A DIACHRONIC ANALYSIS OF SETTLEMENT PATTERNS AND DROUGHT IN THE CENTRAL MISSISSIPPI RIVER VALLEY

by

Shelby Hobbs

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Abstract

The purpose of this research is to study the settlement distributions of the Central Mississippi River Valley (CMV) during the Mississippian Period from A.D. 900-1600. Using radiocarbon dates and site locations, a Geographic Information System model was developed to visualize the spatio-temporal shifts in settlement patterns. This technique revealed a consistent cycle of aggregation and dispersion throughout the Early, Middle, and Late Mississippian Periods. Shifts in settlement patterns were then compared against paleoclimate data from the North American Drought Atlas to see if there was a relationship between site distributions and drought. This analysis found a multitude of decadal drought in every century of the Mississippian Period, and persistent drought events in the Middle and Late Mississippian Periods. Furthermore, this research determined the shift in settlement preferences from the Middle to Late Mississippian Period was likely a consequence of continual long-term drought over the CMV. A further aspect of this research aims to explore the correlations between the CMV and the Vacant Quarter, a region encompassing and lying just north of the CMV centered at the confluence of the Mississippi and Ohio Rivers. Using the aforementioned techniques, this research found both regions exhibit evidence for shifts in settlement distributions but a dissimilar pattern of such. The data as a whole supports hypotheses that state there were significant drought events in the CMV and Vacant Quarter, and that site location preference in the CMV was likely influenced by extensive drought events.

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I would first like to thank my advisor Dr. Andrew Mickelson for his continuous encouragement, advice, and field day lunches, without which I do not think I would have made it to where I am today. I would also like to thank my other committee members, Dr. Katherine Mickelson, my first ever archaeology professor who fostered my pursuit of the field, and Dr. Dorian Burnette, a man whose knowledge and enthusiasm never failed to keep me on the right track. I want to acknowledge my fellow graduate students who were always there with insightful advice or a much-needed break. Some special thanks go out to the lovely people at the State Historic Preservation Offices of Missouri, Arkansas, Tennessee, and Mississippi for their patience and help. Finally, I want to thank my family and friends for always supporting and encouraging me throughout my academic career.

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1. Introduction

This thesis examines the potential influence of long-term drought on changes in settlement patterns within the Central Mississippi River Valley (CMV). The study area (Figure 1) extends from southern Illinois to central Mississippi and focuses on the Mississippian Period (A.D. 900-1600). Regional diachronic studies allow for a better understanding of the interaction between cultural change and environmental factors over time. Examining changes in regional settlement patterns provides information about the social, political, economic, and environmental elements influencing the structure of cultural habitation. Inevitably, change in regional settlement patterns highlights alterations within the same influential factors comprised of social, political, economic, and environmental elements. The catalysts for change in habitation type are seldom clearly determined. In order to answer the perplexing issue of widespread Mississippian settlement change in the CMV this research will utilize multidisciplinary data, including regional site distributions and paleoclimate reconstructions. Similar research has been conducted in the Vacant Quarter, a region north of and partially encompassing the study area (Figure 2). Examining settlement patterns and climate trends will allow for a comparative analysis of CMV and Vacant Quarter developments.

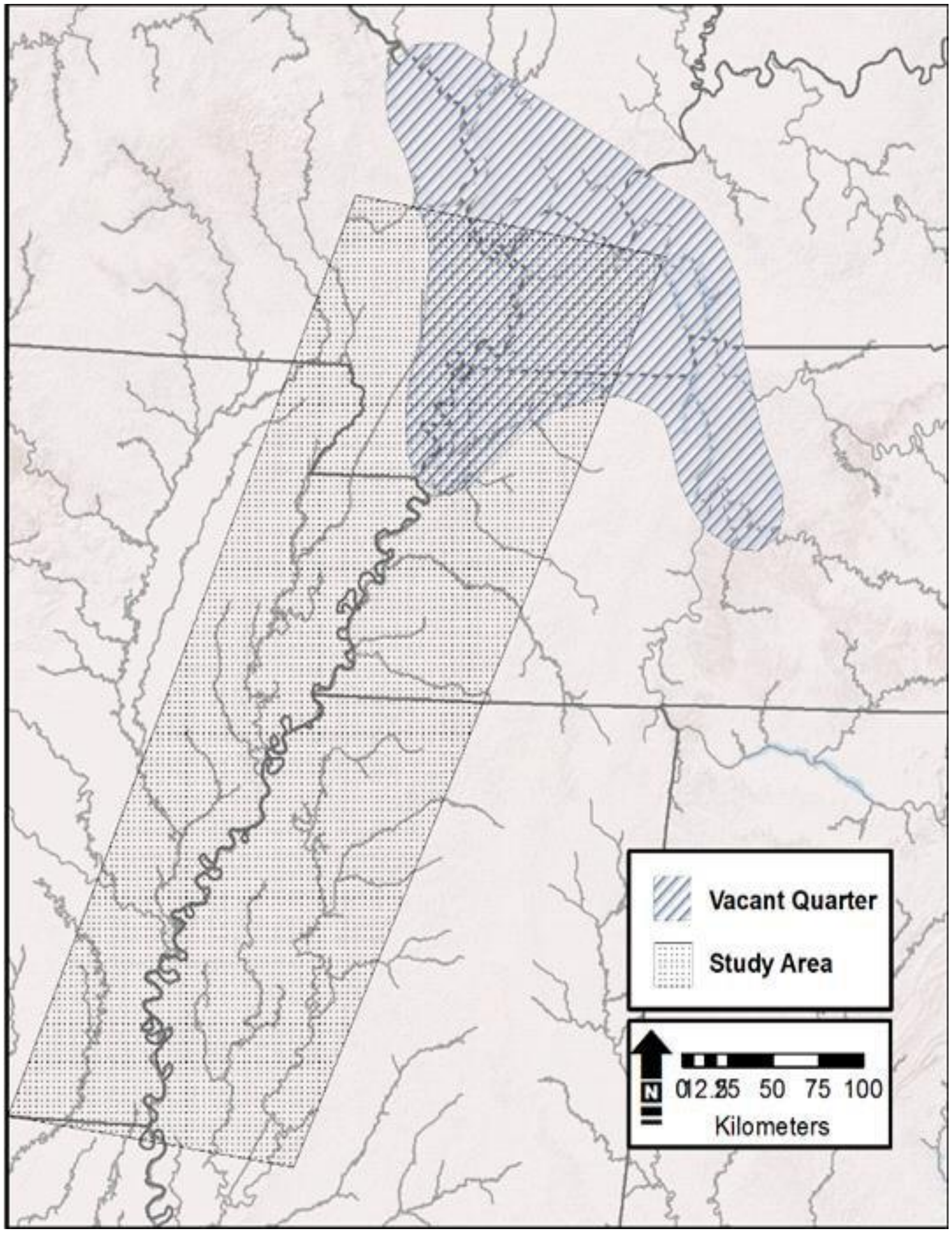


Figure 1. Study area and Vacant Quarter region discussed in the text.

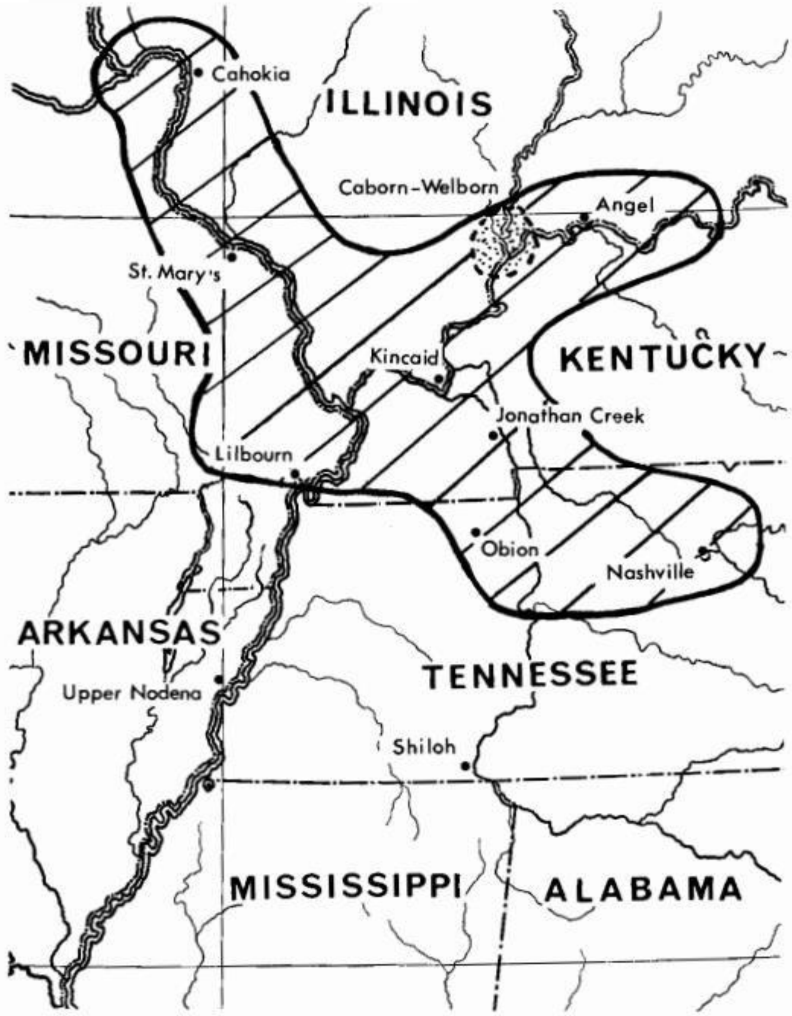


Figure 1. The Vacant Quarter: A.D. 1450-1650.

Figure 2. Vacant Quarter region as first outlined by Stephen Williams (1977).

Significance

Over the past half century, archaeologists have documented the apparent abandonment of large portions of the Mississippi River Valley around A.D. 1400 (Williams 1983; Morse and Morse 1983; Lewis 1990; Cook and Butler 2002; Meeks and Anderson 2013). Stephen Williams first proposed the Vacant Quarter (Figure 2) hypothesis in 1977, describing it as a vacant center within the Mississippian heartland. Williams defined it as an area of abandonment encompassing several river valleys in the Midwest and portions of the southeast. Subsequent research on the Vacant Quarter has focused primarily on the location, intensity, and timing of abandonment. Several of the above cited researchers have suggested a variety of causes for the depopulation of the area, citing warfare, disease, intruders, and climate change. While there is no consolidated theory for abandonment, drought-influenced cultural change as an explanation has grown in plausibility (e.g. Meeks and Anderson 2013).

Research Questions

This research focuses on two interrelated questions. First, what is the relationship, if any, between known drought events and changes in CMV settlement patterns? There has long been an understanding that climate change affects the way populations arrange themselves on the landscape (Williams 1983; Kidder et al 2008; Cobb and Butler 2002). Settlement patterns are dictated by a variety of factors, but it can be said the most influential factor is environment. Humans and the environment have a dynamic, reciprocal relationship. Resource availability is the largest factor of the environment facing human populations, influencing societal cycles of exploitation, conservation, and migration. In cases of sedentary settlement patterns, the relationship between humans and the environment intensifies. For example, deforestation may increase to accommodate town infrastructure leading to accelerated erosion, or continuous flood events may decimate crops and inundate habitation sites. Considering that the study area focuses on the Mississippi River Valley, it is pertinent to take into consideration the ecoregion, soil, and climate when analyzing settlement locations and movement. The second research question relates the CMV as a whole to the Vacant Quarter, considering similar research has been conducted in the Vacant Quarter. Are the patterns of settlement and climate in the study area comparable the Vacant Quarter? Location of Mississippian mound sites in the study area and corresponding radiocarbon dates, help answer the following hypotheses.

Hypotheses

I have developed two sets of hypotheses to examine each of the two questions outlined above. The following section will outline and provide detail for these sets of hypotheses.

Hypothesis Set 1: Hypotheses Regarding Drought and Settlement Patterns in the CMV

H_0: A connection between long-term drought during the Mississippian period (ca. 900-1600 A.D.) and the settlement patterns of the CMV cannot be determined.

H_1: There is no evidence of drought or shifts in settlement change.

H_2: There is evidence for drought conditions but no evidence for shifts in settlement patterns.

H_3: Evidence for shifts in settlement patterns does not spatially correlate with evidence for shifts in climate.

H_4: A correlation between drought and settlement pattern change in the CMV is documented.

The first set of hypotheses discusses the relationship between drought and settlement patterns within the CMV during the Mississippian Period. This set evaluates the available evidence to determine potential cause and effect for abandoned CMV areas.

The null hypothesis (H_0) would be supported by a lack of radiocarbon dates or site locations due to the inability to effectively show change in settlement patterns over time. Furthermore, insufficient paleoclimate data would support the null hypothesis. The data to support the first hypothesis (H_1) are differing climate data reconstructions. Additionally, consistent patterns in settlement would further support the first hypothesis. There is existing data that suggest large portions of the CMV become uninhabited while areas that remain populated experience further settlement nucleation and subsequent population increase (Morse and Morse 1983; Price and Price 1990). Data to support the second hypothesis (H_2) would be visible drought for the CMV while also displaying a consistent pattern of settlements. If there is evidence for changes in settlement patterns in times of consistent average climate, there is support for the third hypothesis (H_3). To confirm the final hypothesis for this set (H_4), there would need to be a change in settlement distribution in the CMV spatially and temporally corresponding to drought events. This last hypothesis only designates drought as a factor for changes in settlement patterns. This is not to say that drought is the sole cause for the abandonment seen in the CMV and Vacant Quarter. Many archaeologists researching societal collapse assert that while drought likely pushed some settlements over the edge to collapse, it was not the sole reason for disintegration of Mississippian communities in the Southeast and Midwest (Meeks and Anderson 2013). For example, other factors combined with drought such as warfare, political instability, or drought induced food crises may have also contributed to the collapse and abandonment of these settlements.

Hypothesis Set 2: *Hypotheses Regarding the CMV and Vacant Quarter*

H_0: A connection in Mississippian settlement reorganization between the CMV and the Vacant Quarter cannot be determined.

H_1: There is no evidence for a correlation in settlement reorganization or drought in the CMV and the Vacant Quarter.

H_2: There is evidence that the CMV experienced similar drought and settlement reorganization seen in the Vacant Quarter.

H_3: There is evidence that the CMV experienced drought, but it is not similar to the pattern seen in the Vacant Quarter.

H_4: There is evidence that the CMV experienced settlement reorganization, but it is not similar to that found in the Vacant Quarter.

The second set of hypotheses uses settlement studies on the Vacant Quarter (Cobb and Butler 2002; Lewis 1990; Meeks and Anderson 2013; Williams 1980, 1983, 1990) to assess the relationship of settlement patterns between the Vacant Quarter and the CMV as a whole. The North American Drought Atlas is used to determine similarities in climate between the Vacant Quarter and CMV as a whole. While the Vacant Quarter northern subsection of the CMV, there has been little related work conducted in the entirety of the CMV. Using this second set of hypotheses, the aforementioned data and previous research on the Vacant Quarter is compared to determine any correlations.

The second set of hypotheses relates to the spatio-temporal connection between the regions of the CMV and the Vacant Quarter. While there is already literature suggesting the depopulation seen in the Vacant Quarter region extends southward, my research aims to further that claim (Morse and Morse 1983). The null hypothesis (H_0) for this set would be confirmed by a lack of adequate data, both archaeological and climatological. The first hypothesis (H_1) would be confirmed by conflicting data for settlement locations and drought data in both the Vacant Quarter and the rest of the CMV. If there are dissimilar drought trends or settlement patterns between the whole of the CMV and the Vacant Quarter region, it is unlikely the abandonment trend seen in the Vacant Quarter is also seen within the greater CMV. Dissimilar abandonment and climate change can be attributed to differencing climate patterns between the regions, leading to different responses from those residing in the Vacant Quarter and other regions of the CMV. Settlements in one region experiencing drought will likely have to change their approach to resource catchment or location as opposed to a region without drought or severe drought. To support the second hypothesis (H_2) the data would need to provide analogous settlement changes in the two regions as well as showing drought phases just before and during those changes in settlement. Support for the third hypothesis (H_3) is present if the data provides disparate drought reconstructions for the two regions. Preliminary data has shown widespread and prolonged drought periods for both regions, although there is evidence to suggest the Vacant Quarter region experienced higher intensities of drought. The fourth and final hypothesis (H_4) for this set would be confirmed if the data shows dissimilar settlement reorganization between the CMV and Vacant Quarter region.

Thesis Outline

The remainder of this thesis is dedicated to testing the above two sets of hypotheses regarding potential relationships between settlement patterns and climate change. The next chapter of this thesis presents an overview of the environmental context, Mississippian culture, discussion of the Vacant Quarter hypothesis, and regional climate trends over the Mississippian Period from A.D. 900-1600. Chapter 3 outlines the research methods employed to collect the data utilized in the research. Chapter 4 includes the results of said methods. Chapter 5 reviews an analysis of the results, discusses the implications of this research, and concludes with a discussion of data discrepancies and future aims for this type of research.

2. Background and Literature Review

The following chapter presents background regarding the natural environment and culture history of the CMV. Environmental regions are discussed to understand settlement patterns and reasons for their change. The archaeological definition of Mississippian culture will be outlined in this chapter, and the following facets will be discussed: the Mississippian ecological niche, subsistence technology, settlement patterns, social organization, and ideology. Understanding the above cultural traits provides a basis for the analysis of changes in settlement patterns as a response to prolonged climate anomalies. Finally, this chapter reviews the climate trends throughout the study area over time. This includes documented climate anomalies, known cultural responses within the archaeological record, and a discussion of maize response to drought.

Environmental Context

The study area encompasses the CMV and outlying tributaries, spanning from southern Illinois downstream to central Mississippi (refer to Figure 1). The region is ecologically diverse, consisting of three distinct landform types (Figure 3). These ecological regions include: Southeastern Plains, Mississippi Valley Loess Plains, and the Mississippi Alluvial Plains. For most of the ecoregions described below, the climate averages at humid temperate with generally hot summers and moderate winters (Chapman et al. 2001; Drummond 2016; Griffith et al. 1998).

The Southeastern Plains feature a relatively equal dispersion of clay, sand, and silt; and are irregular with a variety of ecotones, including arable land, forest, and pasture (Griffith et al. 1998). The streams of the Southeastern Plains are typically “low gradient and sandy-bottomed” spaced on a relatively higher elevation in comparison to the neighboring ecoregion of Mississippi Valley Loess Plains (Griffith et al. 1998).

The Mississippi Valley Loess Plains is a large ecoregion stretching the entire length of the study area from northern Kentucky south to Louisiana. The thick layer of loess distinguishes this region from others, with loess depths reaching over 18 meters in depth in some areas (Griffith et al 1998). The Mississippi Valley Loess Plains are a lower elevation than its eastern neighbor, allowing for wider, channelized streams to inhabit the area (Griffith et al 1998). The silt of this ecoregion provides fertile soils, though erosion can be an issue in steeper elevations and in other areas where historical agricultural practices promoted deforestation (Griffith et al. 1998). Although loess provides fertile soil is does not have the water carrying capacity comparable to the alluvium of the following ecoregion. Therefore, drought would more heavily affect crops planted in loess concentrated soils.

The Mississippi Alluvial Plains extend even further than the Loess Plains, starting at the Mississippi-Ohio River confluence following along the Mississippi river to the Gulf of Mexico (Griffith et al. 1998). This ecoregion is characterized by level floodplains edged by river terraces consisting of loess, clay, sand, and gravel characterize this ecoregion (Griffith et al. 1998). While most of the area is cropland, it was once home to “bottomland deciduous forest vegetation” before the vegetation was removed for crop cultivation (Griffith et al. 1998). The Mississippi Alluvial Plains is the most important to the study, as it extends the full length of the research area and provides the most fertile soil out of all of the landforms in the study region, and it would have been the most productive region for Mississippian agriculture.

The Vacant Quarter is a subregion of interest for this study. Referring back to Figure 1, this region encompasses a portion of the study area, thus there are overlapping ecoregions, including the Mississippi Alluvial Plains and the Mississippi Valley Loess Plains. The main ecological region of the CMV and adjoining Vacant Quarter is the Mississippi Alluvial Plains, where the deepest and most fertile soils exist. The Alluvial Plains was the initial "homeland" of the Mississippian culture and heartland to some of its longest persisting settlements. However, the Vacant Quarter consists of two additional ecoregions, primarily within the hinterlands in which fewer settlements were established within the Interior River Valley and Hills and the Interior Plateau Ecoregions.

The Interior River Valleys and Hills, which makes up the northwest portion of the Vacant Quarter, is described as mostly "wide, flat-bottomed, terraced valleys, forested valley slopes, and dissected glacial-till plains" (Chapman et al 2002). This ecoregion consists of both pasture and forest with loess, deep clay, and silty alluvium amenable to agriculture (Chapman et al 2002). The settlement of Cahokia, the largest known town of the Mississippian culture, inhabited this ecoregion until the 13th Century A.D.

The second ecological region of the Vacant Quarter, the Interior Plateau, consists of grasslands and forested uplands with its lower elevations lending itself as flat and fertile lands (Drummond 2016). Parts of this region, particularly those in Kentucky, contain karst topography of sinkholes and caves due to underlying limestone bedrock, while most of the western region consists of high amounts of alluvial soil (Drummonds 2016).

