LATE WOODLAND CULTURAL ADAPTATIONS IN THE LOWER MISSOURI RIVER VALLEY: ARCHERY, WARFARE, AND THE RISE OF COMPLEXITY

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and hereby certify that, in their opinion, it is worthy of acceptance.

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Introduction

Beginning in Mesolithic times and probably much earlier, the development of archery was an innovation that revolutionized the procurement of food and warfare. This was an innovation that enabled a hunter or warrior to carry out a potentially lethal strike on animals or people at distances greater than a hundred yards or so using a stand-off projectile-weapons technology. Prior to this, other projectile technologies such as the spear, sling, or atlatl (spear thrower) were mostly effective at much closer ranges and had relative disadvantages for their use including a lack of flexibility in casting position and greatly decreasing accuracy as range increased. As incipient archery technology developed and spread throughout the world, bows and arrows of ever more innovative construction and lethality developed. The Late Woodland Period in Central North America was unusual in that widespread societies lacking archery were very quickly thrust into contact with an advancing and very dangerous archery technology that promised major changes for their societies. This was not a change that took place in a uniform or regular pattern, but was instead a very halting and long-term process that culminated with the arrival of formal, organized warfare that was endemic among the later Mississippian cultures of mid-western and eastern North America.

Weapons such as the bow and arrow, the smoothbore musket, the rifle, the machine gun, the ballistic missile, nuclear warheads, etc., all had transformative effects on societies that led to mass changes and further technological innovation. We see wholesale changes resulting from advances in weapons technology, including identifiable events where advances in weaponry proved decisive and changed societies forever. The rapid cavalry maneuvers and superb bows of the Mongols fundamentally transformed the economic, political, and religious structure of Asia and the Near East. The English long-bowmen at Agincourt and Crecy forever put an end to the quaint notion of the heavily armored mounted knight, ultimately undermining the whole feudalistic order. The Union infantry defending Cemetery Ridge at the Battle of Gettysburg with their Springfield rifles forever turned the mass infantry bayonet charge into sure suicide and made warfare an infinitely costlier proposition. By World War I when the horrors of machine-gun warfare appeared, the masses of men who were vainly sacrificed to gain a few feet of ground further demonstrated the folly of mass charges, even when using rifles, again transforming the economic, political, and religious structures of the Old World. Revolutions in killing technology were a major factor in the quest for humans to gain the upper hand against rivals with similar intent. Advances in weaponry similarly impacted past societies as humans discovered new and innovative ways of killing each other. Although other innovations such as the development of fire, writing, farming, etc. had similar large-scale effects where they occurred, I would add to that list, the transformative effects of advances in weapons technology and the resulting increases in the size of economically integrated social groups that seem to accompany mass changes in societies throughout human history (Bingham and Souza 2009; Morris 2014).

Indeed, for most of human history, the drive to develop weapons technology often led to the development of other non-weapons technologies that ironically in many cases, helped improve our lives. Human history over the past two million years may then be characterized as gradual, halting technological change culminating in seemingly brief, but dramatic increases in technological and social sophistication. Although the term "revolution" may be too strong, the process may be best described as the adaptation of new technology that fundamentally altered the fabric of society by enabling communication and information exchange on ever-increasing scales each time they happen (Morris 2014). The primary enterprise in generating large amounts of highly varied culturally transmitted information to be disseminated and diffused is found in non kin-based coalitions that met in societies throughout human history (Bingham and Souza 2009:313). The key here is an advance in social cooperation that enables greater advances in human behavioral sophistication (Bingham and Souza 2009:325). The commonality that defines human non-kin based coalitions is access to potentially coercive weapons technology that was first used for hunting but was subsequently applied to the area of human relations in an attempt to gain advantage over others (Bingham and Souza 2009:341).

The following research addresses the impact of the introduction of the bow and arrow on Southeast societies living along the Missouri river. The introduction of the bow and arrow into prehistoric Missouri during the Late Woodland Period changed the entire Middle Woodland social dynamic and settlement pattern arrangement such that there was a major increase in social cooperation between settlements tied closely to defensive settlement strategies. I seek to employ a series of spatial-statistical tests to demonstrate that at least for the Lower Missouri River Valley, changes in settlement pattern from Late Woodland to Early Mississippian Periods strongly correlate with the introduction of the bow and arrow and that these changes also spurred increases in social complexity. I argue here that conditions created by the arrival of the bow and arrow called for increased coordination and increased communications among settlement locations such that farmer-collector and band-level social groups are coordinating defensive settlement strategy. Such relationships may denote incipient alliance formation or a possible effort at collective defense of closely interacting settlements. I further argue that the first steps towards increased complexity in the study area are primarily in response to defensive actions in response to long range weapons technology.

This study is based on the application of Geographic Information Systems (GIS) approaches to look at viewsheds, site distances, and the degree of inter-visibility among settlements, in combination with other archaeological information about subsistence and settlement structure patterns. I ultimately suggest that the introduction of the bow and arrow may have caused settlements to move to locations that provided both excellent viewsheds relative to previous settlements and inter-visibility among settlements, both of which help decrease the likelihood of surprise attacks and increased the speed with which aid and reinforcements could be delivered to attacked settlements. This defensive structure was then replaced by larger settlements in which larger groups of people came together to provide defense through numbers. Settlement locations also changed, perhaps reflecting the formation of somewhat stable boundary zones along natural geographic breaks. I begin my discussion with a consideration of the underlying theoretical structure, and then provide the relevant cultural historical background. After that I discuss my methods and the data I use in the analysis. Finally, I provide the analysis that supports my conclusions.

Theoretical Background

Although the use of evolutionary conceptual frameworks in archaeology owe much to the ideas of earlier anthropologists and scientists in other fields, the rise of evolutionary applications in Americanist Archaeology received much of its early impetus with work of early neo-evolutionary anthropologists such as Julian Steward (1955) and Leslie White (1949, 1959). Steward and White led a growing movement in the late 1940's and 1950's to reject the ideas of the entrenched culture historical approach with its emphasis on mental phenomena, diffusion, and trait lists, in favor of a more ecological, systemic and evolutionary approach to the study of cultural evolution. Culture historians used a theoretical framework that has been described as "normative" (Flannery 1967; although see Lyman and O'Brien 2004). This means that culture consists of shared ideas, beliefs, and values held in various degrees by members of a given culture. Artifacts are simply products of these culturally shared norms and these tend to change with time, distance, or as outside systems of norms make contact. Therefore, culture historians have always concerned themselves primarily with constructing “time-space grids” depicting cultural variation over geographic space and vast expanses of time (Flannery 1967:119).

In contrast to the cultural-historical perspective of explaining culture change in such terms as the migrations or diffusions of discrete cultural entities into the domain of other culture entities, processualists (and in fairness some ecologically minded cultural-historians) considered culture to be an adaptive mechanism that evolved by interacting with the surrounding environment (Binford 1962; Caldwell 1959). Following White and Steward, Lewis Binford (1962:218) adapted a view of culture change strongly grounded in cultural ecology. Binford integrated White’s (1959) view of culture as the “extra-somatic” means of adaptation of humans to their environment. As outlined by White (1949), a cultural system is described in terms of three horizontal strata: “the technological layer on the bottom, the philosophical on the top, the sociological stratum in between.” The technological factor was seen as determinant of the rest of the cultural system as a whole. Societies therefore adapt to their environments first through their technological subsystems and secondarily through their social and ideological subsystems.

Differing sharply from the cultural historians, a central tenet of processual or “new archaeology” was to explain culture “process” or why culture change takes place. To the processualists, culture could not be understood by the study of a single variable. Culture was instead a multivariate phenomenon whose operation could only be understood by the study of several causally relevant factors that functioned either in combination or independently. It was therefore the duty of archaeologists to isolate these causative variables and to discern the relationships among them (Binford 1965:205). As Binford (1962:217) states, explanation in archaeology is “the demonstration of a constant articulation of variables within a system and the measurement of the concomitant variability among the variables within the system”. He then goes on to say that change in one variable can be shown to affect other variables and that this effect can be predicted and quantified. To many processualists, culture needed to be viewed as a multi-faceted, systemic, and adaptive entity involved in the integration of human societies with their environments.

Within the scope of neo-evolutionary tradition, some processual archaeologists made attempts to demonstrate the predominant role of a limited number of ecological and demographic variables in explaining cultural evolution. The problem was that little of what they observed agreed with their predicted outcomes (Trigger 1989:308). The inadequacies inherent in some early models in processualist archaeology lead to a growing level of dissatisfaction with an approach that was seen as unable to adequately explain systemic variability (Stickel 1982:13).

As Stickel (1982:13) points out, two of the earliest proponents of processualist archaeology, Lewis Binford (1962, 1965) and David Clarke (1965), emphasized the idea of culture being organized into interactive systems, but perhaps failed to adequately account for the variability in such systems. In applying such theory to socio-cultural phenomena, Clarke (1965:128) like Binford, gave primacy to the physical environment as a system in moving equilibrium with several subsystems. The linkage of cultural systems with the broader environment is such that changes in environment lead to changes in socio-cultural systems to a degree that is “dependent on variety within the socio-cultural system.” Clarke goes on to say “in so far as a culture is an adaptation to a specific environment, a change in the environment may produce changes in the culture to maintain equilibrium inversely proportional to the culture’s technological level.”

Flannery (1973:50) points out that a schism developed in processual archaeology almost from the point of its inception. Flannery saw a disagreement between what he called “law-and-order” archaeologists and “serutan” archaeologists. The law-and-order archaeologists made their primary goal the formulation and testing of general laws of culture change according to the deductive-nomothetic “covering law” model of Karl Hempel. These arguments typically took the form of “if A then B” assertions followed by a test in an attempt to formulate general laws of culture change. The proponents of this approach tended to focus on largely monocausal “prime mover” explanations of cultural evolution. While both groups argued for the acceptance of archaeology as a science, the serutan archaeologists drew more of their inspiration from von Bertalanffy’s general systems theory, biological living systems models, and the regulatory aspects of systems (Flannery 1973:51). The systems theory approach differs from the law-and-order approach mainly by the fact that it is more inductive and is skeptical of notions of linear causality and the formulation of general laws that are specific to human behavior (Flannery 1973:52; McGlade and van der Leeuw 1996:8). For the most part, some saw a problem in applying mechanistic-deterministic models to a phenomenon as flexible and variable as human culture and further believed that the Hempelian D-N covering law approach based on the physical sciences was totally inadequate to explain such phenomena (Kelley and Hannen 1986). The non-linear nature of interaction at the heart of complex systems was seen to preclude any simple, reductionist epistemology (McGlade and van der Leeuw 1996:14). Instead, given the complexity of the subject, archaeologists should seek explanatory power in probabilistic, evolutionary-biological theory (Flannery 1986).

Over the history of the development of a unified theory of culture change, few had examined the work of Charles Darwin and the interaction between culture, the environment, and the genotypic variability of individual humans. Darwinian concepts had been known for some time to those on the forefront of archaeological thinking with the processualists even claiming theirs was an evolutionary approach, but there was perhaps a seemingly unbridgeable gap between biological theory and theories of culture change since cultural adaptation was seen as an extra-somatic process (Dunnell 1980, 1982). The processes of biological evolution and natural selection had shaped the manifest expression of every type of life going back to the beginning of time, yet there had been little if any conscious deference among anthropologists to the role of biological-evolutionary processes in the shaping of human culture.

In contrast to the processes of human evolution, most of the cultural data that is used in archaeological research and discourse derives from a pool of data representing the agency of individual human beings over highly variable amounts of time (Dunnell 1995:41), and this study is no exception. Evolution among humans is a two-step process in which phenotypic variation is first created and then acted upon by evolutionary processes such as drift and natural selection. The nature of this variation is non-directional or random as pertains to natural selection or drift, but it provides the basis upon which they operate (VanPool and VanPool 2003). Inheritance and natural selection at the individual level is important in that the resulting effects can sometimes resonate at the population level (Mesoudi and O'Brien 2008:3). In this study, weapons systems are seen as an extension of the individual human phenotype, and are thus subject to the same processes of evolution as other types of human traits (Leonard and Jones 1987; Hughes 1998:347).

All archaeologists basically agree that human societies evolve over time. Where they do not agree however, is the idea that societal evolution is governed by the same processes governing biological evolution, specifically natural selection (Jones et al. 1995:13). By this I mean natural section at the level of the individual. Following Lewontin (1970:1, 1974), the concept of natural selection may only be applied with the presence of three basic premises regardless of the subject matter or research question. These are: 1) variation among individuals leading to the differential reproductive success, 2) the ability for that variation to be inherited, and 3) variation that exists outside of natural selection (see also Dunnell 1980:62-63; Leonard and Reed 1993:649-651; Rindos 1989:11). When the subject of study is human behavior, the first two of these are undeniable in that some human behavior is more conducive to reproductive success than others. In our own society we can easily see the deleterious effects of behaviors from bad diet to criminality to substance abuse. Conversely, we can also see the behaviors that enhance reproductive success from working out, to personal grooming, to the creation of fitness-enhancing technologies. We have also made great strides in creating deadlier and deadlier weapons technology, a phenomenon that also occurred in the past. As Bettinger (2013:118) notes, the shift in pre-historic weapons technology from the atlatl to the bow was associated with a doubling or tripling of success rates of those wishing to kill animal or human targets.

Secondly, we know for a fact that genetic transmission takes place and this is adequate for applying an evolutionary framework (Dunnell 1978:197; 1980:66). As cultural traits are extensions of the outward physical manifestation (phenotype) of individual humans interacting with the environment, those cultural traits that enhance individual fitness will survive and be passed on and those that do not will be selected against. Too often archaeologists forget that selection works on phenotypes and not on genotypes (O'Brien 1996:7).

Lastly, the variation generated independently of natural selection must also be present. This idea is a bit more controversial in that humans are purposive creatures seen more as governed by intentionality and not the uncompromising whims of random genetic mutation and recombination. Evolutionary archaeologists agree with those who say that human behavior is non-random and purposive. Even so, evolutionary archaeologists believe that the idea that variation in human behavior is generated independently of natural selection is correct. As discussed previously, only certain behaviors are successful, and to discuss success in terms of the intent behind successful behaviors makes no more sense than to discuss the failures and the intent behind those failures (Leonard and Abbott 1992). Given that the steps in evolution, the creation of variation, and natural selection, are independent of one another, evolutionary change is opportunistic in that it is neither driven by intention, nor is it teleological (Ramenofsky 1995:135-6).

Evolutionary archaeologists argue that human behavior is random with respect to the selective environment in that humans will try many different behaviors in response to specific environmental influences. Over time some of those behaviors will be more successful than others. For example, when the bow and arrow technology was initially developed, there were undoubtedly many types of raw materials and manufacturing behaviors that were attempted to help improve the performance characteristics of the weapon in various environments and against various targets. Some of these actions undoubtedly resulted in weapons that catastrophically failed or were ineffective. Other actions resulted in a vastly improved stand-off hunting technology that promised much greater material rewards and commensurate reproductive success (see Lyman et al.

2008, 2009). The barbed and serrated Scallorn type arrowhead that flourished for hundreds of years throughout the North American Midwest was just one such successful innovation. It promised greater range and accuracy, and was undoubtedly deadly on both animals and humans as it had both the ability to cut tissue effectively and to penetrate deeply. The success of this hunting technology is independent of the hunter's intention (i.e., the difference between the success of this form and the relative inferiority of other forms is not attributable to differences in the users' intents) and the variation that generated it is independent of the forces of selection.

In summation, as Van Pool and Van Pool (2003) state: evolutionary archaeologists suggest that there are unacknowledged conditions of action and unintended consequences of action that have a bearing on human behavior as a result of natural selection and other evolutionary processes. As Leonard and Jones (1987) state, there is no one-to-one correlation between human reproduction and artifacts and cultural traits that are replicatively successful. Natural selection will however, lead to the gradual elimination of cultural traits that are replicatively unimportant while increasing those that are replicatively important. Ultimately, evolutionary archaeologists and their critics agree that humans make imperfect decisions and are not consciously aware of everything that affects their behavior. Human intention may therefore be the engine of cultural variation that could lead to successful evolutionary adaptations.

THE BOW AND ARROW

One way the bow differs from other early projectile weapons systems such as the spear or atlatl is that it can effectively store the energy of the human muscles in the few seconds before the archer releases the arrow. The power of a bow is the energy stored when the archer nocks an arrow and pulls it back to firing position. In considering the physics of the bow and arrow, what we basically have is a system of two springs. The larger spring is a stave of flexible wood or wood joined with other materials that is bent to a point that its two ends are connected by a cord. The bent piece of wood is storing an immense amount of potential energy such that when the tightly strung cord is pulled even further back and released, great energy is also released. If this energy is imparted to another object, such as a small, flexible wood shaft (arrow), that object can be propelled with great accuracy, power and distance. At the moment of launch, the force imparted to the arrow from the larger flexed stave causes it also to flex and compress into becoming another spring, giving even greater force to the momentum of the projectile upon being released. While the kinetic energy imparted by an arrow strike may be even less than the earlier spear or atlatl weapons systems, its ability to penetrate an animal's hide and internal organs is greater than the other weapons due to the slender arrow shaft and its sharp point (Cotterell and Kamminga 1992:180).

Power in a bow is proportional to the area encompassed by two lines: the unstrung bow, and the string when drawn to firing position. The larger the area encompassed, the greater the power of the bow (Crosby 2002: 74). Therefore, one way to increase the power of a self-bow design is to increase its length (e.g., the English long bow). Bows consisting simply of a wooden stave are called “self” bows. Adding length to increase power (i.e., making a long bow) was fine until the bow became too large to use (Crosby 2002:74). One means of further increasing the power of the bow is to use several different materials such as sinew (animal ligaments, which are extremely strong and elastic) to “back” the bow and thereby make it a stronger spring. Such bows could be much shorter than self-bows without a loss in arrow velocity and power and therefore were far more flexible in terms of how they were used (Crosby 2002:75). Another is to create a “recurve” bow, which is shorter than a long bow, but is more heavily curved causing it to hold more power. When unstrung, recurve bows in fact bend away from the direction the arms will be bent when strung, causing the bows to form a very strong spring, relative to their size (Crosby 2002:73-74). In measures of projectile power using scientific equipment, a bow consisting of recurve design and several materials was able to shoot an arrow of similar weight over 90 m further than a yew longbow (Bergman et al. 1988:666). Still, human muscle power to draw the bow is strictly limited, so there are always practical limits on a bow’s power.

Relative to spears or atlatl darts, bows and arrows confer another major advantage in that the bow has a vastly greater range. Spears can usually be thrown a maximum of around 60 meters with exceptional throws. Exceptional atlatl (spear thrower) dart casts could be close to 150 meters, but usually closer to a hundred. Ethnographic examples of distance-shooting in cultures with traditional archery may demonstrate arrows shot distances in excess of 300 meters (Cotterrell and Kamminga 1992:166-182). As a system of springs and definitely the product of much human experimentation, the bow and arrow is a somewhat complex tool that might not be readily obvious to a highly mobile society of foragers looking for ways to improve their procurement efficiency and ability to defend themselves. As such, the rapid spread of such technology might best be explained in terms of a diffusion of ideas that moves horizontally within and among cultures, with attempts at creating improvements along the way.

A great deal of the excavated evidence for ancient archery in archaeological sites consists only of arrowheads. This is so much so that quite often very little can be deduced about the bow that shot them, even though much may be learned about the methods and organization of warfare from the circumstances of discovery (Miller et al. 1988: 189). The oldest bows known in the archaeological record are self-bows found on the Danish Island of Zealand and dating from ca. 6000 B.C. (Bergman 1993; Clark 1963). The best known self-bow design is perhaps the medieval English longbow, a bow of great power that was nearly as long as the archer was tall (Crosby 2002:74). These types of bows are inexpensive and can launch about ten aimed shots per minute, but do have drawbacks for their use in tight, confined spaces, heavy cover, or from horseback.

Around the 3rd millennium B.C. some important changes were occurring in bow design in parts of the Old World. Techniques of bonding together different materials with different but complementary properties allowed for the construction of more efficient composite bows of compact design (Bergman et al. 1988:668). As a result, composite bows became the most efficient in terms of the transfer of stored energy and gave a greater velocity and flatter trajectory over a longer distance than simple wooden self-bows of similar draw weight. Without a skilled craftsman trained in the manufacture of such complex bows, it would be difficult for someone not adept at bow manufacture to "reverse engineer" the design and might have precluded its adoption on a mass scale by other groups.

Native American archers who developed composite designs had a considerable advantage in terms of more situations where the bow could be used while still retaining extended range. Some composite bows are of such draw weight and power that an arrow not designed for such a weapon might perform poorly when shot from such a powerful bow (Miller et al. 1988:188). This suggests that technique in shooting the arrow often had to compensate for shortcomings in design. The problem is that the sudden acceleration caused by the force of release of a bowstring causes the arrow-shaft to bend as it flies past the archer's grip. Also known as the "archer's paradox," when this happens, a cycle of oscillation is initiated with the arrow shaft (Farmer 1992:3). Usually, the arrows-shaft will recover as it speeds to the target, but if the shaft is not strong enough, the arrow will break. Thin arrow-shafts would therefore likely place limitations on the size and weight of any projectile point. A possible solution to these limitations might be to use composite arrows as well (Miller et al. 1988:188). This leads to the conclusion that the performance of some ancient

Native American bows may have been as much explained by arrow design as by bow design.

In terms of functional considerations, there is some leeway for arrowheads to exhibit minor stylistic differences without performance tradeoffs as unique expressions of social identity (Griffin 1997:281); however, it is possible this is stochastic variability that has no effect on reproductive success. Broad-heads are more effective when penetration is not the sole concern because their broad profile delivered at the end of a wooden shaft will cause extensive bleeding. Further sacrificing penetrating power, barbing of the arrowhead will tend to keep it in the wound so that the mechanical effect of a moving arrow shaft can exacerbate the hemorrhage, unless the target becomes immediately still (Brown 1940). The optimum functional design of an arrow in hunting is best defined by the surface area of the track the arrow makes through the body and the perimeter of that track in cross section (Friis-Hansen 1990: 494-495). The most efficient design in this regard is known as the “cutting arrow” for its ability to cut a deep and wide wound channel and thus cause the maximum amount of damage and shock to vital organs and tissues. Width is the most important dimension of the cutting arrowhead, but use of perimeter of a wound’s cross-section allows one to include the effects of the arrowhead’s thickness. Bow hunters of modern times generally use sharp cutting arrows and these arrows are designed to provide the optimum balance between penetration and disruption of vital organs.

Various types of projections created by side notching or other shaping provide good anchor points for tying the point to the shaft while simultaneously barbing the point. For hunting, a good attachment of the point to the shaft (or at least the foreshaft) is an advantage because movement as the prey runs will enhance hemorrhaging (Flenniken and Wilkie 1989:151). For warfare, it may actually be more advantageous if the point detaches in the wound, leading to a debilitating infection or death.

Native American arrowhead designs are highly variable and are found in many different sizes and shapes, with variation evident even in the same quiver (Mason et al. 1891:71). One possible explanation is that the arrowhead differences related to the range and specialized purpose of each arrow. Another possibility for different sized arrowheads in the same quiver is that the arrows were collected from slain enemies and had multiple places of origin. Arrows vary by weight, dimensions, fletching, and arrowhead design and these factors often relate to the size of the archer, purpose of the bow, and vulnerabilities of the target (Delrue 2007:245). Differing mean distributions of measurements of arrowhead characteristics at differing times and places may indicate movement towards an optimum technology for a given selective environment. However, there is also an optimum in terms of the costs and method of construction for any given projectile point type.

The time it took to fashion an arrowhead might be highly variable depending on a number of factors such as function, design, and material, but an ethnographic example such as Saxton Pope's (1918:117) observations of Ishi of the Yahi tribe saw an arrow made in about half an hour. Ishi further demonstrated fashioning arrowheads of distinct types for different functions such as gifts or for warfare. Others were designed for hunting specific animals. Observations of Ishi also suggest that bow and arrow making might be done in locations away from settlements, and only by men in contexts imbued with shamanistic or magical elements. In actual hunting applications with bows and arrows, much emphasis would have been placed on the natural advantages of the bow in tactics favoring stealth, and ambush from areas of natural cover. These are tactics that would also favor the successful conduct of war and so the greatest hunters with the bow might also make the greatest warriors with its use.

Arrowhead design and artifact design in general is a balancing act between several often conflicting desires. With arrowhead design, the desire was to balance point design that causes a quick death with one that is also durable and re-usable. A longer, thinner, arrowhead relative to width would enable deeper penetration, but would also make it more likely that the arrowhead is damaged or destroyed. A point that is thicker, relative to length is more durable, but may not kill as efficiently (Cheshier and Kelly 2006:352).

Hunting with a bow relies on sending an arrow deep into an animal's body where it passes through and severs blood vessels, arteries and vital organs ideally causing a relatively quick death. The use of poison can radically affect the design of arrowheads and may compensate for certain trade-offs in design (Bergman 1988:668; Jones 2009). The use of poison on an arrowhead would allow for designs that do not make a wide and traumatic cut, but instead allow for maximum penetration to increase the chance of the arrowhead entering the body. Maximum bone breaking and hide penetration ability is provided by an arrowhead with a front angle not exceeding twenty degrees (Hill 1956:121). It then follows that a wide broad-head with perhaps between 30-40 degrees in the front angle would demonstrate an all-around good balance of both hide penetration and cutting qualities (Friss-Hansen 1990:497). The analogy of the modern rifle bullet is very instructive in considering this problem. Modern hunters with high-powered rifles almost always use some kind of soft-tipped bullet on large game animals. The purpose is that once the bullet strikes soft tissue, it expands and "mushrooms" causing a huge wound cavity and maximum transfer of kinetic energy to the target for traumatic effect. Usually, the animal dies instantly or not long after being shot from shock, trauma and disruption in multiple internal organs, causing massive bleeding. It was realized long ago that military-style full metal jacket bullets quite often penetrate well on soft targets but don't expand or even stay in the target. Very often, they produced a long narrow wound channel with the bullet often going completely through the target, carrying most of its kinetic energy and trauma value with it. As a result, unless a vital organ was hit, the animal had to be slowly and painstakingly tracked from its blood trail until it expired from loss of blood.

In many ways the two-sided cutting arrow acted in the same manner as the expanding bullet, causing maximum transfer of kinetic energy, trauma and shock, resulting in either instant death or an easy tracking job. With human targets in battle, attempting to remove a barbed arrowhead from the body would likely require breaking off the fletching to reduce the chance of infection, and pushing the arrow all the way through the wound. Attempting to withdraw a barbed arrowhead from a wound would cause it to lodge in the tissue causing tearing and greater damage. Often the arrowhead may have been secured in such a way that when the arrow was withdrawn, the head would come loose and remain in the body. As a result, the unfortunate victim probably died quickly from massive bleeding.

When an arrow is launched at long range, the chances of hitting the target are increased when the velocity is high, because of its flatter trajectory. However, high initial velocity is only achieved when the total mass of the arrow launched is rather small. Unfortunately, small mass reduces the energy transferred from the bow to the arrow so that there is less momentum to overcome wind resistance at greater distances. Therefore, to improve chances of hitting a target, a compromise must be made in that the arrow must be of smaller mass than perhaps would be preferable to maximize penetration (Klopsteg 1943). By the time the light arrow reached its target at extended range, velocity and therefore, effectiveness may have been much reduced. Hence, the adaptation of bow and arrow technology could be seen as a series of compromises with the primary goal to hit the target, but not necessarily producing a quick death. This may even be more significant in the context of warfare. We know from accounts of English longbowmen of the Middle Ages and Renaissance that the value of the bow was not seen as simply in its killing power or lack thereof, but the ability to harass and cause panic among the enemy at great distances. English militia leaders in 1562 were instructed to use light “flight” arrows, designed for long range shooting to cause panic in the enemy rear. There are accounts of this happening at the

Battle of Spur in 1513, when French men-at-arms broke ranks and ran due to long-range arrow fire (Phillips 1999:582).

SETTLEMENT PATTERN STUDIES AND WARFARE

In considering the question of warfare among the prehistoric Woodland cultures of Midwestern North America and the role it played in the rise of the later Mississippian culture, there is often scant supporting evidence found in the traditional methods and techniques of North American archaeological approaches to studying this question. Owing to the current academic fascination with “Peace Studies” and the accompanying politically-charged rhetoric regarding the human capacity for peaceful behaviors, it is no surprise that finding evidence to the contrary is not always convincing to the academic community (Emerson 2007:135; Otterbein 1999). Traditionally, North American archaeologists looking for evidence of pre-Columbian warfare have sought evidence such as defensive settlement patterns or earthworks, weapons, evidence of interpersonal violence and trauma in mortuary populations, and the symbolic representations of warfare in art or iconography. Any traditional archaeological consideration of warfare therefore usually relies on four main lines of inquiry: settlement data, skeletal trauma, weaponry adaptable to war, and warlike iconography (Lambert 2002: 209).

