquisition (e.g., foraging and hunting), they were ranked with a medium to medium low resistance as they would have posed a challenge to building a settlement as they would require clearing before a settlement could have been established. Areas classified in the landcover dataset as prairie or glade would have been ideal for settlement. These areas would have required less clearing of hardwood growth prior to establishing a new settlement.

Overall, the GLU tool provided a way to visualize how Mississippian peoples adapted to the different environments around the Illinois River Valley under the given weighting scheme. One potential area of future research that stems from these results is the opportunity to test and refine the weighting criteria by applying the model in different locations and/or with different resource priorities.

The tool allows for many different input layers, thus making it a unique option for examining settlement patterns more broadly. This particular area of Illinois, while containing a bluff top region bounding the Illinois River, is not characterized by rugged terrain. Like much of the Midwest, the CIRV is primarily flat land with gentle rises and falls. As such, topographic variables were not used in this study. It would, however, be possible to input topographical variables, such as slope, aspect, viewshed characteristics, and topographic site type (e.g., hilltop vs. riverside) as variables in the model.

The results from the GLU tool were also used to examine the favorability of the 13 major sites. The resistance values within each site were summarized to display the two largest percentage groups of values within each larger site groupings. The first and second most prominent ranges in each major site buffer have been summarized Table 3. The same delineation of low, medium, and high that was used earlier was applied to facilitate comparison with the GLU results. These groupings have been specified below for clarity.

- Low Resistance: 0-19.0, Green
- Medium Resistance: 19.1-50, Yellow
- High Resistance: 50.1-100, Red

Table 3 GLU Results for Major Sites

Major Site Name	Most Prominent Resistance Range	Percentage	Second Most Prominent Resistance Range	Percentage
Star Bridge	20-23	90%	0-3	7%
Kingston Lake	20-23	77%	0-3	17%
Crabtree	20-23	76%	68-90	13%
Hildemeyer	20-23	76%	68-90	13%
Orendorf	20-23	74%	68-90	16%
Vandeventer	20-23	72%	68-90	21%
Fandel	20-23	63%	68-90	19%
Walsh	20-23	63%	68-90	29%
Lawrenz	0-3	59%	20-23	38%
Buckeye Bend	20-22	58%	0-3	37%
Crable	20-23	52%	68-90	31%
Emmons	20-23	51%	68-90	26%
Larson	20-23	48%	0-3	45%

One expected outcome of this analysis was that major sites in the area would have been built in areas most favorable for habitation, and thus would have low resistance values. Only one of the major sites, Lawrenz, had a low resistance value as the most predominant range within its 5-km buffer. Interestingly, Lawrenz is also one of three sites that fall on the east side of the Illinois River. As previously mentioned, Lawrenz was the largest and longest occupied site in the area, around two to three centuries, based on archaeological evidence (Krus et al., 2019). The site also shows some of the most robust and extensive mounds and palisade structures among Mississippian sites in the CIRV, furthering theories that the site was a major sociopolitical hub. Lawrenz was also one of the few sites located on the eastern side of the Illinois river and, based on previous research in this paper, had a large number of smaller sites that were assigned to it via the Near analysis.

All other sites had medium resistance as the most prominent range in the buffer. Buckeye Bend had a fairly balanced ratio of medium and low resistance coverage areas, with medium being the highest at 58%, but having low resistance as the second most prominent at 37%. An interesting observation is that the site with the highest percentage of high resistance area within its 5k buffer, Larson, is geographically close to Buckeye Bend, a site with relatively balanced resistance ratios.

Overall, these results suggest the need for more refined models of suitability in future studies. While most of the sites had medium values as the most prominent resistance group, they were values on the lower end of that group, values less than 30. Many of the sites did have larger percentages of high resistance areas, but this could be explained by the presence water. In the GLU calculations, water as a landcover cell was ranked as high resistance, as settling on water was not possible. But proximity to water was a desirable trait for settlements.