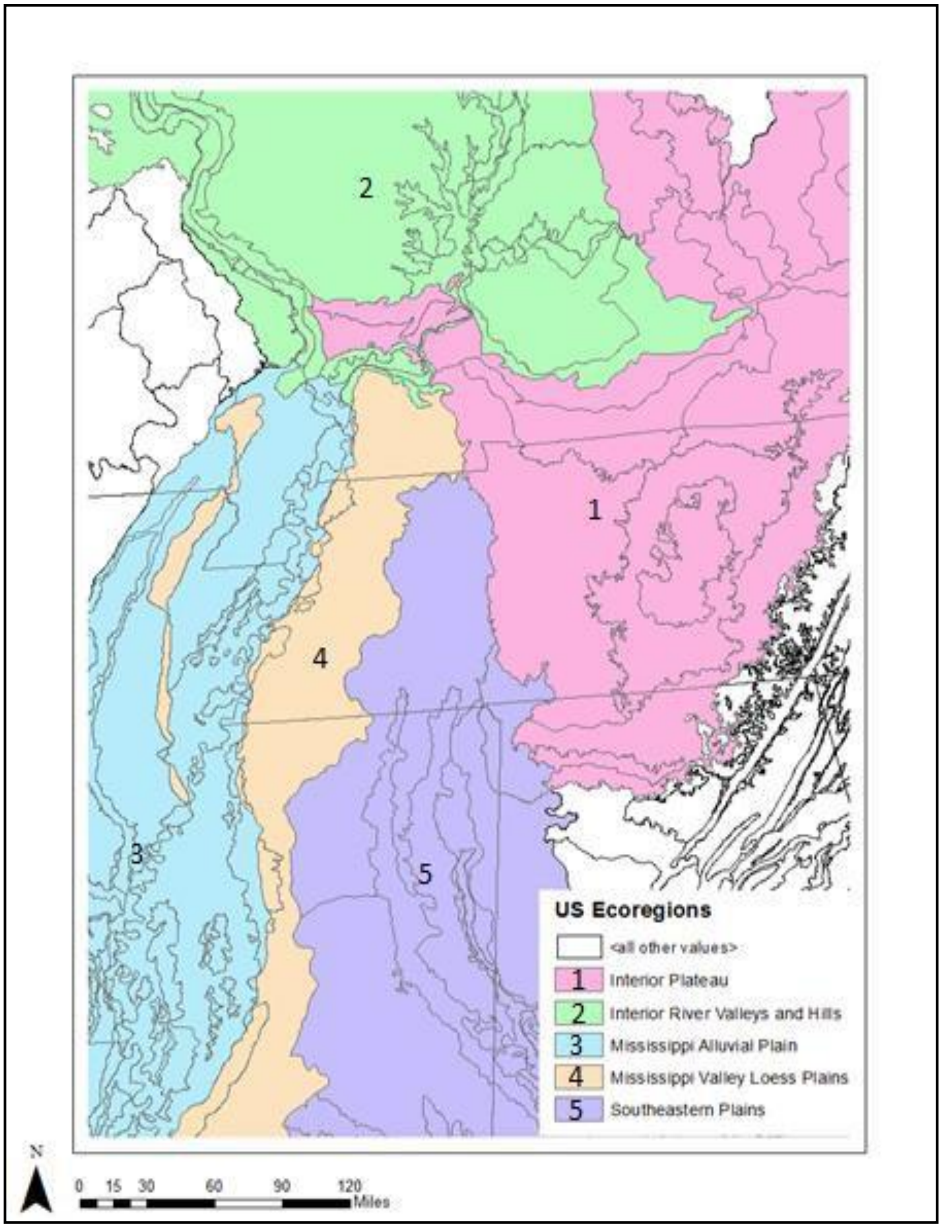


Figure 3. Ecological Regions Discussed in the Text, Including: (1) Interior Plateau, (2) Interior River Valleys and Hills, (3) Mississippi Alluvial Plain, (4) Mississippi Valley Loess Plain, and (5) Southeastern Plains.

Cultural Background

Introduction

The Mississippian culture was a dynamic and complex set of cultural adaptations by the inhabitants of the mid-continent United States from about A.D. 900-1600. The following sections describe these cultural adaptions as the defining traits of the Mississippian culture. To begin, this section will describe the Mississippian chronology and the origin of the culture. Subsequent discussions will detail the Mississippian ecological niche, subsistence technologies, social organization, and ideology.

Chronology

William H. Holmes (1886) first defined the culture as Mississippian in 1886 based upon the distinctive shell-tempered pottery type found across the Southeast and Midwest regions of the United States. Holmes (1886:371-372) notes that the pottery is developed with "a moderately fine-grained clay, tempered in a great majority of the cases with pulverized shells . . . [and is] remarkably homogenous in character, [thus] we are warranted in assigning it to a single period of culture." Over time more traits refining the Mississippian cultural configuration were observed, including stratified political organization, a reliance on maize, monumental earthwork construction, square-rectangular wall trench houses, and the appearance of prestige goods (Griffin 1967; Knight 1986; Smith 1978). The Mississippian culture evolved from the late Woodland culture around A.D. 900 with advances in "technology, production, and community organization" (Morse and Morse 1983). The culture persisted in the CMV through the next five centuries, until a significant demographic shift occurred around A.D. 1400, marked by the cessation of mound-building and depopulation of seemingly arable lands (Meeks and Anderson 2013; Morse and Morse 1983:301; O'Brien and

Wood 1998; Williams 1990). Following the demographic shift, the remaining nucleated settlements in the Mississippi Alluvial Valley experienced population growth and cultural development (Meeks and Anderson 2013; Morse and Morse 1983). Mississippians thrived throughout the southeast United States well into the late 16th century contact period of expeditioners like Hernando de Soto (Morse and Morse 1983).

Due to the regional scale of this research, it is important to note the timing of the Early, Middle, Late Mississippian periods differs between subregions of the CMV due to varying chronological phases across the Southeast. Chronological phases (e.g. Figure 4) in archaeology are defined by distinct cultural material over a region for a given time (i.e. Cherry Valley Phase in eastern Arkansas or James Bayou in western Kentucky), thus demonstrating the diversity of the Mississippian culture while also complicating the categorization process (Lewis 1990; Morse and Morse 1983; O’Brien and Wood 1998). For the purposes of this research, the following designations for Mississippian Periods are Early (A.D. 900-1100), Middle (A.D. 1100-1300), and Late (A.D. 1300-1600).

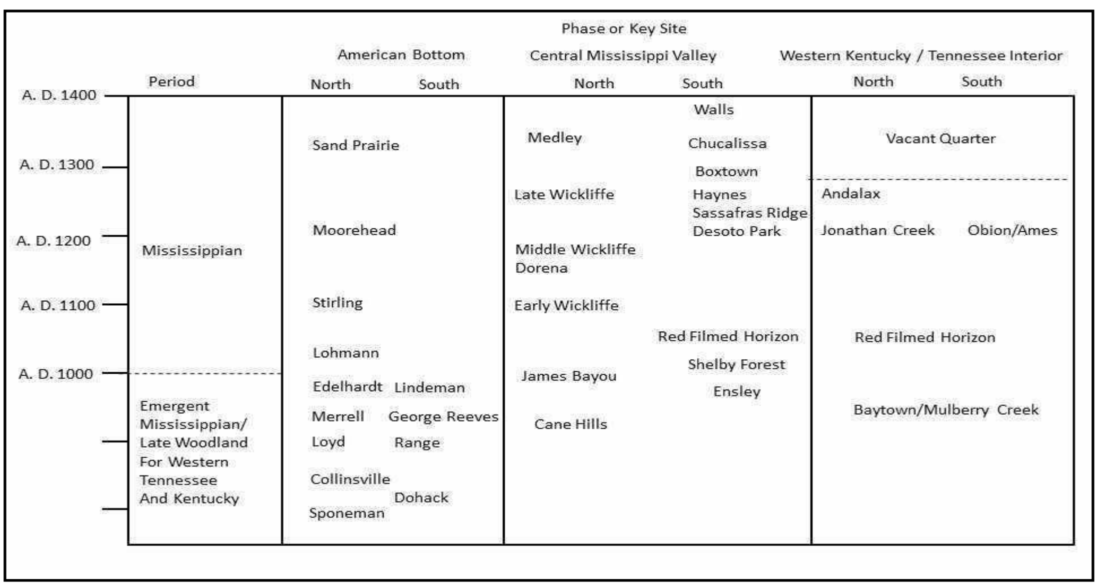


Figure 4. Example of Varying Mississippian Cultural Phases in the Southeast and Midwest (Mickelson 2018: Figure 3).

The Mississippian Niche

Smith (1978:484) defines the Mississippian niche as having one central variable for every adaptive measure: "the size of the net energy subsidy it received." Mississippians settled within an environmental niche comprised of river meander belts, floodplains, and surrounding oxbow lakes (Smith 1978). This zone allowed for populations to exploit an array of resources from the local environment for habitation means and subsistence. Nuts, berries, and fruits were typically collected, while hunting and fishing provided meat from waterfowl, deer, and other small game (Smith 1978). Hunting and gathering subsistence practices persisted in the Mississippian culture, but the production of local cultigens and adoption of maize agriculture allotted the basis for food procurement. The fertile soils of the river floodplains and surrounding woodlands provided these agriculturally based communities the necessary resources for habitation and prosperity.

Subsistence Technologies

The cultivation of maize (*Zea mays*) as a staple crop is one of the key traits of Mississippian communities. Eastern North America was no stranger to the crop before its incorporation into the prehistoric diet as a staple. By at least 200 A.D. maize made its way into the CMV from southwest North America (Smith 1989). In the preceding Woodland Period (1000 B.C to A.D. 900), the Eastern Agriculture Complex consisted of cultivated, indigenous flora that could thrive in a variety of soils and moisture regimes. These plants domesticated by prehistoric populations included maygrass, sunflower, marshelder, and gourds (Gleason and Cronquist 1963; Rindos and Johannessen 1991; Smith 1989). The advent of maize as a staple crop into an already successful cultural and agricultural system was arguably one of the most important events in the prehistory of North America, and is the main distinction of the Mississippian and Woodland diets.

Maize is a high-yield crop with less energy expenditure as compared to previous cultigens and is easily storable (Rindos 1984; Smith 1989). As maize became a staple crop it allowed for less focus on resource catchment and an increase in population growth, political and social stratification, and cultural development. However, it also increased the risk for ecological and economic disaster. The focus of more energy on one crop as opposed to the same energy on multiple cultigens, increased the likelihood for nutrient deficiencies. For example, oak and hickory nuts, foods high in protein and fat, were a large part of the Woodland diet. However, it was found in the American Bottom, and likely other regions of the Southeast, that as maize grew in value, nuts and their trees receded from the archaeological record (Johannessen 1984; Rindos and Johannessen 1991). Although Mississippian populations grew other cultigens and continued to hunt, maize dominated the agricultural complex, and is thus the major factor in where Mississippian farmsteads, hamlets, and towns were located across the landscape. Further, maize is especially susceptible to shortfalls in moisture during certain parts of its growing season. Thus, it is expected that drier climate regimes would negatively affect maize cultivators, which in turn could lead to the abandonment or reorganization of settlements in marginal environments.

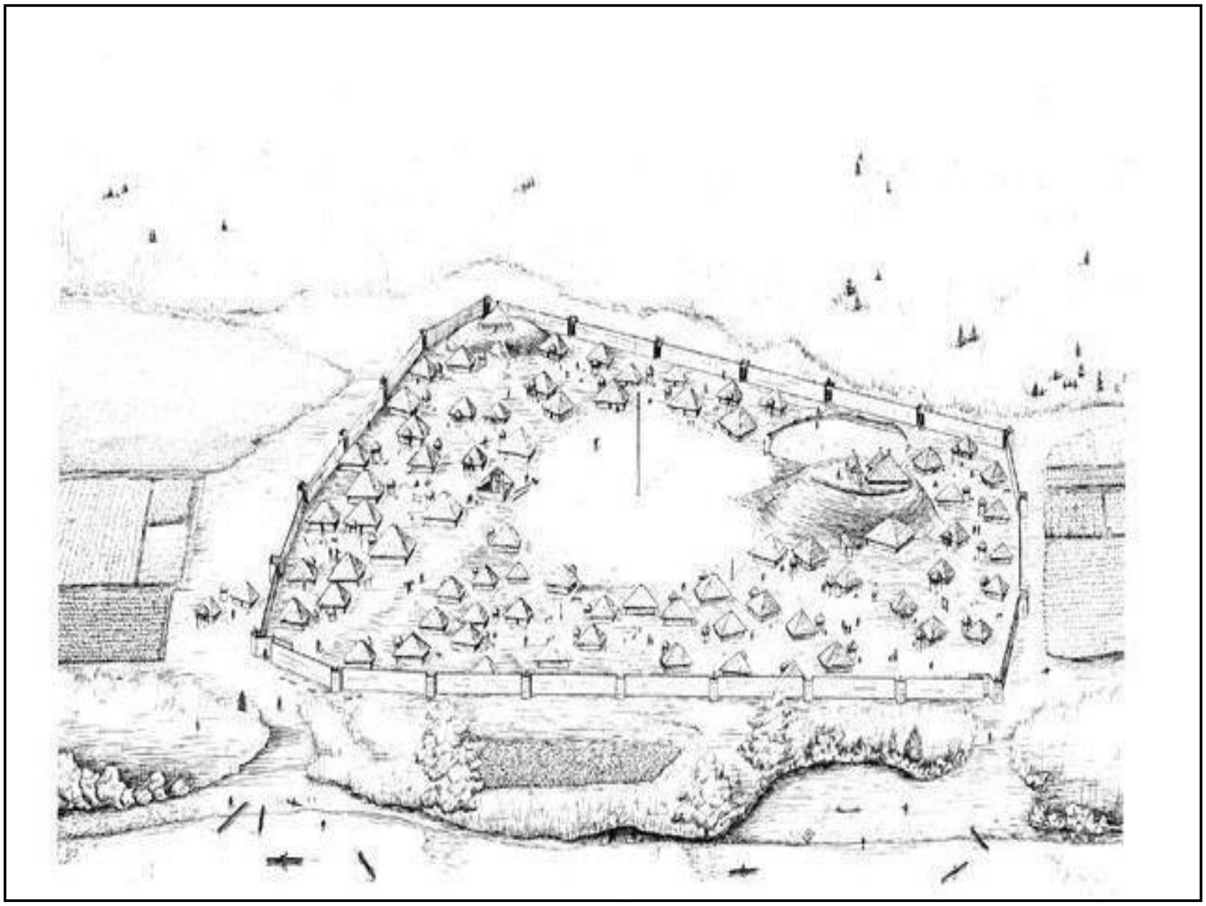
Subsistence technologies make up a great deal of material culture, including agricultural hoes, hunting arrowheads, axes, celts, fish hooks, and other assemblages such as scrapers and grinders for processing meat or plant material (Morse and Morse 1983; Welch 2006). Subsistence related artifacts in the Mississippian culture are generally created using chert, basalt, and even shell (Morse and Morse 1883; O'Brien and Wood 1998). Other types of material assemblages associated with the Mississippian culture include utilitarian and prestige ceramic vessels, gameplay chunkey stones, and a variety of prestige items or decorative artifacts (Bourdreaux 2010; Cogswell and O'Brien 1998; Welch 2006).

Settlement Patterns

The Mississippian Period marked a time of widespread large-scale permanent towns. The distribution of Mississippian town-scale settlements throughout the period were typically located along sections of the river floodplain, usually spaced tens of kilometers apart from each other as a resource acquisition area and as a buffer zone between communities (Hally 2006). One of the theories to explain the increase of sedentism following the Woodland period in the southeast is the advent of maize as a staple crop. This theory explains that as populations grew dependent on maize as a resource, their behaviors changed to better adapt to using maize as a staple crop.These behaviors include, sedentism and development of town-scale settlements, complex sociopolitical formations, and increased production of storage vessels (Morse and Morse 1983; O'Brien and Wood 1998; Smith 1989). Much research has focused on an explanation for why the Mississippian agricultural complex adopted maize. Archaeologist suggest a variety of explanations for the adoption of maize, including: a more suitable climate for maize growth, an imbalance in resources, a conscious effort to combat potential resource shortfalls, a concerted effort to lever social inequality for political gain, or a mixture of them all (Morse and Morse 1983; Smith 1989; O'Brien and Wood 1998).

Town Configuration. Mississippian towns shared a common architectural grammar in how the settlements were laid out (Figure 5). Settlements generally contained a central plaza or open area, the shape of which is pivotal to the placement of the remaining town features (Cobb and Butler 2016; Lewis et al. 1998). The plaza area was flanked by mounds, some of which were topped by elite residences, others with temples or mortuary structures (Cobb and Butler 2016; Lewis et al. 1998). The residential area was situated outside the plaza and mounds, backing up to a protective palisade wall that surrounded the town (Cobb and Butler 2016; Lewis et al. 1998). Furthermore, towns were laid out as large astronomical computing devices which acted as ‘calendars’, helping to maintain the annual agricultural cycle through the scheduling of rituals and public events. This is seen in the archaeological record by orientation of site features aligning with cardinal directions and mound placement relying on solstices and constellations (Brown 1997; Lewis et al 1998). The towns were permanent and occupied year-round usually with outlying farmsteads, accommodating the increase of agricultural practices (Hally 2006; Morse and Morse 1983; Smith 1989). The settlement pattern and town configuration in turn allows for and solidifies increased social and political stratification, creating tiers of authority in the culture from paramount chiefdoms to house location within the town (Earle 1997; Johnson and Earle 1987; Morse and Morse 1983; Smith 1989).

Early Mississippian sites developed in the major river floodplains where nutrient-rich alluvium soils were ideal for maize cultivation allowing for the sustainability of sedentary populations (Emerson and Milner 1982; Morse and Morse 1983; O’Brien and Wood 1998; Smith 1978). Around A.D. 1100, many Mississippian towns with associated outlying farmsteads expanded into the uplands of the Mississippi River Valley in Kentucky, Tennessee, and Mississippi. However, by the Middle Mississippian Period ca. 1300, the same town-scale settlements are abandoned (Mickelson 2018). In the CMV and American Bottom, abandonment is observed for many once thriving town and mound centers by A.D. 1300, and nearly all were never reestablished (Cobb and Butler 2002; Emerson and Milner 1982; Meeks and Anderson 2013; Milner 1986; Morse and Morse 1983; O’Brien and Wood 1998). In the American Bottom, the once clustered, floodplain settlements saw a pattern of households dispersed along higher ground, while there is little to no evidence, at least for towns with mounds, for habitation in the upland tributaries in western Tennessee after A.D. 1250 (Emerson and Milner 1982; Mickelson 2018; Rindos and Johannessen 1991). The large floodplains and river valleys were never vacated, rather they experienced an increase in population nucleation (Foster 2012; Morse and Morse 1983). Large, fortified villages normally residing along main river systems typified the settlement pattern of the Late Mississippian Period (Morse and Morse 1983). This nucleation configuration contrasts with the previous settlement pattern of the town and farmstead type. It is during the end of this period (ca. 1500-1600s) that historical contact occurred in the CMV resulting in increased disease and conflict (Morse and Morse 1983;



O'Brien and Wood 1998).

Figure 5. Typical Mississippian town layout, featured by rendering of the Toqua site in Monroe County, Tennessee. (Image from McClung Museum of Natural History and Culture)

Social and Political Organization

For six centuries before the arrival of the first explorers of the New World, Mississippian communities, large and small, dominate the landscape of the Southeast. These polities, more commonly known as chiefdoms, range in size and elaboration from a town leader to paramount-scale control. In all chiefdoms though, leadership belongs to a hereditary, elite group (Carneiro 1981; Earle 1997; Milner and Schroeder 1999). Carniero (1985:45) describes a paramount chiefdom as "an autonomous political unit comprising a number of villages or communities under the permanent control of a paramount chief." (Carniero 1981; Earle 1997; Peebles and Kus 1977). Social stratification is also present in the archaeological record through housing locations, differences in food availability, and the disparity of prestige goods through the communities.

Some believe the chiefdom scale of governance may be the intermediary level before transitioning to statehood, if one thinks progressively, in a unilinear fashion (Earle 1997; Johnson and Earle 1987). Within the chiefdom scale of social and political organization, some have introduced a 'cycling' theory that describes the "formation, florescence, and fragmentation" of individual chiefdoms due to consistent sociopolitical shifts, the inherent instability of chiefdoms, or changes in the environment (Anderson 1986; Milner and Schroeder 1999:103).

Ideology

Ideology shaped the culture and lives of Mississippians in almost every way. The influence of ideology over culture is observed through Mississippian community layout, social organization, and artifact assemblages. Prestige items, such as decorative pottery, effigy artifacts, or other material religious motifs, come from and develop the elaborate and complex ritualistic lives of the Mississippians (Dye 2014). Originally it was thought prestige goods only held value in the political and economic realms, giving their owners status-affirming power and prestige.

However, that wealth, power, and prestige came from the ideological ties to religious institutions engrained in the culture (Dye 2009, 2014). The culture's deep-seated ideology, that of culture heroes, godly ancestors, and a nature influenced religious cosmos, affirmed every aspect of the Mississippian life (Dye 2014; Sabo et al. 2015)

Mississippian community layout exemplifies the importance of ideology within the culture. Mississippian ideology consisted of a four-dimensioned universe, emphasized by the culture's tendency to align site features such as platform mounds, important structures, plazas, and more in association with the cardinal directions (Brown 1997; Mickelson 2008, 2018). Furthermore, the ideological tripartite model consisting of an upper, middle, and lower realm is accentuated by the construction of mounds for elite residences or ceremonial purposes, denoting the importance of levels of power and separation of space (Brown 1997; Lewis et al. 1998). Finally, celestial bodies, particularly the sun, moon, and star constellations, played a major role in the ideology of the Mississippian culture; in particular, the summer and winter solstices, making up the longest and shortest days of the year (Brown 1997). The layout of important site features of most Mississippian settlements reflects their astronomy-driven ideology because it interlaced so heavily with the ritual cultivation and harvest of the agricultural complex (Lewis et al. 1998).

Scenarios of Regional Scale Abandonment:
The Vacant Quarter Hypothesis and Subsequent Research

Stephen Williams first proposed the Vacant Quarter hypothesis at the 1977 Southeastern Archaeological Conference based upon his work throughout the American Bottom and CMV (Williams 1990). The Vacant Quarter (Figure 2) encompasses areas of the Ohio-Mississippi confluence, the Cumberland River Valley, the Lower Ohio River Valley, and northern parts of the CMV. Before Williams could publish on the Vacant Quarter, he introduced his theory on the

Armorel phase and its Markala horizon (Morse and Morse 1983; Williams 1990). The Armorel phase is described as a phase of the late Mississippian Period delineated by a horizon of artifacts, including copper eagle motifs and square, shell buttons (Williams 1980, 1983, 1990). Williams proceeded to map these Markala markers and outlined what had only been briefly discussed in the past: the appearance of a vacant region in the midcontinent of North America during the late Mississippian Period (Price et al 1976; Williams 1980, 1983, 1990).

While the Vacant Quarter hypothesis is largely accepted today by archaeologists and even members of other disciplines, it has not conceptually progressed without revisions and even some opposition. In the early stages of debate over the Vacant Quarter hypothesis, there were three major competing theories. First, Williams, who proposed the hypothesis, stated there was an abandonment of the permanent town and ceremonial mound centers in the region starting around A.D. 1450 which continued until about A.D. 1550 (Williams 1980, 1983, 1990). The second theoretical camp, as typified by Morse and Morse (1983), accepted the premise of the Vacant Quarter hypothesis but posited that abandonment started at least a century earlier than Williams proposed, and that the extent of the vacant region should include larger portions of the CMV to the south of the area first proposed (O'Brien and Wood 1998). The third group, e.g. R. Barry Lewis (1990), opposed both the original and revised Vacant Quarter hypothesis, asserting that there was not enough evidence to support the claims for regional depopulation. Lewis argued that while town centers with mounds were abandoned there were likely smaller settlements in the proposed region with little variation in cultural material, thus limiting our ability to discern differences in habitation and refuting a wholescale abandonment theory (Lewis 1990; O'Brien and Wood 1998). Lewis's theory on the Vacant Quarter is especially important for areas where farmsteads persisted past large town-scale mound settlements, like those seen in western Tennessee. From the beginning, it is clear that the Vacant Quarter hypothesis is a question of time-space systematics, requiring the refinement of regional chronologies and more data on settlement patterns.