Perhaps the most basic starting point for any warfare-related study of a research area is to have to have a basic understanding of how groups of people are arranging themselves across the landscape and how these arrangements might be changing over time. Gordon Willey (1953) once described settlement pattern studies as a starting point for the functional interpretation of archaeological cultures that represented not just their relationship with the natural environment, but technology, and mechanisms of social interaction and control. Settlement patterns can be productively studied from three scales: the individual structure or dwelling, the way that these dwellings are arranged within communities, and the manner that these dwellings or communities are distributed across the landscape (Trigger 1968:55). For the purposes of this paper, I will focus on the last two perspectives as the most relevant to reconstructing the intensity of warfare associated with the introduction of the bow and arrow.

The conventional view is that where warfare is endemic, settlements are quite often built on elevated ground or on the bends of rivers where walls or palisades may be more easily constructed (Trigger 1968:66; Moss and Erlandson 1992:74; Jones 2004; Schaepe 2006:674). Where warfare is not a constant threat, it is likely that sites are located more in deference to an available nearby resource, rather than a location where defensive considerations are more prevalent. However, there is also the possibility of a redoubt where if warning was sufficient, the settlement's occupants could go to avoid a marauding enemy (Maschner 1998: 33). Ideally, the best location for settlement would most likely be both easily defensible and have access to nearby resources. Among prehistoric small-scale societies, it may be that mobility itself may have constituted an important defensive strategy, but one that would be difficult to document archaeologically (Lambert 2002:216).

The spacing of human habitation across a landscape is a complex, multivariate phenomenon that is not amenable to easy interpretation. As Hodder

(1976:53-54) states, when humans locate a settlement on a given landscape, a very large number of variables are taken into account. These variables include the presence or absence of water, vegetation, soil type, topography, defensibility, building materials, and location of other settlements, which all subject a settlement location to varying “pulls,” and will therefore tend to distort patterns of site spacing (Haggett 1965: 94). The myriad of different responses possible for this host of factors can therefore make site spacing rather unpredictable. These factors fall under what could be termed “landscape” archaeology, defined by Savage (2006:330) as an integrated holistic approach that places much emphasis on individuals and individual behavior as central to research. Individuals are key in that it is individual human behavior that results in the cultural patterns we see across a humanly modified landscape. In this approach, landscapes are conceptualized in terms of the social, cognitive, and the physical. Human information transfer and action affect and shape all three of these realms (Savage 2006:330).

Settlement location may sometimes be suggestive of a concern for transport costs and efforts aimed at minimizing movement or making it easier (Johnson 1977:485; Hodder 1976:58). Hodder (1976:85) states that clustering of settlements can result from several factors including the presence of localized resources, the presence of large towns or religious shrines, availability of services, and protection or defense. Very often, regular site spacing is associated with central place theory models that stipulate competition between market centers and control over their periphery. However, as Johnson (1977:495) and

Bray (1983:182) point out, movement minimization and regular site spacing can occur in the absence of market institutions. The placement of sites serving as base camps in the center of habitual use areas or site catchments demonstrates a non-market cause of regular site spacing. A concern with maintaining/defending borders or frontiers is another factor favoring regular site spacing. Sites may be regularly spaced in a cooperative manner to facilitate communication between sites in a common defensive strategy. Thus, the effect of the physical aspects of landscape on settlement is very much a part of settlement analyses including this study (Roberts 1996:48), but such factors can be and often are overshadowed by regional political forces, coercive external threats, the pull of trade markets and other macro-scale social and political phenomena can affect decisions concerning settlement location (Fedick 1995:17; Haggett 1965: 95).

Roberts (1996:45-46) points out that human settlement over varying landscapes is not just a matter of simple economic determinism. The fact is that landscapes have a cultural aspect that goes beyond economic activity, and may also include a cosmic element that rises above the practical world to embrace the sacred. Landscapes are therefore culturally perceived and culturally molded with the sacred and the practical often going together. In the process of evaluating landscapes of human settlement, a number of issues arise: 1) defining regional boundaries, 2) determining the major factors of the natural and human environments that have a potential to affect settlement choice, and 3) looking at cultural factors that affect social, political, or economic organization in human settlements.

In evaluating settlement patterns, we are dealing with a boundary issue in that geographic boundaries or buffer zones were undoubtedly recognized prehistorically as an integral part of the settlement landscape. Geographic space is always delimited by physical or human conditions that affect settlement patterns (Evans and Gould 1982:279). Human social boundaries are dual constructions in that they are a completely artificial way of dividing the physical landscape and as such, they serve not just as dividing lines, but also as places where specific activities take place (McCarthy 2008). We have to remember that information and materials move not just across boundaries, but also along them (Savage 2006:335).

Frontiers and Buffer Zones

Geographical boundaries or frontiers that separate different social groups are places of contact and conduits where ideas and material products are often traded back and forth in a peaceful and sometimes mutually beneficial relationship (McCarthy 2008; Parker 2006:82). However, as places where cultural differences or possessions are often on mutual display, boundary zones can also be the location for hostile action or threat posturing, even when active warfare is not present. Owing to the distrust often generated due to tense or hostile contact, groups will often attempt to mark the boundaries of their territories with different types of cultural features or sometimes with a natural physiographic boundary. One of the most persistent myths among studies of warfare in small scale societies is that such hostilities between groups do not result in acquisition of territory of one group from another, when in fact such outcomes have been common among pre-industrial societies (Keeley 1996:108-109). During the late prehistoric and historic occupation of Missouri, for example, the Osage continually fought for territory with other groups (Burns 2004), a pattern reflected throughout world prehistory (Morris 2014).

Be that as it may, there are those instances where the acquisition of territory in warfare may not be intended and may be epiphenomenal to motivations for war that have no little or no territorial ambition. In fact, the pattern of vacating territory out of fear of hostilities often leads to the creation or widening of buffer zones, followed by the victors expanding their presence into the buffer zone (Keeley 1996:110). An extreme example of this is found among the nomadic Nuer tribe of the Sudan who in seventy years of relentless raiding of their neighbors, managed to increase their territory from 8,700 square miles to 35,000 square miles (Keeley 1996:111). Concentrating on portions of the American Bottom of the Mississippi River and the Lower Ohio River Valley, Stephen Williams (1983, 1990) proposed his “Vacant Quarter” hypothesis for Late Mississippian abandonment of these river valleys and surrounding uplands around A.D. 1450-1550. Although his view is not universally accepted, Williams did not postulate a complete depopulation of this area, but more likely population re-location. However, he did document the cessation of mound-building and the demise of ceremonial centers and year-round villages in the region. Although other scholars have postulated warfare as a possible cause in aiding Late Mississippian abandonment in this region, they do so with the caveat that ecological deterioration may have had a strong causal role. Part of the difficulty is that detailed paleo-climatic data for this region is lacking. (Cobb and Butler 2002:637).

Where population density is minimal, buffer zones can stretch for several miles wide of unoccupied land where those entering would do so only at great personal risk. Individuals or small groups would undoubtedly sometimes venture into the buffer zone only to fall victim to raiding parties or frontier patrols (Keeley 1996:112). As such, buffer zones were ideal places where coalitionary raiding among males could be deployed to defend reproductive territories, acquire females from enemy encampments, and to eliminate rival conspecifics. That is not to say that warfare is the only cause of buffer zones and depopulated hinterlands. Abandonments in the U.S. Southwest and in the Eastern Woodlands of Late Mississippian times may have contributing ecological explanations, but it also appears that they are often accompanied by warfare.

Long Range Weapons and the Rise of Coalitionary Settlements

Although this practice undoubtedly took place in earlier times, for the Woodland cultures of Midwestern North America, the arrival of the bow and arrow at the beginning of the Late Woodland Period would have made such raiding vastly more efficient and productive from the standpoint of killing enemies and capturing resources. Raiders could now attack from much greater distances, from behind heavy cover, and at very little risk to themselves. Defensive strategies would change to address this new threat. It has been argued by Kelly (2005) that the decisive factor in the balance of power between intruders and territorial defenders is detection over weaponry. It follows that asymmetrical detection abilities might outweigh superiority in weapons and numbers and might help determine the outcome of border incursions by outside groups (Kelly 2005).

A possible solution to the problem of defense against long-range weapons might be found in increased social cooperation between settlements, which would increase the likelihood of detecting raids before they occur and the ability to extract costs (through capture or killing) raiders either before or after a raid was conducted. At the very least, alliances among geographically close settlements would decrease the likelihood of a massacre through the application of overwhelming enemy force, given that potential victims could flee to allied villages and/or reinforcements could be summoned to help villages under attack. The formation of such defensive alliances would then be reflected in changes in settlement patterns, which would still necessarily reflect other requirements such as access to necessary resources. It follows then that there are certain spatial settlement arrangements that can best be explained by the addition of cooperative defense to the other factors affecting settlement location. Under contexts of extreme threat, cooperative defense might even be the paramount factor, with settlement locations reflecting a primary concern for defense against long-range weapons fire.

The rise of coalitions and coalitionary tendencies is represented archaeologically as evidence for people coming together and beginning to live in ever larger, more cooperative groups, an occurrence that can be detected through the careful study of settlement pattern change through time. The distribution of sites over time as it relates to site dispersion vs. clustering, site spacing patterns, localized resources, and defensive topography, could also indicate significant patterns in terms of the relationships between the spread of weapons technology and changes in socio-political complexity. I argue that such changes at least in the Lower Missouri River Valley are predominantly related to the widespread adaptation and use of revolutionary long-distance weapons technology.

With the introduction of the bow and arrow, outlying sites located where they were not part of larger site clusters or associations might see increased efforts to locate in defensive or in highly concealable locations, or to construct defensive features such as earthworks or palisades. These site locations could also be “redoubts” for used on occasion as the need arises (Maschner 1998:33). Movement to locations that are defensible, but with sub-optimal access to food resources could potentially be offset by the greater hunting abilities offered by long-distance weapons technology. Faunal resources could now be exploited to a much greater degree than with older, less efficient projectile technology due to far greater range, accuracy and stealth (Bettinger 2013).

With increasing social cooperation, settlement clustering, nucleation, defensive site spacing, site viewsheds, and line-of-sight arrangements are practical options whereby collective defense against attackers relies more on the ability to communicate, and to quickly move warriors to reinforce defenses at points of attack and counterattack if necessary. Alternatively, settlements could compensate for such considerations with either increased concealment or construction of earthworks or wooden palisades to help deflect incoming long-range projectile attacks. However, even with palisaded defenses, viewshed and line of sight would still be important defensive considerations to help blunt a surprise attack.

As has also been argued in the prehistoric Southwest (Wilcox et al. 2007), one theory of settlement pattern changes for riverine Woodland peoples from the Middle Woodland to the Mississippian Period is that settlements in large part, redeployed to reflect much tighter, closely-knit units, and were situated such that settlements of minimal group bands could more easily signal and communicate with their maximal group bands. If site spacing was at regular intervals, such spacing may have been for the defense of frontiers and ease of communication. This theory predisposes that populations would have moved out of some areas (abandonment) and into others (aggregation) in response to some sort of external stimulus. One possible response to such stimulus could have been increased raiding with long-range weapons where small or isolated settlements could be easily attacked and wiped out.

Among highly mobile band-level forager groups, the drive for an increasingly sedentary lifestyle could then relate closely to a desire for movement-minimization that would allow for more effective collective defensive strategies against attack. The agglomeration of human groups into closely interacting settlements also has the advantage of reducing personnel and material movement and information transfer costs (Johnson 1977:488-489). Increasing requirements for coordinating activities among population agglomerations will also often favor the development of leadership hierarchy to minimize the cost of information transfer required for coordination of activities (Johnson 1977:492). Movement minimization also has the effect of helping to avoid predation by raiders such that foraging for food either alone or in small isolated groups could be extremely costly and not worth the risk of doing so. Decreased mobility could thus act to limit boundary incursions or close contacts with members of hostile groups. In a social environment in the process of rapid transformation by new weapons technology, these changes would ultimately act to enhance individual fitness.

Site clustering or nucleation then can be a defensive strategy for collective defense in that attackers are at far greater risk of being killed or injured due to the increased ability for those being attacked to quickly generate a counterattack. Site clustering or nucleation could also help provide an effective defense against attack in geographic locations with high resource potential, but poor defensive potential. With increasing cooperation and population aggregation as a means of self-preservation, the presence of localized resources in considering settlement location is more important than movement of site locations to higher altitudes or obviously defensive topography. The ability to signal other sites is also a major advantage since it could help compensate for the lack of defensive topography and increase a settlement's defensive capabilities. The possibility of defensive frontiers, borders, or de-militarized hinterlands should also be considered and be identified.

Settlement Choice and Crucial Resources

When there is any consideration of the resources necessary for humans to survive on the landscape, the most important resource for animals, plants, and humans is access to a source of water. Water is the primary resource to consider in models of settlement activity because without it, animals, plants, and humans cannot long sustain themselves. Other resources necessary to human life must also gravitate towards a source of water, and this makes the presence of water the primary determinant of human settlement choice. This is why the Lower Missouri River Valley was such an important crossroads for the development of human settlement and complexity in the North American Midwest (Harl 1991). The river gave life, and it is no accident that river valleys were crucial to the development of more complex human societies virtually everywhere they occurred. However, rivers and watercourses can also be places of transit, conducive to human movement in watercraft for use in transport, but also as possible avenues of attack.

Along with a source of water, the maximum size and ability of a community to stay in one location for any length of time is limited by the production potential of the surrounding environment, and the effectiveness of the subsistence technology to exploit it. This includes the capacity for acquiring and storing food, as well as processing and transporting it (Trigger 1968:61). I would also argue that defensive strategies against projectile weaponry have an effect on settlement longevity in that if they are found to be inadequate, movement to a different location will almost certainly result in the face of warfare.

In Hoard's (2000) study of Late Woodland Period occupations of Central Missouri, he lists three classes of sites. These include burial mounds, short-term occupations and long-term occupations. Short-term occupations suggest their use for resource acquisition for less than a season. Long-term occupations consist of those sites with higher artifact density and features usually consisting of large concentrations of burned rock, and evidence of structures or storage facilities. Interestingly, while Hoard says most long-term sites occur in lowland settings, there are exceptions such as site 23CY499, a residential site on a high upland terrace, replete with storage features and far from any major drainage (Hoard and Anglen 2000). This site is interesting not just because of its upland setting, but also due to the large quantity of deer bones that Sturdevant (1990) interprets as a winter deer hunting camp. Hoard (2000) indicates that the presence of Late Woodland storage features with starchy and oily native seeds and tropical cultigens suggests an important horticultural element for subsistence requiring lowland settings. However, the presence of deer bones is equally pronounced in Late Woodland sites in Central Missouri as well as the remains of fish and mussels.

Harl's (2000) study of Late Woodland sites is closer to the mouth of the Missouri River, and includes the same pattern with some sites in lowland areas but also sites in elevated locations away from the river. Food procurement included indigenous seed cultigens, waterfowl, mussels and deer. Interestingly, there is evidence of increased social cohesion with dwellings placed next to each other with a joint food preparation area including earth ovens and storage pits. This arrangement was found at the upland site of 23SL370A, located on an upland bluff crest. Burials were placed near the bluff edge. Harl (2000:272) indicates that there is evidence of bow and arrow adoption at this time by the presence of Scallorn points in site assemblages. Others have suggested that in the Late Woodland Period, the major valleys served as the locations of villages with populations moving into smaller upland homesteads in a pattern of seasonal transhumance (Holley 2000: 153).

Changes in settlement pattern can reflect changing resource exploitation, but they can also represent a response to increased warfare. In fact, both can be accomplished at the same time. It is possible that one reason for movement of sites to upland settings was to maximize exploitation of deer populations with the greater efficiency and reach of newly adapted bow and arrow technology. An increase in corn cultivation could also be at work here in that corn is conducive to growing in upland settings (Hoard 2000). Hall (1980) concluded that the combination of increased corn cultivation and the adoption of the bow and arrow altered the earlier Middle Woodland lifestyle such that the exploitable land base was greatly expanded to include areas outside lowland resources. However, this is not to discount defensive considerations in settlement pattern choice. Settlement patterns can be both conducive to exploitation of resources and also defensive against attack at the same time. The two are not mutually exclusive of each other.

MISSOURI GEOGRAPHY AND CULTURE HISTORY

As an entity for study of human occupation over thousands of years, the state of Missouri is an incredibly diverse geographic area with a myriad of physiographic regions and vegetation zones. In describing parts of Missouri in terms of living space for humans, we have to in some measure make sense of Missouri's geographic diversity from the perspective of how humans may have utilized it throughout prehistory. In terms of prehistoric human occupation, there are definitely locations in Missouri where productive capacity for resources was far greater than in other regions. For much of Missouri prehistory, humans lived primarily in riverine areas where settlements were not far from Missouri's major river systems and associated drainages. A major locus of cultural development in Missouri's river systems was in the Lower Missouri River Valley, which has consequently been the focus of study (Harl 1991; O'Brien and Wood 1994). The Lower Missouri River Valley is unusual in that it borders two very different physiographic zones to the north and south. As such it would have been a major crossroads for human interactions moving not just east and west along the Missouri River, but also for traffic moving along or across the borders of three different physiographic zones.

Prehistoric Cultural Chronology

Although there is a certain amount of regional variation in the literature regarding the exact dates and the range of these time periods, the cultural chronology of prehistoric Missouri generally conforms to the following temporal ranges as indicated by O'Brien and Wood (1994:4):.

Paleoindian Period	9250 - 7500 B.C.
Early Archaic Period	7500 – 5000 B.C.
Middle Archaic Period	5000 – 3000 B.C.
Late Archaic Period	3000 – 600 B.C.
Early Woodland Period	600 – 250 B.C.
Middle Woodland Period	250 B.C. - A.D. 450
Late Woodland Period	A.D. 450 – 900
Early Mississippian Period	A.D. 900 – 1200
Middle Mississippian Period	A.D. 1200 – 1400
Late Mississippian Period	post - A.D. 1400

Details of the Woodland and Mississippian periods, which are the time periods relevant to this research are presented below.

Missouri Climate during Prehistory

To obtain any understanding of past human occupation of the landscape requires a careful assessment of interactions between the population in the study area and the environment. To gain such an understanding requires careful study and consideration of human interactions with local geomorphology, topography, geology, soils, and floral and faunal populations. None of these factors exists in isolation, but all have an integral relationship with the evolution of human biological and cultural development (Harl 1991:12).

In considering the correlation between human adaptations to the environment and climate, the question is not so much one of ultimate causality, but of proximal causality. If climate change affects human cultural adaptations, then we need to inquire as to the form these changes take and why. We know that long-term fluctuations in temperature can adversely affect human/plant interactions, exacerbate natural disasters (flooding, etc.), and can lead to increased rates of disease for human communities (Zhang et al. 2007: 403).

Throughout the prehistory of the Midwest Region, there have been numerous climatic episodes that may have had significant environmental and cultural impacts for people living in the area of the lower Missouri River Valley. The Holocene was a period of warming and drying that began roughly 11,500 years ago that replaced the much cooler and wetter Pleistocene Epoch. To the present day, the Holocene has been marked with several widespread periods of alternating warming and cooling that took place on a more or less global scale and affected how humans settled and lived.

Even though the Middle and Late Woodland periods in Missouri are associated with several different documented episodes of climate fluctuations, it is very difficult to accurately gauge the effects these episodes had on human cultural development (O'Brien and Wood 1994:171, 230). Paleo-climatological reconstructions in the northern American Midwest have established drought episodes at roughly 1650, 1000, and 800 years before present and these dates correspond with contemporaneous drought events much further west. However, it is difficult to accurately gauge the degree of spatial and temporal heterogeneity represented by such studies due to the presence of local, non-climatic factors (Booth et al. 2006). It is likely that the greatest changes in the Missouri landscape occurred with the constantly fluctuating meander of the Mississippi and Missouri Rivers that have been documented as occurring over vast stretches of prehistory (O'Brien and Wood 1994:171) and this is in large part why this study focuses on the lower Missouri River Valley.

When looking at the available literature for recent studies of prehistoric climate fluctuations in Missouri, there are very few avenues for accurately estimating the effects of worldwide changes in climate on human cultural development in portions of prehistoric Missouri. High resolution paleo-climatic data for geographic areas such as the Missouri and Mississippi River Valleys is not abundant, but a significant source of environmental change comes from massive flooding that occasionally afflicted those living in or near the floodplains of large rivers. There is a substantial body of evidence to suggest that these catastrophic floods did affect cultural continuity and development throughout various periods of prehistory (Kidder 2006: 221-222). This is especially important in the context of Woodland-Mississippian Period adaptations in Missouri and their predominantly riverine nature.

Middle Woodland-Early Mississippian Periods

The primary marker for the beginning of the Woodland Period in Missouri is the widespread use of pottery technology that signaled an increase in sedentism, dietary changes, the beginnings of localized resource exploitation and horticultural food-production practices. In a process that may have begun as early as the Late Archaic Period, human-plant interactions where intensifying, leading to the beginnings of domestication for certain species and making year-round habitation of certain locations possible by about 250 B.C. (O'Brien and Wood 1998: 210-211, 216). Much of what we know about the Early and Middle Woodland Periods in Missouri comes from sites in two primary geographic areas. These areas are portions of the Mississippi and Missouri River Valleys (O'Brien and Wood 1998:170). For populations living in the river valleys, the increased population growth that usually accompanied increasing sedentism would have led to ever-larger numbers of people living in increasingly circumscribed territories.

The Middle Woodland Period in Missouri was a time of vast pan-regional networks of trade and contact whereby exotic goods traveled great distances and mostly had points of origin in circumscribed areas of Illinois, Ohio, Wisconsin and Louisiana (O'Brien and Wood 1998:217). Burial treatments in Middle Woodland Missouri also somewhat reflected the presence of these exotic goods and perhaps differential status in a variety of burial types. These burials usually took the form of an inner construction of stone or timber around the deceased that was then heaped with dirt to form a mound. Sometimes these burials were designed so that one burial mound could receive new interments from time to time.

The consensus among scholars seems to be that these high-status individuals were almost always adult males, and achieved their standing through abilities valued by society and not through ascribed status and the trappings of permanent social hierarchy. The entire pan-regional system was a highly dynamic apparatus set up as a hedge against resource unpredictability and as a means of transmitting information. In addition to trade, it enabled what were probably tribal-level groups to occasionally come together as larger aggregates for purposes of exchanging information and new blood (O'Brien and Wood 1998:218-219). Mound building and earthwork construction at this time may represent the establishment and strengthening of group identities and social boundaries that persisted to the time of European contact (Yerkes 1988:317).

Around 200 A.D., the system of pan-regional exchange changed somewhat in character in that there was increased decorative standardization and stylistic similarity between localities, which is suggestive of decreased social distance between different groups. Objects representing individual prestige were less common than objects focused on increasing group unity (Harl 2000:272). The flow of exotic goods was no longer necessary to maintain far-flung social networks, which is reflected in the widespread standardization in pottery style that comes about in the Late Woodland Period. The similarities in pottery styles from so many different parts of Missouri during the Late Woodland Period indicate either direct contact between groups or diffusion of ideas (O'Brien and Wood 1998:221-224; Braun 1977). This is important, because it could reflect a widespread and well-established presence of mechanisms useful for the exchange and dissemination of ideas and technology. Just as we have widespread standardization and utilization of pottery technology among groups, we also have the potential for dissemination and use of other forms of technology. Alternatively, the similarity of decoration on Late Woodland vessels means they could have been produced just about anywhere and might instead represent widespread local community cohesion and egalitarianism (Harl 2000:272).

One of the distinctive characteristics of the Late Woodland Period compared to the Middle Woodland is the increased use of corn. However, any association between increased reliance on corn agriculture and the bow and arrow after about A.D. 600 seems to be undermined by the fact that corn's importance as a subsistence resource was increasing at least 300 years before the bow and arrow were introduced during the Late Woodland Period. Full-blown intensive agriculture wasn't present until the subsequent Mississippian period, which is at least 100 years after the general adoption of archery (McElrath et al. 1999:17). The Late Woodland Period is interesting not only for the technological change taking place, but also the revolutionary drive towards increased social cooperation and complexity, settlement pattern changes centered on the rise of complex political units, craft specialization, leaders with ascribed status, and the beginnings of organized, endemic warfare.

In Early Mississippian times after about A.D. 900, the shift towards increased political complexity culminates in much larger, more complex political units. The large riverine Mississippian towns of the American Midwest probably represent kin-based, hierarchical, chiefdoms with ascribed status and concomitant mechanisms of wealth re-distribution and presumably, warfare. In

Shelby's (1935) description of the Spanish de la Vega account of Mississippian society, warfare seems to be endemic, widespread, and even institutionalized among the large Mississippian towns with small-scale raiding and ambushes being the most common forms. The account speaks of Native Americans as highly skilled with their bows and having the ability to fire six or seven arrows in the time a Spaniard could manage a single musket or crossbow shot. Mississippian warriors never traveled or went anywhere without the accoutrements and weapons of war.

Foremost and most feared among these weapons was an advanced recurve bow (Hamilton 1982:36-39), as Mississippian archers attacked enemies by first showering them with withering arrow fire. In the end, one can surmise from the account that the prime motivation in war in this particular situation was not for more land or material gain, but for ostentation and display of bravery and prowess on the battlefield (Gibson 1974: 131-133). The acquisition of land if it occurred may have been a secondary consequence. This was a way to possibly mitigate the negative effects of primogeniture in which only the eldest sibling inherited rank, wealth, power and commensurate reproductive success. However that may be, ultimately, the desire for status is part of the drive for increased reproductive success at the expense of rival males also striving for the same (Glowacki and Wrangham 2014). Primogeniture as a means of avoiding deterioration in lines of descent has been documented as existing in the proto-historic Mississippian Natchez chiefdom located in southwestern Mississippi that was first encountered by the De Soto expedition of 1542-43 (Gibson 1974:131), and French missionaries of 1700-31 (White et al. 1971). Given widespread cultural similarities, it may have been a common institution among other Mississippian chiefdoms.

A common culture and widespread system of local production in weapons, and other items with common symbolic and religious aspects, seem to be factors unifying Mississippian tribal units. In some cases, these autonomous political units would seem to fit Renfrew's (1996:116) notion of an "Early State Module" in that they are closely related, interacting political units, making up an area of cultural homogeneity possibly engaging in what Renfrew (1996) would term "Peer Polity Interaction" and "Competitive Emulation". In this process, the full range of interaction and exchange of information and goods among political units, along with competitive displays of prestige and power, would enable a shared trajectory of development and growth. These are heavily competitive chiefdom level polities with multiple tiers of hierarchy in some proximity to one another, each with fluctuating, politically and/or environmentally circumscribed surrounding territories.

ARCHERY AND WARFARE IN THE LATE WOODLAND

Although bow and arrow technology has been the subject of several technical studies and ethnographic descriptions, very little effort has been focused on studying the prehistoric development and cultural effects of the arrival of the bow and arrow. There is certainly some debate about how early the bow makes an appearance in the North American Midwest, but it is generally considered at around A.D. 500-700 (Shott 1993:425). The consensus is that at least by the middle part of the Late Woodland Period, full-blown archery technology seems to be present throughout the Midwest (Blitz 1988:131), although there are arguments for a much earlier arrival of bow and arrow technology in other parts of North America (Aikens 1970, 1976; Ames et al. 2010; Maschner 2013). The slow progression of archery technology was most likely a consequence of the difficulty through trial and error experimentation, of creating a functional weapon, a process that undoubtedly took time. It may also be that those possessing the technology closely guarded the techniques and materials of manufacture.

In looking at subsistence trends during the Middle and Late Woodland periods of Midwestern North America, the dominant pattern is that of a mixed collector-farming strategy that utilized native cultigens. A simple hunting-gathering existence also persisted for people in many regions (Railey 2010:3). Although it can be argued that warfare of varying degrees has always existed regardless of the social complexity of societies, increased levels of organization and sophistication for the conduct of warfare has always gone hand in hand with increases in social complexity (Ember and Ember 1992; Morris 2014; Carneiro 2000). Among band-level foragers, there are certain conditions that may work together to hinder the expression of warfare between groups. These have to do with widespread social and kinship networks and the relative abundance of subsistence resources (Bishop and Lytwyn 2007:32).

The bow and arrow at least doubled, and may have tripled the ability of a hunter or warrior to kill animal or human targets (Bettinger 2013:119). Its utilization in all likelihood, led to the intensification of prehistoric warfare in much the same manner as the introduction of firearms led to the violent transformation of societies throughout the proto-historic and historic periods (Blitz 1988:136). The techniques used for hunting with advanced projectile weapons such as stealth, concealment, surprise and pursuit/stalking also would have been useful for military applications. It would have been easy to adapt a weapon first used for hunting to offensive operations aimed at engaging other humans. The higher rate of fire, greater accuracy and range of the bow and arrow caused archery to be capable of inflicting far greater casualties than close-in shock weapons or shorter-range projectile weapons. The bow and arrow when first used in warfare, must have been devastating in its effects against those wielding axes, clubs or spears who were killed or maimed before they could get close enough to strike a blow (Emerson 2007:137-8).