Overall, the results of the exploratory analysis using Circutscape appeared to show significant potential for future use in archaeology. The methodology offers new opportunities for a deeper examination of the habitat traits that explain the distribution of settlement sites in the CIRV. This analysis only examined three environmental factors: historic land cover, distance to the Illinois River, and distance to tributaries of the Illinois River. As previously mentioned, factors that were not considered in this study include slope and topographic position. While these factors were not included due to the relatively flat terrain of the study area, they could certainly be examined as potential variables to further refine the technique. Another way to enhance the analysis would be to include a layer for the soil type. Soils data for the study region are accessible in GIS formats from sources such as the USDA National Resource Conservation Service (Soil Survey Staff) and could serve to further improve the results of the GLU tool.

Another potential path for future research is to look at temporal change of the sites. In the current study, the decision was made to treat all sites in the area as though they were established and operated in and around the same general period in time. Archaeological evidence indicates that there is more variation in the record. Looking not only at where, but when these sites were established and prospered may provide deeper insight into their spatial distribution.

Overall, this methodical approach could be expanded upon and replicated in the CIRV and similar study areas to better understand settlement distribution patterns. It is difficult to deduce and understand the why of which settlements were placed where, but these analysis techniques could help shed light on this subject. A common question in the CIRV, when examining prehistoric Mississippians, is when and why did they vacate the area? It is possible that further examination of settlement pattern could lend more insight into one day answering those questions.

Conclusion

Perhaps the larger scope of this project lies in the question of how examination of archaeological settlement patterns stands to be advanced by the use of GIS-based analyses. The goal should never be to remove the human interpretation of data and results, but to expand the tools archaeologists have access to and expand their ability to better understand peoples of the past. Before more widespread use of spatial pattern analysis, much emphasis was placed on simple statistics to aid in the understanding of archaeological settlement patterns. Despite some of the early enthusiasm for the use of statistics as a way to understand spatial data, the late 1970's found that neither classic nor traditional statistics were enough to fully understand spatial data in archaeology (Arias, 2013). With statistics limiting archaeologists to only examining point data, it was found that much of the wealth of archaeological data was left out of the examination, resulting in misleading information (Arias, 2013). With the emergence of GIS and geospatial computations, archaeologists are now able to advance their understanding of sites by considering many different variables beyond site location. The cultural and historical knowledge held by archaeologists must always be the backbone of interpreting and understanding GIS-based computations (Jones, 2017).

Examining settlement patterns in relationship to ecological and cultural variables stands to benefit just as much as other areas of archeology have from the use of GIS. By using both previously tested techniques and experimenting with some of the other capabilities of GIS, the results of this research shed light on not only the settlement patterns of prehistoric Mississippians, but also to stand as an example of how GIS continues to add value in answering a variety of questions in the field of archaeology.

Appendix

Habitat and Resistance Table Values

Table 4 Habitat and Resistance Table

Data Layer	ID	Class Description	Extra Info	Habitat Value	Resistance	ExpandCells
LCD	1	Prairie	Historic Landcover data set from the 1800s	0.8	0	0
LCD	3	Water/River		0.0	70	0
LCD	4	Forest		0.7	20	0
LCD	5	Bottoms, Bottom land		1.0	0	0
LCD	12	Marsh		0.2	80	0
LCD	14	Swamp		0.2	90	0
LCD	20	Field, Enclosure		1.0	0	0
LCD	21	Water/Pond		0.0	70	0
LCD	31	Low Land		0.8	20	0
LCD	54	Mound		0.8	20	0
LCD	73	Spring		0.0	70	0
LCD	125	Island		0.6	70	0
LCD	193	Bluff		0.2	80	0
LCD	267	Water/Lake		0.0	70	0
LCD	312	Wet prairie		0.8	20	0
LCD	332	Glade		1.0	0	0
LCD	370	Swale		0.1	90	0
LCD	409	Slough		0	90.000	0
LCD	437	Slash		0.2	80.000	0
LCD	505	Barrens		0.9	10.000	0
LCD	747	High Ridge/Sandy Ridge		0.7	30.000	0
LCD	782	Bushy Prairie		0.7	10.000	0
LCD	787	Thicket		0.7	30.000	0
LCD	1494	Wet Land		0.1	90.000	0
LCD	2240	Bayou		0	80.000	0
LCD	2264	Orchard		1	0.000	0
TRIBS	1	0-500 M From River		1	0	0
TRIBS	2	500-1000 M From River		1	0	0
TRIBS	3	1000-1500 M From River		0.95	5	0
TRIBS	4	1500-2000 M From River		0.95	5	0
TRIBS	5	2000-2500 M From River		0.9	10	0