Recent refinement of the Vacant Quarter hypothesis comes from Cobb and Butler (2002), and Meeks and Anderson (2013). Cobb and Butler (2002) analyzed site distributions in the hinterlands of the Lower Ohio River Valley and found that depopulation seen in the Vacant Quarter, at least in their region of study, occurred at the early end of Williams's estimates around 1400 A.D. (Cobb and Butler 2002). Furthermore, they determine the abandonment was a widespread phenomenon that affected both settlements along major drainages and smaller ones in the hinterlands (Cobb and Butler 2002:636). Finally, Cobb and Butler (2002) state that to discern a cause for abandonment, researchers should look to other regions and periods. Meeks and Anderson (2013) used tree-ring reconstructions to determine water availability and percentage of crop storage in the Vacant Quarter from A.D. 1200-1500. The research focused on four drought events in five regions of the Vacant Quarter and they determined that drought-induced food stress existed, and that outright crop failure was the probable explanation for Mississippian depopulation of the region (Meeks and Anderson 2013). Meeks and Anderson (2013) also found that the abandonment of the region ended at least three decades prior to 1458, and that while drought certainly influenced the creation of the Vacant Quarter, it was not the sole catalyst to decline and collapse.

Other researchers proposed several other factors leading to the population decline in the Vacant Quarter region, including: disease, warfare, soil preference, climate fluctuations, etc. (Anderson et al. 1995; Meeks and Anderson 2013; Morse and Morse 1983; Williams 1980, 1990). Surprisingly, Williams (1990:175-176) noted the well-known Southwest drought in the thirteenth century that resulted in sociopolitical changes, depopulation, and unprecedented settlement aggregation, but dismisses similar causes for the Vacant Quarter region. However, Williams did discuss briefly the instability of maize and how fluctuations much like that seen in the Southwest, could have been a major cause for depopulation in the Vacant Quarter, if that were indeed the case (Williams 1990). In 2007, two publications from paleoclimatology teams proposed multi-centennial drought as the cause for cultural change, one attributing drought to the Vacant Quarter and the other to the fall of Cahokia, located in the most north-western portion of the Vacant Quarter region (Benson et al. 2007; Cook et al. 2007).

Review of the Paleoclimate Data

Climate Trends

Current climate research provides evidence for two major climatic anomalies in North America preceding and during the Mississippian Period. The first is the Medieval Warm Period or the Medieval Climate Anomaly (MCA) appearing around A.D. 950 and lasting until A.D. 1300, and the second is known as the Little Ice Age (LIA) beginning around A.D. 1300 and lasting for about three centuries to 1600 A.D. (Oglesby et al. 2011; Seager et al. 2007; Wanner et al. 2008). The MCA saw a series of megadroughts across much of North America, some spanning multiple decades and sometimes occurring over most of the United States (Benson et al. 2007; Cook et al. 2007; Oglesby et al. 2011). The LIA consisted of a cooler and wetter climate across the continent (Wahl et al. 2012). To better understand the mechanisms of these climate anomalies, research focuses on the interactive global processes affecting regional climate. The Atlantic Multidecadal Oscillation (AMO) is one of these processes affecting long-term, sea surface temperature (SST) fluctuations (Oglesby et al. 2011). There is research suggesting that AMO warm conditions in the North Atlantic reflect drier conditions across the United States, and conversely cooler periods produce wetter conditions (Oglesby et al. 2011). In addition, shorter term changes in SST, such as the Pacific Decadal Oscillation (PDO) and the El-Nino Southern Oscillation (ENSO), are analyzed to understand anomaly mechanisms (Benson et al. 2007; Cook et al. 2007; Oglesby et al. 2011; Wahl et al. 2012). Understanding the processes that affect regional climate can aid in the knowledge of prehistoric culture change and provide anticipatory information for future potential climate events.

Archaeological Record

Case studies derived from the historical and archaeological records provide insight into cultural responses to drought events. For example, in the historical record, there are decadal-length droughts across the United States that occurred in the early 20th century, commonly known as the Dust Bowl (Burnette and Stahle 2013). The U.S. government responded to those affected by drought with livestock and monetary assistance, though most farmers and ranchers fled the desiccated area for more suitable land (Cook et al. 2007; Worster 1979). It has been well documented that in prehistory, drought occurred just as severely, as evidenced in the southwest United States by multi-decadal length drought from A.D. 900-1300 affecting the ancestral Puebloan culture and eventually leading to the ‘Chaco collapse’, due to the lack of water access, inhibiting crop production and thereby population sustainability (Benson et al. 2007; Cook et al. 2007). By modeling demographics through the methods of palynology, dendrochronology, and geomorphology, it was found the depopulation of the Puebloan region likely coincided with the prehistoric droughts (Axtell et al. 2002; Cook et al. 2007). Another example of prehistoric culture response to climate is seen through the case of the Viking culture in Greenland. Sailing from Scandinavia, the Vikings found and colonized the island of Greenland during the MCA, which provided optimal farmland on the island and a decrease in sea ice for safer travel (Folger 2017). During this period there was social development, evidenced by dispersed, growing settlements and continual ivory trade back to the homeland, however much change for the Vikings in the 14th century (Folger 2017). The era of the LIA not only brought with it cooler climate, growing sea ice, and oceanic storms, but there began trade into Africa, lessening the need for Greenland's ivory, as well as the immense impact of the Black Plague on the majority of Europe (Folger 2017). While researchers debate the cultural response to climate and other influential factors, the Vikings did not persist in North America, Greenland, and Iceland past the 14^{th} century. Whether they fled to Europe or met a grim fate in Greenland, the culture faced decline and a large part of that is due to a major climatic anomaly. These cases indicate the importance of multidisciplinary work between archaeologists and paleoclimatologists. Analyzing prehistoric climatic trends can provide an incredible amount of information about culture change, as it has for the Puebloans and Vikings.

Maize and Drought

In this study maize is utilized as an indicator species to better understand the consequences of drought and what likely would have been the outcome of drought for much of the Mississippian people growing maize as a staple crop. Maize is a warm weather plant that grows over five months and thrives in the thick, sandy loam soils of the Mississippi floodplain alluvium. The life stages of maize are categorized into vegetative states and reproductive states, as seen in Table 1 (Kansas State University 2017). Each vegetative state is broken down by the number of leaves that have sprouted (Kansas State University 2017). About five weeks after plant emergence during the V6 phase, ear shoots begin developing, and by phase V10 around 8 weeks since emergence, the tassel (pollen bearer) begins to show (Hanway 1966; Kansas State University 2017). Following the V10 stage the reproductive stage begins. It is between the V10 phase and the R1 phase that poor moisture regimes are most detrimental to the health of the plant and the grain yield as it will greatly delay the silking process in which pollination will occur (Hanway 1966; Kansas State University 2017). Also, if at any point between V10 and R1 are leaves severely damaged or removed it will significantly reduce the grain yield of the plant as pollination will not occur in that ear shoot (Hanway 1966; Kansas State University 2017). About three months after plant emergence and generally two to four weeks after silking, the cob is intact and kernels are growing; at this point any moisture stress will limit kernel size and rate of growth (Hanway 1966; Kansas State University 2017). From this phase, unless there is severe drought, moisture stress will only affect kernel size until maturation of the plant (Kansas State University 2017).

Table 1: Growth Stages of Corn (*Zea mays*). Red represents the time at which the plant is most susceptible to drought conditions, and yellow indicates the period at which drought will greatly reduce grain yield.

Vegetative Stages	Reproductive Stages
VE: Emergence Stage	R1: Reproductive Stage One- Silking
V1: Vegetative Stage One- First Leaf	R2: Reproductive Stage Two: Blister
V2: Vegetative Stage Two- Second Leaf	R3: Reproductive Stage Three: Milk
V3: Vegetative Stage Three- Third Leaf	R4: Reproductive Stage Four- Dough
V4: Vegetative Stage Four- Fourth Leaf	R5: Reproductive Stage Five: Dent
V5: Vegetative Stage Five- Fifth Leaf	R6: Reproductive Stage Six: Physiological Maturity
V6: Vegetative Stage Six- Sixth Leaf	
V7: Vegetative Stage Seven- Seventh Leaf	
V8- Vegetative Stage Eight- Eighth Leaf	
V9- Vegetative Stage Nine- Ninth Leaf	
V10- Vegetative Stage Ten- Tassle Formation	

Based upon modern corn species and modern average PDSI, drought would affect maize most during the early reproductive stage, typically near the third month of the life cycle around July and consequently, often the driest month of the year for North America. With increased aridity and likely a lack of cloud coverage, air and soil moisture would decrease, inevitably increasing evapotranspiration processes, causing damage or death to the plant or at the least a significant reduction in grain yield. For much of the early Mississippian Period, populations grew increasingly dependent upon maize as a resource, however, the multi-decadal droughts that followed this prosperous phase increased the likelihood of diminished crop yield and potentially outright crop failure.

Summary

Drawing knowledge from the archaeological record, prehistoric climate trends, and the life cycle of maize, allows for a well-rounded examination of the abandonment of Mississippian occupied regions. While drought would not have been the ultimate cause for migration or decline, it would have inevitably impacted the subsistence practices of those residing in affected areas. This impact in subsistence practices would have been stimulated by a lack of water resources to sustain the maize crop, reducing grain yields, and thereby limiting the available food for the town. It can be said that food stress would lead to social unrest, strain on the political system, weaken the economic system, and potentially spark tribal warfare. In the case of prolonged drought over a large affected area, like that seen in the Puebloan culture, water and food crises can lead to a multitude of systemic issues in the society, eventually leading to collapse. Outside the realm of natural disasters, it is unlikely that a single event can cause the decline of a culture. Thinking back to the example of the Vikings, it was the combination of detrimental factors that lead to Greenland's vacancy, and in the case of Mississippian abandonment and eventual cultural decline, their fate was likely met in a similar manner.

3. Methods

Data Review, Collection, and Compilation

The research employed a variety of methods to analyze temporal settlement patterns and drought in the CMV and adjacent areas through time. The methods employed here include: 1) a literature review, 2) database construction, 3) drought data manipulation, and 4) spatial analysis using Geographic Information Systems (GIS). The following sections will describe the process of data collection and the methods used to analyze said data for this study. Site location and radiocarbon data came from a literature review and site files from several State Historic Preservation Offices (SHPOs) in the study area. Drought reconstructions and Palmer Drought Severity Index (PDSI) values were extracted from the North American Drought Atlas (NADA). GIS was the primary technique used for the spatial analytic methods of the study. Data manipulation and comparative spatial analyses were made using GIS, and included overlaying archaeological data with climatic data to search for shifts or abandonment of settlements.

Literature Review

An intensive review of the Mississippian literature included published and unpubished materials including books, journals, theses, site reports, and dissertations. Site location and radiocarbon age make up fifty percent of the necessary data for this study. Much of the site locational data was acquired through SHPO site files and online databases. Additionally, locational data was found through georeferencing maps in publications of known sites. Georeferencing is a spatial analysis tool in which maps are digitized and aligned overtop a similar map with geospatial coordinates to find the general site locations otherwise undocumented. Radiocarbon data was acquired similarly through the literature review and from

SHPO resources. The major discrepancy for the radiocarbon data is the conflicting literature, where about half of the radiocarbon dates acquired by this study do not specify whether the reported date(s) were calibrated or not. Calibration of radiocarbon dates are important because the main element in calculating radiocarbon age, atmospheric carbon 14, has not been consistent throughout history.

Paleoclimatology Data

Paleoclimatology is the study of climate on the scale of the total history of the Earth (Mishra and Singh 2010). This avenue of research is pertinent in the discovery of prehistoric climate conditions including the timeframe of interest (A.D. 900-1600). Past climate reconstructions are a result of data proxies including lake and dune sediments, historical records, pollen grains, loess, coral, caves, ice cores, tree rings, and more (NOAA 2017). The following section will describe the proxy data and methods used for this study's paleoclimate reconstructions.

Dendrochronology. One of the main contributions to paleoclimatology is through the science of dendrochronology (modeling past climate with tree ring data). Trees grow biannual rings in association with spring and winter. By analyzing the width of the ring from the growing season of many trees over similar time and space, dendrochronologists can determine the average moisture and temperature regimes for a given region (Fritts 2001). Dendrochronology is probably the most accurate form of dating prehistoric climate conditions (Cook et al. 2009; Mischra and Singh 2010). Tree ring data is already in use across the globe, has modeled the intensity of the United States droughts of the 1930s and 1950s, and even provided information used to calculate the intensity of potential future drought events (Cook et al. 2009; Mischra and Singh 2010; Seager et al. 2007; Stahle and Dean 2010; Woodhouse and Overpeck 1998).

Palmer Drought Severity Index (PDSI). Dendrochronology utilizes the Palmer Drought Severity Index (PDSI) formulated by Palmer (1965) to quantifiably measure the moisture level of soil using the relative temperature and precipitation of a region. Using modern PDSI values overlapping with modern tree ring data, prehistoric tree ring data can be evaluated and calibrated to fit a model of reconstructed prehistoric temperature and moisture values (Frittz 2001). PDSI is now the most widely used method for measuring drought indices with negative values associated with warm and dry conditions and positive conditions associated with cool and wet conditions (Mishra and Singh 2010). The index allows for the spatio-temporal quantification of drought, the severity, and in some cases crop susceptibility. Table 2 represents the PDSI classifications for each paleoclimate reconstruction from the North American Drought Atlas (NADA) used in this study.

Table 2. Drought and Wet Classifications of Palmer Drought Severity Index (PDSI)

Drought	**Classifications**	**Pluvial**	**Classifications**
Categories	PDSI Values	Categories	PDSI Values
Extreme Drought	(-infinity, -2]	Slight Wet	[0.5, 1)
Severe Drought	(-2, -1.5]	Moderate Wet	[1, 1.5)
Moderate Drought	(-1.5, -1]	Severe Wet	[1.5, 2)
Slight Drought	(-1, -0.5]	Extreme Wet	[2, infinity)
Normal	(-0.5, 0.5)		

Paleoclimatology Review

The 2010 update to the North American Drought Atlas (NADA, also known as the Living Blended Drought atlas; Cook et al. 2010) used point-by-point principal component regression to develop a gridded reconstruction of summer (June-August) PDSI reconstructions over North America. NADA is a matrix of 1,843 annual tree-ring chronologies compiled into an 11,396 point 0.5 X 0.5^{o} grid (Cook et al. 2010). The matrix files consist of the reconstructed summer PDSI, the instrumental summer PDSI covering the period of A.D. 900-2003 for the study area in the United States, the calibrated R-squared, the verification period RE, and the verification period CE, and a suite of calibration and verification statistics (Cook et al. 2010). Reconstructions in NADA date back to A.D. 0 and back to A.D. 900 over the entire area, making it an excellent tool for tracking climate trends in the CMV and Vacant Quarter during the Mississippian Period.

Geographic Information Systems

All of the aforementioned site and paleoclimatology data were compiled into data layers for manipulation in Geographic Information System (GIS). GIS is an assortment of tools that assist in “data acquisition, spatial data management, database management, data visualization, and spatial analysis” (Conolly and Lake 2006:11). The use of GIS allows for the integration of various datasets and for analysis of the data spatially, temporally, and comparatively.

GIS Research Techniques Utilized

The purposes of GIS for this research were data compilation, georeferencing data, performing spatial analysis, and the development of comparative maps. As previously mentioned, the georeferencing tool provided site locations from maps published in the archaeological literature. The spatial analysis function allowed comparative analyses between drought events and settlement change through the input and manipulation of site and paleoclimate data. Furthermore, this tool allowed for the comparative analysis between the study area and the Vacant Quarter region. Finally, GIS provided the ability to develop maps that provide the ability to visually show settlement patterns and climate reconstructions spatially and temporally.

Potential Problems

There are potential problems with this research. First, while there is an abundance of radiocarbon dates in the literature, many do not indicate whether or not they have been calibrated. Furthermore, there has been little research in the uplands of each state within the study, thus the results may be skewed for the CMV. Second, user error is likely with the development of the radiocarbon database. Many sites were identified through overlaying maps into GIS, thus there are not precise coordinates for several sites in the study. Additionally, many of the sites within the radiocarbon database are the most well-known and largest sites in the CMV and Vacant Quarter, and therefore almost always have dates for all Mississippian components. This may also skew the results, showing mostly sites with every period in their radiocarbon dates. The small sample size of radiocarbon dates may also present issues within the research.

4. Results and Analysis

The results of the comparative analyses are presented and discussed here. This chapter is organized so that it aligns with the methodology chapter. The results of these analyses are interpreted as to how they may relate to the archaeological record.

Settlement Patterns

Mississippian Site Distributions

Fifty-one radiocarbon dates at twenty-eight Mississippian sites were used in the analysis of this study. The geodatabase was constructed with the following site criteria: site name, site number, radiocarbon age, calibrated age, Mississippian period designation, lab number, and source for coordinates and age (See Appendix). In the most general sense, the Mississippian period settlement pattern was one of initial expansion, contraction, and eventual aggregation into the Mississippi River floodplain or elsewhere. In the Early Mississippian Period the archaeological record shows sites located typically along major river floodplains and in some smaller tributary floodplains. This coincides with the distribution seen within the study area during the Early Mississippian Period (Figure 6). The Middle Mississippian Period displayed similar settlement patterns, however, around 1250-1300 A.D., abandonment of permanent, year-round sites in the tributary river floodplains of the Mississippi Basin (Figure 7) and uplands began. Following the Middle Mississippian period, the majority of large, permanent settlements of the Late Mississippian period existed in the major floodplains once again. The distribution of the sites within the study containing a Late Mississippian component (Figure 8) coincide with the archaeological and historical record, showing large nucleated settlements in the Mississippi River floodplains. Some of the sites within the study were occupied throughout the Mississippian period and the majority of these sites are found within the Mississippi River floodplain, likely providing consistent and predictable water and soil resources necessary for the maize production during periods of instability and drought. Late Mississippian sites located outside the Mississippi River Valley, such as Parkin/Casqui, remain in the floodplain of the major St. Francis River, which contained a notably expansive and complex paramount chiefdom along the St. Francis River (Morse and Morse 2000).

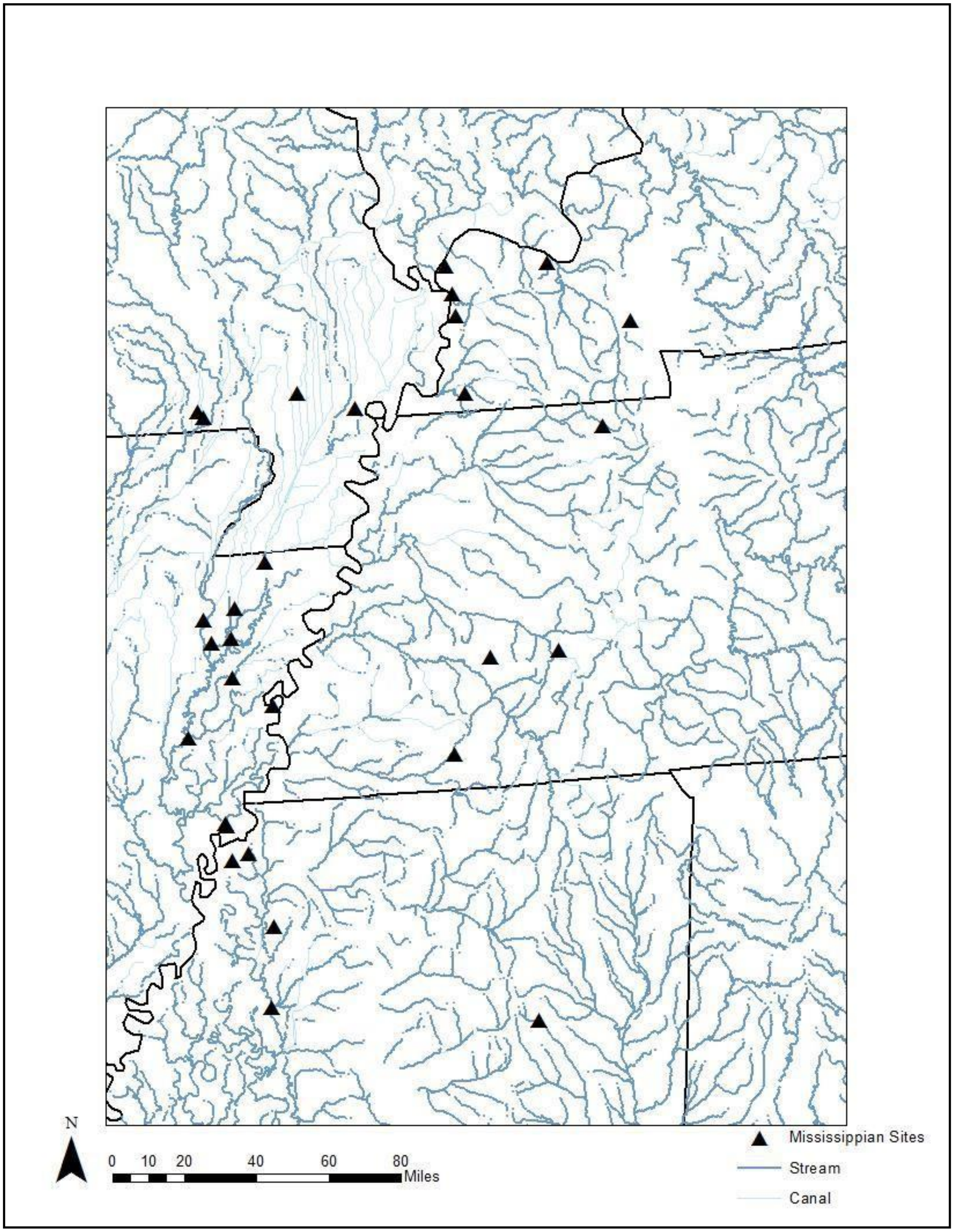


Figure 6. Mississippian sites in the study region with radiocarbon dates.