From the descriptions of Spanish explorers who first entered Southeastern North America, the Native Bow averaged about 50 to 60 inches in length and had a draw weight of about 50 pounds. The Spanish described it as having a killing range of about 200 paces (160 meters) and metal armor provided almost no protection against it. The Spanish soon abandoned their metal armor in favor of quilted cotton armor that proved more effective against powerful native bows. The natives had tactics whereby they quickly approached the Spanish, loosed their arrows and then quickly backed off to avoid Spanish musket fire (Jones 2004:2320-2321). These hit and run style tactics with the bow may have been hundreds of years in the making and were undoubtedly refined to high levels of effectiveness against more stationary enemies.

Fortifications

The earliest fortifications in the North American Southeast date to the Late Woodland Period (Jones 2004: 2417) and it is no accident that this is close in time to the introduction of the bow and arrow. Although once thought of as fortifications, earlier sites with enclosures from the Middle Woodland Period such as Marksville in Louisiana (Vescelius 1957) or Old Fort in Missouri (Wood 1973), either have too many entrances or lack the height characteristics to be defensive constructions. They also enclose areas too vast to be defended in any practical manner by small numbers of people.

Although much removed in time from the subject matter of this study, an illustrative example of Native-America tactics with advanced projectile weapons against stationary settlements might be the Iroquois Campaign of 1649 against the neighboring Huron tribes who lived in isolated, palisaded villages and whom they intended to disperse and eliminate as a threat. The Iroquois had large numbers of advanced projectile weapons (firearms) and had adapted their battlefield tactics to use them. The Huron had far fewer such weapons and lacked the sophisticated tactics of the Iroquois for maximizing their effect in battle. When the “armies” from both sides engaged, the result was a decisive victory for the Iroquois (Otterbein 1993:20). A significant aspect of the battles between the Iroquois and Huron was the ineffectiveness of palisaded villages in providing adequate defense to keep forces larger than small raiding parties at bay (Otterbein 1993:18). Although some would attribute this to the size of the attacking army (Otterbein 1993:18), I suspect that advances in projectile weaponry were a major contributing factor behind the inadequacy of palisades as defensive constructions, because the mobility that was the best defense against the slow firing musket was impossible in a fortified position. In earlier times with the absence of gunpowder, and with no obvious ability to carry out a prolonged siege, assaulting a palisaded settlement might well have had a different outcome and could have been disastrous for the attacker.

One possible solution to increasingly effective defenses was a surprise assault that could carry sufficient force through the gateway or entrance of the town to achieve a quick victory. This presupposes that a sufficient force to mount such an attack could get close enough to the entrance without being seen. Another method of assault known from historical accounts was to use flaming arrows from a distance in an attempt to set the town and wooden palisade on fire (Larson 1972: 390). There is the account of Garcilaso de la Vega who reports just such an assault by Native Americans upon the Spanish fortress at Chicaza

(Varner and Varner 1951:399). However, in historic accounts of these types of assaults, the palisaded defenses usually had to be breached before the town could be completely burned (Larson 1972: 390). There are also Spanish historical accounts by De Soto of Native Americans surrounding their fortifications with “free fire” zones such as at the town of Mabila, by cutting down every tree or removing every obstacle to enable better detection and defense against enemies approaching (Jones 2004: 2446). In this case, the defense was complemented by the addition of a tall palisade with openings through which archers could shoot. De Soto’s assault on Mabila was a victory for the Spanish, but it exacted a terrible toll in dead and wounded (Jones 2004: 2452).

The Arrival of the Bow in Missouri

To attempt to gauge the presence of bow and arrow technology in the archaeological record of deep antiquity is difficult given that the organic remains of actual bows and arrows rarely survive to provide such unequivocal evidence of their presence. Instead, we are left predominantly with the stone projectile points that may have been used with such weaponry. To understand the performance characteristics these points had when used with actual weapons pushes us in the direction of experimentation with copies of the actual points and attempting to use them in various weapons systems of recent construction. The typical commonsensical assumption is that projectile points of larger dimension were used with the earlier atlatl weapon system whereas much smaller points were used as arrow tips. However, there is no clear and obvious demarcation as to what would definitely be an atlatl tip vs. what would be an arrow tip (Thomas 1978; Schott 1997).

There is no question that when the bow first appeared in the American Midwest, there must have been much experimentation to see what sort of woods and materials were acceptable in bow/arrow construction, and what sorts of points had acceptable flight and impact characteristics (Lyman et al. 2008). As one might expect, the earliest arrow points in Missouri were on the large side, and likely could have first doubled as atlatl dart tips. These may be represented by such points as the Kings Corner Notched and Rice Side-notched types (Figure 1) that appeared as early as the Late Archaic Period, but were made well into the Late Woodland Period. As the technology was improved through experimentation, bows and arrows became more and more efficient, and the points became smaller and better-made.

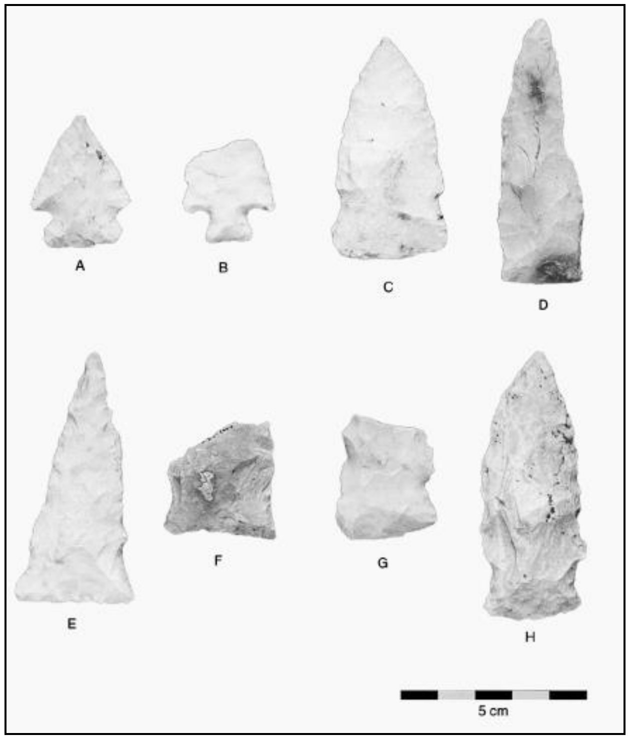

Figure 1: Kings Corner Notched and Rice Side Notched Points (Hoard and Anglen 2008:108).

The culmination of the more efficient arrow points was probably the Scallorn Point (Figure 2), which is quite common in the North American Midwest at the Late Woodland-Mississippian transition and is present until the end of pre-contact times. The Scallorn Point was present in Missouri and much of Midwestern North America over a roughly thousand year span from AD 400 to AD 1400 (Chapman 1980:312). These are small, serrated, corner-notched points with expanding stems or barbed shoulders that were almost certainly used with the bow and arrow weapon system. The serrations, barbs and knife-like design would have made these points extremely effective and deadly on either animals or humans. To a skilled flint-knapper, these would not have been difficult to manufacture quickly and in large numbers.

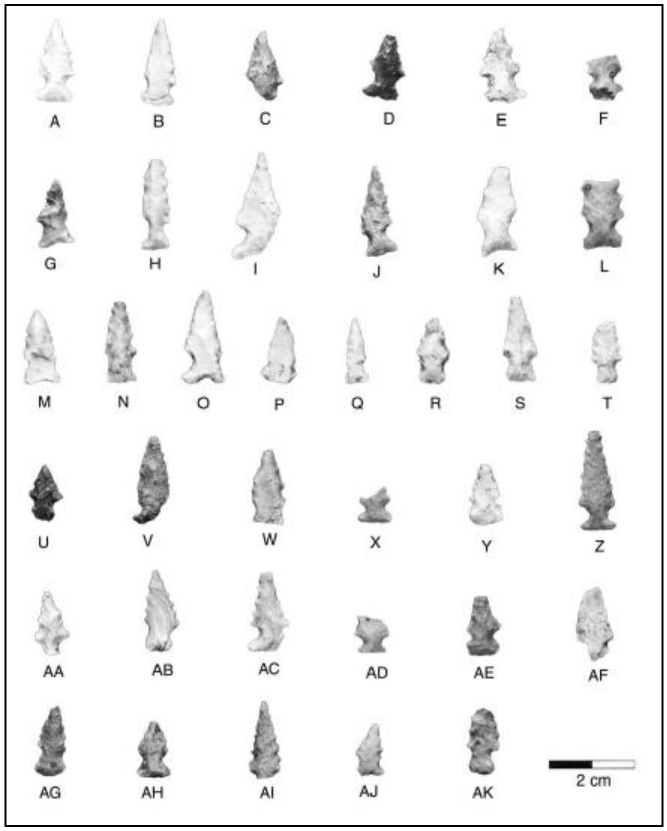

Figure 2: Scallorn Points (Hoard and Anglen 2008:109).

It is no accident that concomitant with the rise of increasingly complex Mississippian societies at the end of the Woodland Period, evidence of arrow-related trauma in humans increases in many parts of North America (Jones 2004; Blitz 1988:136), Direct skeletal evidence of arrow wounds associated with the initial introduction of the bow and arrow and the subsequent development of the Mississippian culture is lacking in Missouri, probably in part because of the lack of relevant skeletal analysis and in part because arrow wounds often produce soft tissue trauma that does not leave any evidence of an arrow strike unless a bone is hit. From studies of modern injuries inflicted by projectile weaponry, projectiles impacting a person’s frontal area might not impact bone in about half the cases and even then might not leave distinct damage that would be diagnostically recognized as arrow-related damage (Walker 2001:584). Therefore, the numbers of arrow-related traumas in burial populations are probably far lower than what actually occurred, and even the arrow-related trauma that is reflected on the skeletons will only be recorded when analysts look for such evidence (Emerson 2007:138-9). To date, the only known example of a projectile point embedded in human remains from burials in the Lower Missouri River Valley is a Late Archaic example of a dart-point tip embedded in the spine of a sub-adult burial at the Truman Road Site in St. Charles County, Missouri (Harl 2000:48). Although much removed in time from the Late Woodland Period, this lone example of death by projectile weapon probably reflects a much more common event that is under-represented in the archaeological record throughout Missouri prehistory.

Although the skeletal evidence from Missouri is scant, there is abundant archaeological evidence for endemic warfare in the Late Woodland and Early Mississippian Periods in other areas of the northern midcontinent and Mississippi River Valley of the United States (Milner et al. 1991; Turner 1986:132). Unequivocal signs of warfare include human skeletal traumas; the construction of fortified or defensible settlements, which increases dramatically outside of Missouri at about A.D. 800-1000; and analysis of Late Woodland mortuary data, indicating the definite use of the bow and arrow in warfare as indicated by injuries from arrow strikes (Emerson 2007:130).

The Bow and the Rise of Complexity in the Lower Missouri River Valley

Scholars debate the effects that introduction of the bow and arrow had on native North American societies and the nature of warfare when archery was first adopted (Bingham and Souza 2013:145; McElrath et al. 1999:5). Bingham and Souza (2013) suggest archery fundamentally transformed cultures throughout the continent by providing a coercive means of allowing the formation of larger political units. Others such as Bettinger (2013) suggest that the introduction of the bow for the most part led to a reduction in levels of socio-political complexity and reduced the drive towards site aggregation and nucleation due to the increased economic independence and protection that a more efficient hunting tool could offer smaller groups. Still others believe that the superiority of the bow against such earlier projectile weapons as the atlatl is vastly overstated and that it did not offer a significant economic or coercive advantage prior to the emergence of complexity (Walde 2013; Shott 1993). The impact of archery does in fact seem to vary depending on local culture history and environmental contexts. It does seem clear that in places where the introduction of the bow and arrow precedes the arrival of incipient complexity, archery does not act as an immediate spur for increased complexity, which usually takes a while to develop. In many cases, including the Lower Missouri River Valley, it seems to be the case that a few hundred years or so pass between the arrival and widespread dissemination of the new technology and the appearance of more complex, sedentary life-ways and social inequality. The same appears to be true in other parts of North America where a similar pattern can be observed (Boyd 2004:314,326; Kennett et al. 2013).

Certainly, other factors contributed to the emergence of complexity where it occurs after the appearance of the bow and arrow, and there are situations such as in the U.S. Southwest where the emergence of complexity substantially predates the appearance of the bow and arrow (Van Pool and O'Brien 2013:112). The example from the U.S. Southwest is instructive because the available evidence here suggests that the "intensely lethal" warfare involving the bow and arrow was at least partly responsible for migrations, site aggregation, nucleation and definite inter- and intra-community social differentiation, even after the first appearance of complexity (Van Pool and O'Brien 2013:114). This view is not opposed to mine and I would argue that something similar was at play in my study region. A major difference is that where complexity was already present in the U.S. Southwest, it had not yet arrived in the Lower Missouri River Valley.

There is no doubt that complexity can certainly first appear without the arrival of advanced projectile weapons, but the delay between the initial introduction of archery and the formation of social complexity in geographic regions that previously lacked complexity does not mean that the bow and arrow does not alter the social dynamics such that it becomes a primary catalyst to the emergence of complexity. There is no stimulus to social change that is mutually exclusive of all other possibilities, but some do have much more of an effect in different regions than others. Local context matters (VanPool and O'Brien

2013:116). As the Lower Missouri River Valley is a heavily forested, riverine environment, the bow could have had a much greater impact as a weapon of ambush and “fire and run” types of tactics that work by attrition, and rely on stealth and concealment. Given the uncertainties of defense in such an environment, I believe the coercion and fear of long-range weaponry would lead ultimately to increasing site aggregation, nucleation, and social inequality, culminating in the complex, chiefdom-level societies of the Mississippian Period. As the earlier atlatl weapon system lacks the range, rate of fire and stealth capabilities of the bow, I do not believe it would have the same effect in this environment. In the Lower Missouri River Valley, the lethality of the bow as a long-range weapon of coercion and fear could have had a heretofore unseen effect on social relations in the semi-mobile horticultural village societies of the Late Woodland Period. While this may be an overstatement, I would strongly advocate for further research to aid the development of further warranting arguments in this direction.

RESEARCH DESIGN

I expect that the introduction of the bow and arrow into prehistoric Missouri during the Late Woodland Period changed the entire Middle Woodland social dynamic and settlement pattern arrangement such that there was a major increase in social cooperation among settlements tied closely to defensive settlement strategies. I seek to employ a series of spatial-statistical tests to evaluate whether changes in the Lower Missouri River Valley settlement patterns from Late Woodland to Early Mississippian Periods strongly correlate with the introduction of the bow and arrow and whether these changes also spurred increases in social complexity. Specifically, I consider four main lines of evidence: 1) site viewshed, 2) site inter-visibility, 3) settlement clustering and nucleation, and 4) settlement landform. I anticipate that these lines of evidence will reflect the following general trends in the study area over previous time periods.

1) Sites in the study area should demonstrate increased settlement clustering with a bimodal pattern of clustering in high resource areas and single sites in more defensible or obscured locations. By “high resource” areas, I mean bottomland areas of the Lower Missouri River Valley that are highly conducive to resource procurement as documented by Harl (1991:26-35).

2) Sites or site clusters in the study area should exhibit increased line-of-sight visibility to each other relative to periods without bow and arrow technology.

3) Sites or site clusters in the study area should exhibit increased viewsheds at possible avenues of approach, or conversely increased concealment as ways of dealing with territorial incursions.

4) Site area in the study area should increase in size as population nucleation increases over time.

In the next several chapters, I will consequently argue that conditions created by the arrival of the bow and arrow called for increased coordination and increased communications among settlement locations such that farmer-collector and band-level groups coordinated to create a defensive settlement strategy. Initially, each site in the cooperative likely maintained an independent catchment area, but as cooperation extended to aspects such as food production, sites began to nucleate into larger settlements. Thus, it is possible that the impetus towards increased social cooperation brought on by the introduction of the bow and arrow started the process towards eventual site nucleation that appears in later periods. Below, I consider expectations associated with each line of evidence in more detail.

Site Viewshed

One means of defending against long range attacks in the study area was to increase viewsheds of surrounding ground to enhance detection of territorial incursions early enough to mount effective defense. Ideally, viewsheds should correspond as much as possible with site catchment areas in order to maintain security for individuals working outside of the settlement boundaries. However, the limits of site catchment area could far exceed viewshed. In settlement arrangements where defense against attack is the primary consideration and where critical resources are not located close by, resource procurement for the occupants would likely be one of the primary instances of vulnerability as small, isolated logistical groups would be comparatively easy targets for raiding. Among the Middle and Late Woodland Period riverine horticultural/foraging societies of Eastern North America, cycles of resource exploitation usually involved movement to a number of spatially discontinuous resources in a seasonal round of migration. If we add a new class of weapons that can strike from much greater distances with greater accuracy and in greater volume and rate of fire, any small foraging party and even the main community would be in even greater danger than before, a consideration that would be expected to change settlement patterns.

Widespread concern for locating settlements where the approach of marauders could best be seen is a universal inclination that would gain increased importance with the presence of long-distance stand-off weapons technology. Settlement locations or arrangements with extensive viewsheds could help defend against incoming missiles potentially lobbed from a distance of over a hundred meters, the effective limit of aimed archery. This would put a premium on site locations where there is a full range of view for at least a hundred meters in any traversable direction (which would help protect the main village) and that could observe as much of the relevant catchment area as possible (which would help protect isolated work parties), so as to allow for accurate defensive arrow strikes or to allow sufficient time to flee or signal for help. This does not discount that the presence of small scale horticultural fields could also be protected with the aid of extended viewsheds and produce a similar pattern, but again we are talking about protection from predation, be it human, animal or pest.

Such a concern for viewshed has been documented elsewhere, and has produced multiple patterns based on the characteristics of the perceived threat and local geography (Maschner 1998:32). Diachronic settlement studies such as those by Maschner (1998) have been used to demonstrate that the presence of warfare is often accompanied by settlements situated with concern for defensive viewshed arrangements or locations that are hidden or difficult to access. In studies from other geographic areas, defensive settlement patterns associated with the bow and arrow allow excellent surrounding views that provide for maximum early warning of an attack and allow the use of projectile weaponry such that projectiles may be “rained down” on the attackers from a distance (Lambert 2002:215; Maschner 1998: 32-33). The two key factors when considering defensive uses of viewshed in settlement choice are thus early warning of attack and maximizing the effect of projectile weaponry against attack.

Settlement locations of pre-agricultural societies in heavily-forested, riverine environments with a repeated, widespread pattern of long distance visibility of any traversable surrounding territory have few parsimonious explanations beyond fear of long-range attack or possibly spotting game. In the time range we are discussing, large scale agricultural fields have not yet appeared, so there really are few other explanations for areas of extended visibility surrounding settlements. Given the increased settlement movement to upland locations, such settlement landscape visibility could be epiphenomenal to upland resource procurement. However, is the presence of other non-random factors in the settlement landscape also epiphenomenal? If you combine the concern for landscape visibility with increased settlement clustering, skewed catchments and a systematic network of line-of-sight relationships among sites, I believe the expected pattern is distinct from most other alternatives. This is especially true if the pattern differs from previous time periods with less tactically-efficient weapon systems.

Site Inter-visibility

In considering interaction among archaeological sites of the Late Woodland Period, we begin with an initial premise that interaction decreases as the distance between sites increases. This is not always the case as with the high levels of long-distance interaction in the preceding Middle Woodland Period, but is more generally true due to the increased costs of long-distance movement.

We also typically assume that similarities in artifact assemblages between sites relate to the degree and nature of interaction between those sites (Johnson 1977:481). If the focus of the defensive network is to allow pooled bodies of defending/attacking warriors and/or rapid retreat to safety, there must be time for allied settlements to respond quickly to the point of attack. Settlements separated by several kilometers might not offer the ability to quickly assist each other, especially if information must be transmitted in person. However, defensive settlement locations may also hinge on signaling ability in addition to actual geographic distance, which may allow reinforcements from a distance to arrive in cases where they otherwise wouldn’t have time and/or for settlements not yet under attack to prepare their defenses. In studies of prehistoric settlement strategies, only a few North American studies have focused on the ability to signal others based on simple line-of-sight or viewshed analyses (Ellis 1991; Swanson 2003; Wilcox et al. 2007). Of course, sites might be organized to allow inter-visibility for reasons aside from defense, instead reflecting factors from ritual/ceremony to hunting to preventing crop predation. However, signaling and site intervisibility would be central to a defensive settlement system.

While it is clear that signaling could take many forms from smoke to mirrors to flag-waving, it is also clear that the distances involved in these different forms of signaling would differ greatly in terms of the effectiveness of each method (Swanson 2003:755). For example, others have used the general rule of about 10 miles as the maximum distance to be able to send smoke signals that could be clearly seen by others, but some experimentation is needed in this regard (Wilcox et al. 2007:6). Further, past studies have considered topographic prominence and tower or platform features as integral to signaling strategies, but more studies need to consider whether simple line-of-sight visibility between sites at the standing height of the average person would have been a major factor in settlement considerations. In contexts of active or even threatened warfare, visibility over the surrounding landscape and with other sites from ground-level is especially important where settlements might be temporary camps, or are located primarily for food procurement.

This study does not discount the role of signaling features such as towers, platforms or fire features on elevated landforms, but here I am most concerned with locations where settlements could see each other at the height of the average person. The reason for this is that there are costs involved with maintaining even a part-time or periodic presence at elevated observation outposts when the same effect might be achieved with careful settlement positioning. Based on a survey of the cultural resource management-generated literature, there are also few if any elevated signaling features known from the Lower Missouri River Valley in the Woodland and Early Mississippian Periods. Although tree lookouts or wooden constructions could have been used for this purpose, there is little if any evidence of this type of structure that has survived. To be sure, inter-visibility between sites can occur by mere chance placement of sites over time and there is no absolute way of indicating sites with inter-visibility are contemporaneous (Swanson 2003:760). However, if a site is part of a larger site settlement pattern, with inter-visibility relationships in a physiographically variable environment, the question of a chance occurrence becomes less likely. Due to the fact that landforms in the study area are highly variable, a useful approach to test for significance of site inter-visibility is to compare sites of multiple time periods, especially those where archery technology is present and those where it is not. Changes in site inter-visibility can then be evaluated to determine if it became a more significant issue in the context of increasingly effective standoff weaponry.

Based on the work of Wobst (1972), Clark (1975), and Dennell (1983), Savage (2006:331) proposes the hypothesis that foraging societies divided their social territories based on minimum group subsistence (resource collection) bands, and maximum group socialization bands. The minimum group subsistence bands would be oriented around the material needs and requirements of day to day life. The larger, maximum group band would be oriented to facilitate contacts with other maximum group bands, trade, acquisition of mates, the defense of commonly-held territory, and maintain harmonious coexistence within maximal-band territory between the smaller subsistence-level bands. It is possible that maximum band relationships are visible in the presence of line-of-sight relationships between sites so that the entire band could be mustered in the event of some emergency such as an attack, but even if just portions of the band are intervisible with any given location, it would be expected that defensive networks would use some means of communicating quickly by line of sight.

Settlement Clustering and Nucleation

Given the much greater range of the bow and arrow over earlier weapons, the ideal site pattern might be a cooperative network of site-clustering such that defensively-arrayed outer settlements could warn of an attack to quickly mobilize inner settlements to stem the incursion, creating a pattern like a spiderweb in which outer settlements act as tripwires that ultimately protect inner settlements from surprise attacks. Defenses at the point of contact would have good line-of-sight communications with other sites in the network such that they could quickly signal for reinforcements from inner settlements exactly when and where they were needed from warriors in other parts of the defensive network, creating a system of defense in layers. This would make the need for permanent defensive structures or palisades, which would be difficult to build for short-term settlements, much less necessary as any raid on the connected sites would trigger a rapid response with overwhelming defensive force at the point of attack. Such an arrangement would also allow for sufficient mobility to follow a seasonal round of resource procurement. Such a “circling the wagons” strategy with good interior routes of movement and communication might allow site clusters in geographic areas of high resource potential but less than ideal defensive potential.

Regular spacing of archaeological sites across the landscape is often interpreted to be a reflection of competition among sites or the presence of site resource catchments. Clustering of sites is often interpreted as related to such factors as presence of highly-localized resources or the emergence of a nearby powerful center (Niknami et al. 2009:268). I also argue that both site clustering and regular site spacing within clusters can be highly cooperative defensive arrangements, and settlement systems so-arranged can have a complementary function in terms of the protection of a frontier or boundary line and a concern with internal communications.

Regular site spacing or site clustering with good line-of-sight communications could thus reflect an overwhelming concern with territoriality, collective response against attackers, and the desire not to be "overrun." Defense against attackers has also been proposed as an important factor in population nucleation into site clusters or one large site since increasing compactness of a community offers several advantages for defense against raiders. In placing settlements closer together or moving people into fewer larger settlements, people can act more effectively as a group. It also makes it easier to construct features such as palisades or fortifications to defend larger numbers of people (Drennan 1988: 284-285). I therefore propose that increased clustering of sites, regular spacing of sites, or movement to ever larger sites on the landscape is in many cases a direct response to the emergence and spread of advanced projectile weapons technology that can strike from distances greater than a hundred meters. These patterns could stand in contrast to sites distributed evenly or clustered in resource rich zones, which would be expected in the absence of defensive considerations. A consideration of viewsheds, site intervisibility, and local ecology will consequently allow me to differentiate among clustering caused by mapping onto resources and the patterns I expect to result from the introduction of archery, especially when comparing settlement patterns before and after the adoption of the bow.

Settlement Landform

A major factor humans have used in selecting settlement locations throughout prehistory has been a careful consideration of topographic setting. Commensurately, archaeologists study settlement patterns from the perspective that it is important first to understand the landforms and topography of locations where sites occur. This includes not just the geological processes that led to their formation, but the distribution of topographic settings such as river valleys, hills, and so forth across the landscape (Butzer 1982; Ravesloot and Waters 2004:203). Landform is a major environmental factor influencing many of the other important elements of settlement location characteristics. These include ecology, available plant and animal resources, soil types, and certainly defensive considerations. Landform affects the locations of settlements because settlement location is the outcome of the interaction among the environment, culture, and human biology. Therefore, a consideration of landform is integral to this study, both to evaluate the defensive and environmental contexts of settlements.

Ecoregions and the Lower Missouri River Valley

The research addresses the distribution of archaeological sites within a defined physiographic region in relation to the arrival of archery technology using statistical-spatial analysis based on Geographic Information Systems technology

(GIS). In selecting a research design applicable to settlement pattern research, it is important to understand that we are really dealing with a bewildering variety of heterogeneity in terms of site function, site area, landscapes, and terrain. We must consider whether the chosen analyses are the best choices for considering research questions involving the movement of humans across environmentally and physiographically variable landscapes. It then follows that the most effective means of completing an analysis is to select methods in which the local environmental and physiographic variability has minimal impact on the analyses performed. To do this we must choose study areas where the influence of terrain and environment on site location is relatively homogenous (Bevan and Connolly 2006:229).

To better define a bounded study area for spatial analysis, an *Ecoregion* was selected from an already extant digital map layer created by the U.S. Environmental Protection Agency (2013) that denotes….

"areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. They are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. The approach used to compile this map is based on the premise that ecological regions can be identified through the analysis of patterns of biotic and abiotic phenomena, including geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. The relative importance of each characteristic varies from one ecological region to another (Ecoregion Shapefile Metadata 2013)."

It is my premise that such regions would have also been recognized prehistorically and that this dataset would very aptly represent bounded areas of ecological and physiographic similarity in considering desired settlement locations of the post-Archaic periods of prehistoric Missouri. Put another way, by considering a single ecoregion I will be able to differentiate the aspects of the settlement systems associated with ecological considerations from those associated with the creation of defense settlement networks. In the case of this study, a clipped portion of the River Hills Ecoregion was utilized representing the Lower Missouri River Valley. This area represents not only an area of environmental homogeneity, but is also a core area of prehistoric cultural development in the North American Midwest. In this study, I compare settlement patterns in the Lower Missouri River Valley by time period to Include Middle Woodland, Late Woodland, Terminal Late Woodland/Early Mississippian and Early Mississippian periods (Figure 3).