Data Layer	ID	Class Description	Extra Info	Habitat Value	Resistance	ExpandCells
TRIBS	6	2500-3000 M From River		0.9	10	0
TRIBS	7	3000-3500 M From River		0.85	15	0
TRIBS	8	3500-4000 M From River		0.85	15	0
TRIBS	9	4000-4500 M From River		0.8	20	0
TRIBS	10	4500-5000 M From River		0.8	20	0
TRIBS	11	5000-5500 M From River		0.75	25	0
TRIBS	12	5500-6000 M From River		0.75	25	0
TRIBS	13	6000-6500 M From River		0.75	25	0
TRIBS	14	6500-7000 M From River		0.65	35	0
TRIBS	15	7000-7500 M From River		0.65	35	0
TRIBS	16	7500-8000 M From River		0.65	35	0
TRIBS	17	8000-8500 M From River		0.5	50	0
TRIBS	18	8500-9000 M From River		0.5	50	0
TRIBS	19	9000-9500 M From River		0.5	50	0
TRIBS	20	9500-10000 M From River		0.5	50	0
TRIBS	21	10000-10500 M From River		0.25	85	0
TRIBS	22	10500-11000 M From River		0.25	85	0
TRIBS	23	11000-11500 M From River		0.25	85	0
TRIBS	24	11500-12000 M From River		0.25	85	0
TRIBS	25	12000-12500 M From River		0.25	85	0
TRIBS	26	12500-13000 M From River		0.25	85	0
TRIBS	27	13000-13500 M From River		0.25	85	0
TRIBS	28	13500-14000 M From River		0.25	85	0
TRIBS	29	14000-14500 M From River		0.25	85	0

Data Layer	ID	Class Description	Extra Info	Habitat Value	Resistance	ExpandCells
TRIBS	30	14500-15000 M From River		0.25	85	0
TRIBS	31	15000-15500 M From River		0.1	90	0
TRIBS	32	15500-16000 M From River		0.1	90	0
TRIBS	33	16000-16500 M From River		0.1	90	0
TRIBS	34	16500-17000 M From River		0.1	90	0
TRIBS	35	17000-17500 M From River		0.1	90	0
TRIBS	36	17500-18000 M From River		0.1	90	0
TRIBS	37	18000-18500 M From River		0.1	90	0
TRIBS	38	18500-4200 M From River		0.1	90	0
ILRIV	1	0-500 M From River		1	0	0
ILRIV	2	500-1000 M From River		1	0	0
ILRIV	3	1000-1500 M From River		0.95	5	0
ILRIV	4	1500-2000 M From River		0.95	5	0
ILRIV	5	2000-2500 M From River		0.9	10	0
ILRIV	6	2500-3000 M From River		0.9	10	0
ILRIV	7	3000-3500 M From River		0.85	15	0
ILRIV	8	3500-4000 M From River		0.85	15	0
ILRIV	9	4000-4500 M From River		0.8	20	0
ILRIV	10	4500-5000 M From River		0.8	20	0
ILRIV	11	5000-5500 M From River		0.75	25	0
ILRIV	12	5500-6000 M From River		0.75	25	0
ILRIV	13	6000-6500 M From River		0.75	25	0
ILRIV	14	6500-7000 M From River		0.65	35	0
ILRIV	15	7000-7500 M From River		0.65	35	0