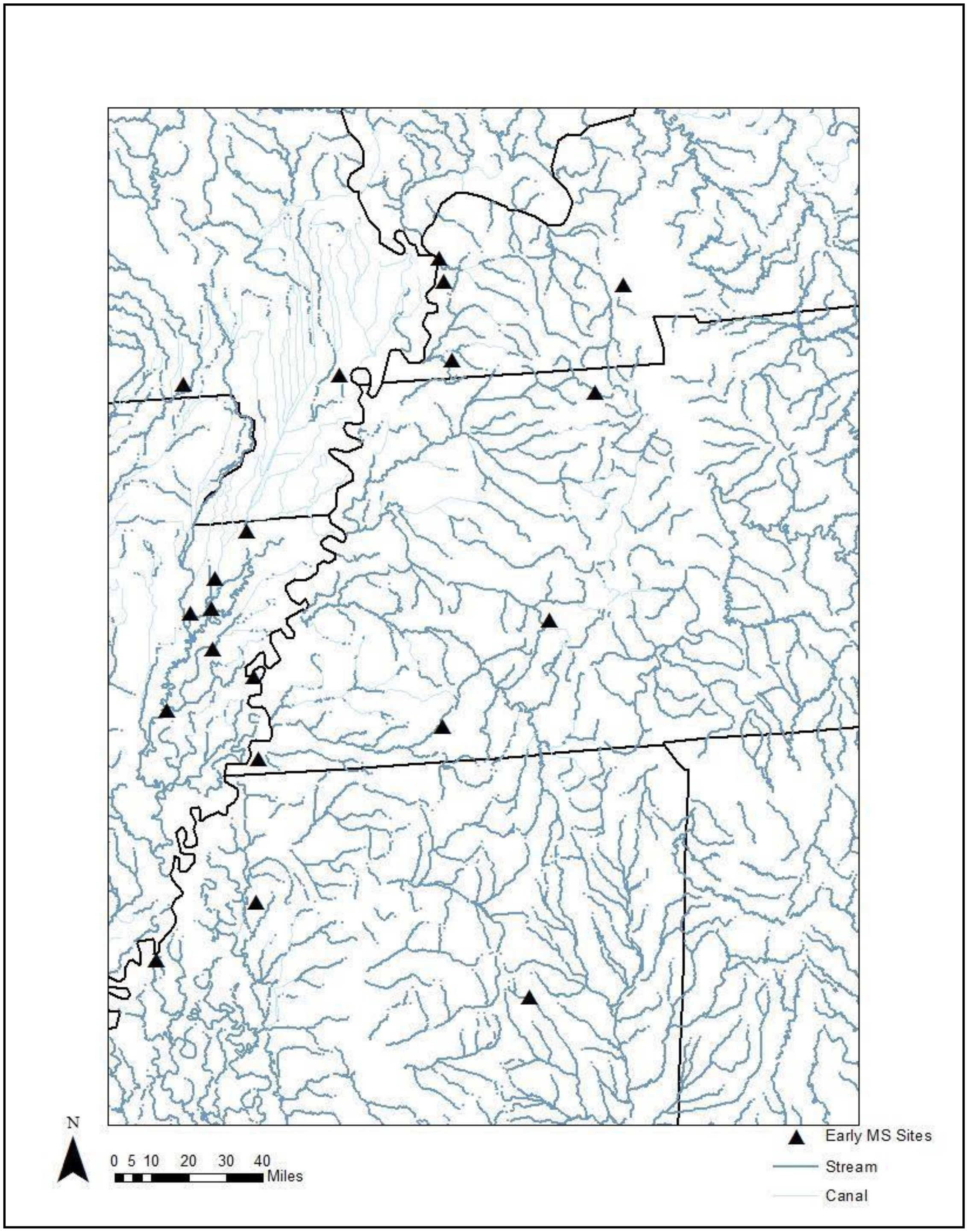


Figure 7. Mississippian sites with an Early Mississippian component.

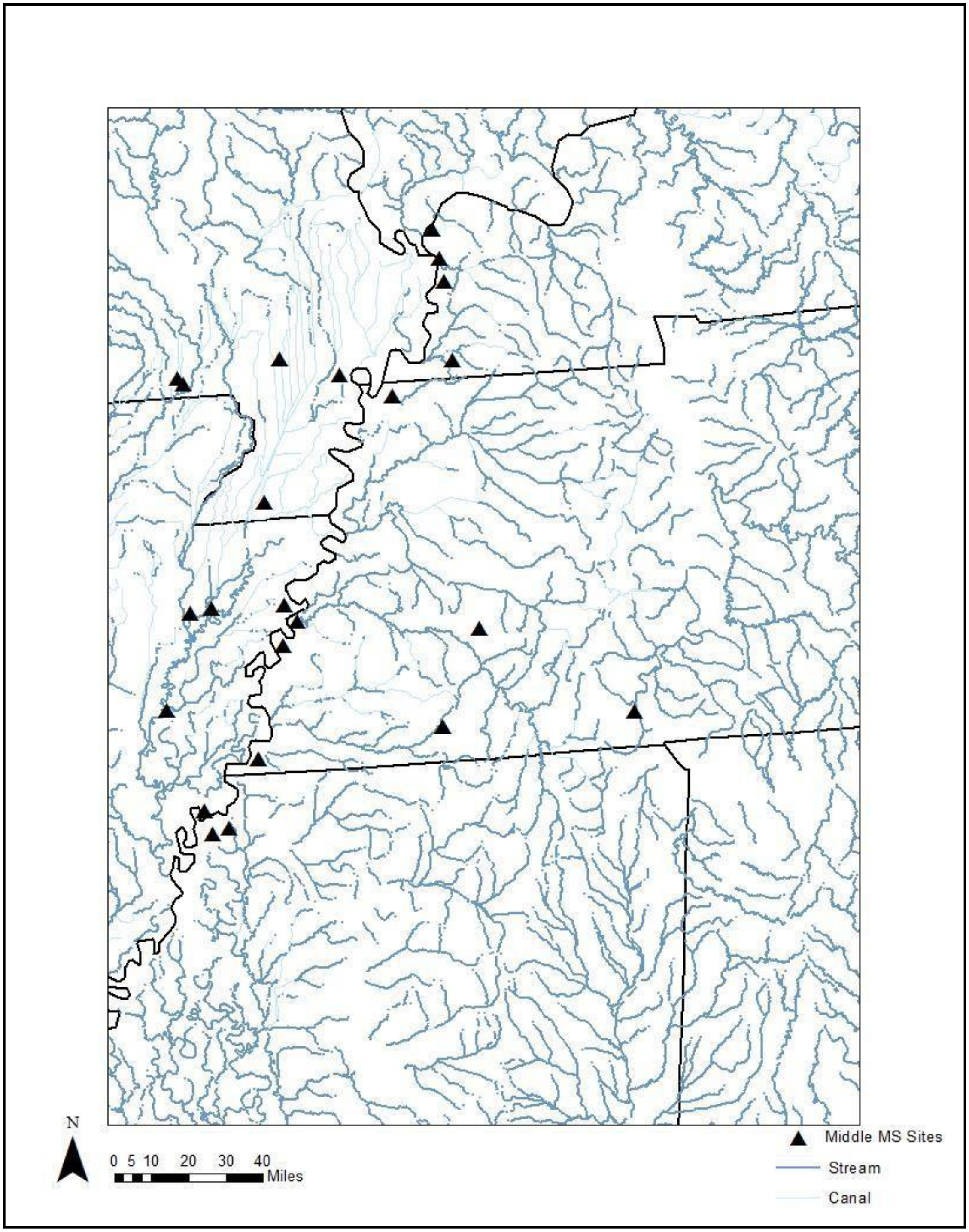


Figure 8. Mississippian sites with a Middle Mississippian component.

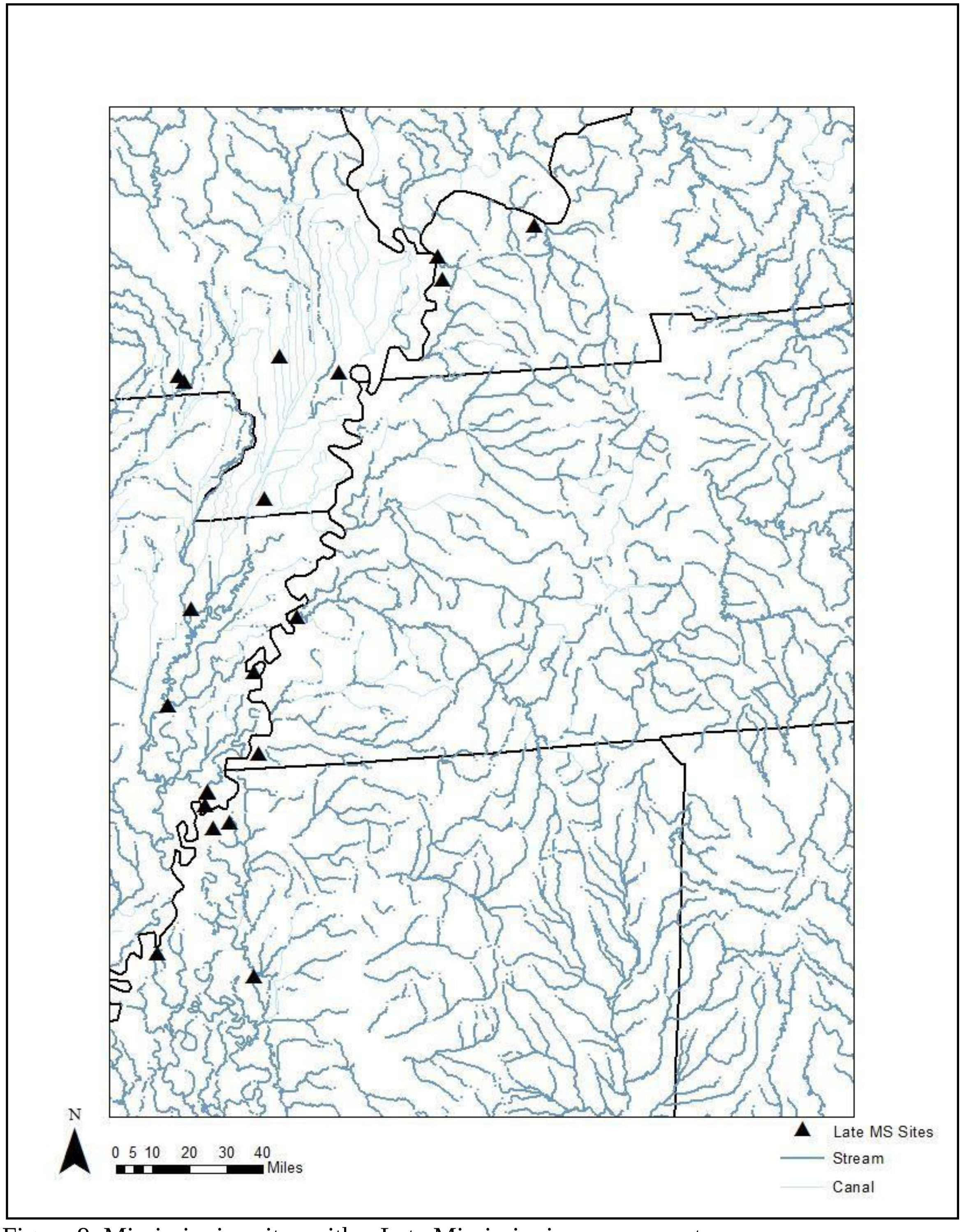


Figure 9. Mississippian sites with a Late Mississippian component.

Drought Reconstructions

The following section will describe the predominant climate patterns across the study region during the whole of the Mississippian Period. A general overview of the climate in each period will be detailed, including Early Mississippian (A.D. 900-1200), Middle Mississippian (A.D. 1200-1400), and Late Mississippian (A.D. 1400-1600). Finally, there will be a discussion of drought events that would have affected the region and populations.

Early Mississippian Climate (ca. 900-1100)

As a whole the Mississippian Period, from A.D. 900-1600, shows 'slight drought' over the entire CMV. This is indicated by a PDSI value of -1 to -0.5 shown in Figure 9. The Early Mississippian period exhibits a relatively normal summer PDSI value of -0.5 to 0.5 across the majority of the region for the time A.D. 900-1100 (Figure 10). This suggests optimal moisture and temperature regimes, likely promoting or at the least sustaining agricultural production. However, when analyzing the time period using a time series plot, drought is evident from 940-985 A.D. (Figure 13). The following time series (Figure 14), show relatively average and even pluvial period for the CMV, however starting around 1100 A.D. there is a clear trend back to a period of drought.

Middle Mississippian Climate (ca. 1100-1300)

Following this optimal climate is the first observed drought event for the Mississippian people. The whole of the Middle Mississippian period exhibits 'slight to moderate' drought indicated by the range of summer PDSI in the area from -1.5 to -0.5 (Figure 11). What is most interesting about Figure 11 is the outline of the displayed moderate drought. The outline resembles almost exactly the Vacant Quarter region shown in Figures 1 and 2.

In the early 13th century there is evidence of ‘slight to extreme’ drought across the entire study area designated by summer PDSI from –infinity to -0.5 (Figure 12). For two decades (1220-1240 A.D.) the CMV is subjected to severe drought with some areas showing PDSI of extreme drought. The following five years from 1240-1245 A.D. indicate extreme drought over the whole of the CMV (Figure 13). Figure 18 best depicts this period of drought through the form of a time series, showing the PDSI at its worst around 1240 A.D. The climate from 1250-1280 is relatively average with PDSI values that do not exceed the -1 range. However, by 1280 A.D., the next twenty years show PDSI values of -1.5, indicating moderate drought levels throughout the majority of the CMV (Figure 14). Figure 21 shows this drought period in detail with a time series, proving it to be a cyclical, thirty-year drought event.

Late Mississippian Climate (ca. 1300-1600)

The overall Late Mississippian climate is highly variable. There are periods of severe and extreme drought interspersed with pluvial periods lasting the same amount of time, generally on the scale of a few years to decades. In this section, only the drought events extrapolated from the PDSI data of the Late Mississippian period will be discussed. From 1300-1310 A.D. there is summer PDSI from ‘average to severe’ drought, shown by values from -2 to -0.5 (Figure 15). The moderate drought covers most of the study region, with the decadal, severe drought located over a region including Cahokia.

The next observed period of drought event covered 20 years from 1350-1370 A.D. To better visualize the nature of drought during this period, it is examined at the decadal frame of 1350-1360 A.D. (Figure 17) and 1360-1370 A.D. (Figure 18). The first drought event is from 1350-1360 A.D with summer PDSI values reaching severe drought levels over the majority of the CMV (Figure 17). During 1360-1370 A.D., the drought conditions spread and worsen, with severe drought conditions over all of the CMV and extreme drought covering large portions of the study region (Figure 18).

From 1370-1380 A.D. the climate of the CMV returns to average PDSI values again with drought levels only present within outlying regions. The next drought event occurs over 20 years again, thus to better visualize the nature of drought over the region and during this time, the drought event is analyzed at the decadal frame of 1380-1390 A.D. (Figure 19) and 1390-1400 A.D. (Figure 20). The first decadal drought event, spanning 1380-1390 A.D., shows extreme drought over the northern part of the CMV ranging as far north as the Great Lakes region (Figure 19). This event also displays severe drought levels covering the remaining area of the CMV. The following decade of 1390-1400 A.D. shows a reduction in the area of the extreme drought, while severe drought levels are repeated in the same locations as before during the previous period (Figure 20). This severe drought covers the whole of the CMV.

During the early years of the 15th century, PDSI levels indicate relatively average to fluvial climate conditions over the study region. However, from 1430-1440 A.D. there is evidence of slight to severe drought, with the Vacant Quarter again being the most adversely affected (Figure 21). The moderate drought region makes up the rest of the CMV. A major drought event is observed, which lasts from 1450-1460 A.D. and is the most severe drought to occur in the study region during the time frame of 900-1600 A.D. (Figure 22). Extreme drought, exceeding PDSI values of -2, span the whole of the CMV and almost the entire region displayed on the map. Figure 29 best shows these drought events from 1430-1470 A.D. using a time series. It is clear that 1450-1455 A.D. experienced the worst of the drought during this time.

The 16th century had a varied climate pattern similar to the previous century. From 1510-1520 A.D. severe drought covered the CMV with a pocket of moderate drought located near Crowley's Ridge in Arkansas (Figure 23). The next major drought event spanned 1560-1570 A.D. with extreme negative PDSI values over the majority of the CMV and severe drought its periphery (Figure 24). The time series from Figure 32 highlights the drought from 1550-1580 A.D., showing continual drought, the worst of which being from 1565-1570 A.D.

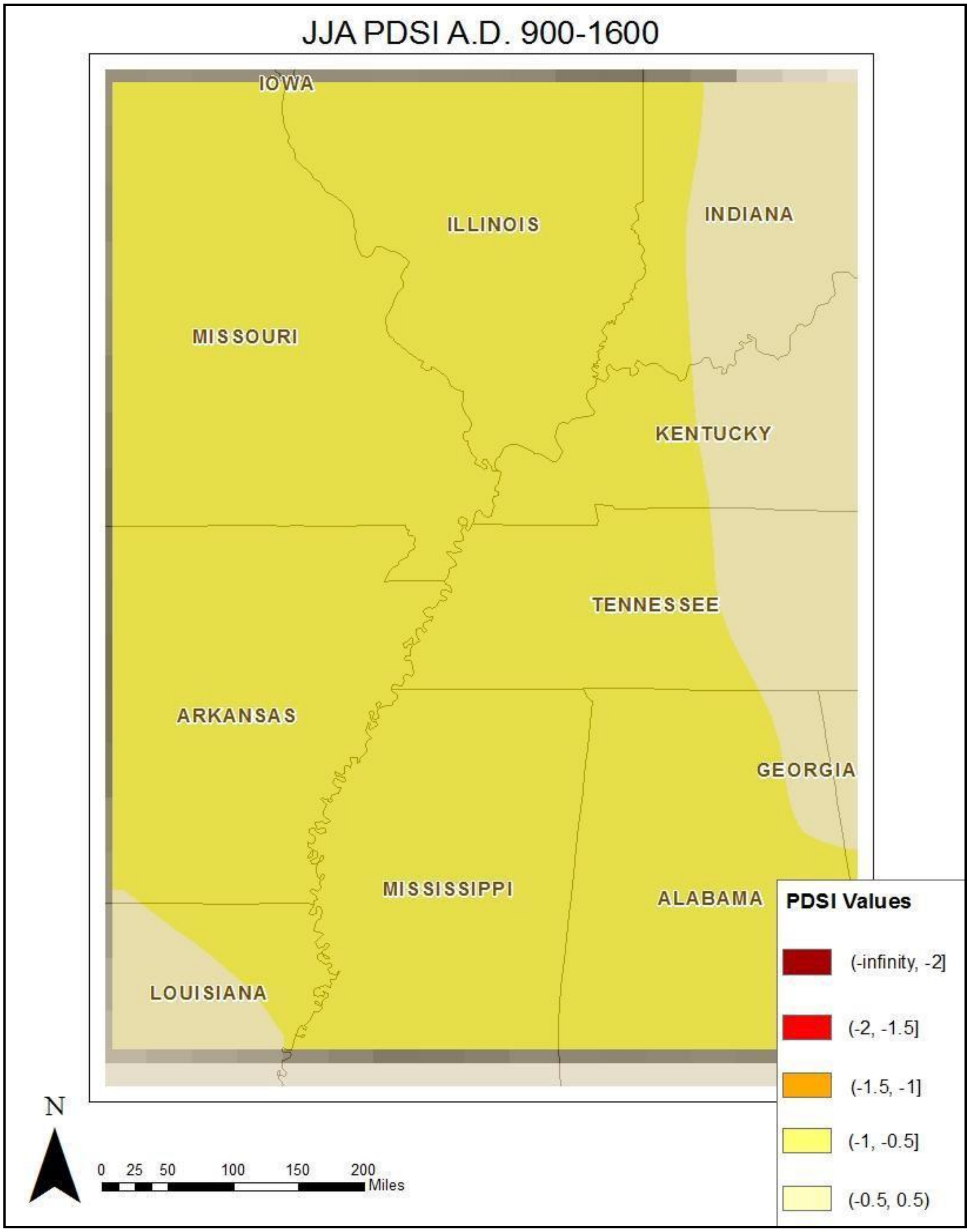


Figure 10. Map of Values for JJA PDSI 900-1600 A.D. (North American Drought Atlas, 2017).

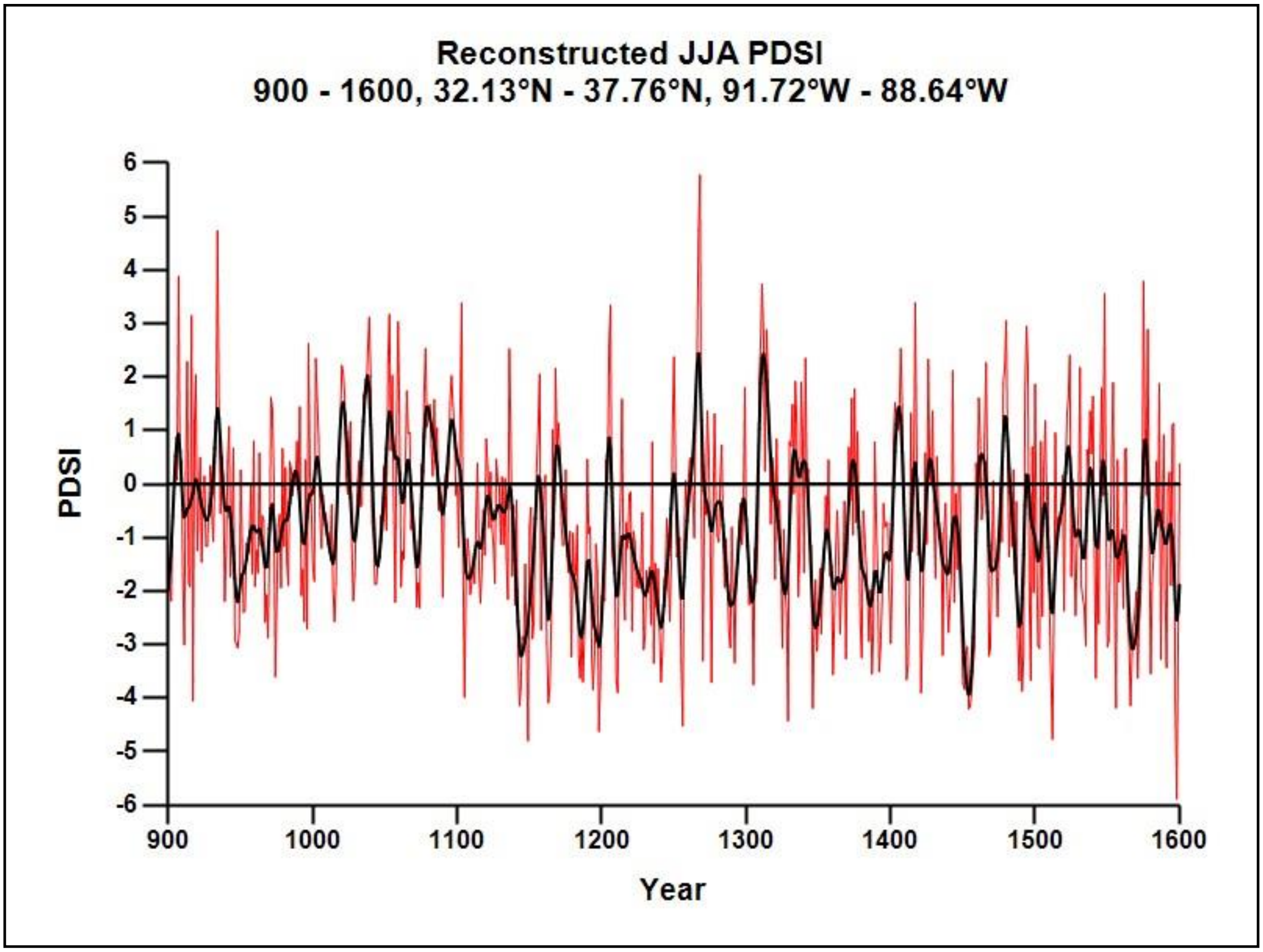


Figure 11. Time Series for JJA PDSI Values from 900-1600 A.D. (North American Drought Atlas, 2017).