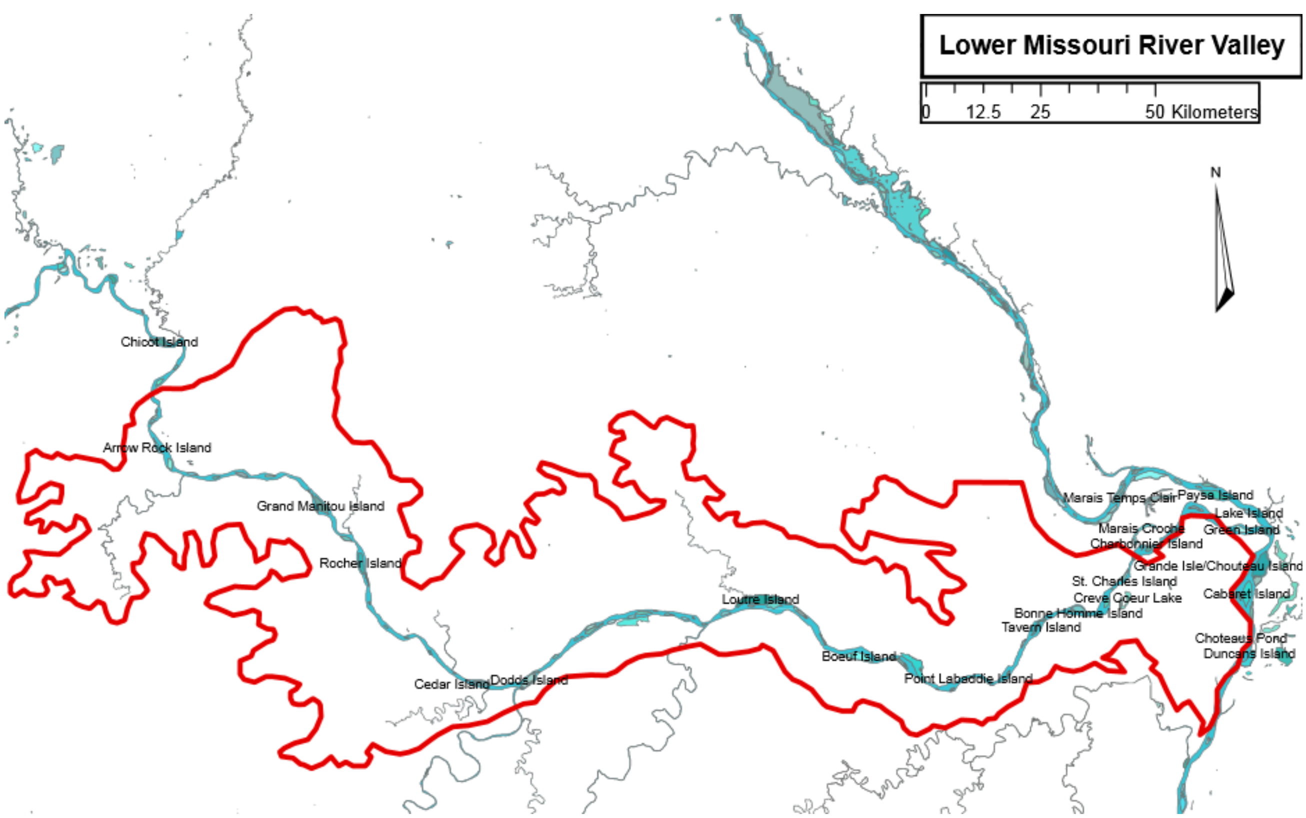

Figure 3: The Lower Missouri River Valley.

Missouri SHPO Archaeological Geodatabase and Site File

The basic data set to be used is the Missouri State Historic Preservation Office (SHPO) Archaeological Sites and Surveys Geodatabase. The Missouri SHPO geodatabase consists of roughly 30,000 site polygons and roughly 15,000 survey polygons. Both site and survey datasets are linked to relational tables of multiple categories of data and represent many decades of accumulated information contributed by multiple generations of both avocational and professional archaeologists. Beginning in 2004, the State of Missouri commenced an effort to put all of the archaeological site and survey information in the State Historic Preservation Office Cultural Resource Inventory into an easy to use, relational GIS database format. Without the use of this data format, the research conducted for this paper would not have been possible. The software used to interpret and present the data for this paper is ESRI, ArcGIS 10.1.

The SHPO geodatabase is a work in progress that is constantly being updated and as such, it is a mere snapshot of the archaeological record in the State of Missouri. Due to the fact that much of the work generating archaeological site data is related to human land-use and development, it is a very small sampling of vastly greater geographic areas that remain un-surveyed. Furthermore, the vast majority of the archaeological work done in Missouri is simple “phase one” survey that utilizes opportunistic or probabilistic sampling strategies and relies on either surface inspection or near-surface shovel test probes. Due to this fact, much of the true variability extant in the archaeological record may have been missed in those areas surveyed. Be that as it may, the database does reflect a substantial sample of the archaeological record of Missouri, and is the best source for information on settlement location and cultural-historical affiliation. While I freely acknowledge the limitations of the data used for this paper, I believe it is still of great use for the furtherance of archaeological knowledge and to help generate future research.

As to the nature of the sites, as we have noted, the vast majority of site information comes to us from the examination of surface finds during archaeological survey performed walking transects at defined intervals. There are limitations to such data; a site listed simply as “lithic scatter” might conceal buried features resulting from a larger settlement than evident from the surface. Fortunately, this will not be a major problem with this research. Our primary concern is site location and macro-scale inter-site spatial and visual relationships as they possibly relate to cultural changes coming about through introduction of new technology, as opposed to measurements of site size. This is information that is readily available and apart from survey bias, is largely accurate.

Another possible issue with settlement pattern analyses is the ephemeral or highly episodic nature of occupation at some sites, possibly leading to the conclusion that settlement patterns might be more the result of episodic occupation of a favored environment rather than reflective of a larger scale social process occurring between sites at roughly the same time (Bevan and Connolly 2006:230). We can perhaps distinguish between the two interpretations by detecting patterns that would only make sense if the sites were contemporaneous. If two or more sites are located such that they were able to signal each other, or spaced to avoid intruding on other site catchments, the argument for contemporaneity is strengthened. This argument does not hold everywhere and there are known situations in the U.S. Southwest where communities moved a short distance and rebuilt, creating a similar pattern (VanPool 2014 personal comm.). Still, by examining the multiple lines of evidence considered here, it should be possible to evaluate the propositions I outlined above. I am not dismissing concerns that sites aren't contemporary and I would appeal to future research along these lines to better establish site contemporaneity by time period in the study area. I am merely using the information currently available to suggest the possibility of meaningful patterns in the archaeological record of the Lower Missouri River Valley.

METHODS

This study is highly dependent upon GIS methods and techniques. GIS applications are increasingly common and powerful methods for developing and testing models of how humans situate themselves across the landscape (Savage 2006: 331), but their use for studies of this type continues to be limited. GIS studies rarely take terrain and vegetation into account, instead often treating the world two-dimensionally as a flat surface where only distance among sites and resources is important (e.g., distance to nearest water source, distance to lithic raw material source, distance between settlements, etc.). Considerations of human space should ideally include the full range of environmental factors that influence human settlement choices including terrain and vegetation. This more complete approach to GIS analysis is required for the four main lines of evidence used here: 1) site viewshed, 2) site inter-visibility and communication between settlements, 3) settlement clustering or nucleation, and 4) settlement landform. Ever improving GIS technology combined with the aforementioned SHPO geodatabase and additional databases discussed below provided by the State of Missouri fortunately provide the tools and data necessary to include terrain, vegetation, distance, and other relevant variables in this analysis.

Settlement View-shed and Inter-visibility

Viewshed and line-of-sight analyses are closely-related tools used to gauge the visibility between two or more points on the landscape. Such analyses are structured by selecting an observer point and one or several points on the landscape that may be visible from that observer point. The analysis can then determine if the points would be visible based on the height of the observer, the height of intervening vegetation and land forms, and the height of whatever is being observed at the specified point. With this technology, it is possible to select a single site or series of sites and find out the resulting locations that can be seen from those points. The alternative to using GIS technology to accomplish this research would be to actually go to the site or potentially large numbers of sites and to take a look around, which would be both prohibitively time consuming and methodologically inferior in that it would be difficult or impossible to accurately identify what portions of the landscape are actually visible without some sort of “markers” indicating the location of other sites or important features that would be otherwise obscured. The presence of GIS technology has made it far easier to pursue interesting landscape-related research questions by very quickly allowing the detection of patterns within large datasets. This is where computer-based inquiry allows such a major advantage because it involves repeating many operations that would be heretofore very difficult or time-consuming without this technology.

Viewshed and line-of-sight analysis differ slightly. Viewshed is a consideration of one observer point and all surrounding points on the landscape that may be observed (i.e., it answers the question, “What can I see from here?”). Line-of-sight analysis evaluated whether a single observer at a location can view one or a few highly specific fixed points of reference such as other settlements (i.e., it answers the question, “Can I see that spot from here?”). Viewshed analysis is based on two assumptions: 1) what is not visible from a settlement is less easily controlled or dealt with than what is visible, and 2) what is visible is under the direct influence of that settlement (Dytchowskyj et al. 2005). Line-of-site analysis is based on the idea that an observer wants information about specific points on the landscape.

The consideration of both viewshed and line-of-sight data with GIS technology rely on some specialized mapping technologies that have the ability to produce digital elevation models (DEMs) over vast reaches of landscapes. DEMs are landscape maps that are generated in a computer with precise data about landscape elevations and form. Additionally, all humans observe the landscape not as a barren surface, but one with trees, and vegetation. We therefore also need to consider not just the height and form of the land itself, but vegetation as well. To use only the DEM would be like doing the analysis with the surface of the moon. To also consider vegetation, we need a very specific kind of DEM that takes into account how land-cover affects the view of someone looking across the landscape. The technology that is most able to capture this aspect is known as LIDAR or *Light Detection and Ranging.* LIDAR is a remote sensing technology that measures distance by the use of laser ranging of features on the landscape. It thus measures the topography of vegetation, as opposed to the underlying ground.

The viewshed and line-of-sight analyses performed for this research uses LIDAR-produced DEMs. The only downside to this approach is that LIDAR is of snapshot of recent land-cover and may not adequately reflect changes in land-cover hundreds of years into the past. This is likely not too significant of a problem, given that vegetation is generally a product of topography and other factors that will lead to at least general consistency over the last several millennia. However, modern vegetation will only imperfectly reflect areas that may have been clearcut or otherwise modified. Given the intense labor requirements for such efforts, it is unlikely that substantial clearcutting was used in the past. It seems more likely that people would try to find locations with naturally good visibility as opposed to trying to clearcut large tracks between distant villages. Of perhaps greater concern is the impact of modern development, which does tend to create larger, more open areas free of vegetation. Fortunately, development in the study area is minimal and has not fundamentally altered vegetation patterns. Still, current vegetation is the best but not necessarily a perfect way to take into account the effects of land-cover on past lines of sight and viewsheds.

The analysis used two different LIDAR databases, because of differences in coverage and utility. The LIDAR imagery used for the line-of-sight analysis uses a mosaic dataset of the entire Lower Missouri River Valley. This mosaic imagery is maintained on a remote server at the Missouri Spatial Data Information Service (MSDIS), and can be utilized in whole to do the line-of-sight analysis for the entire study area. Unfortunately, viewshed analysis must be completed in a more piecemeal manner using a different database due to the magnitude of computer operations and the memory intensive requirements involved. Each time a viewshed analysis is performed the operation uses so much computer memory that it can usually only take advantage of one LIDAR Tile at a time without causing the ArcGIS 10.1 software to crash. Therefore, I have reduced the viewshed analysis to the eastern portion of the Lower Missouri River Valley, the only portion of the study area that has large contiguous tiles available (Figure 4). I have also attempted to confine the analysis to those locations where modern construction and land use does not adversely affect viewsheds. However, even in those areas where there is development, it may not affect the entire viewshed, and there is much it can still tell us. As with the line of sight analysis, the observer height at each settlement location (observer point) has been set at about five feet. I have also added curvature correction to account for the curve of the Earth’s surface on observer points.

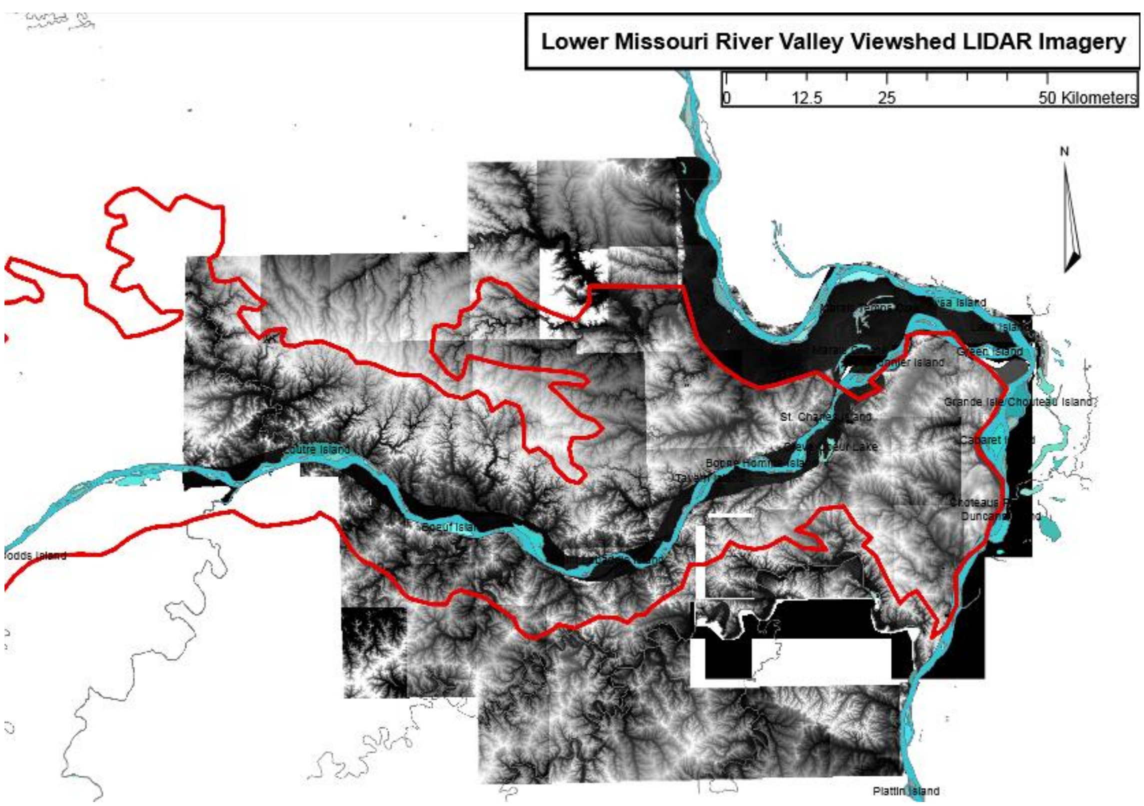

Figure 4: Lower Missouri River Valley and Lidar Tiles Used for Viewshed Analysis.

Settlement Clustering or Nucleation

Several statistical approaches can be used to evaluate settlement clustering and nucleation.

1) Nearest Neighbor Analysis

Following the work of Koster-Washburn (1974:316-322), the nearest neighbor analysis enables the isolation of all the specific aspects of settlement pattern variations through time, allowing the researcher to move beyond making general statements about the use of a given space by a group of people. It allows the researcher to elucidate the systemic aspects of settlement patterns and to relate these aspects to the function of other systems in a given culture. Nearest neighbor analysis measures the deviation of a population distribution within a defined area from a random distribution towards either a clustered or regularly-spaced distribution. The nearest neighbor statistic used in this test is defined by Adams and Jones (1981:314) as:

R=Ra/Re

"Ra is the average distance between a point and the point closest to it."
"Re is the average for such distance that would be expected if the points on the map had been distributed by a completely random process."

The value of R indicates increased clustering the closer it gets to zero; increased randomness is it gets closer to one, and increased even-spacing registers as it gets closer to the maximum R value of 2.15. I should add that in taking the advice of Hodder (1976:41-44), I chose to eliminate most sites from the analysis that lay closer to a border than to their nearest neighbor. The problem is that whenever a boundary is imposed on an area of points, the mean nearest neighbor distance will tend to be greater than would be true if an infinite area were involved.

2) Thiessen Polygons

In concert with line of sight and viewshed analyses are the construction of Thiessen Polygons around each site centroid that can be used to indicate approximate areas of site catchment relative to surrounding settlements to help predict the possible range of settlement resource procurement. To compensate for reduced site catchment areas, clustered settlements will tend to have resource inter-dependency on other sites in the cluster leading to skewed site catchments. The only way this works is with increased social cooperation between settlements.

Thiessen polygons have a long history of proposed use in human geographical studies to help define territorial boundaries surrounding locations of human settlement (Haggett 1965; Hodder and Orton 1976). They are a tool to help elucidate patterned structure in a lattice of human settlements across the landscape. Thiessen polygons are computer-generated lines that are used to divide a region into territories or catchments that might have been under the direct influence of each settlement on the landscape. Their shape relates little to physiographic, terrain or resource data, but is most influenced by the proximity of neighboring settlements. The use of Thiessen polygons makes a lot of assumptions, many of which might not apply to reality, so they are at best an approximation of settlement territories. Analysis of Thiessen polygons may be productively used with view-shed analysis to have a combined effect in defining territorial boundaries for settlement locations (Dytchowskyj et al. 2005:1). In this case, Thiessen polygons were generated for each site centroid by time period to help define possible site territorial boundaries and to detect possible patterns in the settlement landscape on a regional basis. These boundaries are generated based on proximity and location of neighboring settlements whose boundaries they abut. As such, Thiessen polygons change in shape based on the degree of settlement clustering vs. dispersal and can graphically depict settlement patterning.

3) Site Area Frequencies by Time Period

As dispersed sites coalesce over time into clustered site concentrations and nucleation of settlements into much larger sites occurs, the frequency of larger sites as a percentage of total sites should increase in the archaeological record. There are limitations of surface survey in defining true site area, but gross differences in site size will likely be evident (i.e., surface remains will reliably indicate if sites are large or small) (Wandsnider and Camilli 1992). I believe that this data still has much to tell us about long term trends towards site nucleation. For this part of the analysis, I will perform a frequency distribution of site area in square meters by time period to see if a meaningful pattern of increasing site area emerges over time.

Settlement Landform

1) Sites Frequency by Landform

As part of the study region, I will analyze the relative percentages of site location landforms for the Middle Woodland through Early Mississippian Periods using ArcGIS 10.1. The chosen landforms (listed below) are taken from tables of the Missouri SHPO archaeological sites and surveys geodatabase and are categories established by consensus after a survey of Missouri's professional archaeological community. The categories are also consistent with Missouri's archaeological site recordation form. The frequencies of sites occupied by landform would have much to say about where people are choosing to live over time, especially as concerns resource procurement and defensive considerations.

- KNOLL - Small, rounded hill.
- HILL - Portion of the earth's surface elevated above its surroundings (usually with an elevation of less than 300 meters).
- RIDGE - A narrow hill-top or chain of hills.
- SLOPE - Area of inclined ground.
- BLUFF TOP - The top of a high bank with a broad, precipitous, and sometimes rounded cliff face overlooking a floodplain or body of water.
- FLOODPLAIN - Any normally dry land area that is susceptible to being inundated by water from any natural source. This area is usually lowland adjacent to a stream or lake.
- RIVER/STREAM TERRACE - An accumulation of deposits along the sides of a river/stream valley which were deposited when water levels were higher. .
- HILLSIDE/BENCH - A shelflike area of rock with steep slopes above and below.

ANALYSIS

Here I present the results of each analytic method described above.

Settlement Viewshed

The figures below (Figures 5-13) are representative figures reflecting settlement viewsheds by time period. Each observer point was the site centroid, calculated as the center point based on site geometry. As previously mentioned, modern land modification is an issue for at least some site locations (e.g., compare Figures 9 and 10), but this influence is not uniform and does not prevent meaningful consideration of viewsheds. Unfortunately, there is no easy way to summarize or quantify viewsheds for all of the sites by time period, given that: 1) viewsheds are calculated using a single observer point on a site of potentially substantial size; 2) factors such as land/vegetation modification lead to variation that is not easily quantified, and 3) the software does not have the ability to conduct statistical calculations on viewshed area generated for observer points in each LIDAR tile. The best thing we can do is simple observation of locations of sites from multiple time periods with relatively little historic land modification to try and detect obvious patterns (Figures 5-13). In the cases observed, there was no obvious difference in viewshed by time period. Instead, it appears that viewsheds are an important settlement consideration in the study area regardless of time period, perhaps reflecting the “if you can see it, you can control it” school of thought that holds that direct observation is central to controlling a swath of land (Dytchowskyj et al. 2005). Further, many sites are multi-component, which in turn necessitates the viewsheds for these sites do not change (Figure 5).

Each period reflects variation. Viewshed for some site locations is very little or non-existent, perhaps indicating a concern with remaining hidden (Figures 9-11). For other locations viewshed is partial with some portion of surrounding area obscured (Figures 5-8; 11-13). Finally, some sites appear to have near 360 degree visibility (Figures 5-8). Landform and visibility are inextricably linked. However, there is so much variability within and between landforms of the study area that even settlements located on similar landforms might have highly variable viewsheds and settlements located on distinctive landforms might have similar viewsheds. To gauge how the observed settlement viewshed patterns compared to a completely random point pattern, I have generated the same number of observer points as sites for each time period and plotted them randomly within the study area using the random point generator in ArcGIS 10.1 (Figure 14). I then ran the viewshed test for some of these random points to see how they compared with the actual site viewshed patterns. Again, while I cannot statistically compare viewshed for actual sites vs. random points, I can make some general observations. As the following figures 15-18 show, it appears that the random points produce a reduced viewshed relative to many of the archaeological settlements. While some prehistoric settlements have limited viewshed, the randomly generated points seem to be more uniformly obscured from the surrounding landscape. It appears that the desire to see surrounding territory from the vantage of at least some settlements is a common inclination regardless of weapons technology.

I again emphasize that modern LIDAR groundcover interpretations of the recent landscape are at best an imprecise rendition of the Late Woodland landscape, but the prehistoric use of locations with limited viewsheds could be could be explained by several possibilities. First, it could be that some settlements were designed to remain hidden, and therefore minimized their viewsheds relative to other settlements that tried to monitor the surrounding territory. This might be a very good strategy for settlements that are surrounded by other settlements within a settlement cluster, in that the “hidden” sites would be known to the people within the cluster but unknown to potential enemies. As a result, these hidden settlements could serve as redoubts in cases of attack, which would be focused on the more easily defended border settlements with good viewsheds. The fact that some sites that were completely obscured from the surrounding territory but are visible to nearby sites supports this possibility’s plausibility (Figures 9-11). This arrangement could be a chance occurrence, but it may also be intentional. The ability to see an allied settlement and yet remain obscured from surrounding territory would be a definite tactical advantage in that raiding parties would be unaware of warriors coming from the hidden settlement. However, once the obscured site location was known, the tactical advantage would be mitigated at least somewhat, and the previously hidden village might be more susceptible to ambush attack if enemies could use the cover to get close to the settlement without being detected. A second possibility is that the locations with the best viewshed were consistently used, but that less ideal locations had to be used as well because of population size and density and resource location. A final possibility is that prehistoric land modification, perhaps completed only for defensive work but more likely also a product of timber requirements for building and maintaining architectural features and for heating and cooking fires, greatly increased the viewsheds around the prehistoric settlements, producing excellent viewsheds at locations that today are obscured. These possibilities of course are not mutually exclusive of one another. The concept of hidden defensive settlements although plausible, is an area for caution in that there are multiple non-defensive explanations for the apparent site obscurity.

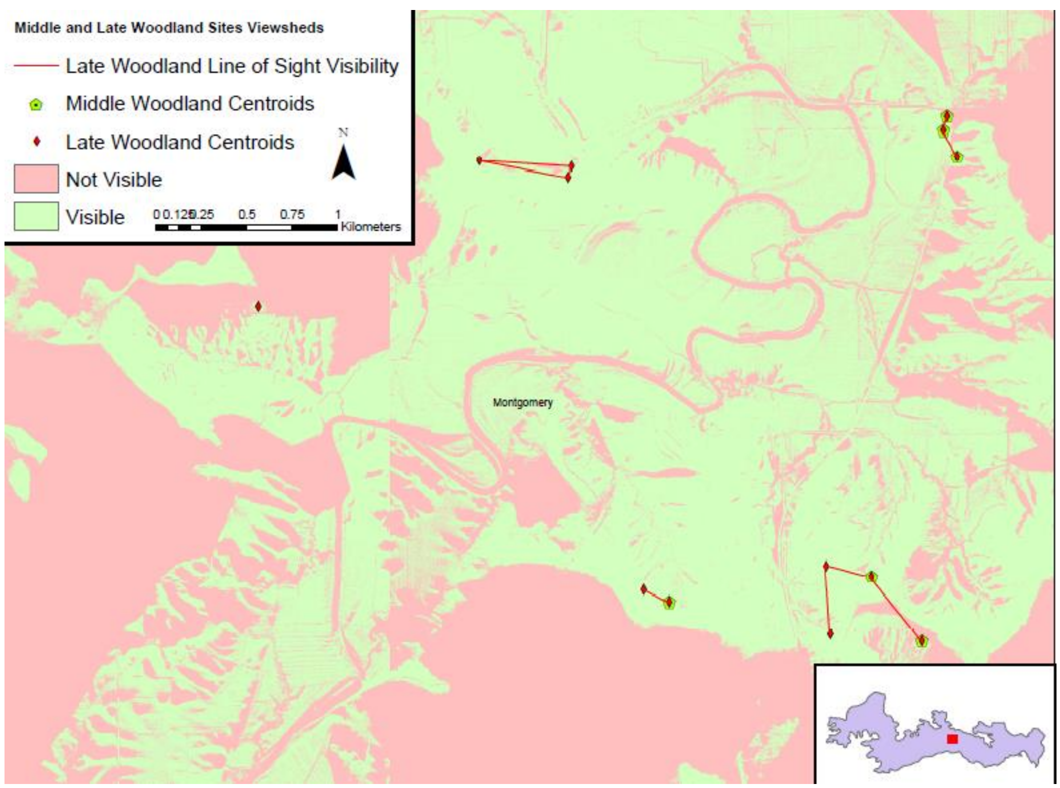

Figure 5: Multi-component Sites and Variable Viewshed patterns with Line of Sight Overlay.

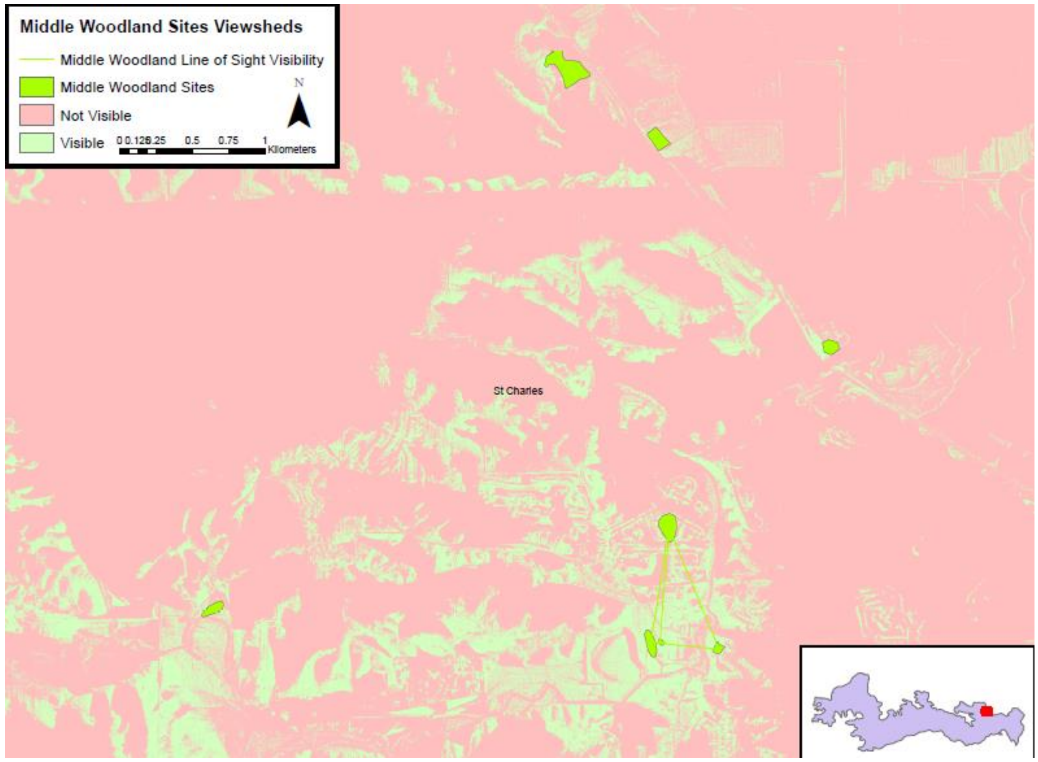

Figure 6: Middle Woodland Sites with Variable Viewshed Patterns and Line of Sight Overlay.