Data Layer	ID	Class Description	Extra Info	Habitat Value	Resistance	ExpandCells
ILRIV	16	7500-8000 M From River		0.65	35	0
ILRIV	17	8000-8500 M From River		0.5	50	0
ILRIV	18	8500-9000 M From River		0.5	50	0
ILRIV	19	9000-9500 M From River		0.5	50	0
ILRIV	20	9500-10000 M From River		0.5	50	0
ILRIV	21	10000-10500 M From River		0.25	85	0
ILRIV	22	10500-11000 M From River		0.25	85	0
ILRIV	23	11000-11500 M From River		0.25	85	0
ILRIV	24	11500-12000 M From River		0.25	85	0
ILRIV	25	12000-12500 M From River		0.25	85	0
ILRIV	26	12500-13000 M From River		0.25	85	0
ILRIV	27	13000-13500 M From River		0.25	85	0
ILRIV	28	13500-14000 M From River		0.25	85	0
ILRIV	29	14000-14500 M From River		0.25	85	0
ILRIV	30	14500-15000 M From River		0.25	85	0
ILRIV	31	15000-15500 M From River		0.1	90	0
ILRIV	32	15500-16000 M From River		0.1	90	0
ILRIV	33	16000-16500 M From River		0.1	90	0
ILRIV	34	16500-17000 M From River		0.1	90	0
ILRIV	35	17000-17500 M From River		0.1	90	0
ILRIV	36	17500-18000 M From River		0.1	90	0
ILRIV	37	18000-18500 M From River		0.1	90	0
ILRIV	38	18500-4200 M From River		0.1	90	0