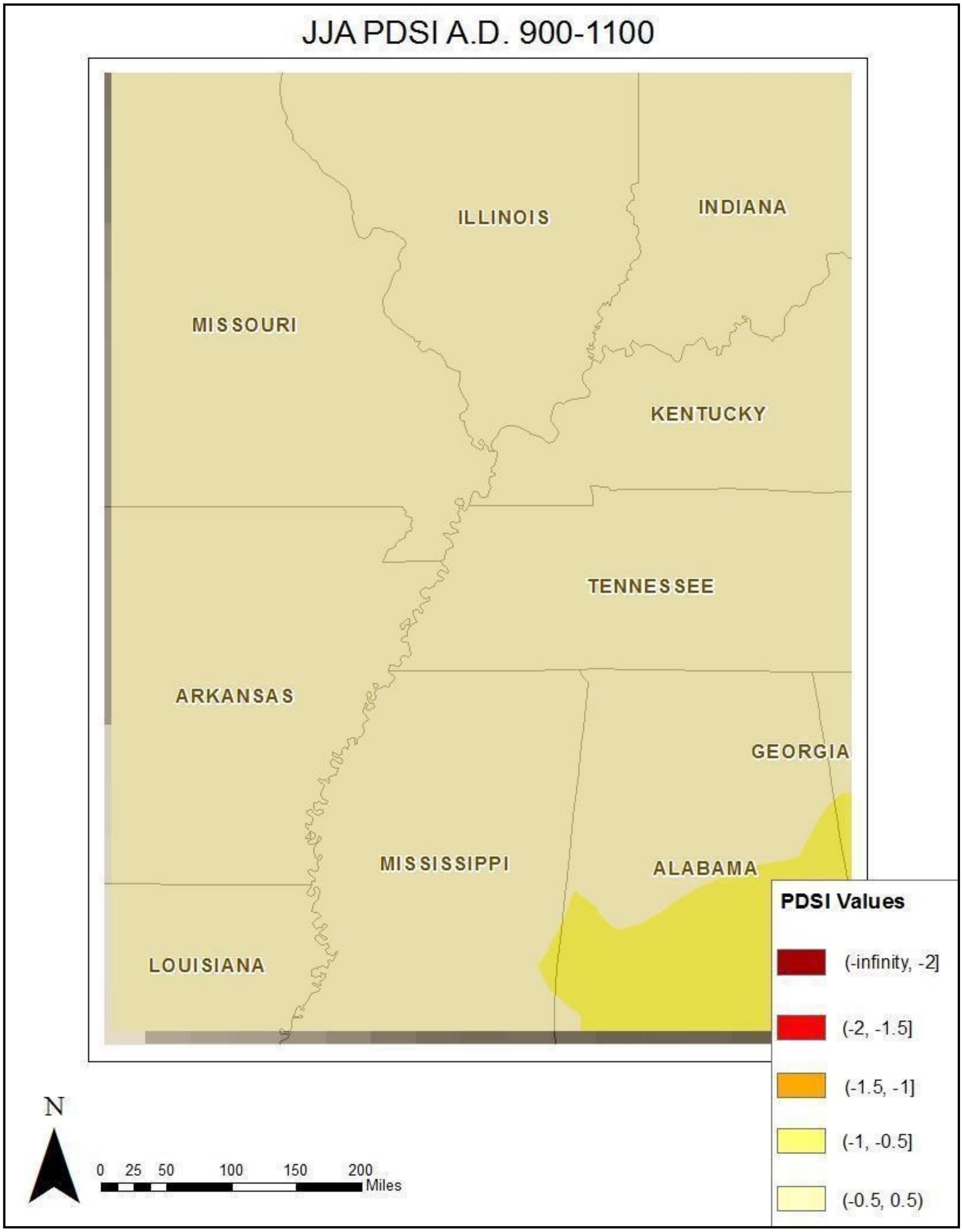


Figure 12. Map of Values for JJA PDSI 900-1100 A.D. (North American Drought Atlas 2017).

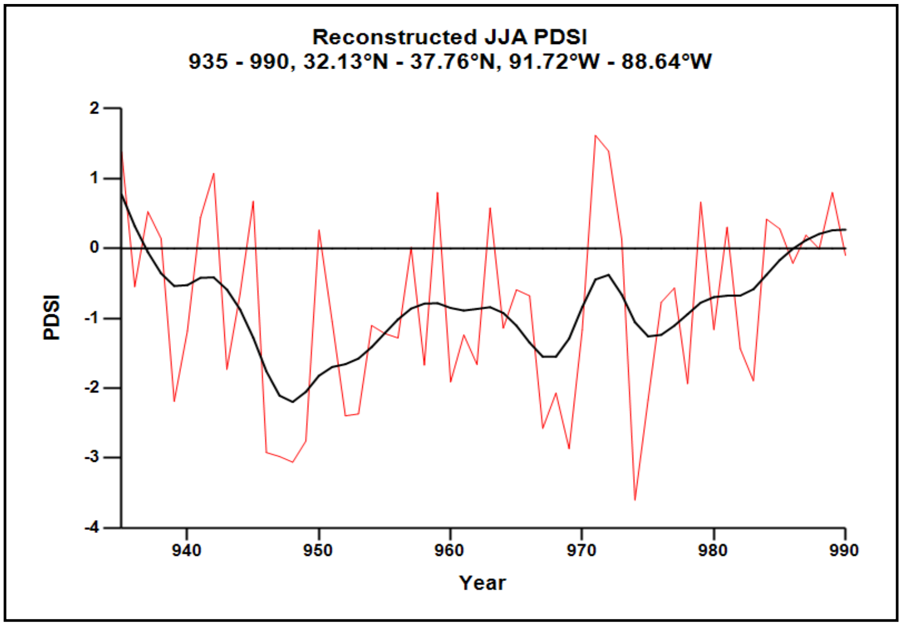


Figure 13. Time Series for JJA PDSI from 935- 990 A.D. (North American Drought Atlas, 2017).

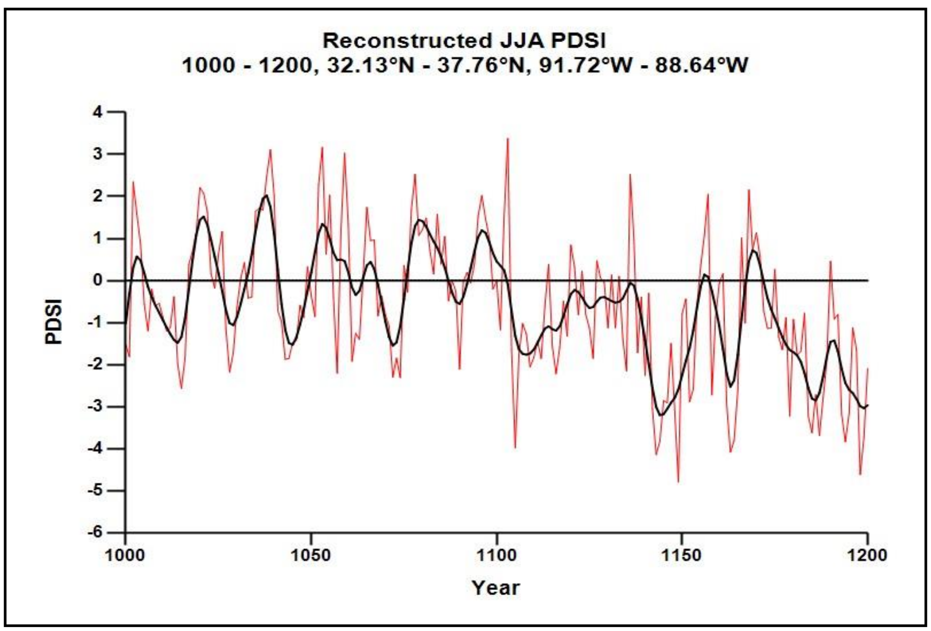


Figure 14. Time Series for JJA PDSI from 1000-1200 A.D. (North American Drought Atlas, 2017).

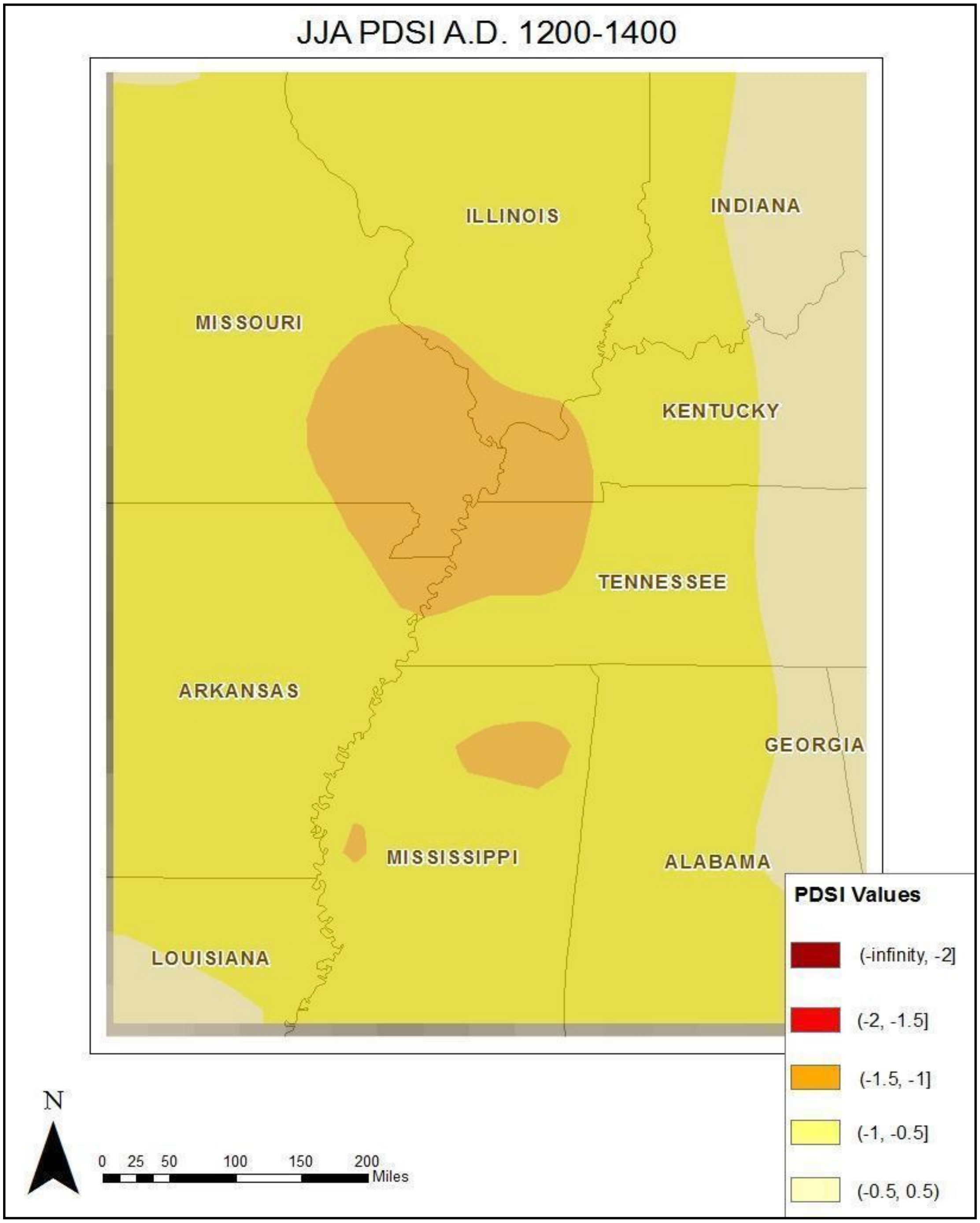


Figure 15. Map of Values for JJA PDSI 1200-1400 A.D. (North American Drought Atlas, 2017).

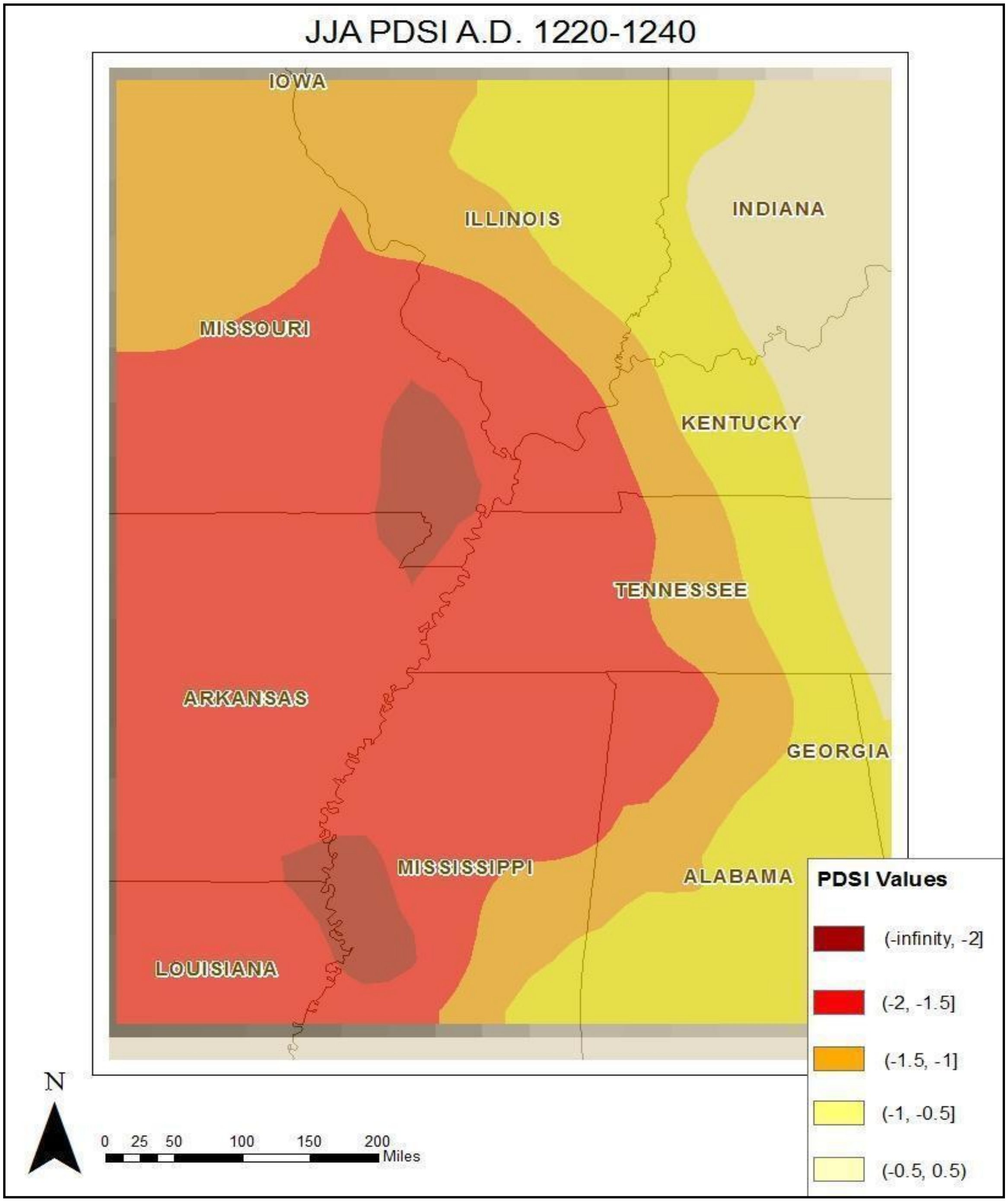


Figure 16. Map of Values for JJA PDSI 1220-1240 A.D. (North American Drought Atlas, 2017).

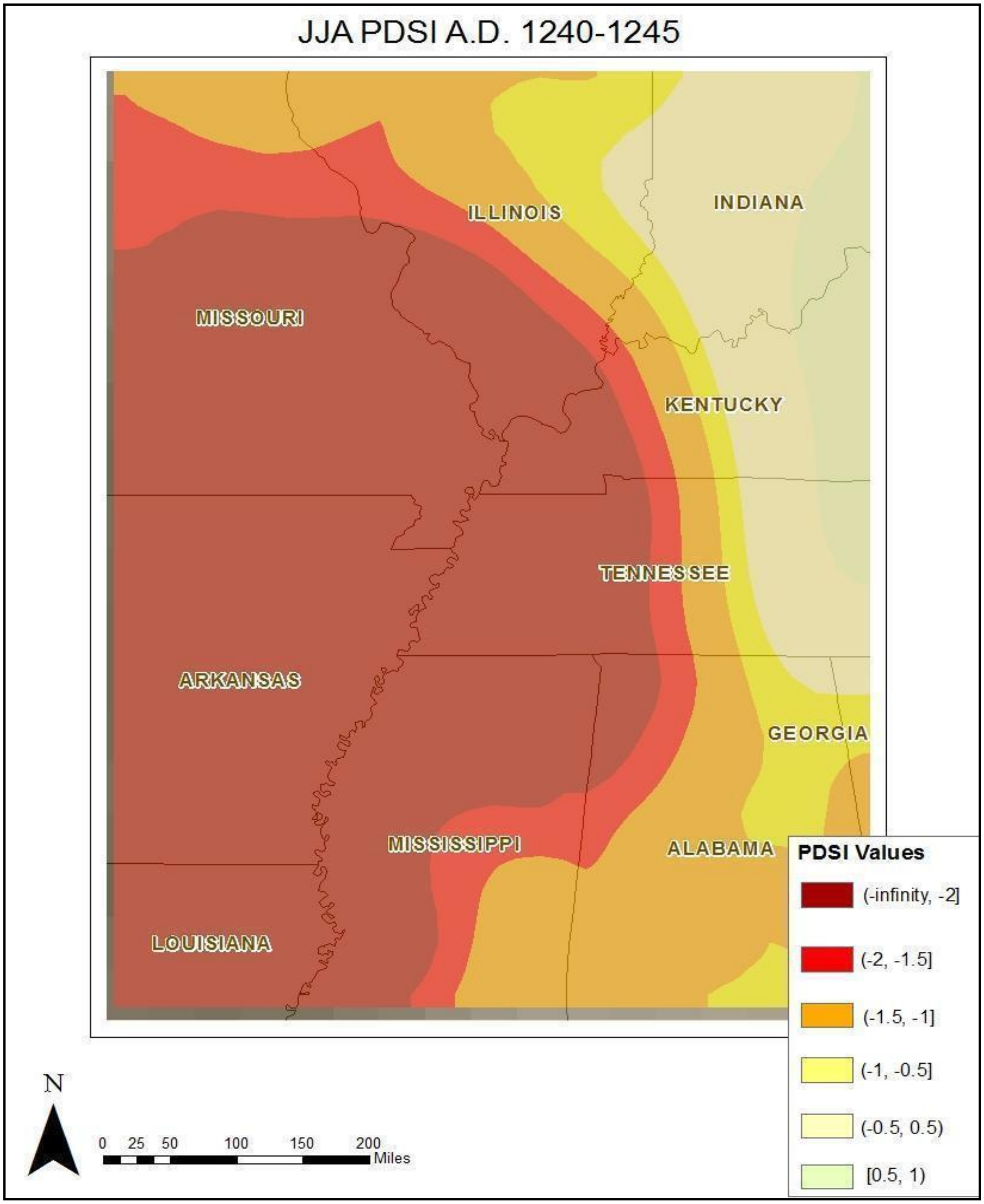


Figure 17. Map of Values for JJA PDSI 1240-1245 A.D. (North American Drought Atlas, 2017).

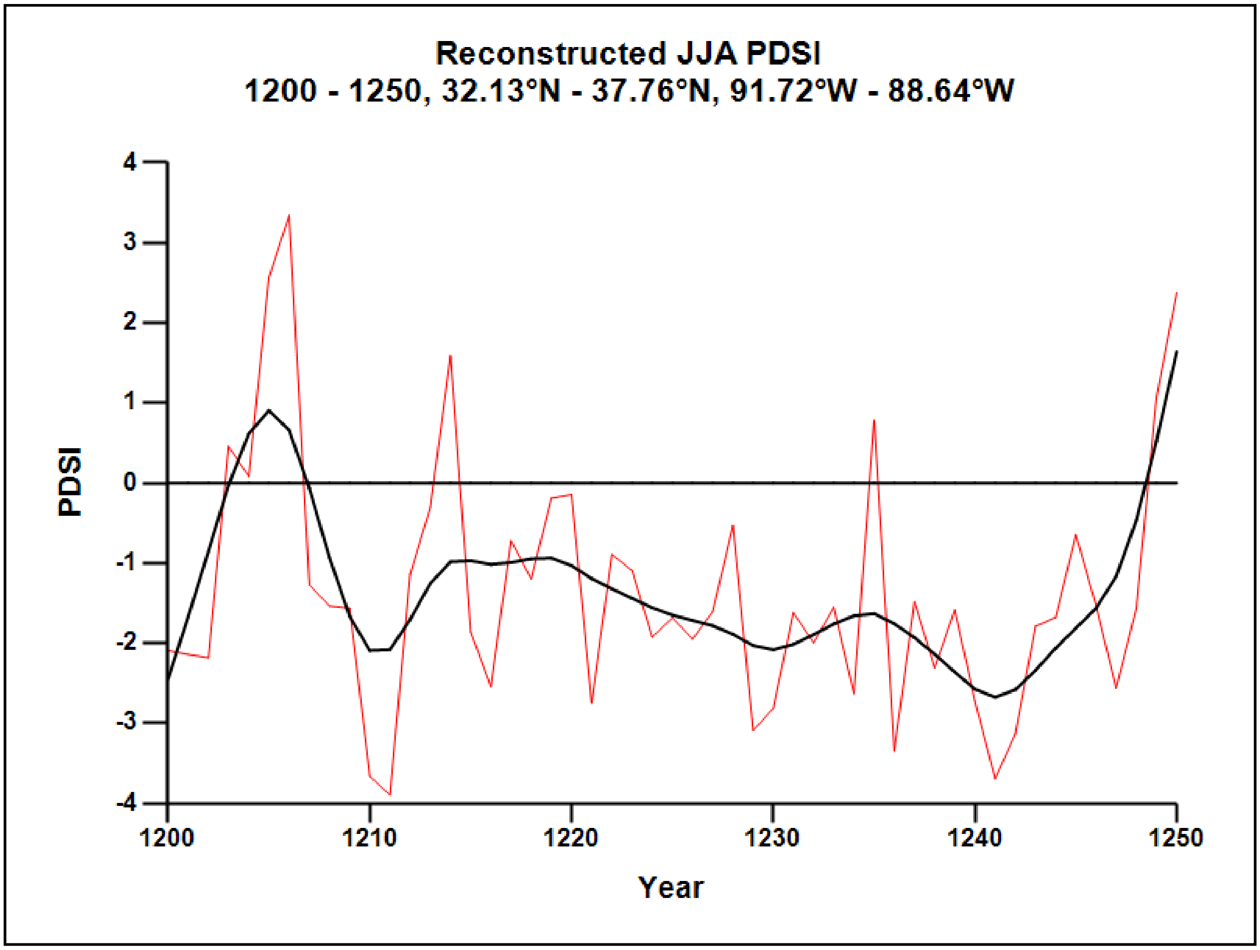


Figure 18. Time Series for JJA PDSI Values from 1200-1250 A.D. (North American Drought Atlas, 2017).