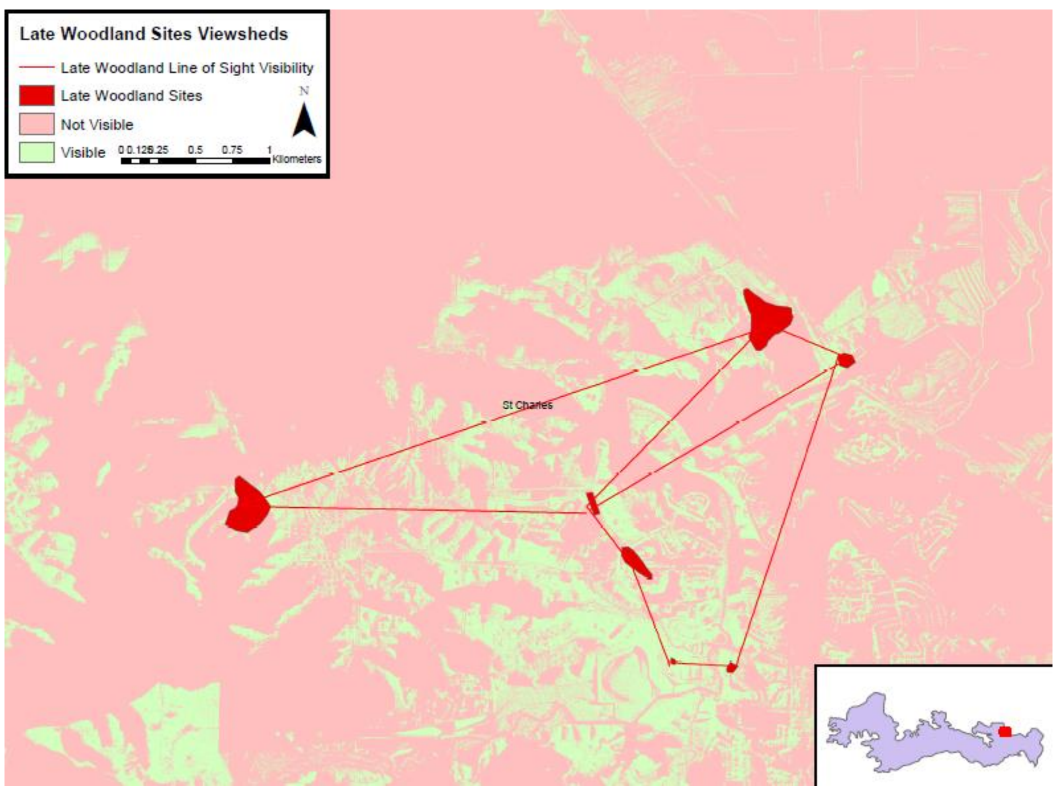

Figure 7: Late Woodland Site Viewsheds and Line of Sight Overlay.

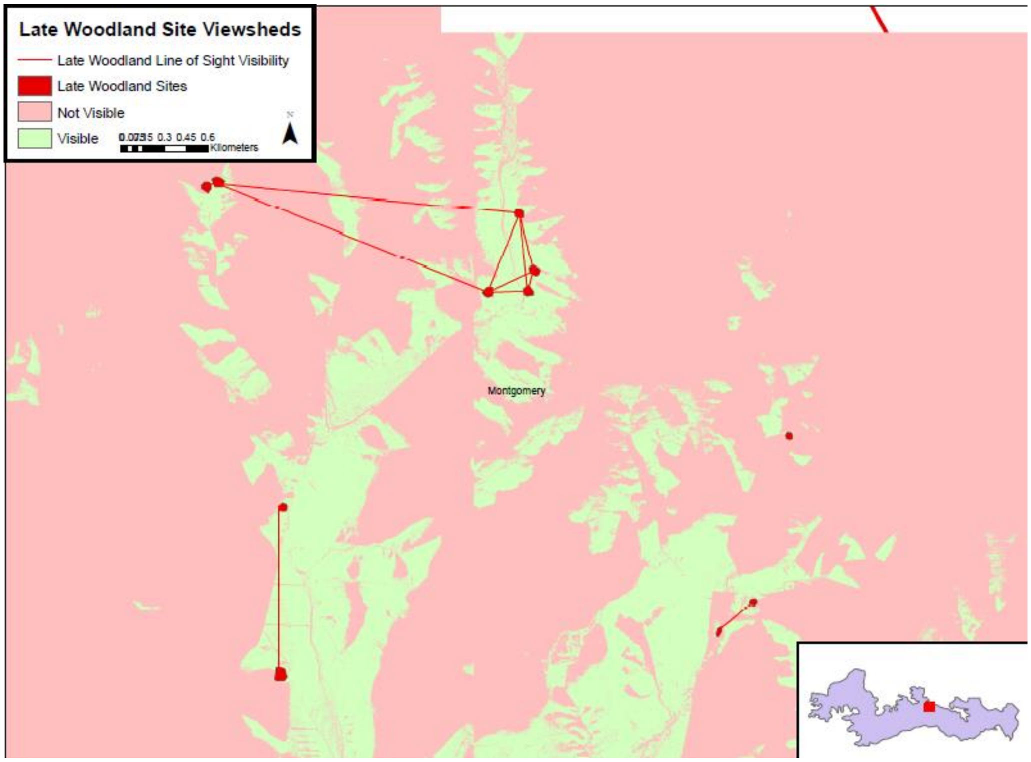

Figure 8: Late Woodland Sites Viewsheds and Line of Sight Overlay.

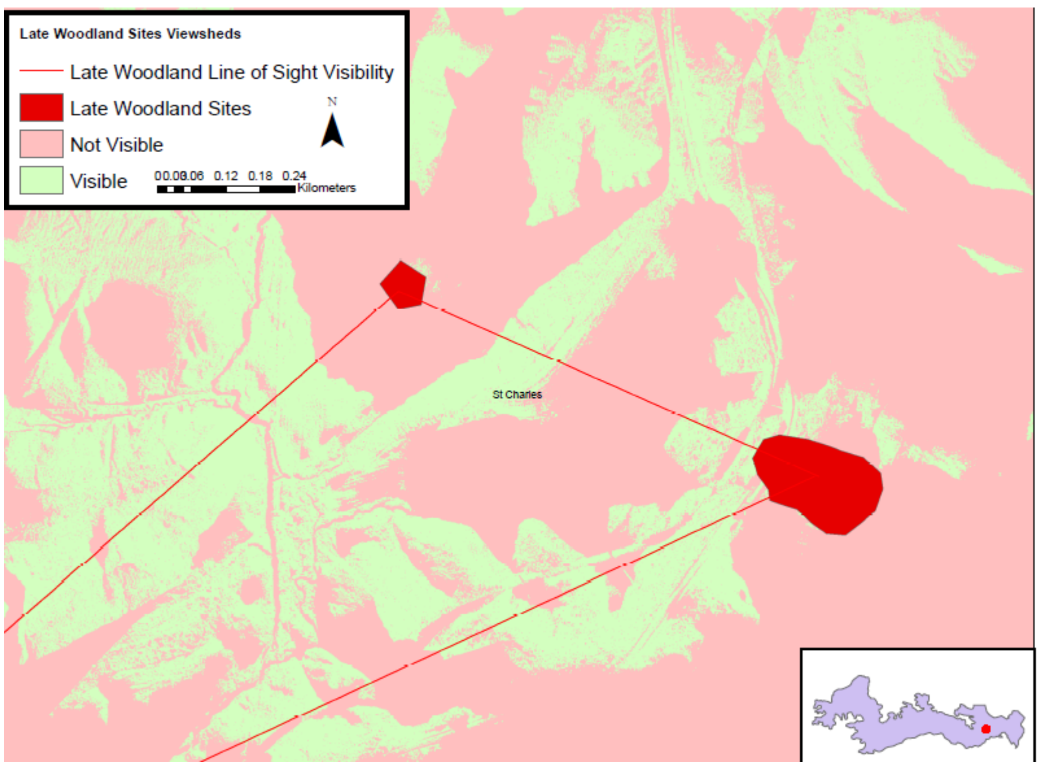

Figure 9: Late Woodland Site Viewsheds with Complete and Partial Site Invisibility Combined with Site Inter-visibility.

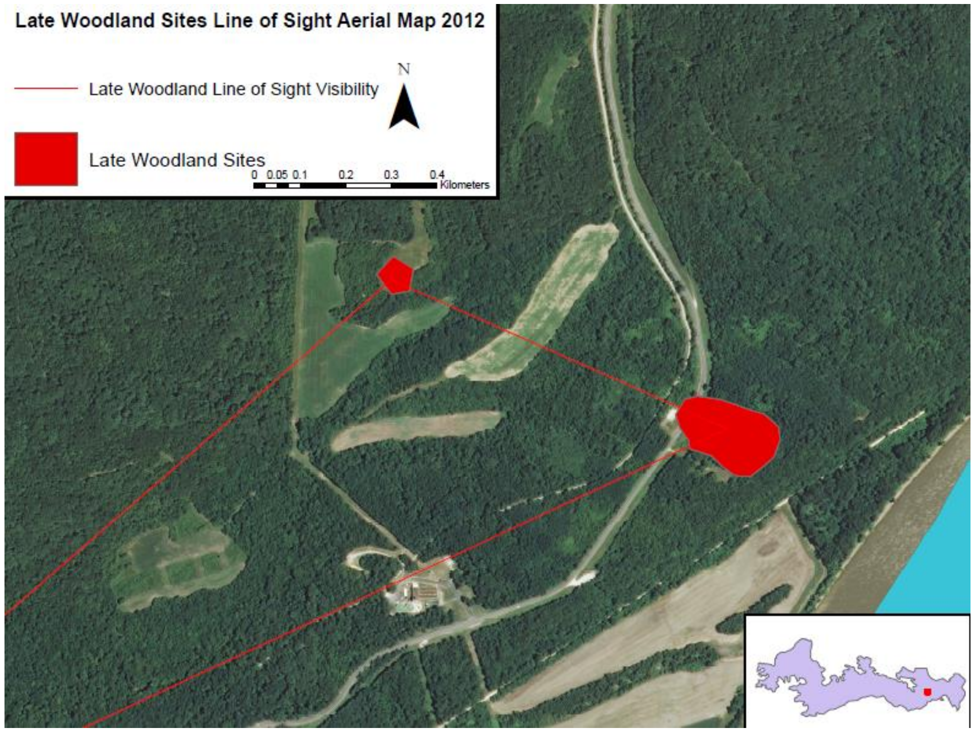

Figure 10: Late Woodland Sites Aerial Imagery to Illustrate Modern Land Modifications and How it Affects Viewshed (NAIP 2012).

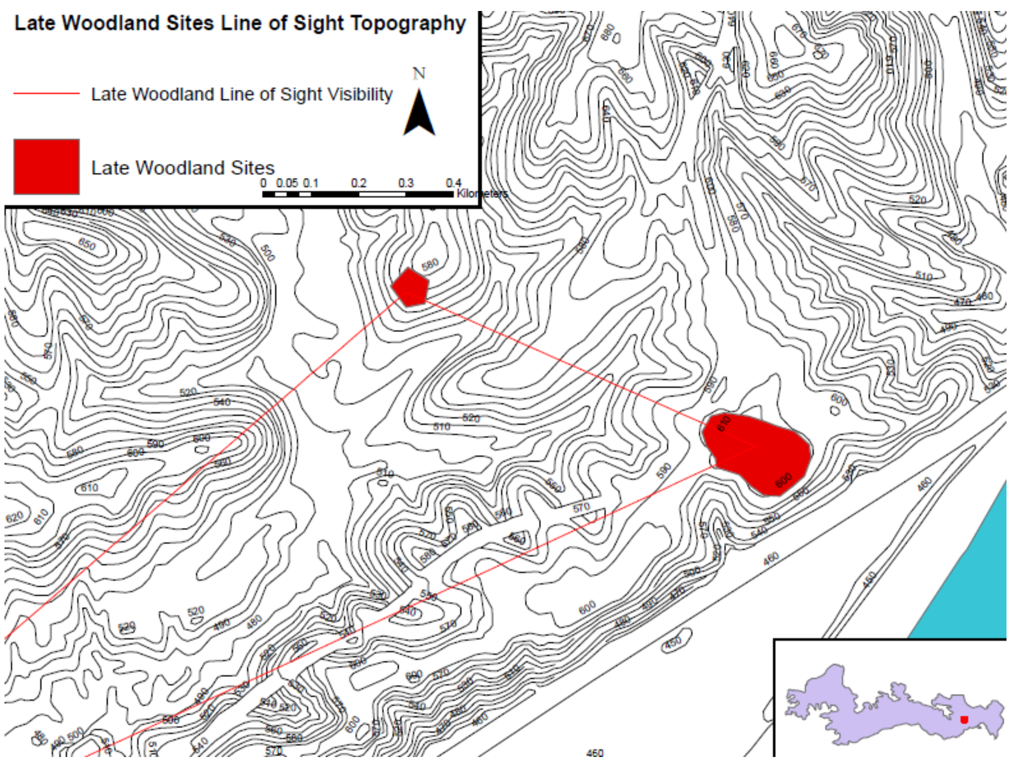

Figure 11: Late Woodland Sites Topographic Map to Illustrate how landform affects Viewshed.

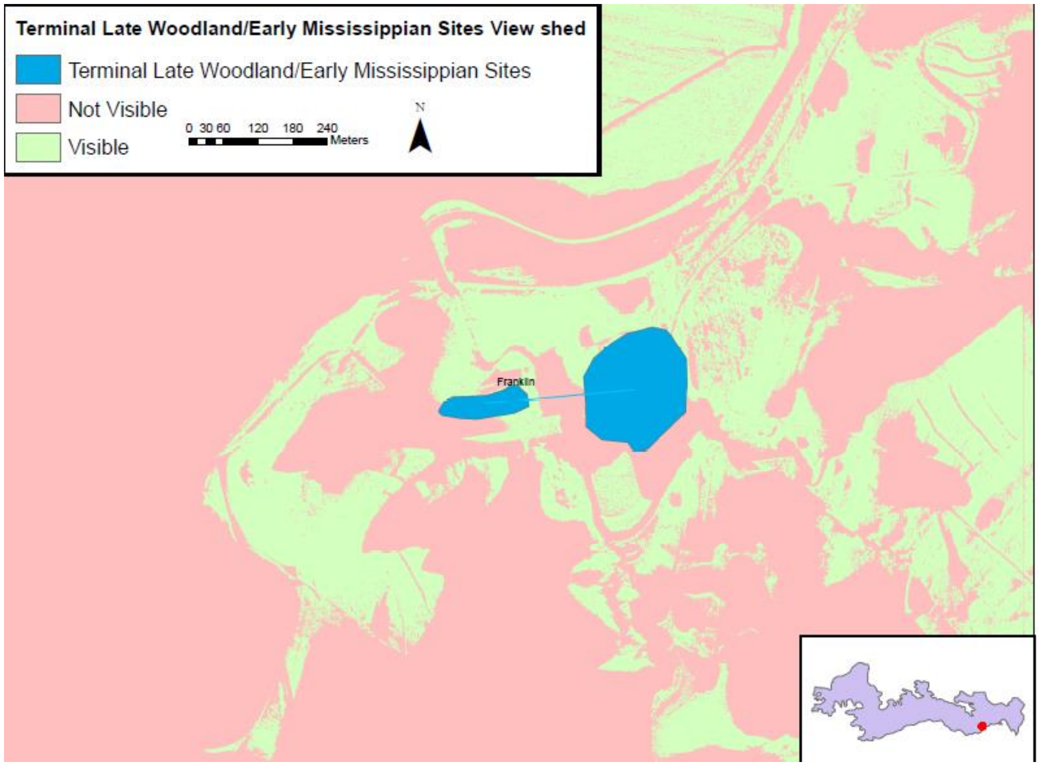

Figure12: Terminal Late Woodland/Early Mississippian Site Viewsheds with Line of Sight Overlay.

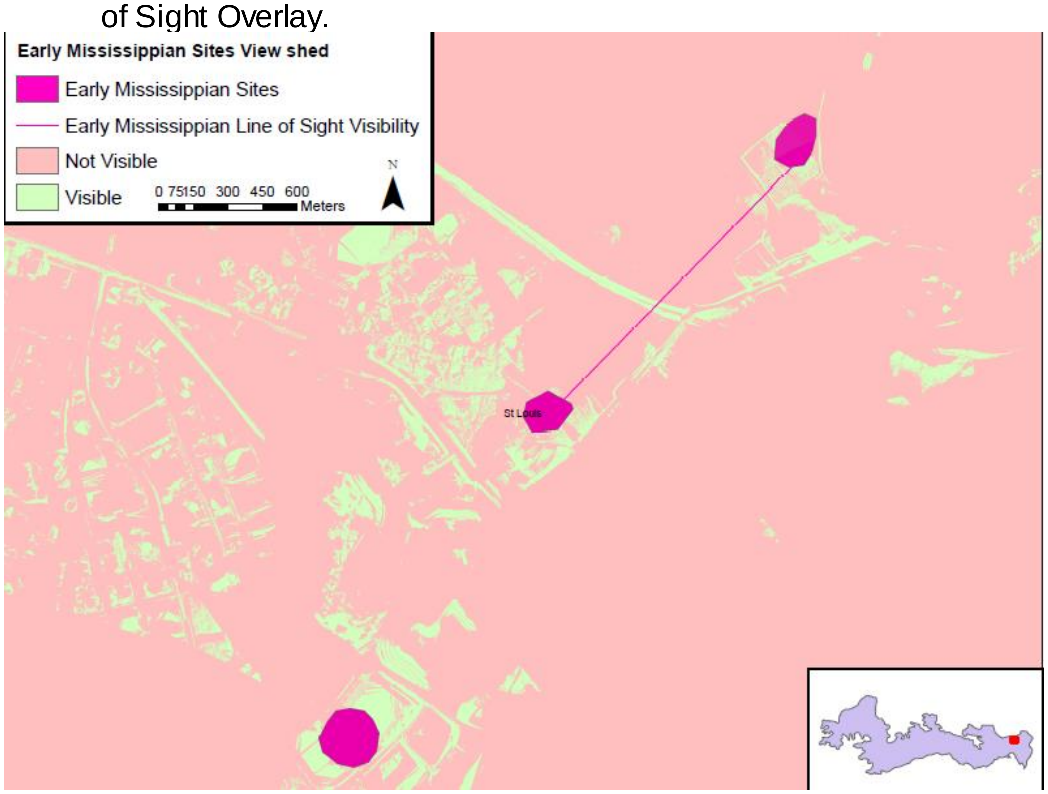

Figure 13: Early Mississippian Sites Viewshed with Line of Sight Overlay.

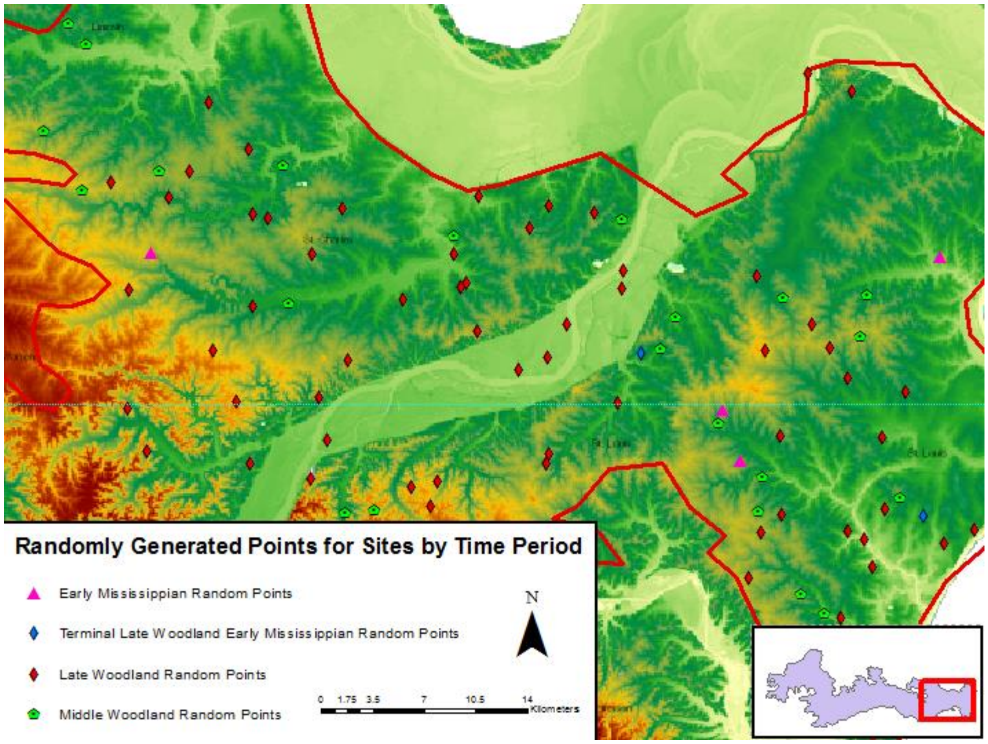

Figure 14: Randomly Generated Site Locations by Time Period.

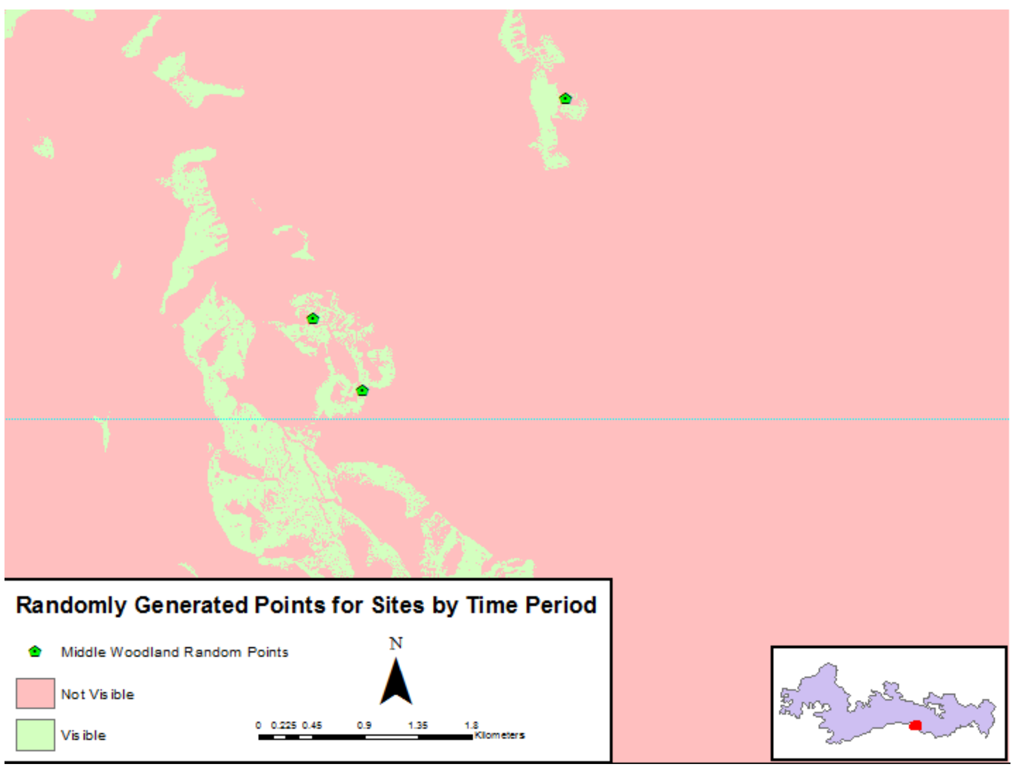

Figure 15: Random Middle Woodland Point Viewsheds.

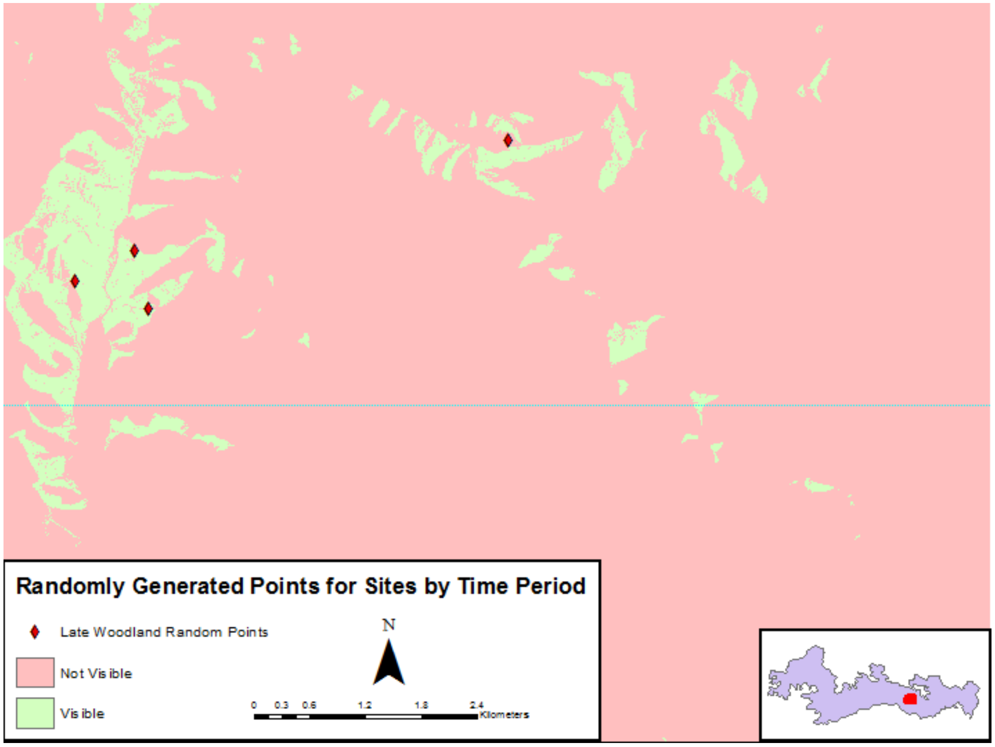

Figure 16: Random Late Woodland Point Viewsheds.

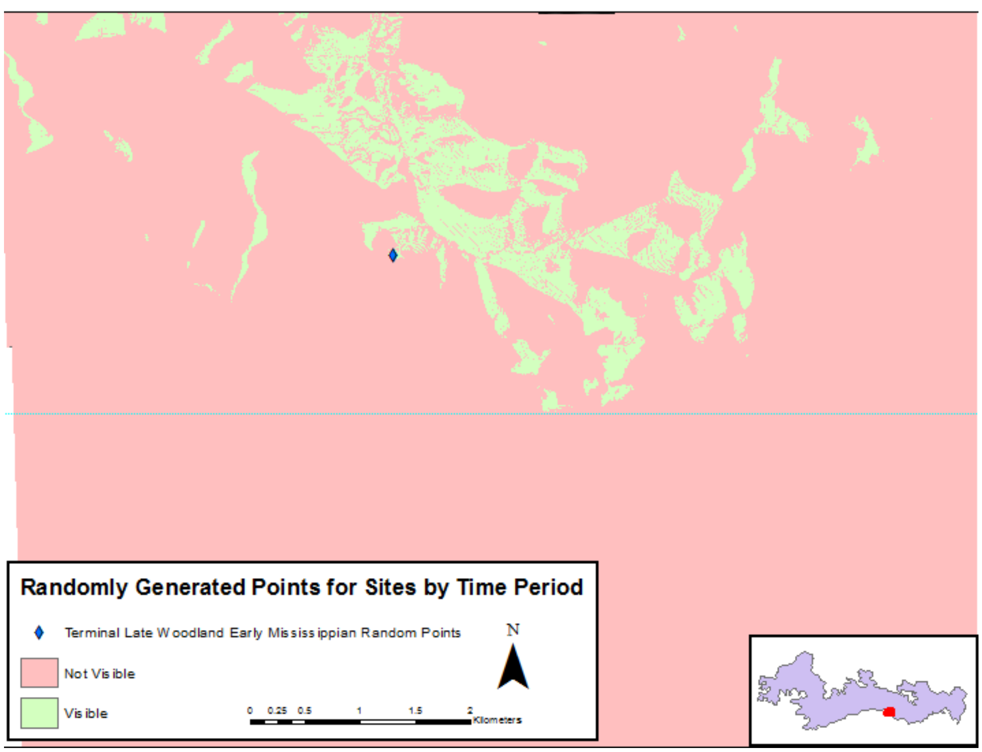

Figure 17: Random Terminal Late Woodland/Early Mississippian Point Viewshed.