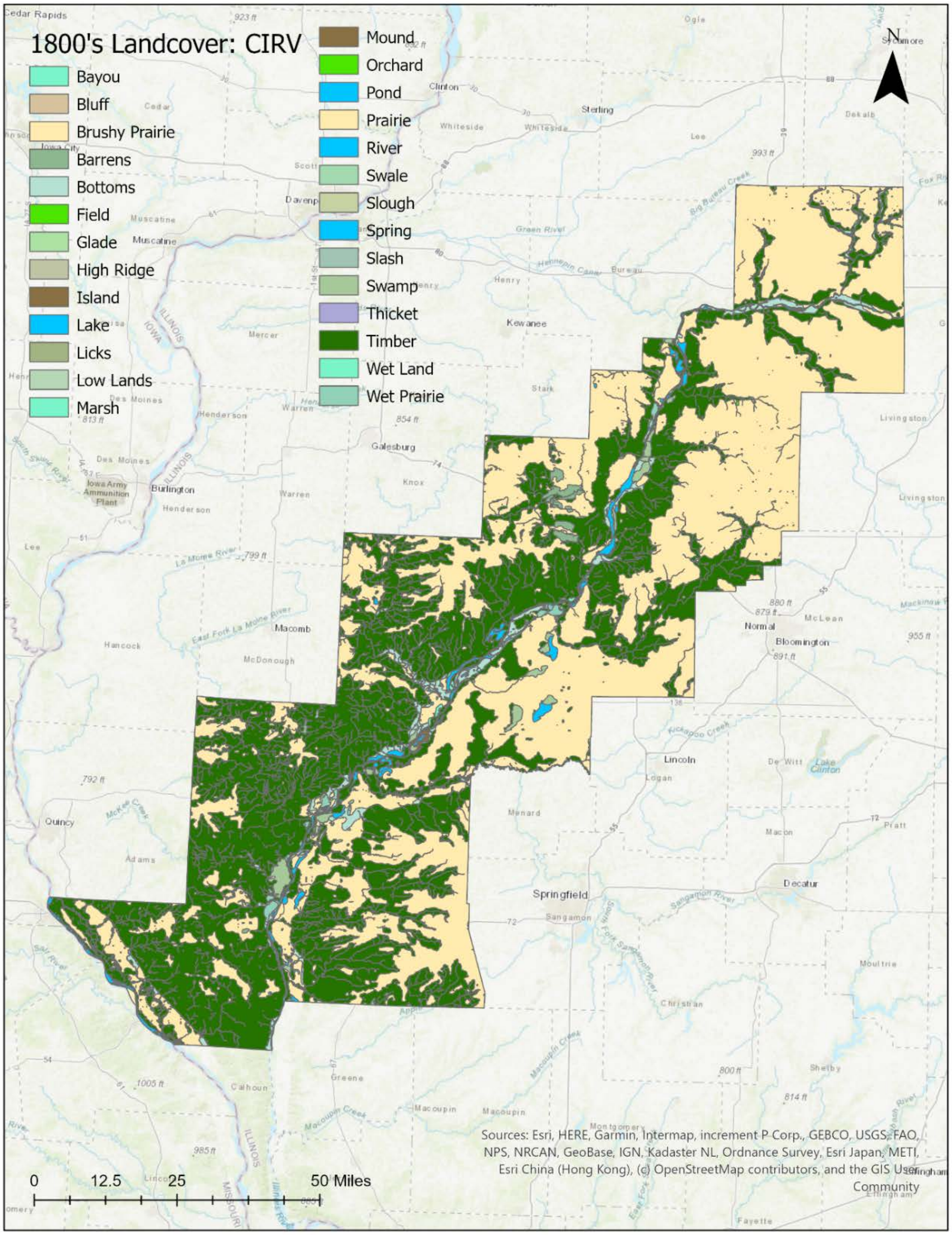

Figure A-9 Illinois Landcover in the Early 1800s. Data from the Illinois Department of Natural Resources, Illinois Natural History Survey

References

Arias, V. M. (2013). *Application of GIS and Spatial Data Modeling to Archaeology: A Case Study in the American Southwest* (Doctoral Dissertation). ProQuest Dissertations Publishing, 2013. 3601130

Bardolph, D. N. (2014). Evaluating Cahokian contact and Mississippian identity politics in the late prehistoric Central Illinois River valley. American Antiquity, 69-89

Beier, P., Spencer, W., Baldwin, R., & McRae, B. H. (2011). Best science practices for developing regional connectivity maps. *Conservation Biology*, *25*(5), 879-892.

Bird, B. W., Wilson, J. J., Gilhooly III, W. P., Steinman, B. A., & Stamps, L. (2017). Midcontinental Native American population dynamics and late Holocene hydroclimate extremes. *Scientific reports*, *7*, 41628.

Chandra, A. K., Raghavan, P., Ruzzo, W. L., Smolensky, R., & Tiwari, P. (1996). The electrical resistance of a graph captures its commute and cover times. *Computational Complexity*, *6*(4), 312-340.

Conrad, L. A. (1991). *The Middle Mississippian Cultures of the Central Illinois Valley* (pp. 119-156). University of Illinois Press, Urbana.

Dickson, B. G., Albano, C. M., Anantharaman, R., Beier, P., Fargione, J., Graves, T. A., ... & Littlefield, C. E. (2019). Circuit-theory applications to connectivity science and conservation. *Conservation biology*, *33*(2), 239-249.

Diniz, M. F., Cushman, S. A., Machado, R. B., & Júnior, P. D. M. (2019). Landscape connectivity modeling from the perspective of animal dispersal. *Landscape Ecology*, 1-18.

Doyle, P. G., & Snell, J. L. (1984). *Random walks and electric networks* (Vol. 22). American Mathematical Soc..

Ducke, Benjamin & Kroefges, Peter C. 2007, ‘From Points to Areas: Constructing Territories from Archaeological Site Patterns Using an Enhanced Xtent Model’, Conference on Computer Applications and Quantitative Methods in Archaeology, Berlin, Germany, 2-6 April

Ebert, D. (2004). Applications of Archaeological GIS. *Canadian Journal of Archaeology/Journal Canadien d'Archéologie*, 319-341.