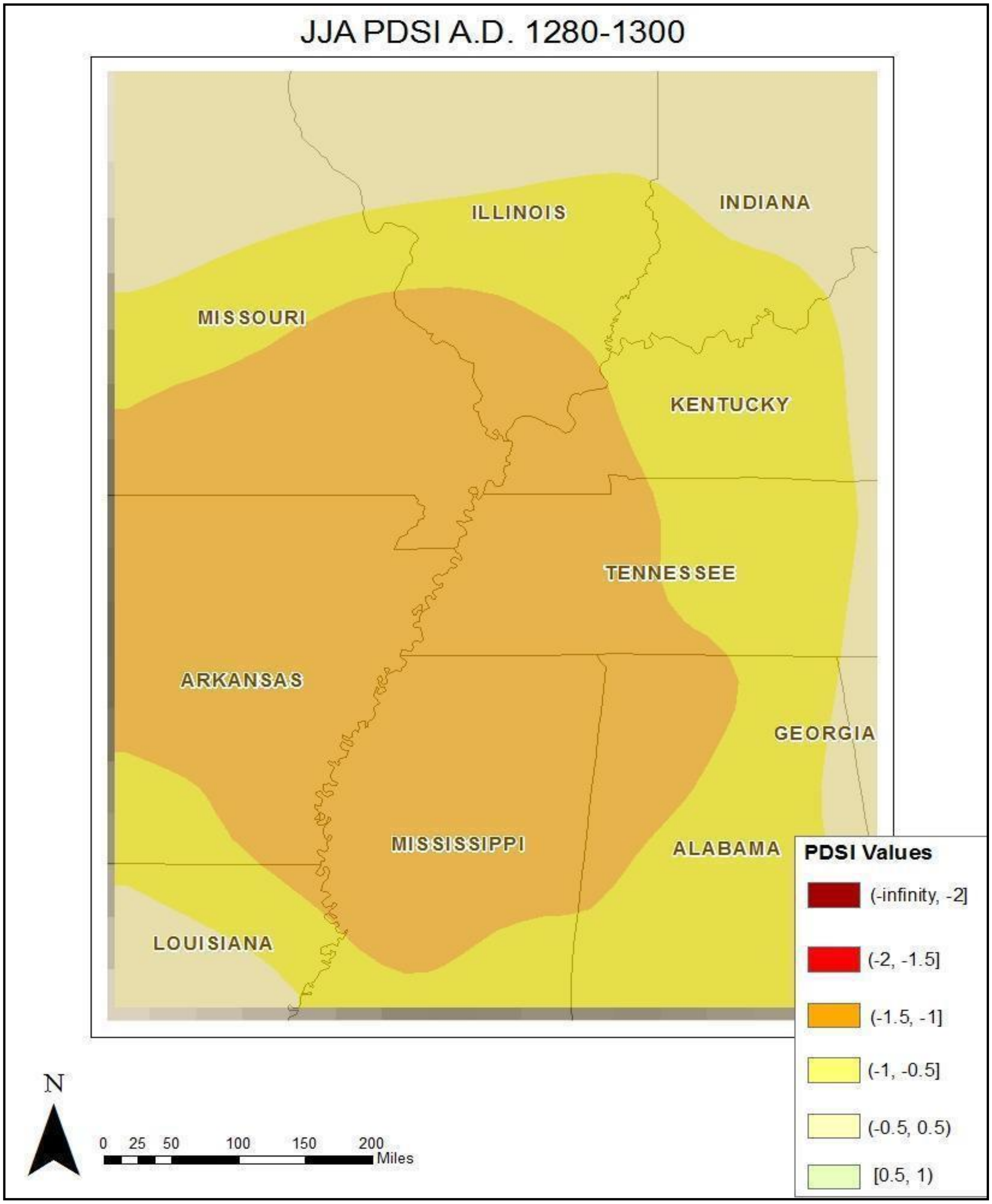


Figure 19. Map of Values for JJA PDSI 1280-1300 A.D. (North American Drought Atlas, 2017).

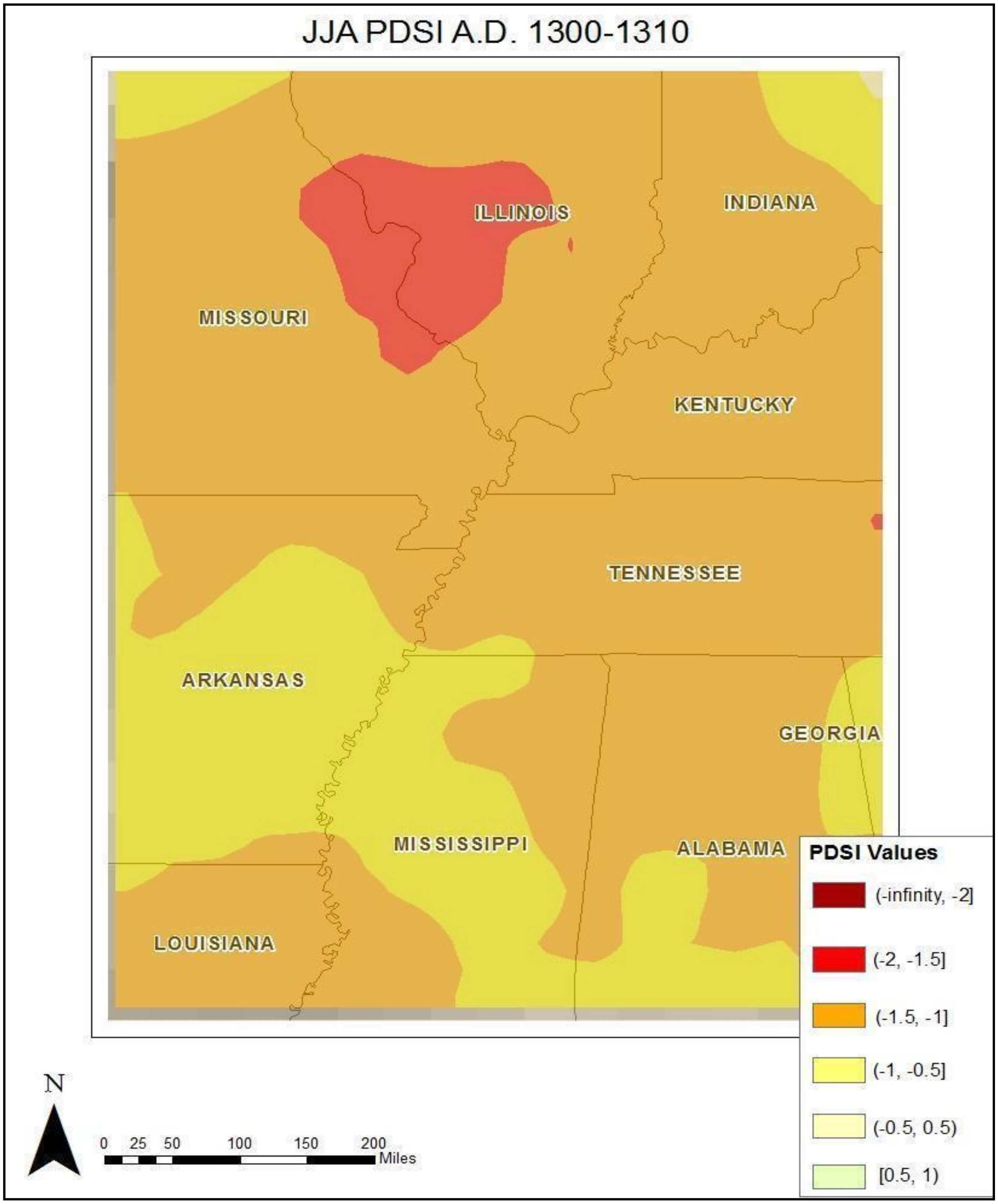


Figure 20. Map of Values for JJA PDSI 1300-1310 A.D. (North American Drought Atlas, 2017).

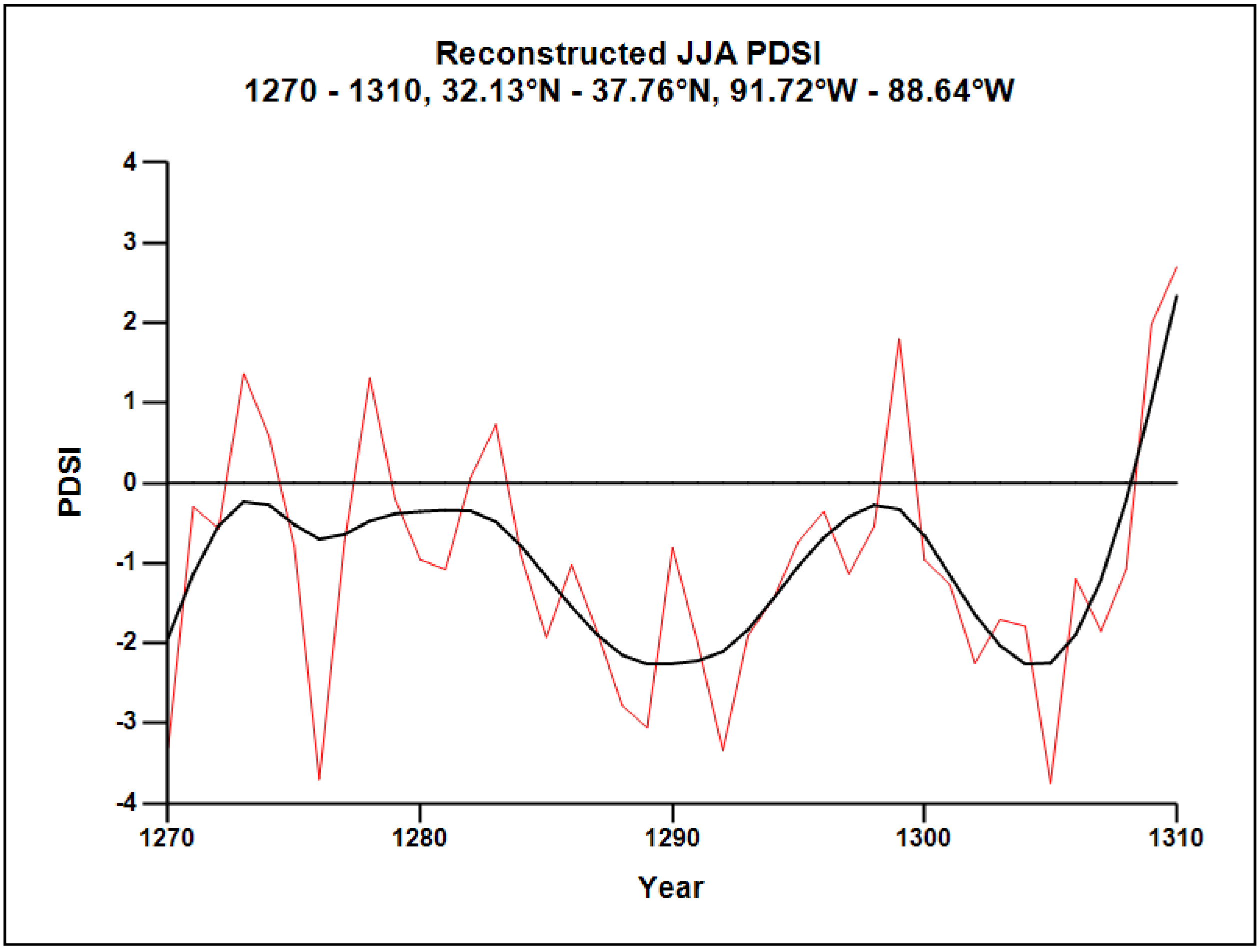


Figure 21. Time Series for JJA PDSI Values from 1270-1310 A.D. (North American Drought Atlas, 2017).

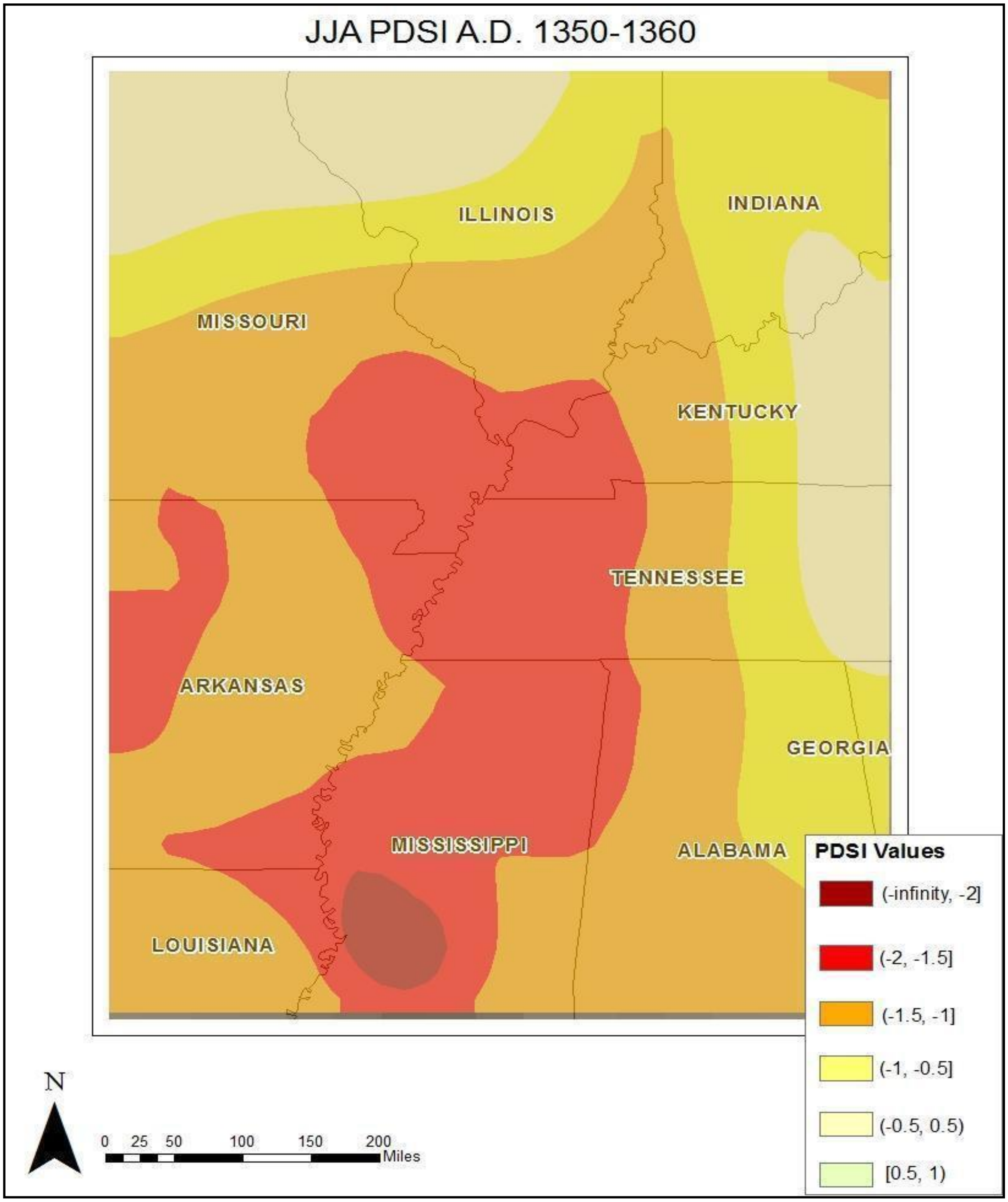


Figure 22. Map of Values for JJA PDSI 1350-1360 A.D. (North American Drought Atlas, 2017).

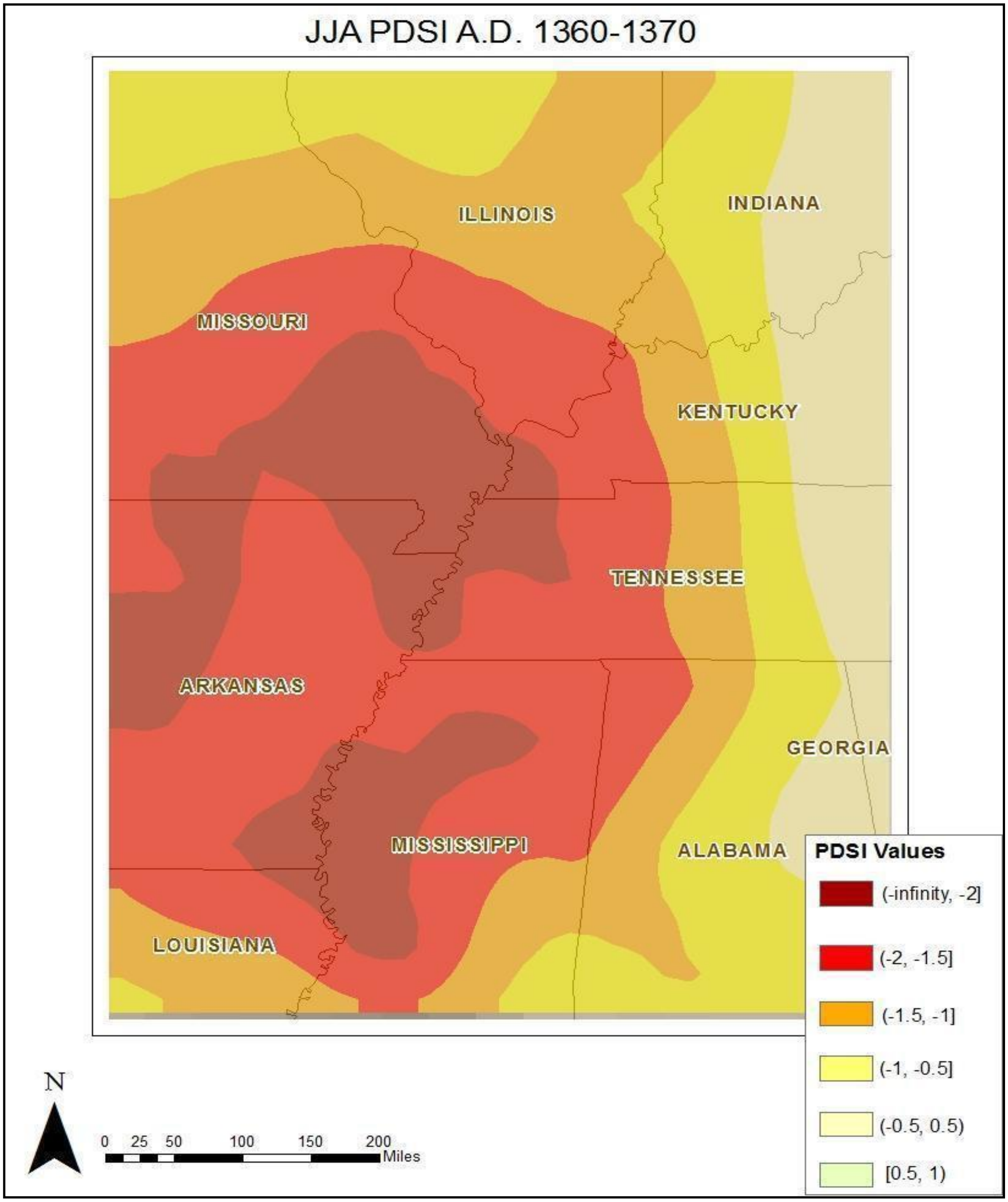


Figure 23. Map of Values for JJA PDSI 1360-1370 A.D. (North American Drought Atlas, 2017).