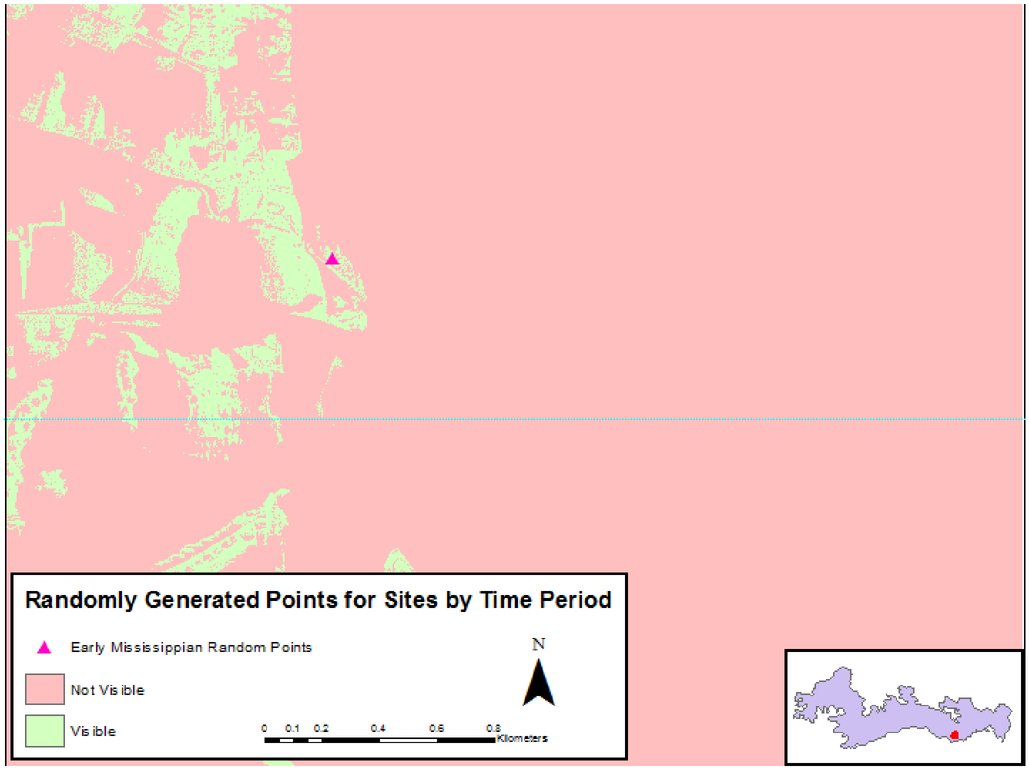

Figure 18: Random Early Mississippian Point Viewshed.

Settlement Inter-visibility

After carefully reviewing the entire study area in ArcGIS with all line of sight linked settlements by time period, the below table (Table 1) was created as a representation of settlement clusters and total settlements that all have line-of-sight relationships between them, along with all isolated settlements. In the second part of the table, I have also separated all line-of-sight settlements by upland or bottomland locations. In the table, total line-of-sight linked clusters are a representation of the number of settlement clusters consisting of multiple settlements together in line-of-sight relationships. Total of sites linked by line-of-sight consists of the total number of single sites with line-of-sight relationships. Total of isolated sites are those sites not in any kind of line-of-sight relationship, but it is possible that these could represent survey bias. Line-of-sight linked sites by landform represent the location of sites linked in line-of-sight relationships in either upland or lowland physiographic settings.

In the following maps (Figures 19-22), I have attempted to demonstrate how line of sight relationships work in a settlement landscape for each time period. There are definite differences in line of sight relationships among settlements for each time period for the study area. Some of these differences may reflect settlements that were occupied and then abandoned and therefore not inter-visible with later sites, but I do believe the overall picture does give us a general trend or pattern that is valid. What the maps demonstrate is the increasing concern with line-of-sight relationships during some time periods over other time periods. They are not a complete reflection of all line-of-sight linked sites in the study area. As with viewshed analysis, to gauge how these line-of-sight patterns compare to a completely random point pattern, I have generated the same number of random observer points as sites for each time period and plotted them across the settlement landscape. I then ran the line-of-sight test for these points to see how they compared with the observed line-of-sight patterns.

What the observed pattern demonstrates is that the ability to see nearby sites appears to be most important in the Late Woodland Period over all other periods, perhaps reflecting increased social cooperation, combined with settlement dispersal over the landscape. In the Middle Woodland, there are only 21 clusters of sites linked by line-of-sight. In the Late Woodland, this number jumps to 64 clusters. Overall, 78% of Late Woodland settlements, when the bow and arrow were adopted, are linked by line of sight, which is greater than the preceding Middle Woodland period where 50% of the settlements were so linked. This figure drops to 25% and 28% in the Terminal Late Woodland/Early Mississippian and the Early Mississippian. In the Middle Woodland Period, 67% of sites linked by line-of-sight are located in upland settings, but during the Late Woodland, this number jumps to 77%, perhaps reflecting increased concern with higher locations for defensive considerations. However, during the Terminal Late Woodland/Early Mississippian Period this number declines to half the sites. In the Early Mississippian sites, fully 75% of sites are located in lowland settings. It appears that as settlements grow larger and nucleation increases, site inter-visibility becomes less of a factor, likely reflecting a shift from defense in layers to defense in numbers as agriculture enables larger and larger settlements. There is also much less of concern with locating sites in upland settings, perhaps signaling a change in defensive strategy due to population nucleation into much larger settlements.

To compare these results with randomly generated points by time period, only 16% of the random Middle Woodland points were linked by line-of-sight (20 sites). Only 31% of the random Late Woodland points were linked by line-of-sight (92 sites). None of the randomly generated points for Terminal Late Woodland/Early Mississippian and Early Mississippian were linked by line-of-sight. These numbers reflect that the observed line-of-sight relationships for all time periods are not a chance occurrence.

There are other possible explanations for some of these trends that relate to changes in resource exploitation from the Middle Woodland to the Early Mississippian periods that involve greatly expanding exploitable resource zones and moving to multiple resource zones on a seasonal basis. According to Hoard (2000:222-227), the two most common types of faunal resources found in Late Woodland sites of Central Missouri consist of deer from upland settings and fish and mussels from lowland contexts, although faunal preservation in Late Woodland sites in Central Missouri is often poor. It is possible that lowland sites were occupied from spring through late summer to tend horticultural fields and exploit lowland fauna. It is also possible that lowland settlements could have been occupied for the entire year. Most of the lowland Late Woodland sites are located at the edge of ecotonal areas near slopes leading to upland forests that could be readily exploited. This follows a general pattern similar to other Late Woodland sites in Missouri. Native plants such as goosefoot, knotweed, maygrass, and little barley (Harl 2000: 272) were cultivated in lowland areas with the occasional use of maize and wild plants. There was also a preference for deer and fish with upland camps perhaps representing winter deer camps (Sturdevant 1990). It is possible that bow and arrow technology made hunting easier (Harl 2000: 272). However, even if the expanded exploitation of multiple resource zones accounted for increased clustering or even distribution of sites in resource patches, it would not explain the apparent increases in site inter-visibility during the Late Woodland Period. It is also possible that Late Woodland site clusters in upland settings represent a palimpsest of briefly occupied hunting camps in a good hunting area. However, the clustering of sites with line-of-sight relationships does not appear to be a chance occurrence. Furthermore, the need for defensive cooperation between sites and resource exploitation are not mutually exclusive of each other. It is possible that both could be occurring at the same time. The shift to a far greater percentage of lowland settlements during the Early Mississippian Period and reduction in line-of-sight relationships between settlements probably relates not just to incipient agriculture, but also to the idea of collective defense by much larger populations.

Thus, it is possible that the arrival of the bow and arrow initially increases coordination among allied sites when it first arrives such that the layered defenses provide a more effective means of countering long range projectile weapons with a high rate of fire. The line of site relationships among Late Woodland settlements facilitates communication to enable coordination among sites to quickly focus defensive efforts to points of incursion from other sites in the layered defense. The creation of large population centers in the Mississippian periods reduces the need for layered defenses in that large counterattacking forces can be quickly brought to bear without the need for layered defenses. Warriors in large population centers are not so spread out as in a network of smaller settlements and can thus respond to attacks far quicker than with dispersed settlement patterns.

Time Period	Number of Sites Total	Total of Line-of-Sight Linked Clusters	Total of Sites Linked by Line-of-Sight	Total of Isolated Sites
Middle Woodland	121	21	61	60
Late Woodland	289	64	228	61
Terminal Late Woodland/Emergent Mississippian	8	1	2	6
Early Mississippian	14	2	4	10
Line of Sight Linked Sites by Landform	**Upland**	**Bottomland**		
Middle Woodland	41	20		
Late Woodland	177	51		
Terminal Late Woodland/Emergent Mississippian	1	1		
Early Mississippian	1	3		

Table 1: Statistics for Sites Linked by Line-of-Sight.

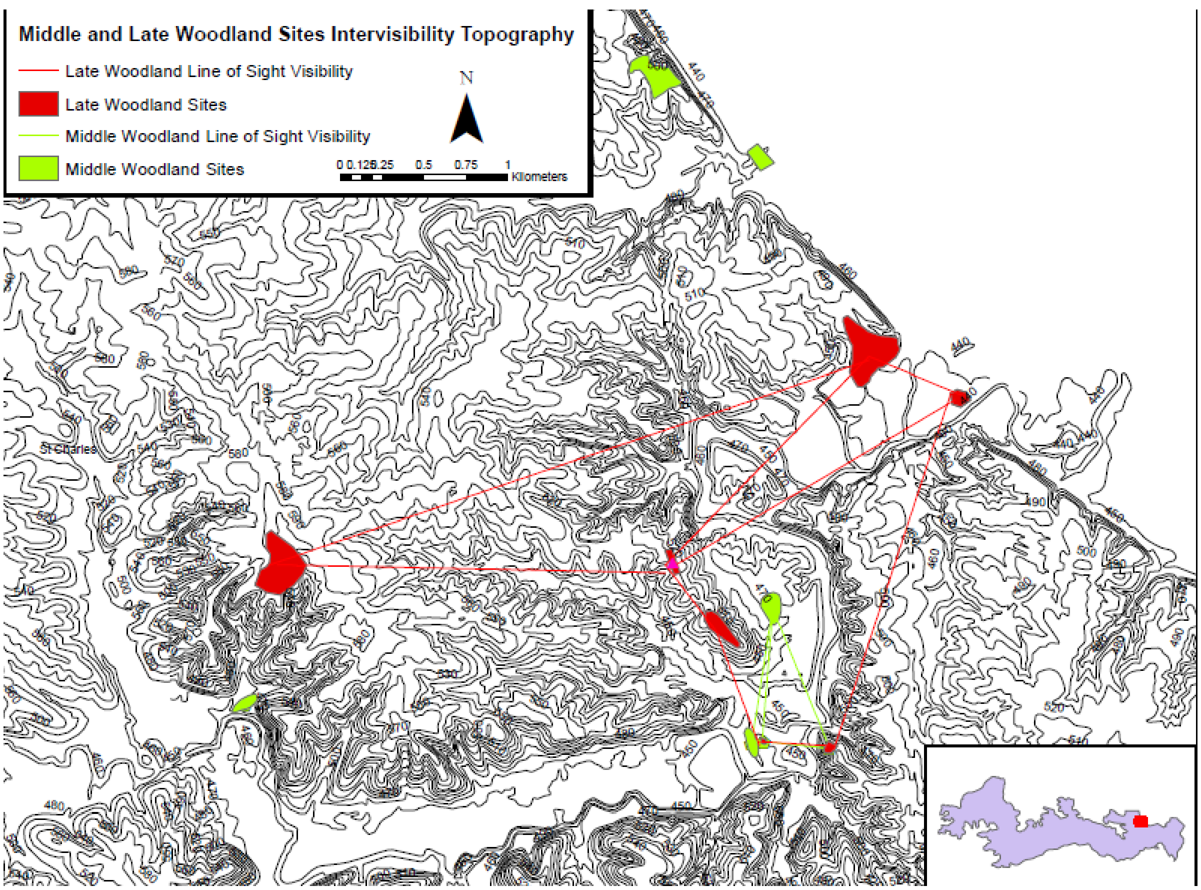

Figure 19: Example of Line-of-Sight Linked Sites and Associated Topography for the Middle and Late Woodland Periods.

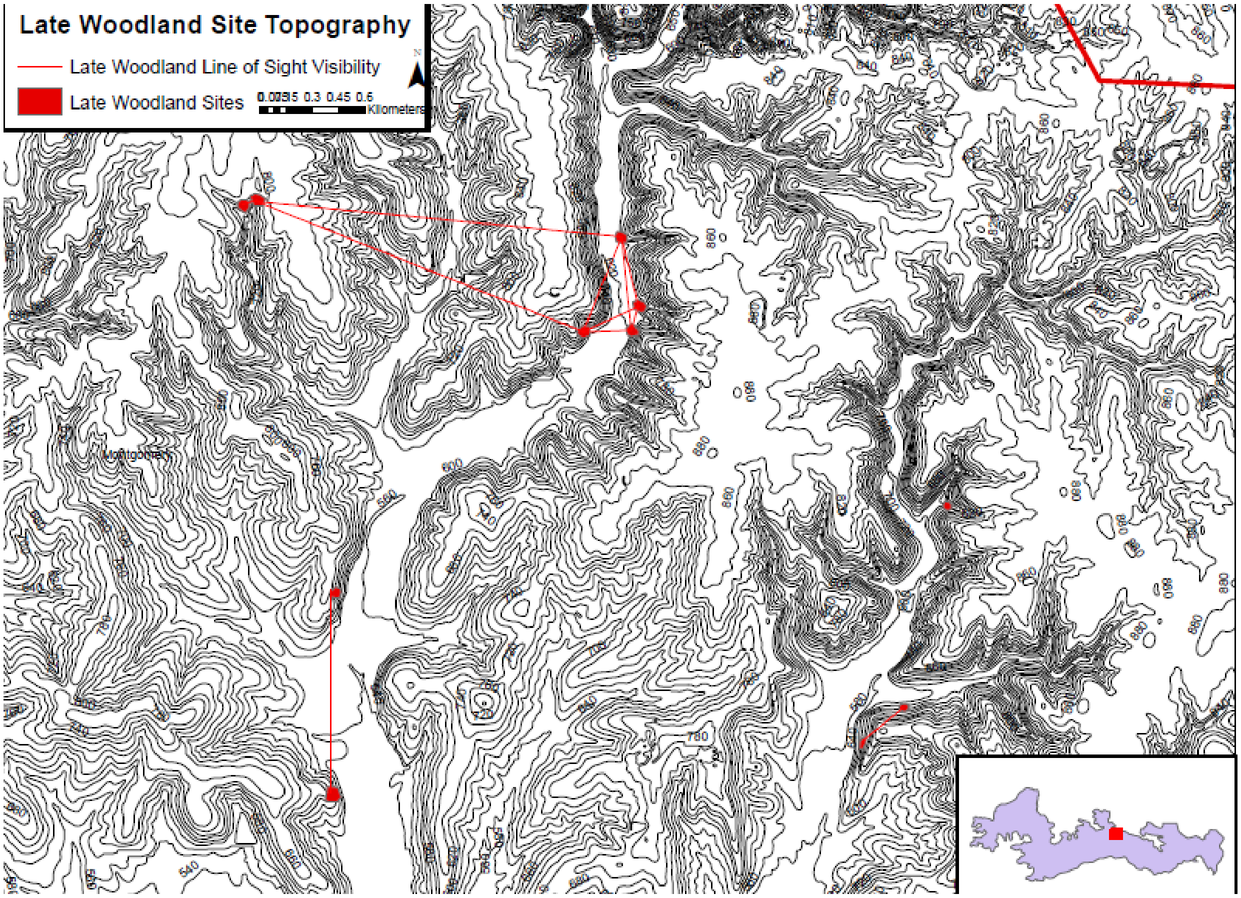

Figure 20: Example of Line-of-Sight Linked sites for the Late Woodland Period with Associated Topography.

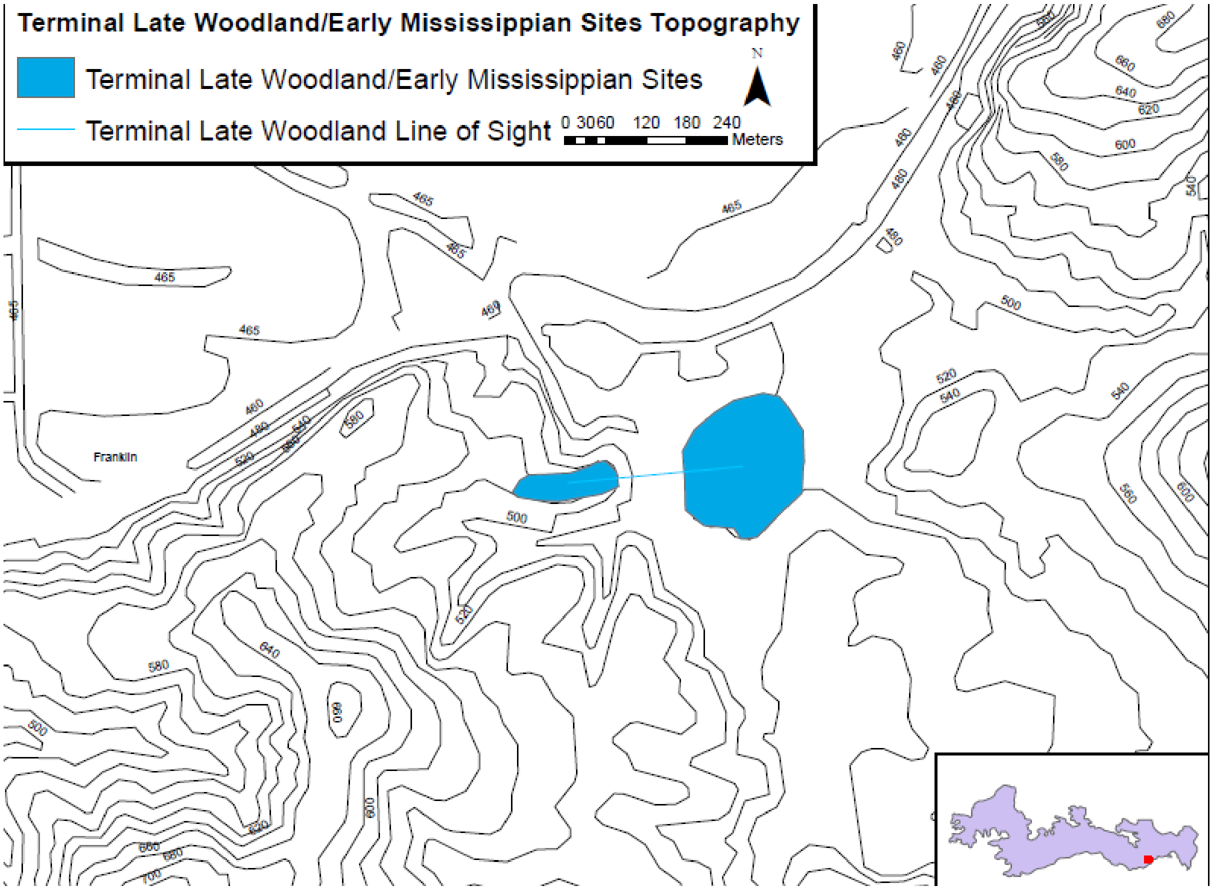

Figure 21: Example of Line-of-Sight Linked Sites for the Terminal Late Woodland/Early Mississippian Period with Associated Topography.

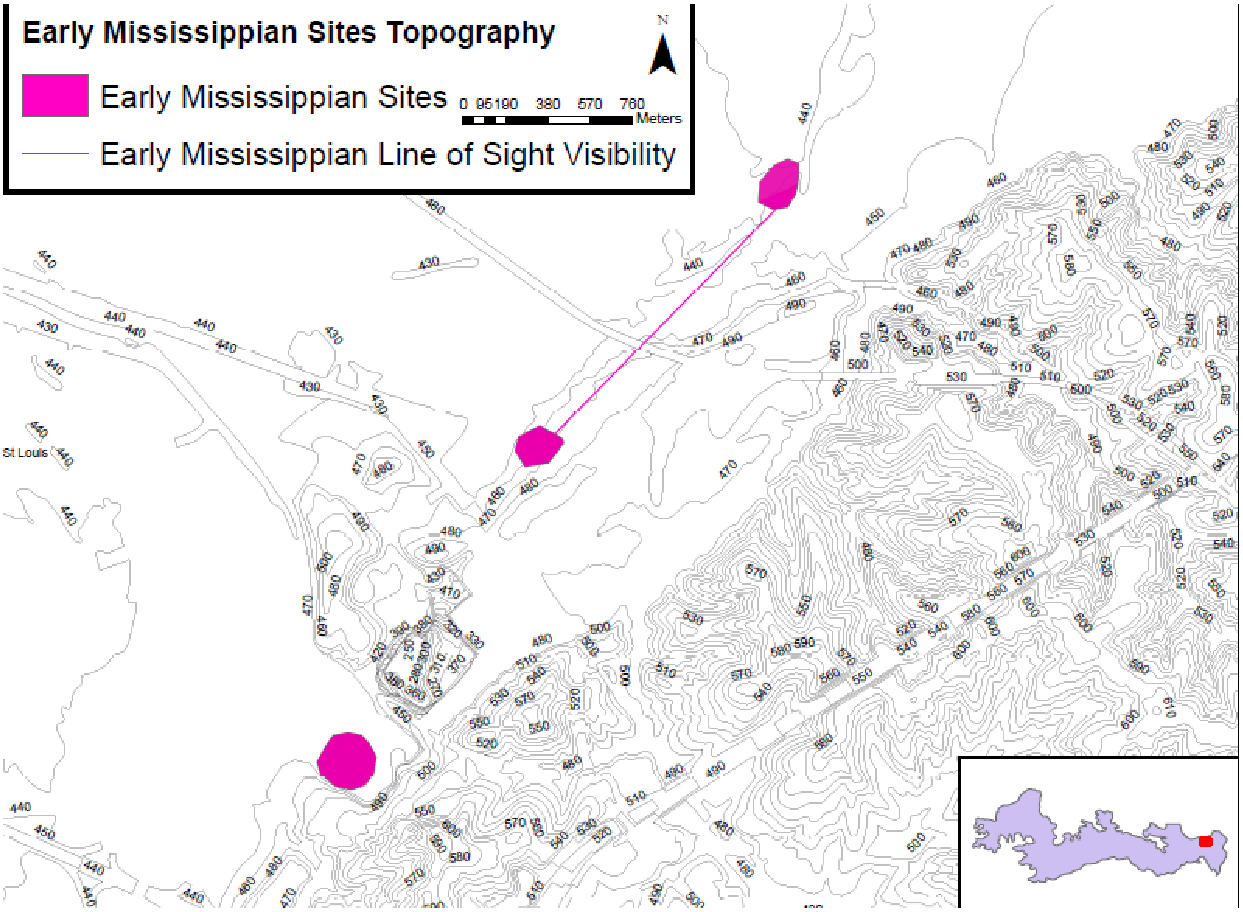

Figure 22: Example of Line-of-Sight Linked Early Mississippian Sites with Associated Topography.

Settlement Clustering or Nucleation

1) Nearest Neighbor Statistic

The Nearest Neighbor statistic for sites by time period is reported in Figures 23-26 using ArcGIS 10.1 printouts. The nearest neighbor index for the Middle Woodland Period is .49, indicating a clustered settlement pattern. For the Late Woodland Period, the figure is .36, demonstrating an even greater level of clustering than the Middle Woodland Period. However, the pattern reverses itself during the Terminal Late Woodland/Early Mississippian Period where the nearest neighbor index increases to 1.3, indicating a more dispersed and evenly-spaced settlement pattern. The pattern changes again in the Early Mississippian Period with an index of .92 indicating a more random settlement pattern. From the results of the nearest neighbor analysis, it is clear that the level of site settlement clustering in both the Middle Woodland and Late Woodland Periods is similar, with the Late Woodland showing a slightly higher level of clustering. The Terminal Late Woodland/Emergent Mississippian Period is more dispersed with sites regularly spaced, and the Mississippian Period has sites locating in a more random manner, relative to each other. Thus, the adoption of the bow and arrow initially corresponded with settlement clustering, but settlement spacing shifted to more uniformly dispersed patterns and finally to larger, aggregated settlements that were more randomly placed (relative to each other) across the landscape.

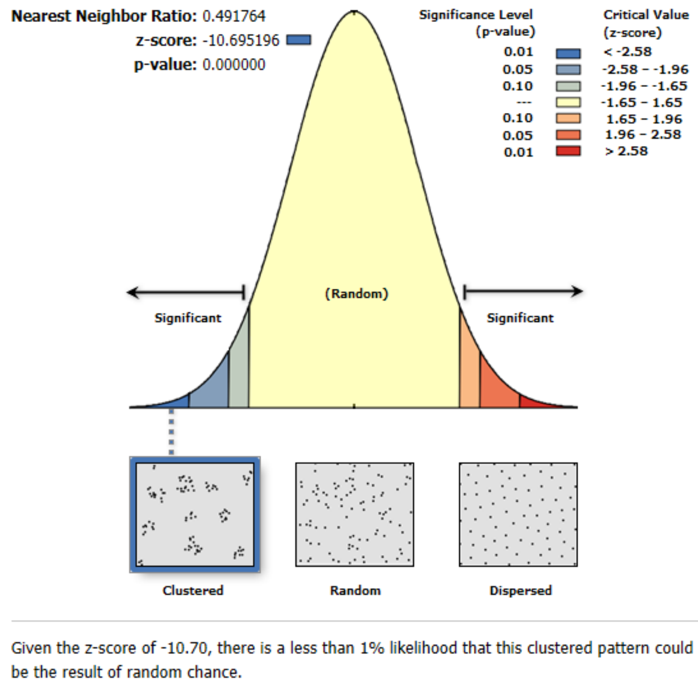

Figure 23: Middle Woodland Nearest Neighbor Results (ESRI ArcGIS 10.1 2014).

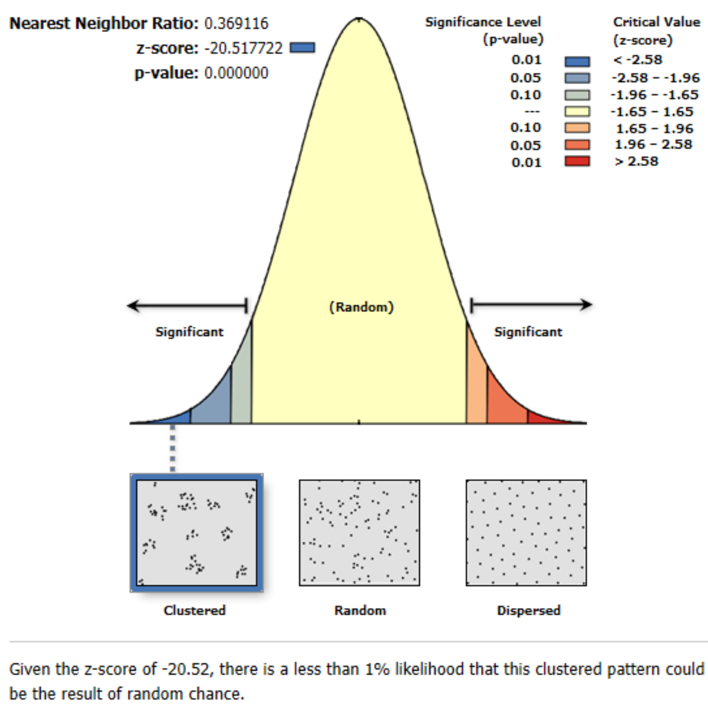

Figure 24: Late Woodland Nearest Neighbor Results (ESRI ArcGIS 10.1 2014).

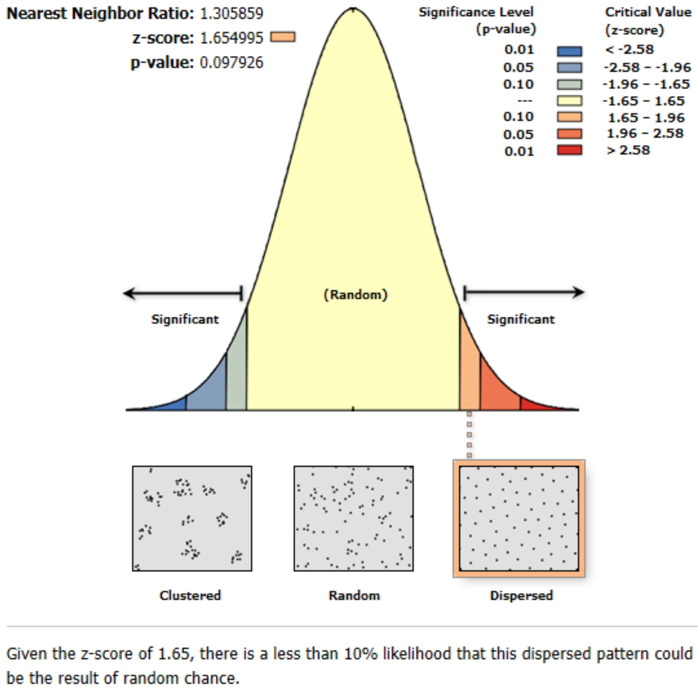

Figure 25: Terminal Late Woodland/Emergent Mississippian Nearest Neighbor Results (ESRI ArcGIS 10.1 2014).