Harn, A. D. (1994). *Variation in Mississippian Settlement Patterns: The Larson Settlement System in the Central Illinois River Valley* (No. 50). Illinois State Museum.

Jones, E. E., Gattis, M., Morrison, T. C., Wardner, A., & Frantz, S. (2012). Exploring Tribal Settlement Ecology in the Southeast: A Case Study from the North Carolina Piedmont, 800–1600 Ce. *North American Archaeologist*, *33*(2), 159-192.

Jones, E. E. (2010). Sixteenth-and Seventeenth-century Haudenosaunee (Iroquois) Population Trends in Northeastern North America. *Journal of Field Archaeology*, *35*(1), 5-18.

Kintigh, K. W., & Ammerman, A. J. (1982). Heuristic approaches to spatial analysis in archaeology. *American Antiquity*, *47*(1), 31-63.

Krus, Anthony M., et al. "Chronology of a Fortified Mississippian Village in the Central Illinois River Valley." *Radiocarbon* 61.3 (2019): 713-731.

Lock, G., & Pouncett, J. (2017). Spatial thinking in archaeology: Is GIS the answer?. *Journal of Archaeological Science*, *84*, 129-135.

Maschner, H. D. (1996). Geographic information systems in archaeology. *New methods, old problems: Geographic information systems in modern archaeological research*, 1-21.

McGarigal, K. (2015, April 21). FRAGSTATS Help. Retrieved April 10, 2017, from https://www.umass.edu/landeco/research/fragstats/documents/fragstats.help.4.2.pdf

McRae, B.H., A.J. Shirk, and J.T. Platt. 2013. Gnarly Landscape Utilities: Resistance and Habitat Calculator User Guide. The Nature Conservancy, Fort Collins, CO.

Merow, C., & Silander, J. A. (2014). A comparison of Maxlike and Maxent for modelling species distributions. *Methods in Ecology and Evolution*, *5*(3), 215-225.

Milner, G. R., & Chaplin, G. (2010). Eastern North American population at ca. AD 1500. *American Antiquity*, *75*(4), 707-726.

Milner, G. R., Chaplin, G., & Zavodny, E. (2013). Conflict and societal change in late prehistoric eastern North America. Evolutionary Anthropology: Issues, News, and Reviews, 22(3), 96-102.

Niknami, K. A., Amirkhiz, A. C., & Jalali, F. F. (2009). A GIS Technical Approach to the Spatial Patter Recognition of Archaeological Site Distributions on the Easter Shores of Lake Urmia, Northwestern Iran. *Archeologia e Calcolatori*, *20*, 261-276.

Niknami, K. A., Irandoust, H., & Tahmasebi, A. (2013). Environmental and Cultural Factors Influencing Parthian Archaeological Site Distribution in the Sarfirouzabad Plain of Kermanshah, Northwest of Iran. *International Journal of Geoscience,4*(1), 69-77.

Pluckhahn, T. J., & McKivergan, D. A. (2002). A Critical Appraisal of Middle Mississippian Settlement and Social Organization on the Georgia Coast. *Southeastern Archaeology*, 149-161.

Schroeder, S. (2004). Current Research on Late Precontact Societies of the Midcontinental United States. *Journal of Archaeological Research*, *12*(4), 311-372.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at https://websoilsurvey.nrcs.usda.gov/. Accessed 05/01/2018.

Tarkhnishvili, D., Gavashelishvili, A., Murtskhvaladze, M., & Latsuzbaia, A. (2016). Landscape complexity in the Caucasus impedes genetic assimilation of human populations more effectively than language or ethnicity. *Human Biology*, *88*(4), 287-300.

Wilson, G. D., Bardolph, D. N., Esarey, D., & Wilson, J. J. (2020). Transregional Social Fields of the Early Mississippian Midcontinent. *Journal of Archaeological Method and Theory*, 1-21.