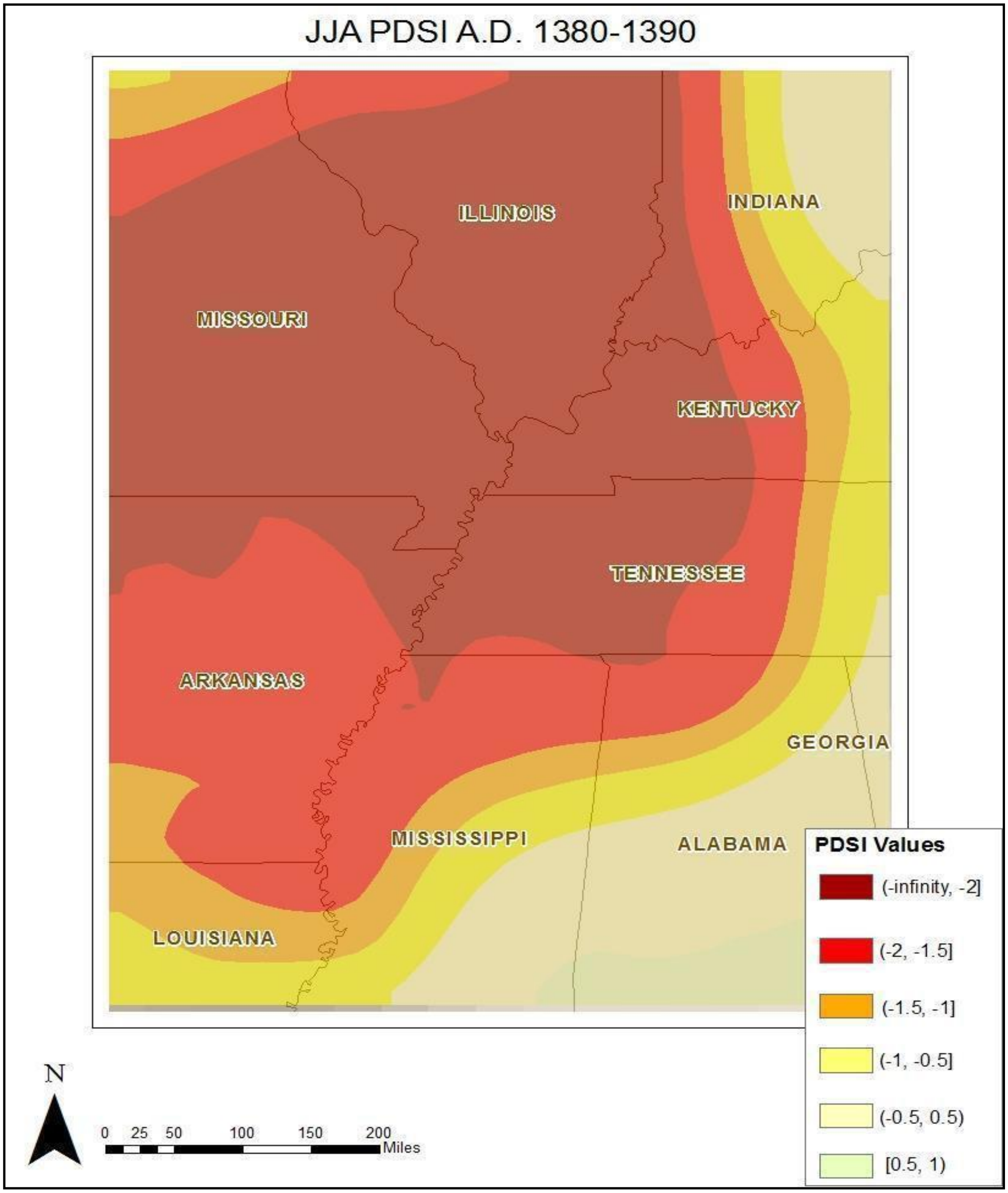


Figure 24. Map of Values for JJA PDSI 1380-1390 A.D. (North American Drought Atlas, 2017).

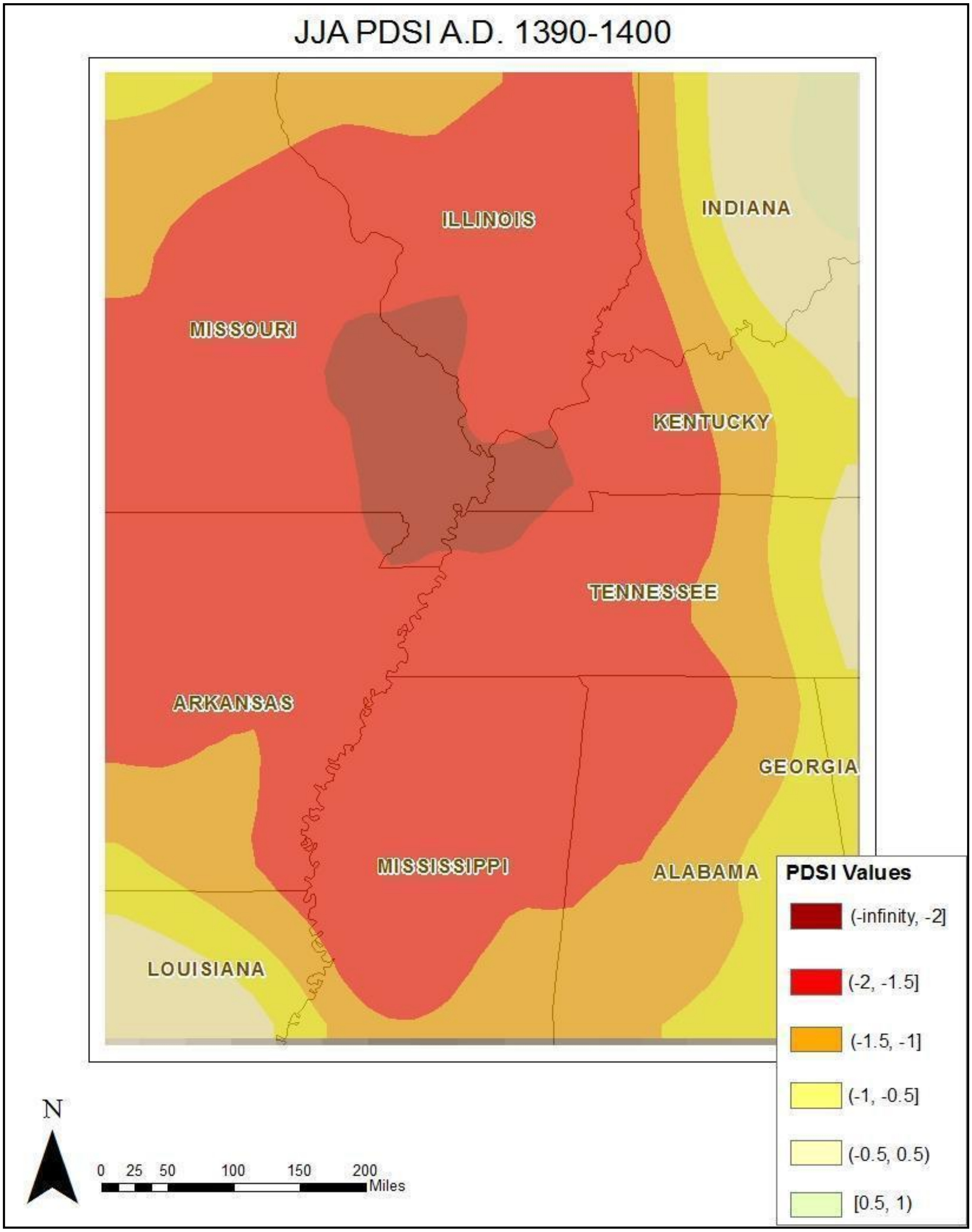


Figure 25. Map of Values for JJA PDSI 1390-1400 A.D. (North American Drought Atlas, 2017).

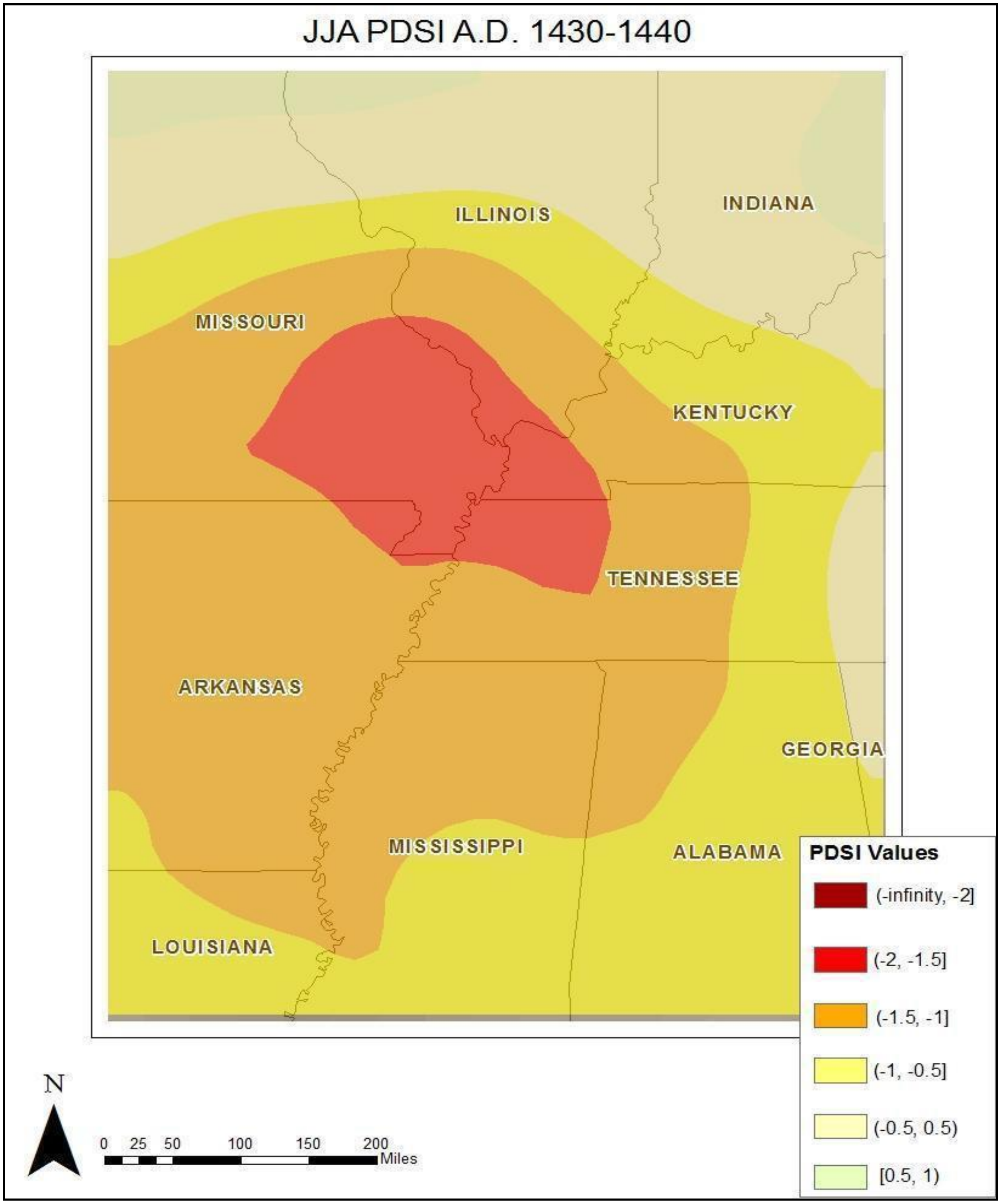


Figure 26. Map of Values for JJA PDSI 1430-1440 A.D. (North American Drought Atlas, 2017).

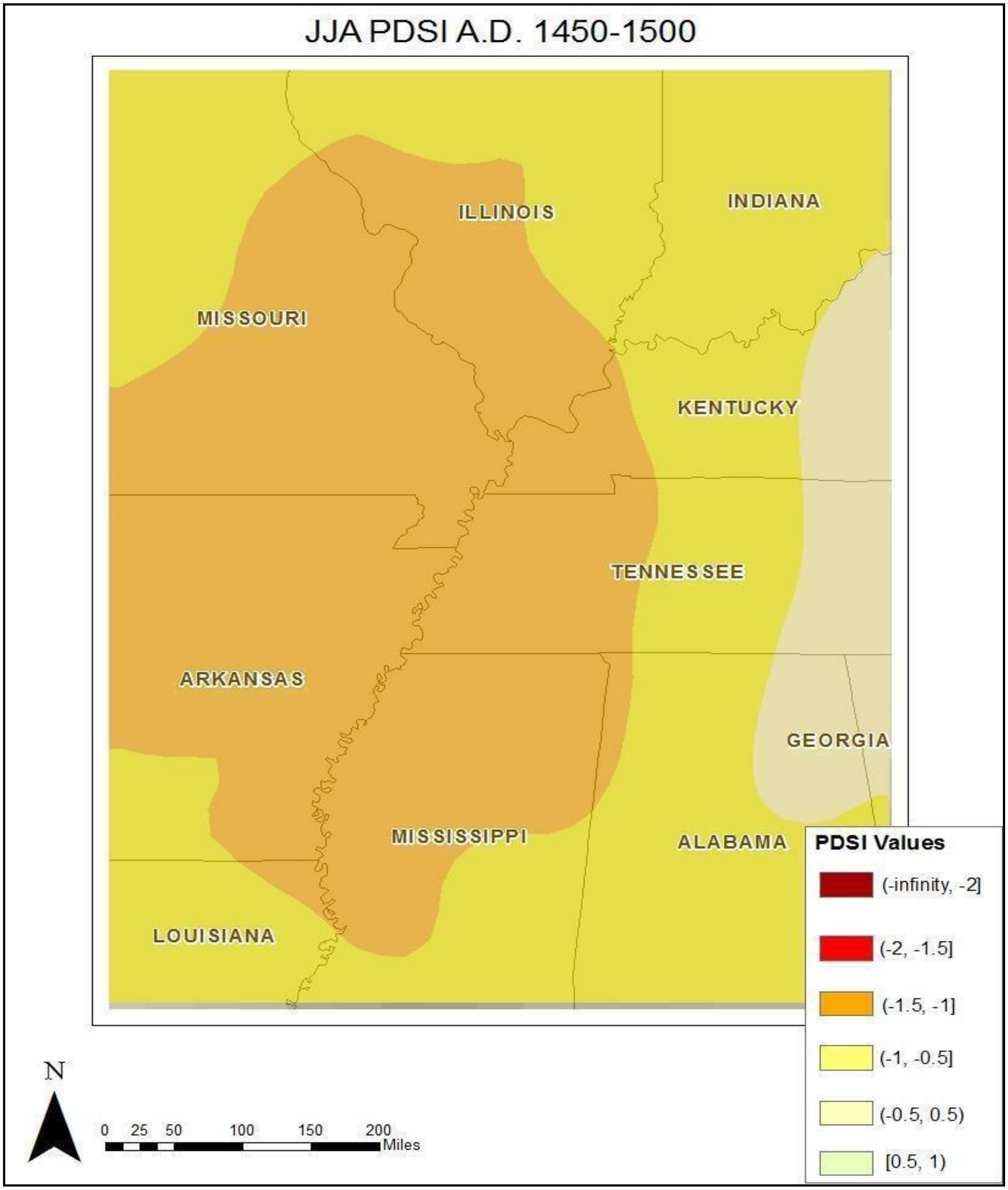


Figure 27. Map of Values for JJA PDSI 1450-1550 A.D. (North American Drought Atlas, 2017).

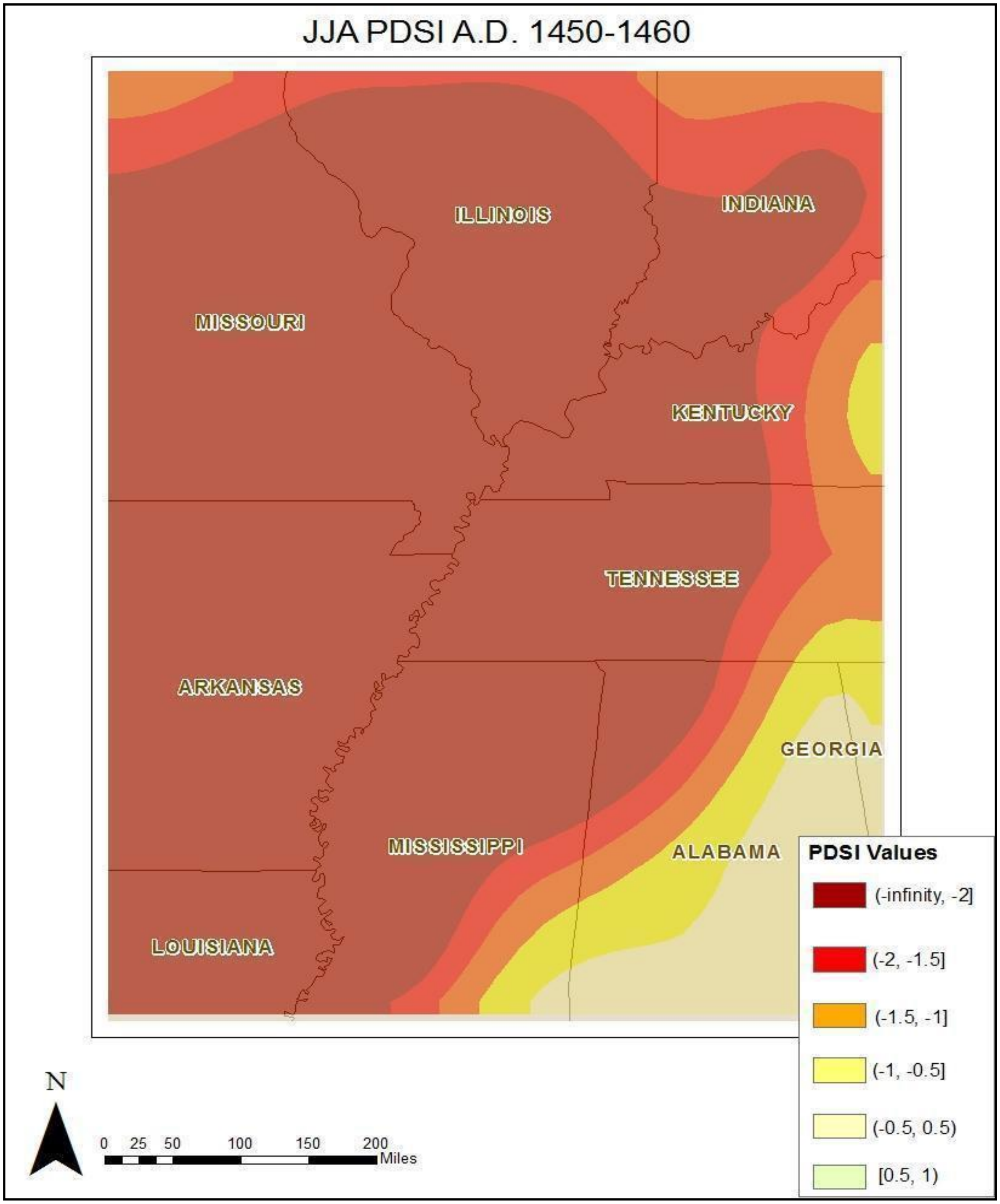


Figure 28. Map of Values for JJA PDSI 1450-1460 A.D. (North American Drought Atlas, 2017).

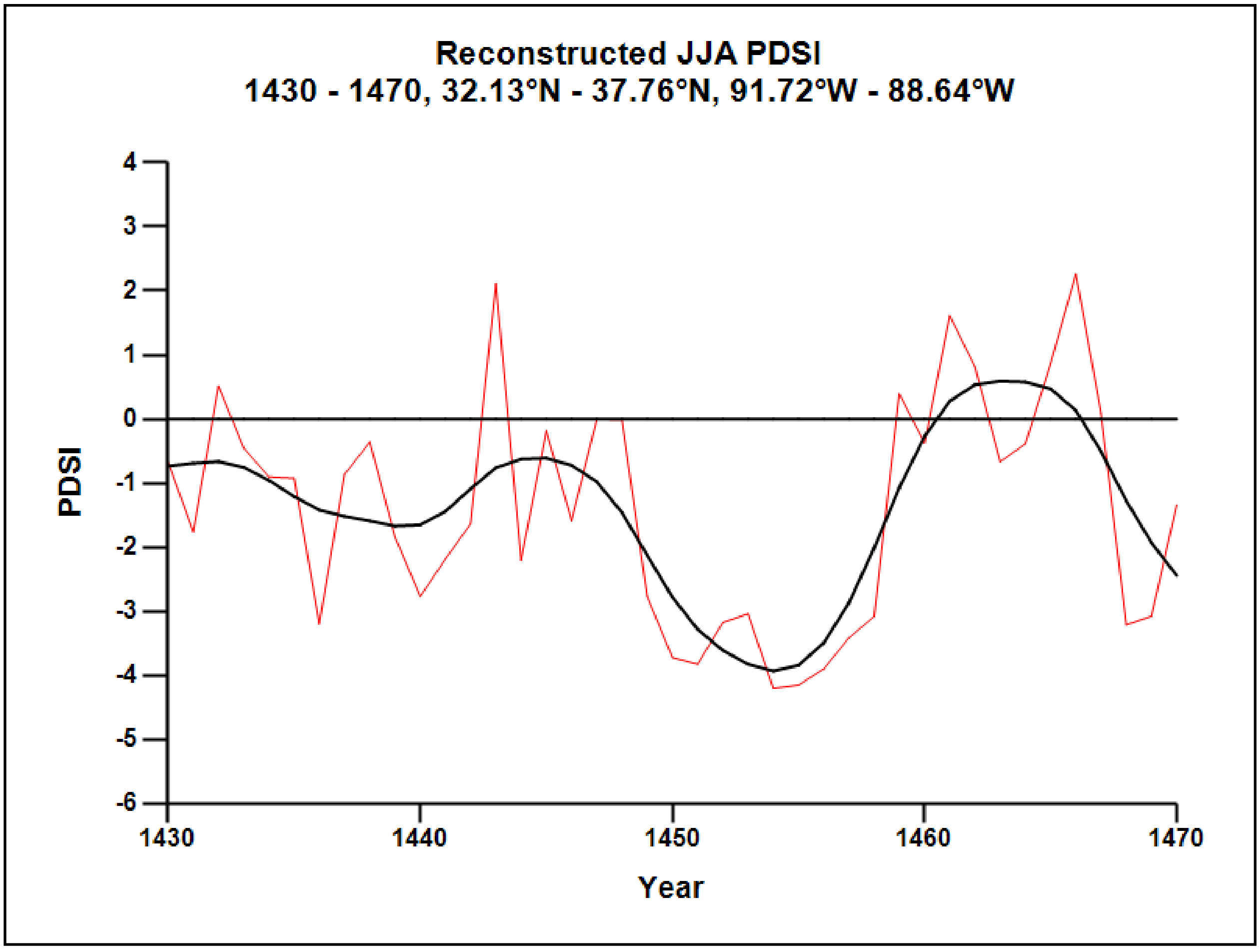


Figure 29. Time Series for JJA PDSI Values from 1430-1470 A.D. (North American Drought Atlas, 2017).