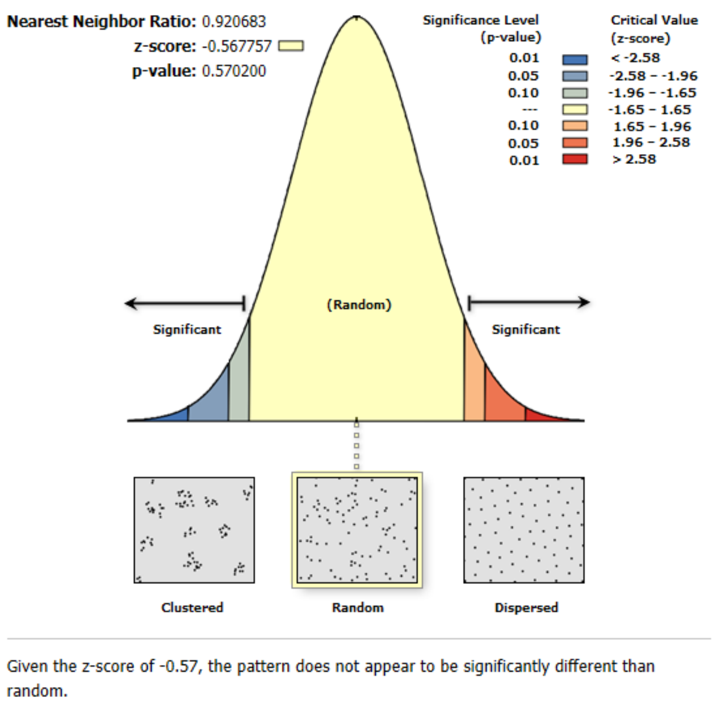

Figure 26: Early Mississippian Nearest Neighbor Results (ESRI ArcGIS 10.1 2014).

2) Regular Site Spacing – Defense of Frontiers, Competition

Although both Middle and Late Woodland sites are clustered, the settlement patterns in the Lower Missouri River Valley for Middle Woodland and Late Woodland sites are different in that Late Woodland settlements are found more often in linear, regularly-spaced arrangements that could denote a possible frontier defense (Figure 27). As with the later periods, this frontier defense is mostly along the eastern part of the southern shore of the Missouri River and may be in place to stem incursions from the northern shore. Given that the river is a formidable, but passable, natural barrier, it would have been a natural boundary among social groups. As many of these settlements have line of sight inter-visibility, they are likely interacting regularly and quite possibly formed defensive coalitions as discussed above.

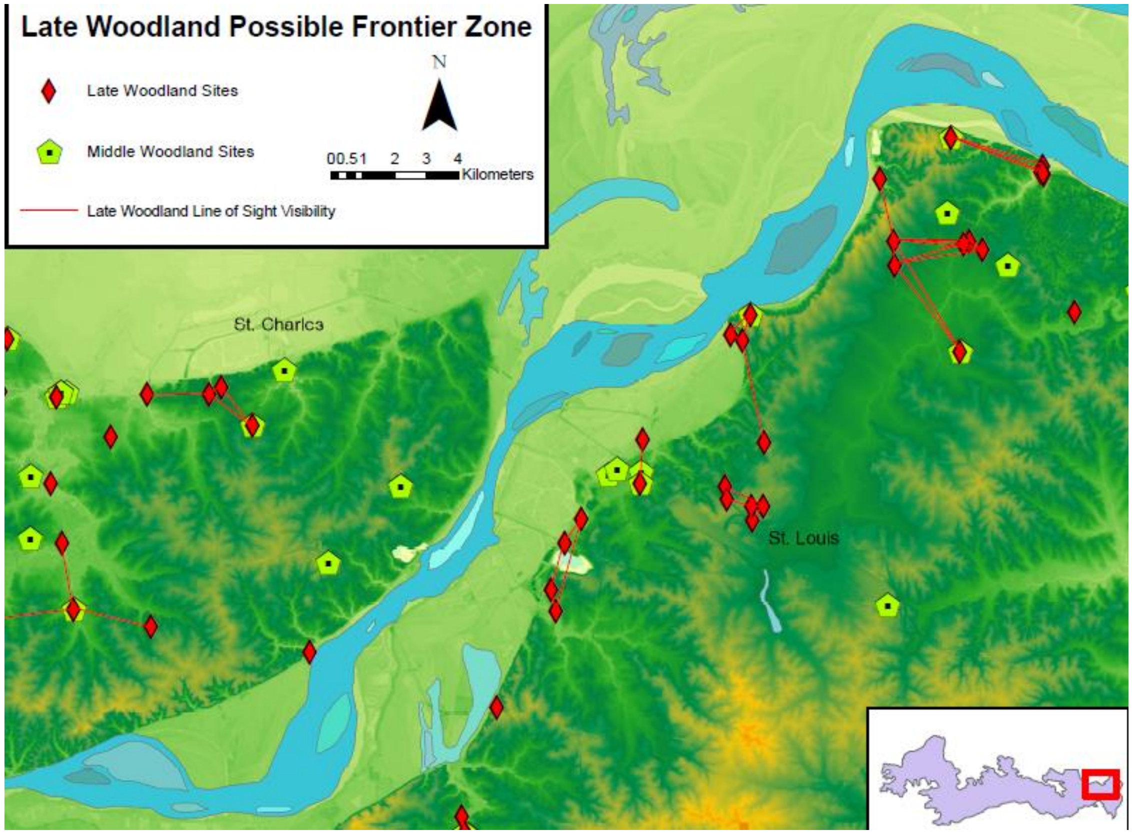

Figure 27: Possible Late Woodland Frontier Defenses in the Eastern Part of the Lower Missouri River Valley.

The settlement patterns in the Lower Missouri River Valley for Terminal Late Woodland/Early Mississippian and Early Mississippian Periods are radically different from the preceding Late Woodland Period. In these later periods, there is evidence of much larger, nucleated settlements arranged in an apparent frontier arrangement on both sides of the Missouri River (Figure 28). Although such linear arrangements at near-regular intervals may denote competing political units, they may be arranged cooperatively to oppose settlements on the other side of the river with the river and bottomlands as a sort of “no-man’s land. The addition of site inter-visibility among some sites of both periods (Figure 29-30) could support possible cooperative defense.

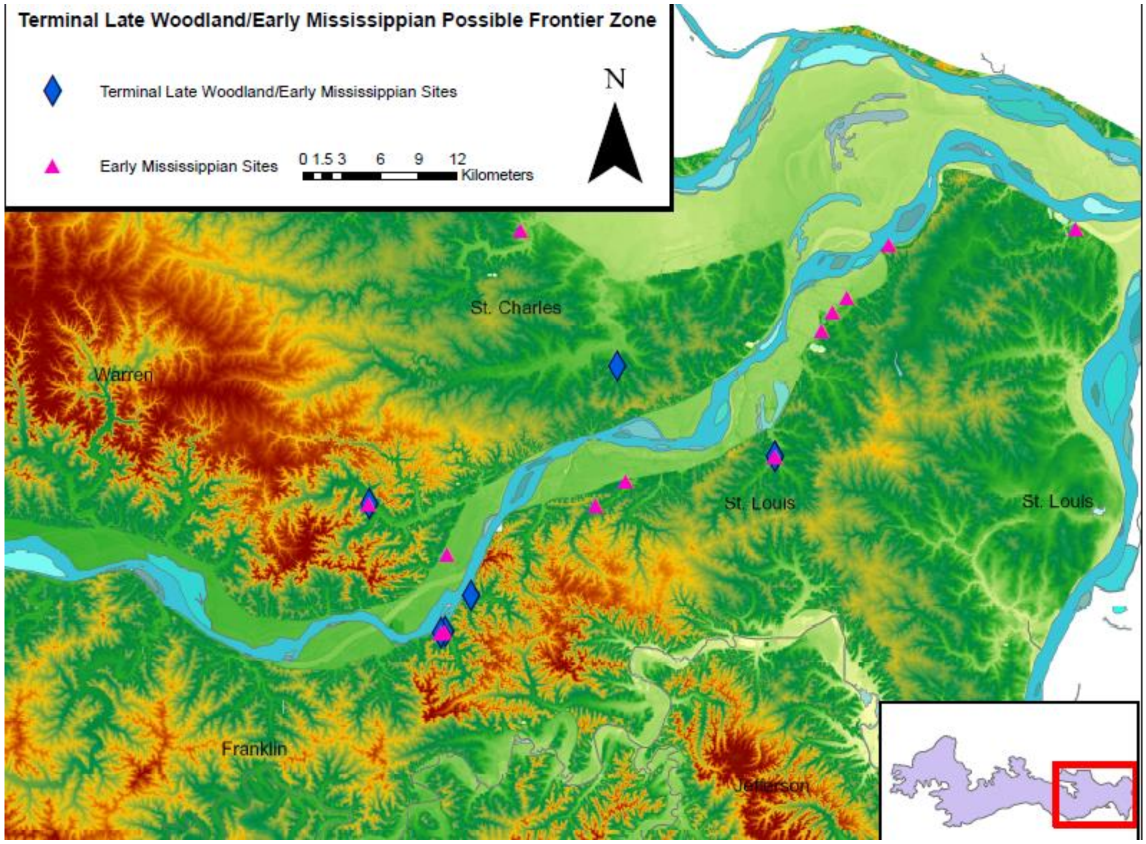

Figure 28: Terminal Late Woodland/Early Mississippian and Early Mississippian Settlements in a Frontier Arrangement.

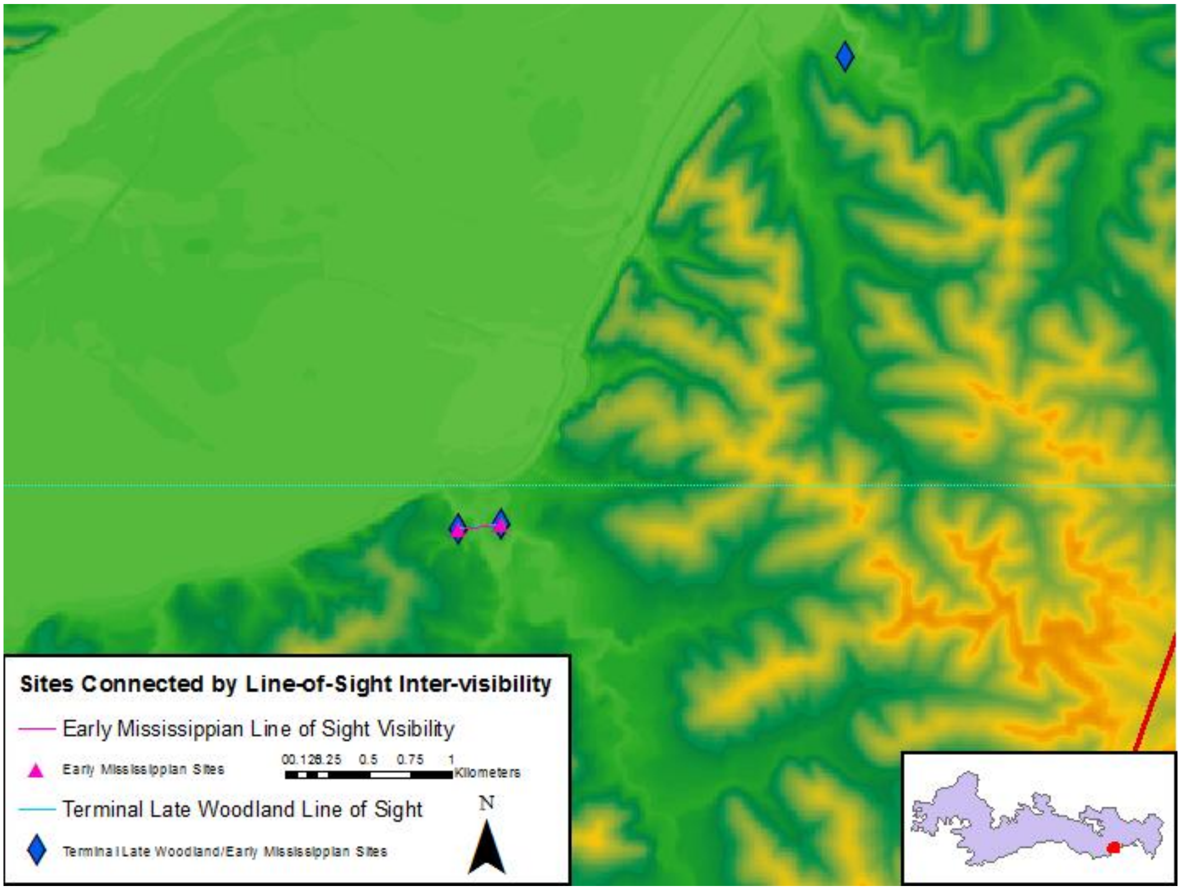

Figure 29: Sites Connected by Line-of-Sight Inter-visibility.

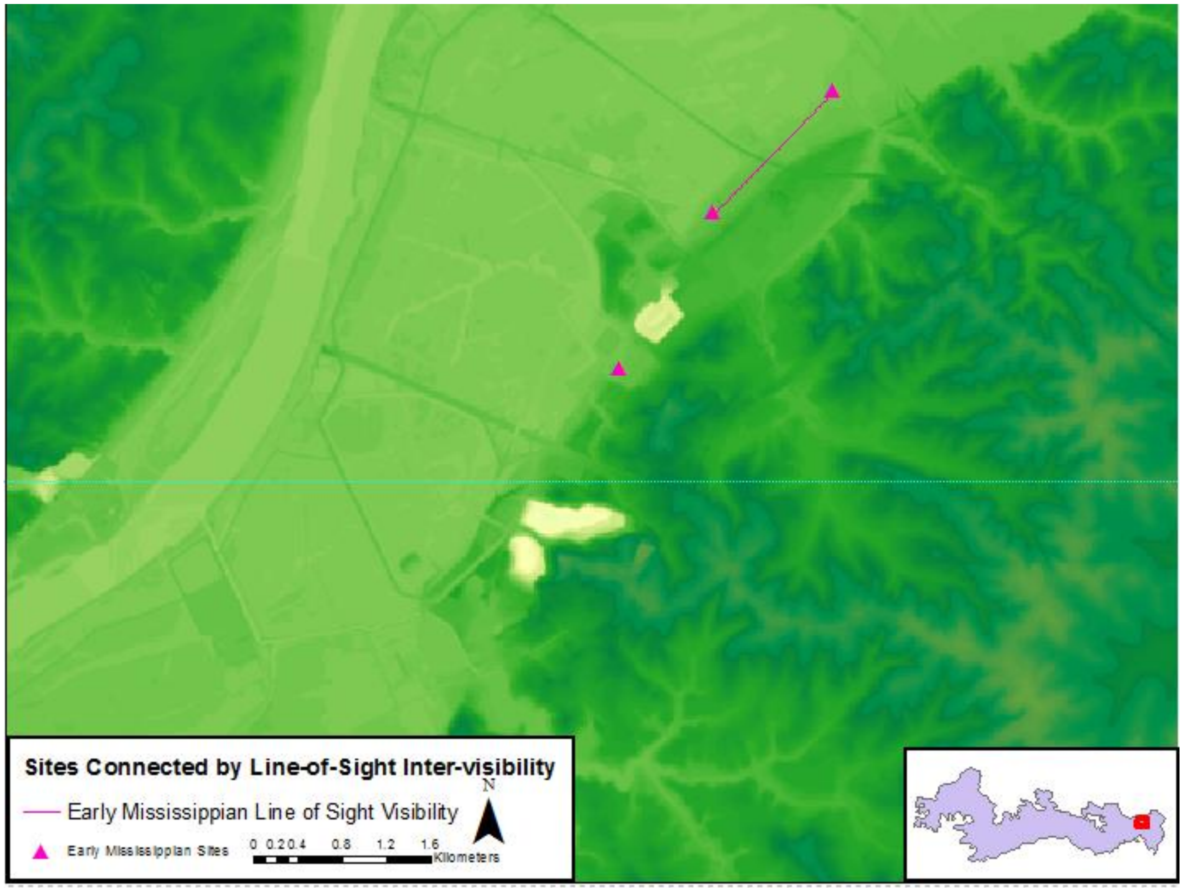

Figure 30: Sights Connected by Line-of-Sight Inter-visibility.

Both the Terminal Late Woodland/Early Mississippian and Early Mississippian Periods are associated with increasing site aggregation and nucleation of people coming from smaller, more dispersed settlements. The regular spacing of the Terminal Late Woodland/Early Mississippian sites likely reflects the sites' arrangement in a linear, near regularly-spaced settlement pattern along the river's course (Figure 28). This regular spacing relaxed slightly during the Early Mississippian period as sites clustered a bit more, perhaps to increase their defensive efficiency and/or to allow increased cooperation with nearby settlements groups and perhaps political rivalry between settlement groups. For example, Figure 31 reflects at least two settlements in direct succession that have a line of sight relationship with two others that are close to being line of sight. Their proximity suggests they are closely interacting centers, but their proximity to a nature geographic boundary could possibly be cooperative and defensive in nature. I do not believe hierarchic control of one site over the others has developed here because hierarchic control is not obviously reflected in settlement rank-size differences.

At this time, the northern opposing shore of the river is apparently depopulated of large settlements, suggesting that there is not an inherent preference for such geographic settings during the Early Mississippian Period. Floodplain-based farmers could have existed on the north shore because earlier Late Woodland horticulturalists and at least one Early Mississippian settlement also did so. Instead, the placement of sites on the southern shore and the abandonment of sites on the northern shore likely reflect cultural dynamics that likely include border maintenance including possible warfare. This could be the barbarian periphery of cooperating Mississippian chiefdoms with the river forming their “maginot line.”

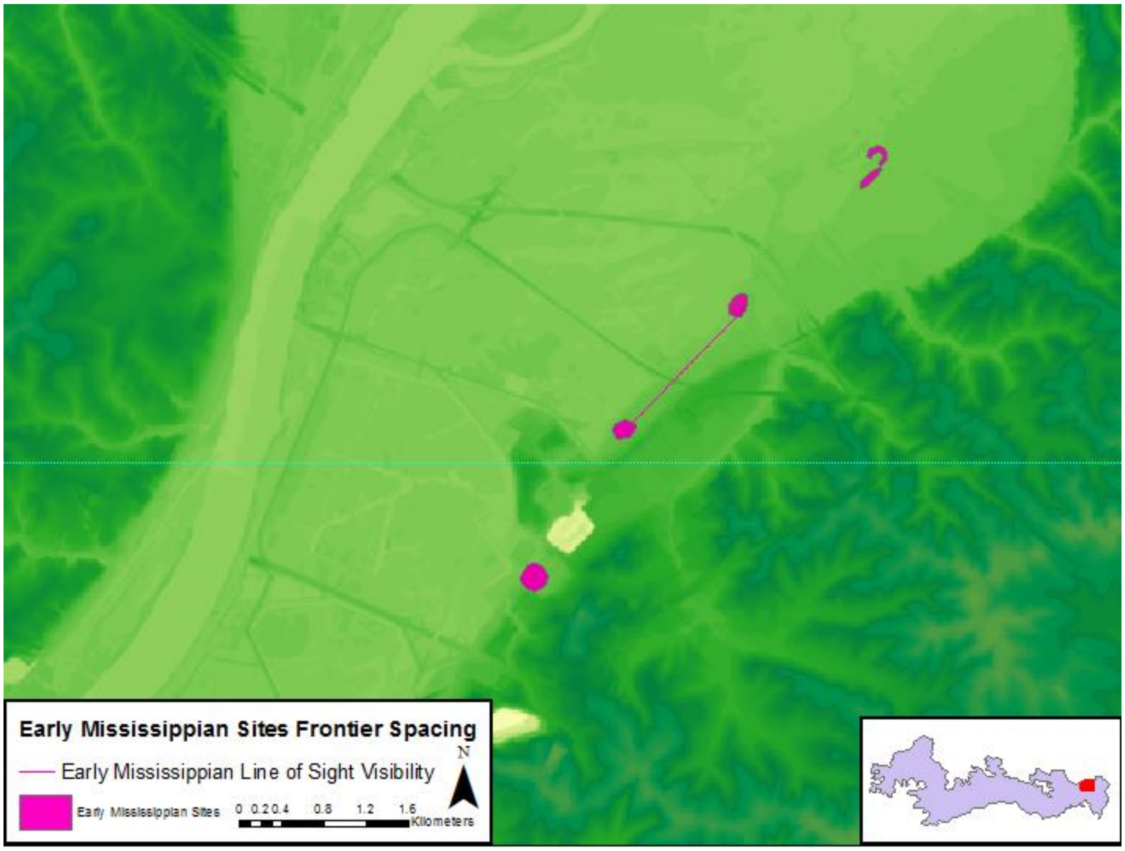

Figure 31: Possible Frontier Spacing of Early Mississippian Settlements.

3) Thiessen Polygons

The huge differences and disconnect in settlement patterns for the Lower Missouri River Valley between the Late Woodland and Terminal Late Woodland/Early Mississippian periods is further illustrated by the Thiessen Polygons analysis. Reflecting the same pattern as the nearest neighbor analysis, the settlement clustering and large numbers of sites of the Middle and Late Woodland periods (Figures 32-33) very quickly give way to a radical restructuring of settlement patterns in the Lower Missouri River Valley (Figures 34-35). The adoption of archery initially reinforces the previously existing site catchment areas but then causes a substantial shift as populations nucleate into larger settlements. This again reflects a shift in settlements dispersed across the landscape to large, more isolated settlements concentrated in the eastern Lower Missouri River Valley. The interlocking defensive lattice and reduced catchments enabled by settlement clustering gives way to large sites, concentrated populations and a defensive strategy suited to large settlements. All of this is enabled by the increased cooperation brought about by the introduction of archery.

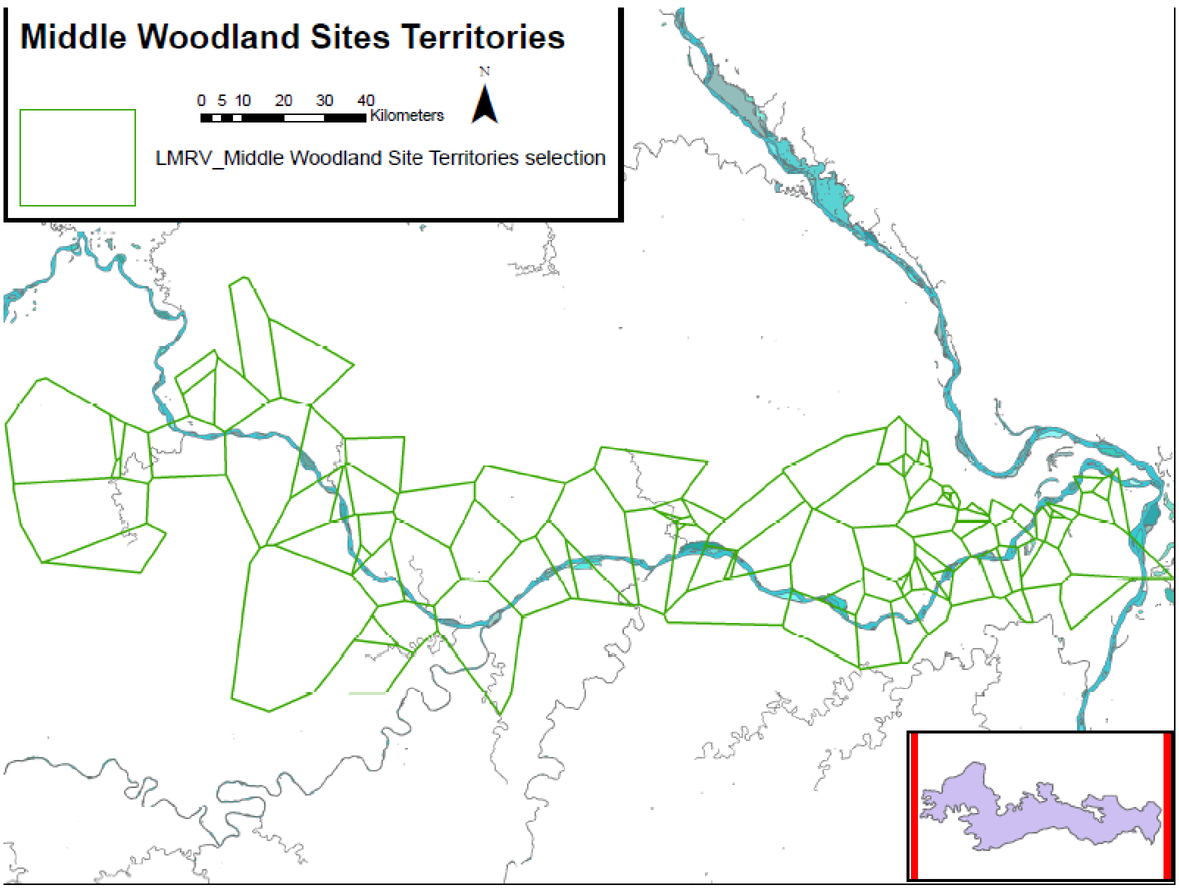

Figure 32: Middle Woodland Period Thiessen Polygon Analysis Represents Large Numbers of Clustered Sites. Red Lines Represent Geographic Extent of Image.

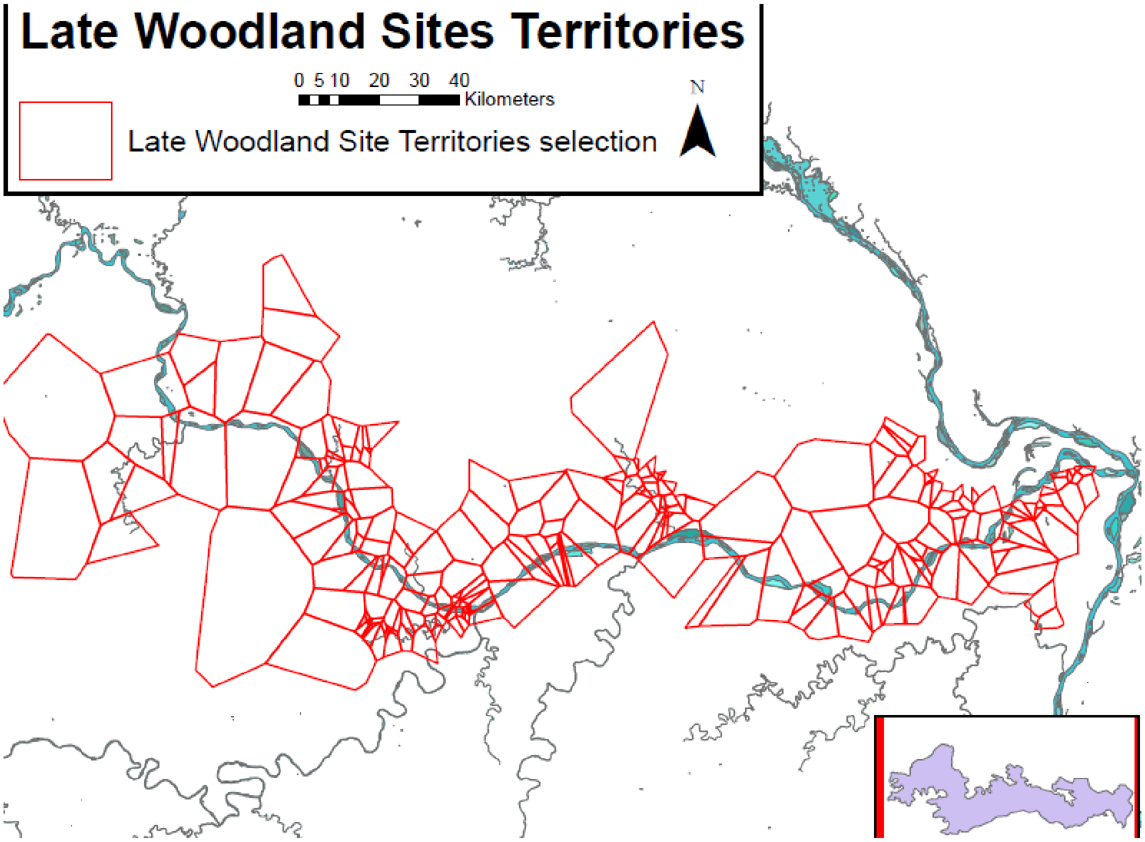

Figure 33: Late Woodland Thiessen Polygon Analysis Represents an Increase in the Number of Settlements over the Middle Woodland Period with Continued Clustering.