Wilson, G. D., Delaney, C. M., & Millhouse, P. G. (2017). The Mississippianization of the Illinois and Apple river valleys. Mississippian Beginnings, 97-129.

Wilson, G. D., Marcoux, J., & Koldehoff, B. (2006). Square pegs in round holes: Organizational diversity between early Moundville and Cahokia. *Leadership and polity in Mississippian society*, 43-72.

Wilson, G. D., Melton, M. A., & VanDerwarker, A. M. (2018). Reassessing the chronology of the mississippian central Illinois River valley using bayesian analysis. *Southeastern Archaeology*, *37*(1), 22-38.

Curriculum Vitae

Kayla Jan Swoveland

Education

Indiana University – Purdue University Indianapolis
MS. Geographic Information Science
July 2020

Indiana University – Purdue University Indianapolis
BA. Anthropology
May 2014

Certificate in Museum Studies
May 2014

Professional Experience

The Polis Center, Indianapolis, IN
December 2016- Present
GIS Analyst

- Team member on FEMA's RiskMAP Project. Updating regulatory flood boundaries for the State of Indiana using ArcGIS and various project specific extensions. Updating FloodMap Desktop (FMD) databases with new data to produce regulatory reports for FEMA.
- Team member on Indiana Department of Homeland Security's (IDHS) Indiana State Multi-Hazard Mitigation Plan update for 2019. Worked to preform statewide flood risk analysis using FEMA's HAZUS-MH software to analyze potential flooding impacts statewide. Work with other team members to write, edit and revise the Indiana Multi-Hazard Mitigation Plan report. Present findings to members of IDHS and Public during a series of meetings.
- Project Coordinator and team member on IDHS's county Multi-Hazard Mitigation Plan updates. Contact and work with county officials to update the mitigation plan for each jurisdiction. Gather required data and preform risk analysis for each county. Work with other team members to write the Multi-Hazard Mitigation Plan for each county. Present project and findings to relevant community leaders through a series of meetings. Managing and training interns to assist on the project as needed.
- Assisting other team members in the center with various projects such as teaching undergraduate Capstone students to use ESRI's StoryMap apps, using StoryMap to create an app for the Carmel-Clay Historical Society, and helping other departments run analysis as needed.

March 2016- December 2016
Geoinformatics Intern

- Preform various risk analyses for county mitigation plans. Using ArcGIS products, HAZUS-MH, and Feature Manipulation Engine (FME) for data translation and conversion. Updating workflows and other documentations. Preparing and reviewing technical reports.

Indiana University- Purdue University Indianapolis (IUPUI) Department of Geography, Indianapolis, IN
August 2015- December 2016
Graduate Department Research Assistant

- Use GIS to digitize archaeological site information gathered as part of the Department of Anthropology's fieldwork in the Central Illinois River Valley. Using ArcGIS products, 3D visualization, and database management.

Conference Presentations

Indiana Geographic Information Council 2019 Conference, Bloomington, IN
"State of Indiana's State Mitigation Plan" May 2019
Co-Presenter

Midwestern Archaeological Conference 2017, Indianapolis, IN
"Unearthing Prehistoric Settlement Patterns: Using GIS to Understand Mississippian Settlement Patterns in the Central Illinois River Valley" October 2017
Poster Presentation

Volunteer Experience

Indiana State Museum, Indianapolis, IN
May 2014- July 2015
Collections Volunteer

Indiana State Museum, Indianapolis, IN
January 2014- May 2014
Archival Intern

Memberships

Indiana Geographic Information Council
2017-Present

Software Skills

- GIS software packages including ArcGIS Desktop, ArcGIS Pro, ArcGIS Online, Hazus-MH, FloodMap Desktop (FMD), FME, ALOHA, and Gnarly Landscape Utilities (GLU)
- Microsoft software including, Excel, Access, and Word