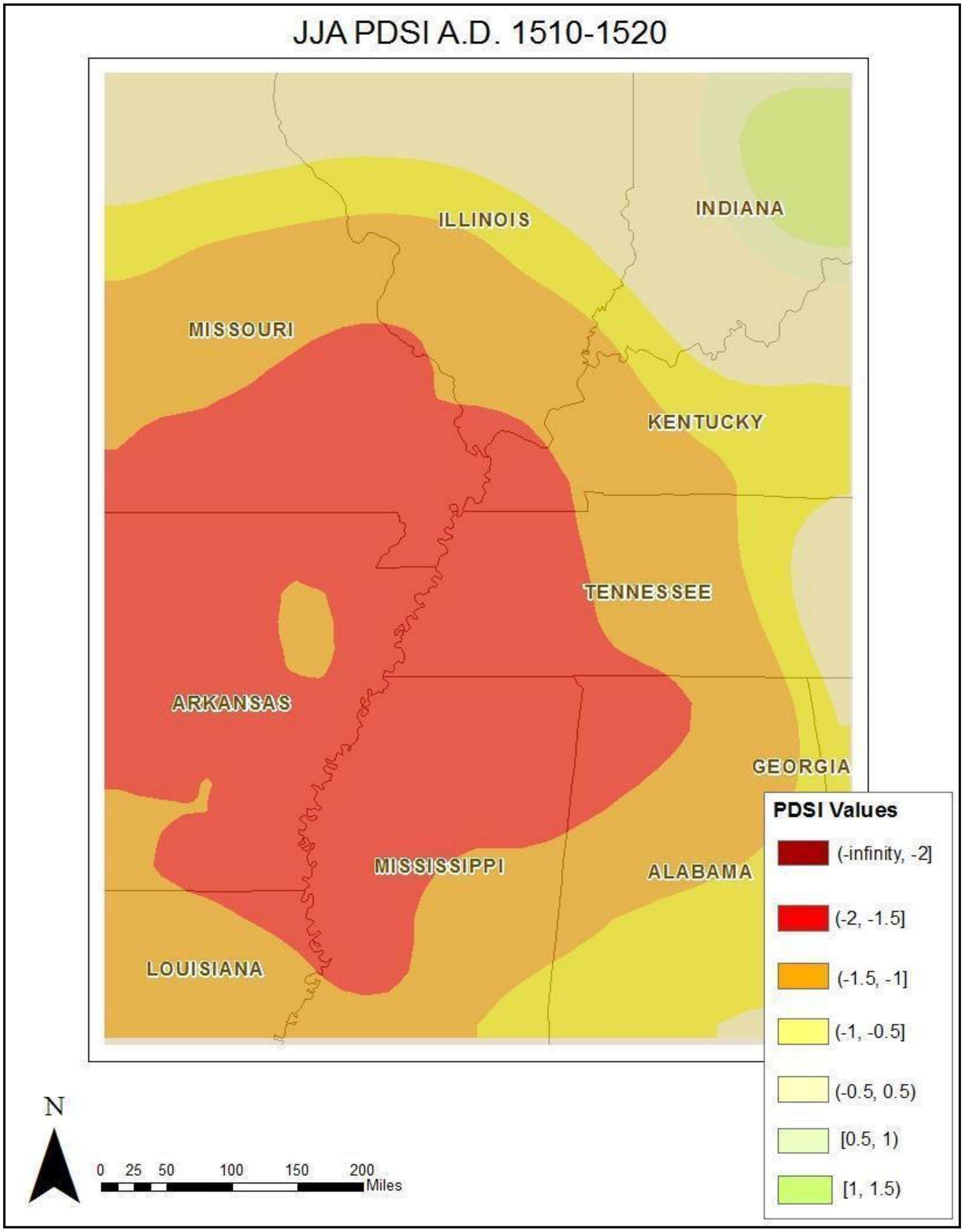


Figure 30. Map of Values for JJA PDSI 1510-1520 A.D. (North American Drought Atlas, 2017).

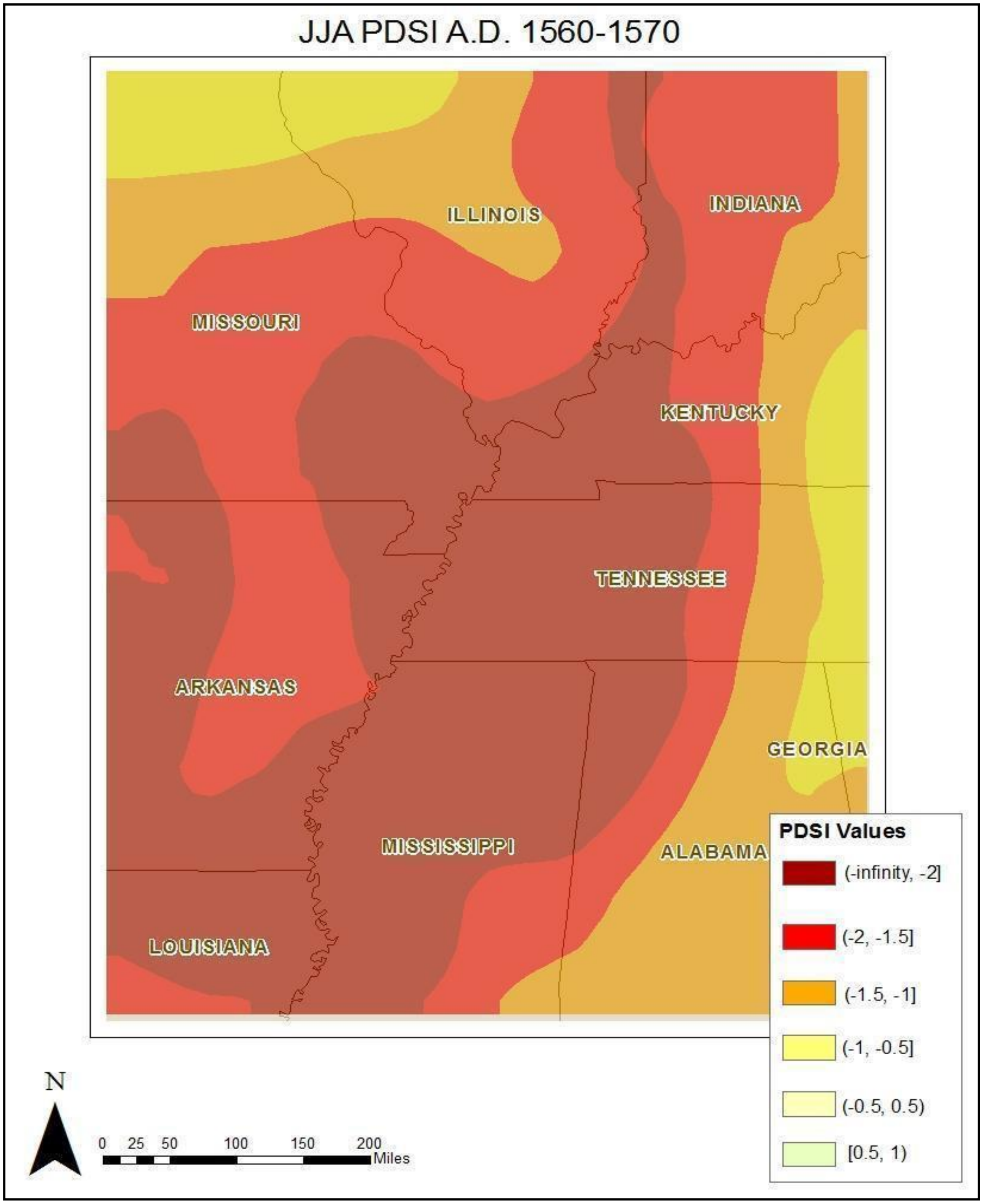


Figure 31. Map of Values for JJA PDSI 1560-1570 A.D. (North American Drought Atlas, 2017).

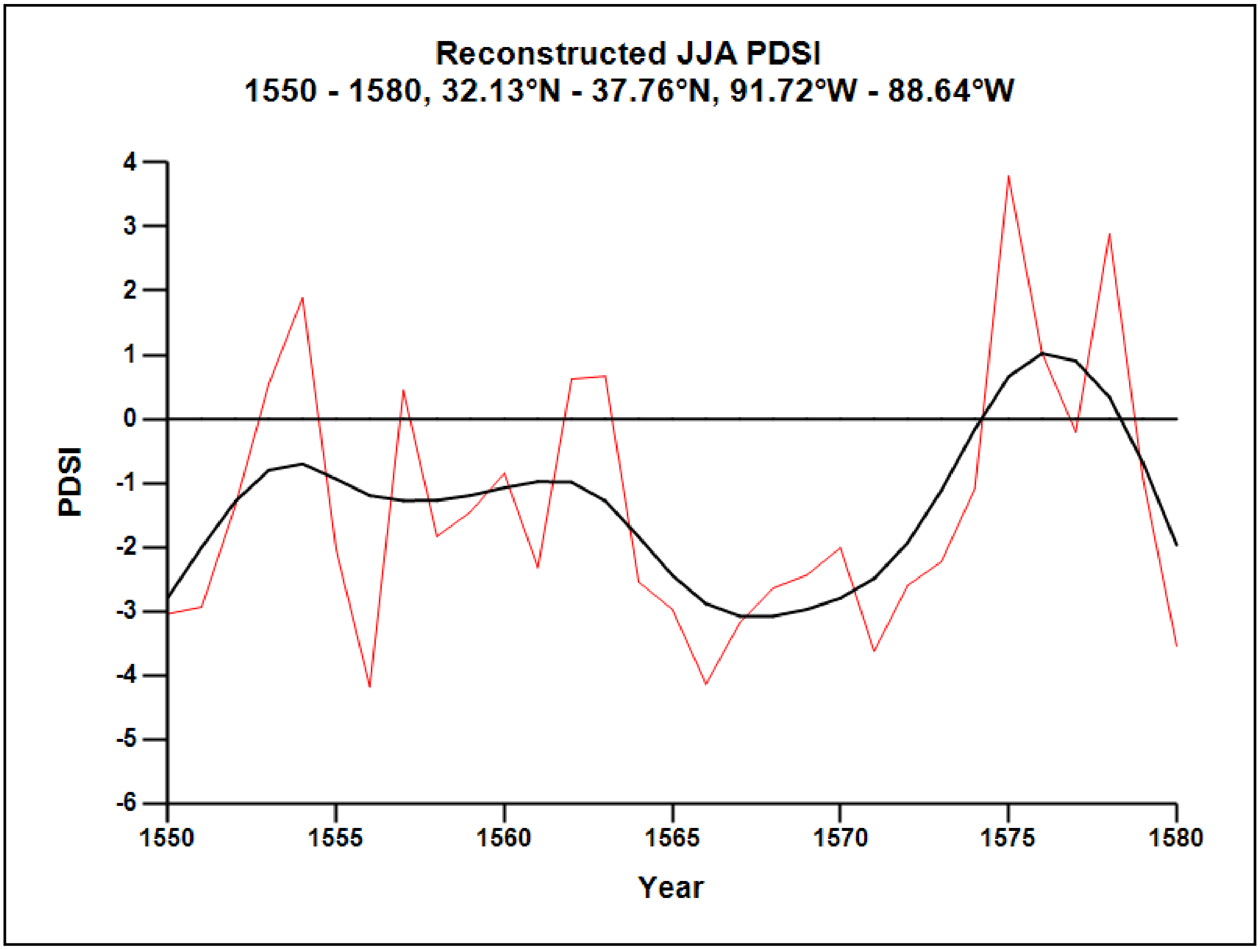


Figure 32. Time Series for JJA PDSI Values from 1550-1580 A.D. (North American Drought Atlas, 2017).

5. Discussion and Conclusions

The results of research on the CMV settlement and climate trends indicate (1) the CMV experienced waves of settlement radiation out of the Mississippi River Valley into the surrounding upland and aggregation of populations in the river valley over time, and (2) that both the Middle Mississippian and Late Mississippian periods experienced widespread and long-term drought events. The Middle Mississippian period drought events spanned 75 years in total, the most severe of which lasted the decade of 1380-1390 A.D. with negative PDSI values up to and exceeding -2, as well as covering the majority of the CMV. The Late Mississippian period droughts were most severe from 1450-1460 A.D. and 1560-1570 A.D., in which both exhibited PDSI values up to and exceeding -2. The drought event from 1450-1460 A.D. covered the largest expanse of the study region and periphery areas seen within the studied time frame of 900-1600 A.D. Given the results of this study, the hypotheses from Chapter 1 may now be evaluated.

Settlement Distributions and Drought

The following section will evaluate the observed data and discuss the hypotheses from Chapter 1. The first set of hypotheses addresses settlement distributions with respect to modeling and drought conditions through time across the Central Mississippi River Valley. The null hypothesis states data or methodology is insufficient in determining a relationship between climate change (i.e. drought conditions) and inferred impacts on Mississippian settlement patterns in the CMV. Spatio-temporal shifts in the distributions of sites in the CMV indicates a sequence of initial expansion (900-1200 A.D.), followed by abandonment (1200-1400 A.D.), culminating in population aggregation at the larger sites in the Mississippi River Valley (1400-1600 A.D.). Additionally, the data used through the North American Drought Atlas provided substantial evidence for drought within the CMV during the Mississippian Period, specifically during periods of settlement change. Hypothesis H_1 states there is no evidence for drought or shifts in settlement patterns. Hypothesis H_1 is refuted by changes of settlement locations within the Mississippi River Valley as well as evidence of droughts throughout the Middle Mississippian and Late Mississippian periods. H_2 states there is evidence of drought but none for settlement change. Hypothesis H_2 is also refuted by the evidence for settlement change throughout the Mississippian Period. The data asserts there are significant changes in preferred site location following the Early Mississippian Period and after the Middle Mississippian Period. Further collection of radiocarbon dates throughout the region will provide additional evidence and likely more clear definitions of settlement change over the Mississippian Period. Hypothesis H_3 states changes in settlement patterns do not correlate with shifts in climate. While the data does not provide significant evidence for the connection between settlement change and shifts in climate, hypothesis H_3 is refuted with minimal inference for movements out of the upland tributaries following long-term drought events as well as aggregation of settlements near the Mississippi River after and during extreme drought. For example, after the droughts in the mid-late 13th century there is a clear abandonment of large town centers in upland Tennessee. Hypothesis H_4 states there is a high-probability that drought led to shifts in settlement patterns during ca. A.D. 900-1600. Hypothesis H_4 is also supported by the several drought events in the CMV throughout the Mississippian Period and the following shifts in settlement distributions seen after the Middle Mississippian Period and during the Late Mississippian Period. Furthermore, evidence from previous studies (Cobb and Butler 2002; Meeks and Anderson

2013) infer a change in settlement in the regions surrounding Cahokia and the Vacant Quarter after a series of drought events in the early Middle Mississippian Period. It is likely, considering the data showing shifts in settlement patterns in the CMV, that the same droughts had similar effects in the study region.

The CMV and the Vacant Quarter

The second set of hypotheses addresses correlations between the Central Mississippi River Valley and the Vacant Quarter. The null hypothesis states the data or methodology is insufficient to determine a connection in settlement reorganization between the CMV and the Vacant Quarter. The null hypothesis is refuted due to evidence of both regions experiencing a change in settlement reorganization. Hypothesis H_1 states there is no evidence for a correlation in settlement reorganization or drought in the CMV and the Vacant Quarter. Hypothesis H_1 is refuted due to the obvious connection of drought and a change in settlement pattern between the two regions. Almost all drought events analyzed covers both regions, indicating there is a connection between the Vacant Quarter and the CMV through periods of drought. Hypothesis H_2 states there is evidence that the CMV experienced similar drought and settlement reorganization seen in the Vacant Quarter. Hypothesis H_2 is refuted due to dissimilar settlement reorganization between the two regions. While the differences in the observed settlement pattern between the two regions could be related to the data or methodology of this research, the data indicates that while the Vacant Quarter was abandoned within the major river floodplains and the hinterlands, the same cannot be said for the CMV as there persists many sites along the Mississippi River during the Late Mississippian Period. While there is an abundance of drought data to support Hypothesis H_2, it must be refuted due to the lack of adequate radiocarbon dates for settlement patterns. Hypothesis H_3 states there is evidence that the CMV experienced drought, but it is not similar to the pattern seen in the Vacant Quarter. Hypothesis H_3 is not validated due to the inclusive drought events over the regions. Hypothesis H_4 states there is evidence that the CMV experienced settlement reorganization, but it is not similar to that found in the Vacant Quarter. Again, while the data may have skewed the settlement pattern results, it displays that the population reorganization occurred in both regions but in a dissimilar fashion. Therefore, the final hypothesis H_4 is accepted.

Conclusions

This thesis examined the potential relationship between climate change (drought) and diachronic shifts in Mississippian settlement patterns utilizing a set of dated sites for the region in comparison to spatially modelled droughts using PDSI data. The data supports the idea that drought existed in the CMV and its Vacant Quarter region. Providing evidence of drought in these regions allowed for the analysis of settlement patterns and cultural behaviors in the context of climate change and town sustainability. The data also supports that site location was likely influenced in part by climate change and consequently resource availability. The data shows a change in site preference from upland tributaries in the Middle Mississippian period back to the Mississippi River floodplain in the Late Mississippian period. Whether this change shows a movement of populations into the Mississippi River valley or an aggregation of populations in the area, it is uncertain. It is most likely that Middle Mississippian period towns in the CMV that experienced severe, consistent drought remained in the area but may have reverted to hamlet style, familial farmsteads. Without persistent, average moisture and temperature regimes, populations would not have been able to sustain crops, particularly maize, and maintain their town-sized population especially in the upland with loess soils. Furthermore, with diminished food reserves and harvests, it would be difficult to ward off any potential attacks from neighboring towns that experienced similar climate related struggles, increasing the need to reorganize or move to a more sustainable environment. Additionally, while the CMV experienced drought, regions north and northeast of the CMV often exhibited average PDSI values or even more positive values than that, providing optimal moisture and temperature regimes for crop cultivation (e.g. Figures 19, 20, and 23). It is possible that populations moved into these areas as well. However, more research is necessary to determine what happened to these populations. The data also supports that settlement patterns changed in both the CMV and its Vacant Quarter region but that the reorganization was dissimilar. According to Meeks and Anderson (2013), Cobb and Butler (2004), and Williams (1990), the Vacant Quarter region of the CMV experienced full-scale abandonment, including all towns with mounds in the uplands and in the major river floodplains. This settlement change is dissimilar from that observed in the CMV. The CMV shows an abandonment of towns with mounds in the upland tributaries but a persistent occupation of towns within the Mississippi River floodplain and other major river floodplains, such as the St. Francis River. A shift to the Mississippi River floodplains or an aggregation of populations in this area during times of drought would make sense considering the soil types of the floodplains and the uplands. The alluvial floodplains are deep, fertile, and consistently maintained by the river, whereas the loess plains of the upland tributaries are much more drought affected.

Alternatively, it could be possible that for the duration of the Medieval Climate Anomaly, essentially the duration of the Early and Middle Mississippian Periods, that Mississippian populations became accustomed to the volatile drought conditions. They adapted to the stress of uncertain water resources with a structured socio-economic-ideological system that sustained them during these instances of drought and consistent catching up following the drought. While the Little Ice Age had its own cases of drought, it is possible that the cooler and wetter climate of this overarching anomaly may have fractured this sustained cultural drought system, so that in periods of wet and cool climate the culture has no mechanisms to deal with the new conditions.

Future Research

In addition to the aforementioned future research, looking into the food storage capabilities of sites affected by drought through paleobotanical analyses would provide further insight into the perseverance of these sites. Comparing these results with those of sites unaffected by drought events will additionally contribute to our understanding of Mississippian diet, storage capabilities, and their tipping point into collapse. It would also be interesting to look at the drought resistance of 8-row, 10-row, and 12-row corn, as these species were rotated in the Mississippian garden. Future research into the soil types over the whole of the CMV may also provide insight into the preferences of settlement locations and whether or not soil was also a factor in crop yields at certain sites.

Future Data Initiatives

The most difficult facet of this research was finding proper radiocarbon dates with matching site coordinates. While a literature review and access to State Historic Preservation records provided sufficient data for this study, it was a process that took years. The Digital Index of North American Archaeology (DINAA) is a relatively new, completely free, open source archaeological site database that works to alleviate this issue and contribute to future research in North America. With more SHPO data access and the addition of further specified time definitions for site areas, this project could revolutionize future archaeological research. DINAA allows the user to download their created data into shapefiles that can be manipulated in GIS. Explaining Mississippian settlement distributions would be far better with this technology and greater accessibility to data.

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Appendix: Mississippian Site Data

Site	Early Date	Middle Date	Late Date	Site #	Source
Adams	900 +/- 70	820 +/- 70	610 +/- 70		Kreisa, Paul 1998 Changing CMV ed. Obrien, Dunnell
Ames	950 +/- 30	670 +/- 30		40FY7	Guidry, Hannah Thesis pg.40
Banks	875 +/- 150		425 +/- 75	3CT13	Archaeology of the CMV, Morse & Morse 1990
Beck Plantation			450 +/- 60	3CT8	Arkansas SHPO
Belle Meade			460 +/- 40	3CT30	Arkansas SHPO
County Line		1325	1511		Prehistory of Missouri, O'Brien and Wood 1998
Cox			370 +/- 30	3LA18	Arkansas SHPO
Crenshaw	1050 +/- 70	890 +/- 50		3MI6	Arkansas SHPO
Denmark		710 +/- 30		40OB4	Hadley, Scott Thesis pg.40
Graves Lake		520 +/- 60	320 +/- 50	40LA92	Mainfort, Moore 1998 Changing CMV Obrien, Dunnell
Hazel		1084	1186	3PO6	Morse & Morse 1983 CMV pg.247
Hollywood		570 +/- 100	490 +/- 70	22TU500	Mississippi SHPO
Jonathan Creek	800 +/- 40				Hadley, Scott Thesis pg.40
Kent		600 +/- 115	310 +/- 90	3LE8	House, John 1993 SEA 12(1):21-32

Site	Early	Middle	Late	Site #	Source
Lilbourn	950	1240	1450	23NM38	Chapman, Carl 1980 Missouri pg 272
Mangrum	930 +/- 60			3CG636	Teltser, Patrice 1992 SEA 11(1):14-30
Moon	870 +/- 60	730 +/- 50	600 +/- 50	3PO488	Benn, David 1998 Changing Obrien,Dunnell pg.231
Obion	1044			40HY14	Morse & Morse 1990 Emergent Mississippian, Bruce Smith pg.153-174
Owl Creek	900 +/- 80			22CS50	Hadley, Scott Thesis pg.40
Parkin	800 +/- 80	460 +/- 80	350 +/- 60	3CS29	Arkansas SHPO
Pinson	820 +/- 120			40MD1	Hadley, Scott Thesis pg.52
Powers Fort		1290	1410		Missouri SHPO
Priestly	990 +/- 60	760 +/- 60	290 +/- 50	3PO490	Arkansas SHPO
Richardson’s Landing		530+/- 70	460 +/- 60	40TP2	Mainfort, Moore 1998 Changing CMV Obrien, Dunnell
Rowlandtown			540 +/- 70		Kreisa, Paul 1998 Changing CMV ed. Obrien, Dunnell
Snodgrass	1140	1390	1450	23BU21	Chapman, Carl 1980 Missouri pg 272
Twin Mounds	770 +/- 70	630 +/- 70			Kreisa, Paul 1998 Changing CMV ed. Obrien, Dunnell
Wickliffe	953 +/- 70	670 +/- 80	550 +/- 60	15BA4	Kreisa, Paul 1998 Changing CMV ed. Obrien, Dunnell
Zebree	938 +/- 55			3MS20	Teltser, Patrice 1992 SEA 11(1):14-30