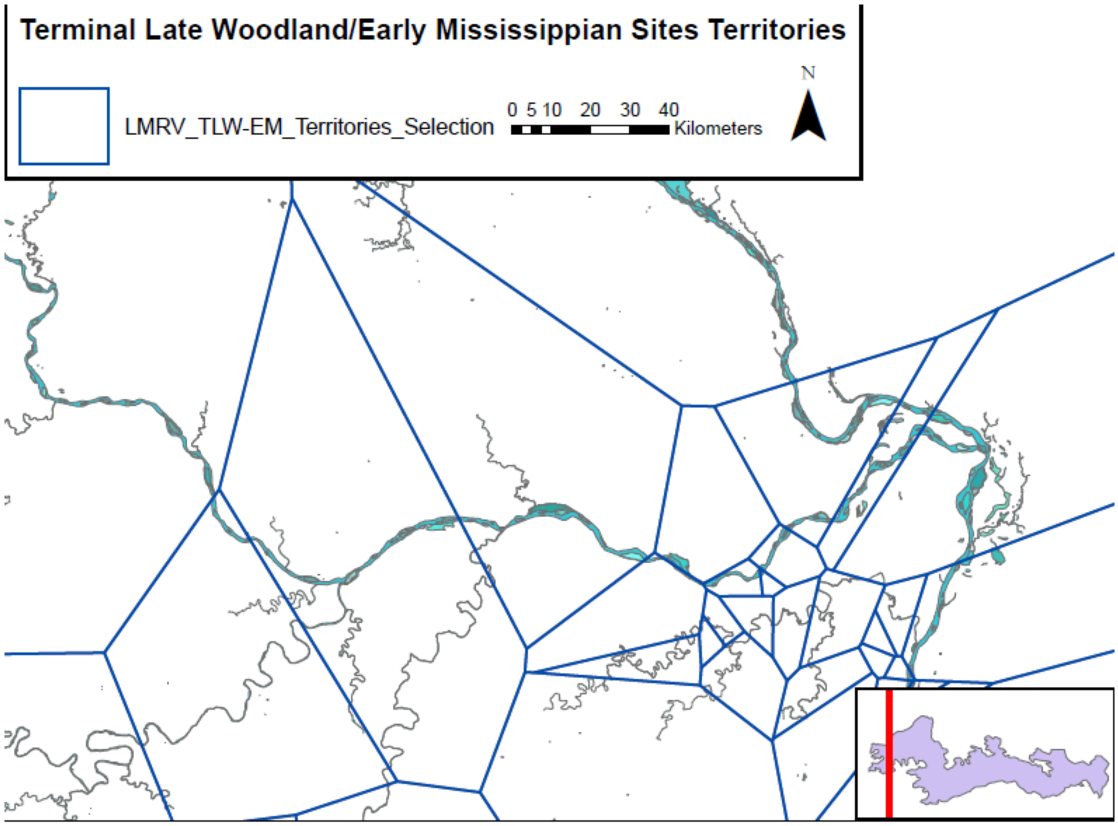

Figure 34: Terminal Late Woodland/Emergent Mississippian Sites Thiessen Polygon Analysis Reflects Settlement Shift Underway with Movement of Populations to Much Larger Nucleated Sites.

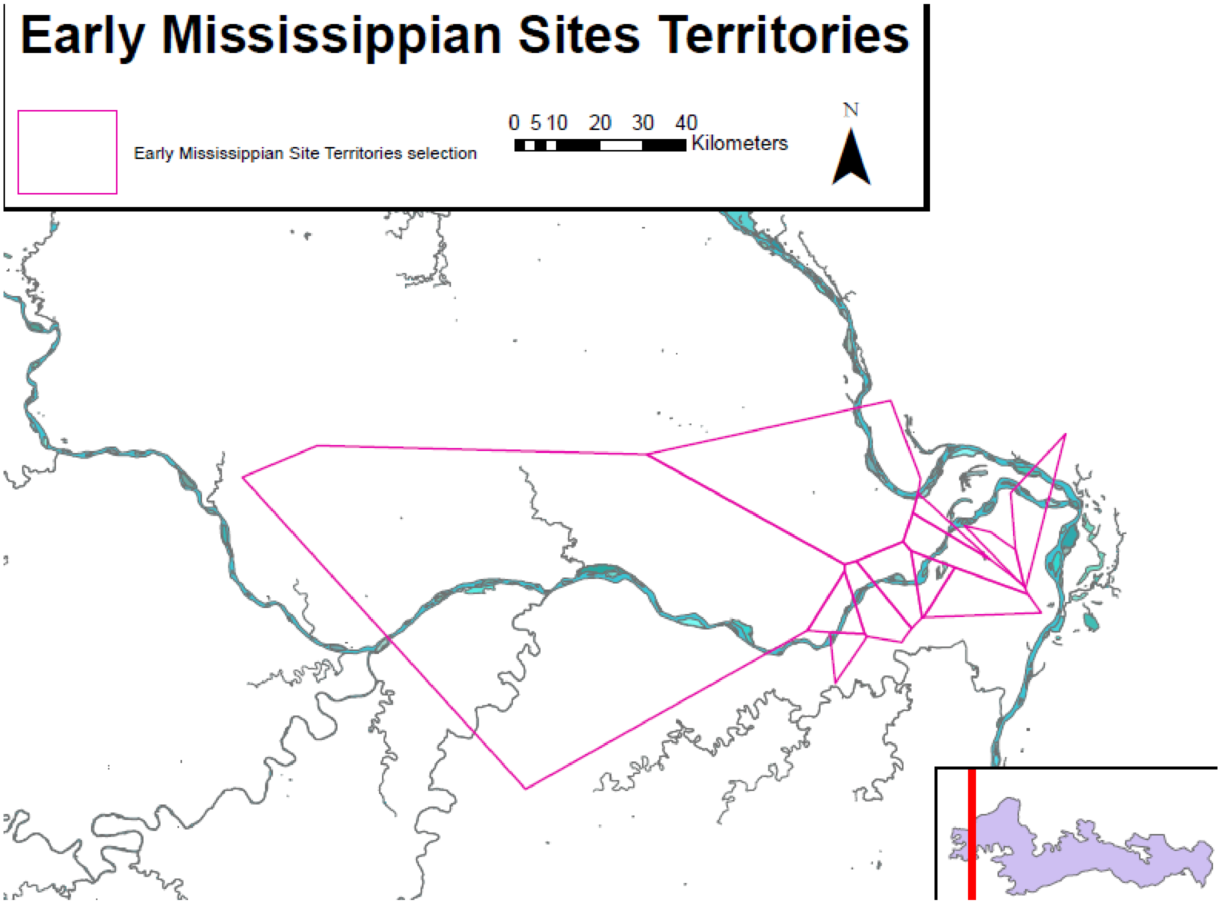

Figure 35: Early Mississippian Sites Thiessen Polygon Analysis Reflecting Re-organization and Aggregation into a Few Large Sites.

4) Site Area Frequencies by Time Period

Note from the following figures (36-39) that there is still a pattern of increasing site size over time as a percentage of total sites. Site area in square meters for most sites remains roughly the same from the Middle Woodland to Late Woodland Periods with large numbers of small sites (Figures 36-37). However, along with a vast reduction in the number of sites, a pattern of increasing site size begins in the Terminal Late Woodland/Emergent Mississippian Period and becomes very apparent in the Early Mississippian

Period (Figures 38-39). This corresponds with a very steep reduction in the number of total sites at the break between the Late Woodland and Terminal Late Woodland/Early Mississippian. What we appear to have is a rearrangement of population by pulling people from the Old Late Woodland settlements and aggregation and nucleation into much larger settlements. Again, there are limitations to this analysis in that any estimation of site size is at best an approximation of actual site extent based on phase one surficial survey practices. However, I think the data is still useful for detecting trends.

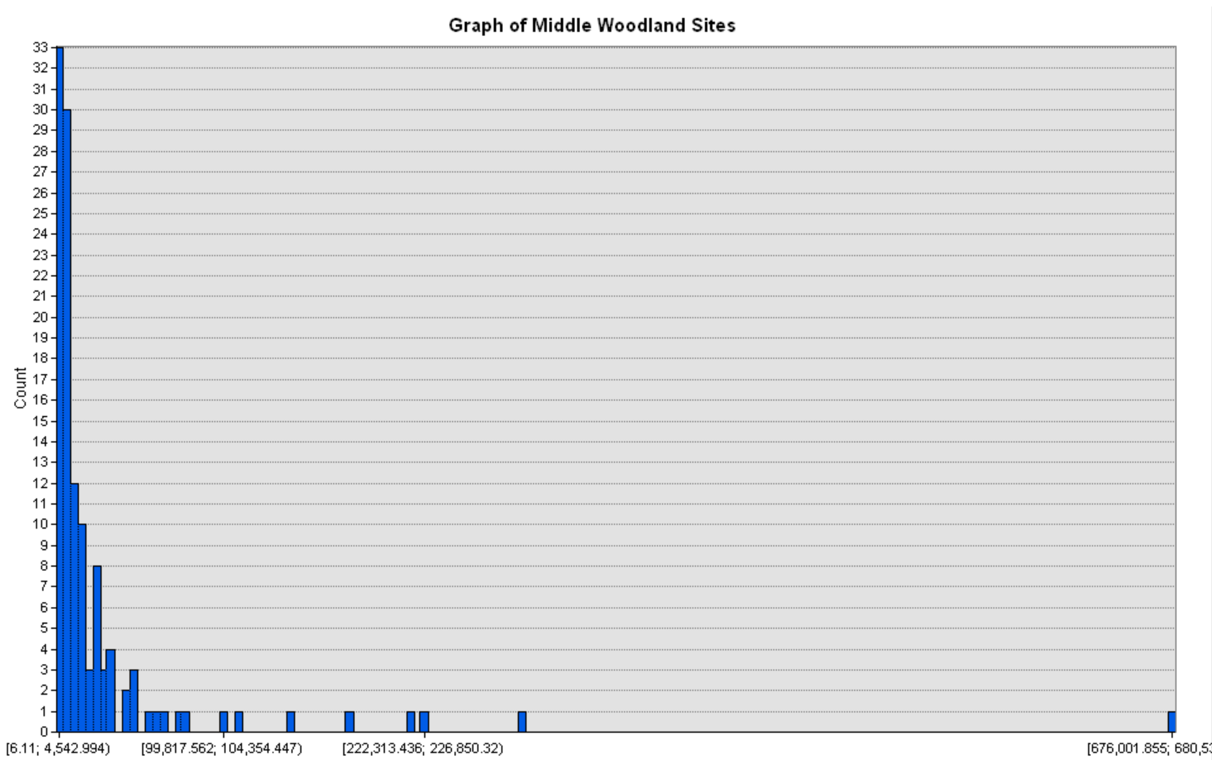

Figure 36: Middle Woodland Sites Frequency by Known Site Area in Square Meters.

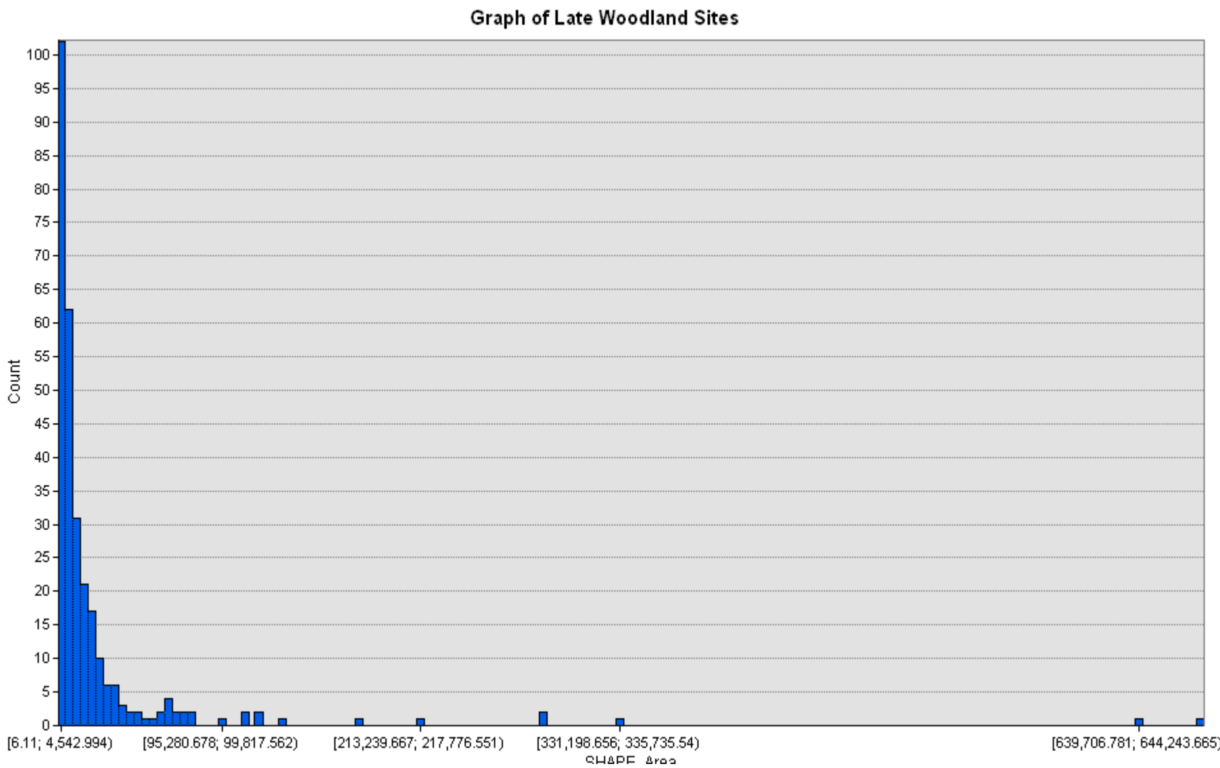

Figure 37: Late Woodland Sites Frequency by Known Site Area in Square Meters.

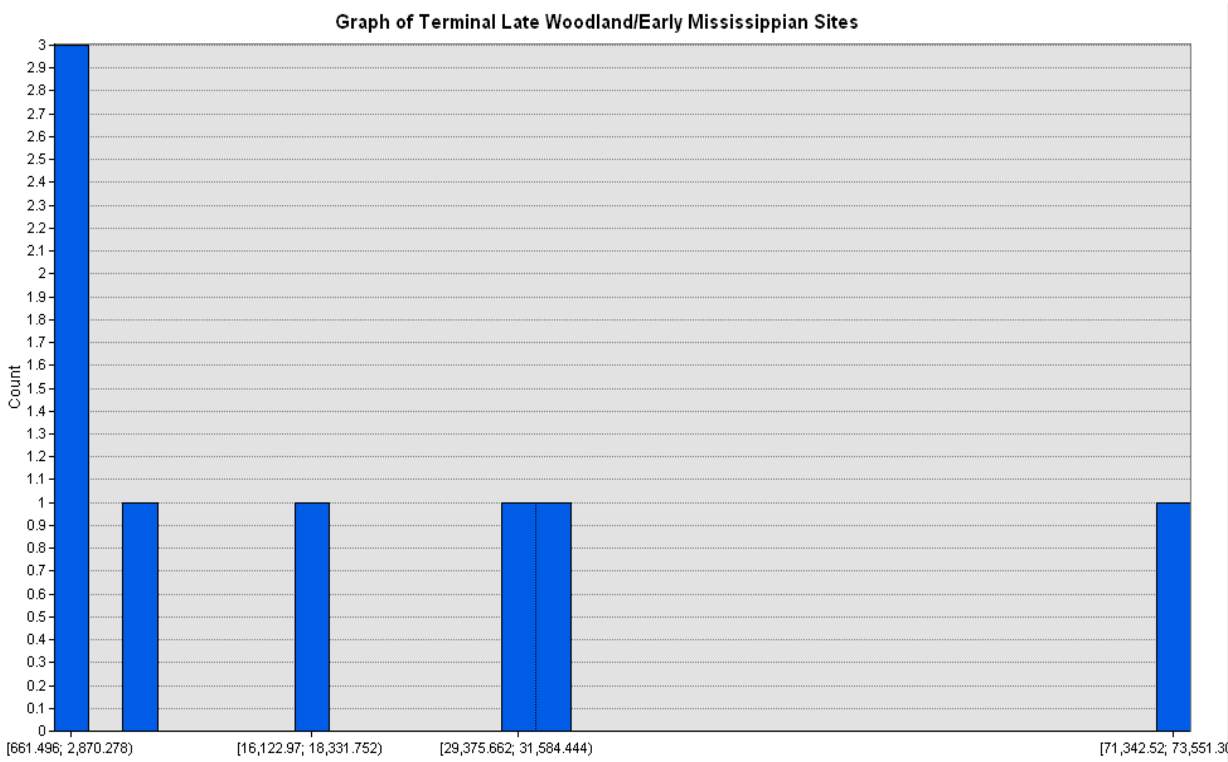

Figure 38: Terminal Late Woodland/Early Mississippian Sites Frequency by Known Site Area in Square Meters.

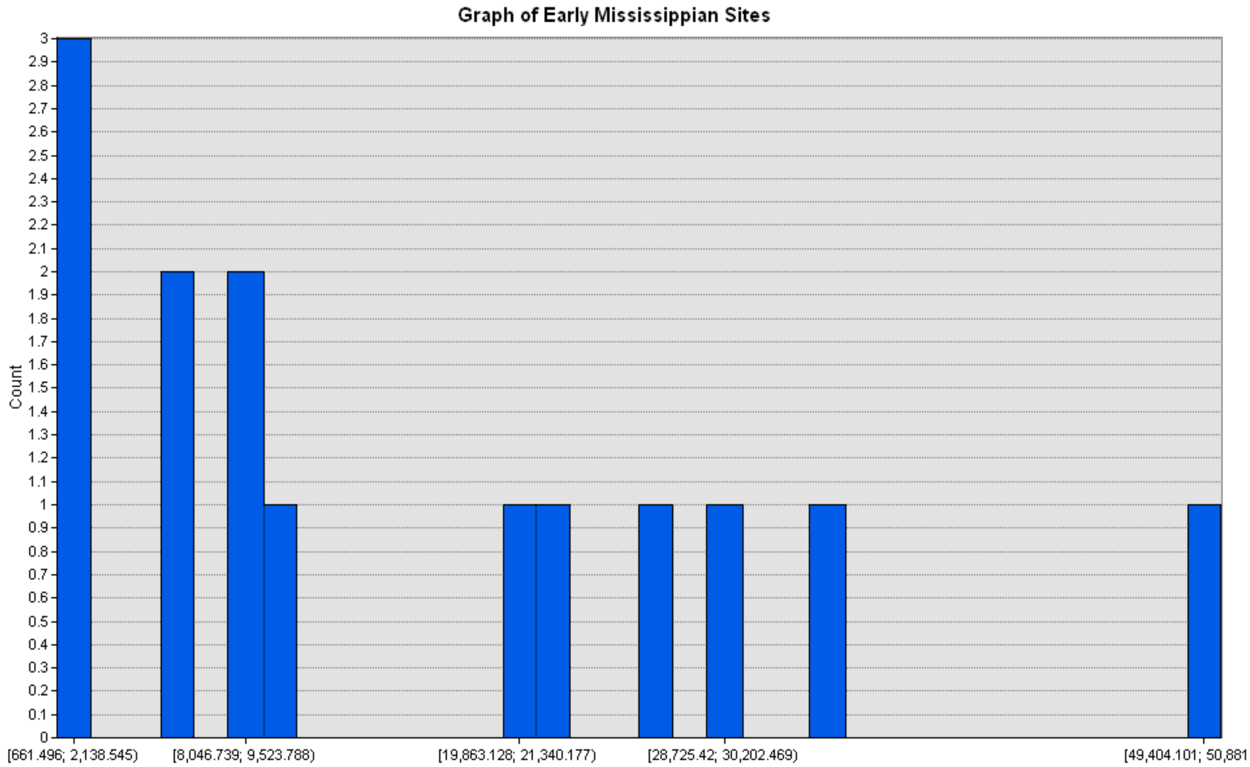

Figure 39: Early Mississippian Sites Frequency by Known Site Area in Square Meters.

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Settlement Landform

Using ArcGIS 10.1 and the Missouri archaeological geodatabase, I have computed the percentage of sites by time period and landform for the Lower Missouri River Valley (Table 2). Although the Middle and Late Woodland percentages are similar in some categories such as river/stream terrace or floodplain, the Late Woodland sites tend to locate more in upland or high physiographic settings, perhaps indicating an increasing concern with defense and exploitation of upland faunal resources. In stark contrast to the Middle/Late

Woodland is the change to an increasing river/stream terrace or floodplain existence at the onset of the Terminal Late Woodland/Emergent Mississippian and into the Early Mississippian periods. Along with site aggregation/nucleation, there is increasing movement in the study area to the high-resource river bottomland at the end of the Late Woodland Period. However, there continue to be settlements in upland settings. This agrees with a general trend of site abandonment and nucleation of populations into larger and larger sites associated with incipient agriculture at the end of the Late Woodland Period.

Lower Missouri River Valley Cultural Affiliation	Hillside/Bench	River/Stream Terrace	Floodplain	Bluff Top	Slope	Ridge	Hill	Knoll
Middle Woodland Sites - 121 Sites	0.008	17	7	9	10	16	9	0.008
Late Woodland Sites - 289 Sites	0.003	20	10	28	7	12	17	0.003
Terminal Late Woodland/Emergent Mississippian Sites - 7 Sites	0	14	42	0	0	0	42	0
Early Mississippian Sites - 14 Sites	0	57	14	0	0	7	21	0

Table 2: Lower Missouri River Valley Percentage of Sites by Landform.

DISCUSSION

To examine the effect of the arrival of the bow and arrow on changes in settlement pattern and increases in complexity, I analyzed four main lines of evidence: 1) site viewshed, 2) site inter-visibility, 3) settlement clustering and nucleation, and 4) settlement landform. Based on these lines of evidence, I proposed that the adaptation of bow and arrow technology should correspond to the following trends relative to previous time periods.

1) Sites in the study area should demonstrate increased settlement clustering with a bimodal pattern of clustering in high resource areas and single sites in more defensible or obscured locations. By "high resource" areas, I mean bottomland areas of the Lower Missouri River Valley that are highly conducive to resource procurement as documented by Harl (1991:26-35).

2) Sites or site clusters in the study area should exhibit increased line-of-site visibility to each other relative to periods without bow and arrow technology.

3) Sites or site clusters in the study area should exhibit increased viewsheds at possible avenues of approach or conversely, increased concealment as ways of dealing with territorial incursions.

4) Site area in the study area should be increasing in size as population nucleation increases over time.

It is apparent from the nearest neighbor and line of sight statistics that although both Middle Woodland and Late Woodland Periods demonstrate similar levels of settlement clustering, there are profound differences in the ratios of sites linked by line-of-sight and the number of linked settlement clusters relative to the total number of sites. In keeping with the model, it is clear that line-of-sight communications are far more important considerations in the Late Woodland when archery was widely adopted than in the Middle Woodland Period; 78% of Late Woodland settlements are linked by line-of-sight, whereas only 50% of Middle Woodland settlements are. In the Terminal Late Woodland/Early Mississippian and Early Mississippian, this figure drops to 25% and 28%. It appears that as settlements grow larger and nucleation increases, site inter-visibility becomes less of a factor, suggesting a shift from defense in layers among allied but separate settlements to defense in numbers for larger, nucleated settlements that were less dependent on other settlements for defense during the transitional Late Woodland/Early Mississippian period. Multi-village defensive coalitions may have again started to form during the Early Mississippian as reflected by a few cases of site inter-visibility and increased clustering relative to the Late Woodland/Early Mississippian transition. Cooperation between settlements thus probably decreases in importance as social complexity associated with nucleated settlements increases, but then increased, perhaps as social complexity began to allow the integration of multiple large settlements. Further, the nucleated Early Mississippian settlements along both sides of the river may have formed a boundary zone between two groups, with the river acting as a natural border.

Focusing more specifically on the Middle Woodland and Late Woodland Periods, there is a notable trend towards more sites in the study region, and the placement of sites on elevated bluff top, slope, ridge or hill locations in the Late Woodland (64% of Late Woodland settlements vs. 44% of Middle Woodland settlements). It is probable that the movement of sites to upland locations was not just for defensive purposes due to the introduction of long range bow and arrow technology, but also to take advantage of the hunting abilities afforded by the bow. There is a definite increase in a preference for deer as found in Late Woodland faunal assemblages of Central Missouri (Hoard 2000:222; Sturdevant 1990) and vertical movement between lowland and upland settings for resource exploitation must have occurred frequently and possibly on a seasonal basis as deer and turkey moved upland to exploit a ripened nut crop (Hoard 2000:223). If all of the higher elevation site locations and floodplain/watercourse locations are taken together for both periods, there is a bi-model distribution between lower-elevation riverine sites and upland sites reflecting the shift to upland locations with good visibility as the bow and arrow were adopted. However, another major difference between the two periods is in the spatial relationships between settlements. As a percentage of total site numbers by time period, non-visually-linked, isolated sites are far more prevalent both before and after the Late Woodland period. It is also interesting that in both the Middle and Late Woodland Periods, the majority of line-of-site linked settlements are upland sites. The Late

Woodland settlement system apparently relied on at least one elevated site in each network of inter-visible settlements, perhaps as a means to warn the others or to signal the presence of game animals.

In the Terminal Late Woodland and Early Mississippian periods, the number of sites is vastly reduced, but the size of sites increases dramatically. The smallest settlements of the Middle and Late Woodland periods are less than ten square meters, while this figure rises to greater than six hundred meters in the Terminal Late Woodland/Early Mississippian and Early Mississippian periods. The bi-modal pattern of sites along watercourses and sites in high, easier to defend locations continues. In these two periods, the more elevated sites tend to be on hilltops or ridges and the bluff tops and slopes are avoided. There are a higher percentage of Terminal Late Woodland/Emergent Mississippian sites in elevated locations than is true of the Early Mississippian Period, but the percentage of visually-linked sites decreases for both periods relative to the Late Woodland.

As far as viewsheds are concerned, all four time periods under consideration display similar patterns of viewshed arrangements. Late Woodland settlements seem to manifest an increased diversity of viewshed arrangements, but there is no way to accurately quantify viewshed by time period other than with observed generalizations. If we were to say that increased site viewshed is a greater concern in the Late Woodland Period over the Middle Woodland, we could make that argument only by virtue of the fact that there are many more known Late Woodland sites than Middle Woodland Sites in the study area. The factor that really stands out as having a definite time specific pattern is site inter-visibility, not viewshed, and this phenomenon can be much more easily quantified.

CONCLUSIONS

The analyses performed above quantified the effect of the introduction of the bow and arrow to changes in socio-political complexity in the Lower Missouri River Valley over a period of about four hundred years from the end of the Middle Woodland Period to the Early Mississippian Period. I argue here that conditions created by the arrival of the bow and arrow in the Late Woodland Period resulted in increased coordination and increased communications between settlement locations such that both farmer-collectors and band-level foragers coordinated defensive settlement strategy and possibly also hunting strategy. Such relationships denote incipient alliance formation or a possible effort at collective defense of closely interacting settlements. Thus, the first steps towards increased complexity in the study area are primarily in response to defensive actions and increased hunting efficiency in response to long range weapons technology. Each site in the cooperative may have maintained an independent catchment area, but the Late Woodland sites do indeed show evidence of increased social cooperation commensurate with the arrival of the bow and arrow in the form of line of sight relationships. It is only when cooperation extends to aspects such as agricultural food production that sites begin to nucleate into larger settlements, which happened rather abruptly at the end of the Late Woodland Period. These shifts may reflect changing defensive or food procurement strategies, at least in part.

Middle Woodland settlements do not reflect the same level of concern with locating settlements in easily defended site clusters with inter-visibility among the settlements. This changed with the adoption of the bow and arrow during the Late Woodland period as small villages faced the possibility of effective, long-range attacks that could potentially lead to the quick application of overwhelming force on unprepared villages. To deal with this potential, settlements moved to less productive upland locations with inter-visible settlement clusters that provided for mutual defense through defense in layers. Attacked people could flee to nearby villages for protection while reinforcements could be moved forward from these villages to repel attacking foes. The likelihood of overwhelming force and the creation of massacres of entire villages was thereby decreased. It also appears that changing resource procurement in the form of increased exploitation of upland fauna was enhanced with the long-range killing abilities of the newly-adopted bow and arrow. The bow therefore both increased the likelihood of offensive warfare, but also aided food production in upland resource zones. Hence, the increased movement of settlements to upland locations in the Late Woodland Period had a two-pronged motivation.

As agriculture became better established, this pattern of defense and resource procurement again changed as people nucleated into larger sites in highly productive, lowland areas. In this situation, defense was still a significant consideration as reflected in both the selection of defensible topographic settings and the apparent creation of a borderland along the river. However, the larger number of people in each village provided safety in numbers and decreased the likelihood of overwhelming attacks that would lead to massive death or damage to the settlement. These shifts in settlement location are not strictly required for the shift from hunting and gathering lifestyles to agriculture, in that settlements could have continually focused on the highly productive lowland areas during the Late Woodland period as was the case during both the Middle Woodland (when H-G was dominant) and the subsequent Mississippian period (when agriculture was dominant). Instead, the combined influence of archery and the selection for effective defensive strategies in the face of archery-based warfare and the increased hunting efficiency of the bow, creates a more parsimonious explanation for the rapid shift to inter-visible, upland sites during the Late Woodland. Archery appears to be the primary cause of what was a seismic shift where settlement patterns altered radically in just a few hundred years.

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VITA

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