CONSILIENCE: RADIOCARBON, INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS, AND LITIGATION IN THE ANCESTRAL CADDO REGION

A Dissertation

by

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ABSTRACT

Through the creation and analysis of databases for radiocarbon, instrumental neutron activation analysis (INAA), and law, macro-level trends are exposed that form the framework of a broader research program aimed at advancing ideas of craft specialization and archaeological theory in the ancestral Caddo region of Southwest Arkansas, Northwest Louisiana, Northeast Texas, and Southeast Oklahoma. The findings of this investigation illustrate the research potential that remains buried within the context of cultural resource management (CRM) reports and legal databases (Westlaw and LexisNexis) that is awaiting consumption within regional research designs aimed at exploring the nuances and trends that appear through synthetic research.

While more can—and should—be done to exploit these resources, this endeavor represents the first logical step toward a more general comprehension of Woodland and Caddo occupations in the region. As a testament to those projects that generated these data, the findings herein are representative of decades of work by numerous academic institutions, archaeological firms, undergraduate as well as graduate students, and avocational archaeologists alike; all of which have and continue to contribute to a more synthetic and dynamic understanding of the things, peoples, and cultures that lie underfoot.

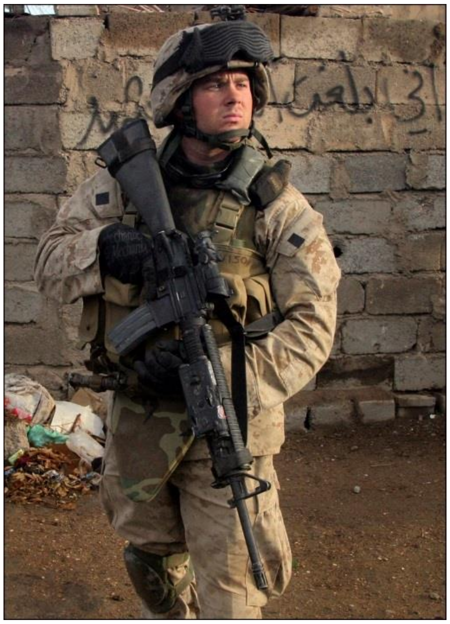
DEDICATION

For Sergeant Byron W. Norwood

Words cannot describe the heartache of losing your best friend. Byron, yours remains the most difficult funeral that I have attended, but getting to see your family at the subsequent State of the Union address was powerful. I still cannot believe that they named the Pflugerville Post Office after you.

Your memory was the driving force behind this endeavor; through all of the late and sleepless nights, the gallons of caffeine, and the incredible silence after all that we went through. When I was tired, you kept me awake. When I faltered, you stood me up. And when I lost motivation, your memory prodded me on and continues to do so.

You were the toughest, funniest, and most fearless Marine that I had the pleasure of serving with. Thank you for the memories Byron; I could not have done this without you. *Semper Fidelis.*



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Finally, the patience and support of my wife during this two and one half year absence was no less than incredible. I'm coming home Lauren. I love you.

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CHAPTER I

INTRODUCTION TO THE VOLUME

> We must never forget that human motives are generally far more complicated than we are apt to suppose, and that we can very rarely accurately describe the motives of another (Dostoyevsky 2004 [1869]: 303).

This dissertation represents a synthetic approach to data collected from cultural resource management (CRM), as well as academic and legal (Westlaw and LexisNexis) domains, and it is focused upon extending the scope of discussions aimed at temporal contemporaneity, trade and exchange, and litigation in the ancestral Caddo territory. With the availability of information garnered from data recovery, testing, and survey projects conducted across the Caddo area, these archaeological data sets are rich in research potential. The investigations presented in Chapters 2-5 are a testament to the variety of prospective topics that can be addressed with these data. The motivation for undertaking these endeavors is to create a foundation from which to begin addressing other topics of concern regarding the Caddo archaeological record, such as the temporal contemporaneity of Caddo sites by type (mound center, settlement, cemetery) within and across East Texas river basins, as well as a reanalysis of the Caddo instrumental neutron activation analysis (INAA) dataset at the landscape level due to misgivings concerning the current interpretation of those data. Building atop this foundation for future Caddo archaeological research inquiries is discussed more fully in the concluding chapter of this dissertation.

Introduction

The Caddo inhabited areas of what are today Arkansas, Louisiana, Oklahoma, and Texas (Figure 1.1) from ca. A.D. 800/850-1838 (Perttula 2012), and were horticulturalists that successfully became agricultural peoples, with a particular focus on maize cultivation (Perttula 2012; Wilson 2012). Their ancestral predecessors were various Woodland period communities that developed between ca. 500 B.C. and A.D. 800. Caddo communities and separate population groups may have first emerged within two areas: the Great Bend of the Red River in southwestern Arkansas and northwest Louisiana, and the other concentrated in the Arkansas River basin in Eastern Oklahoma (Story 1981:148-149). However, other important communities developed early on in East Texas and in the Ouachita River basin in southwest Arkansas, and there may be no "centers" of early cultural emergence.

Archaeological Evidence

While elements of Caddo life share many similarities with the Southeastern Mississippian cultures, cultural developments in the Caddo region do not appear to have developed in concert with their Mississippian counterparts (see Blitz 2010; Livingood 2008). This had led archaeologists to consider Caddo developments as an expression of local and regional processes linked temporally and culturally to the preceding Woodland period (Perttula 2009, 2012) and to interactions between different Caddo groups.

Initial attempts at delineating the temporal and spatial dynamics of Caddo groups and subgroups employed the use of distinctive ceramic styles and mortuary/mound associations of different ceramic types to identify groups of sites with similar artifact assemblages (see Harrington 1920; Krieger 1947; Newell and Krieger 1949). Based upon the Midwestern Taxonomic System (MTS) (McKern 1939), Krieger used information from Caddo sites in concert with stratigraphic data from the Red and Neches River basins to produce the first systematic synthesis of the Caddo area (Perttula 1992) (Figure 1.2).

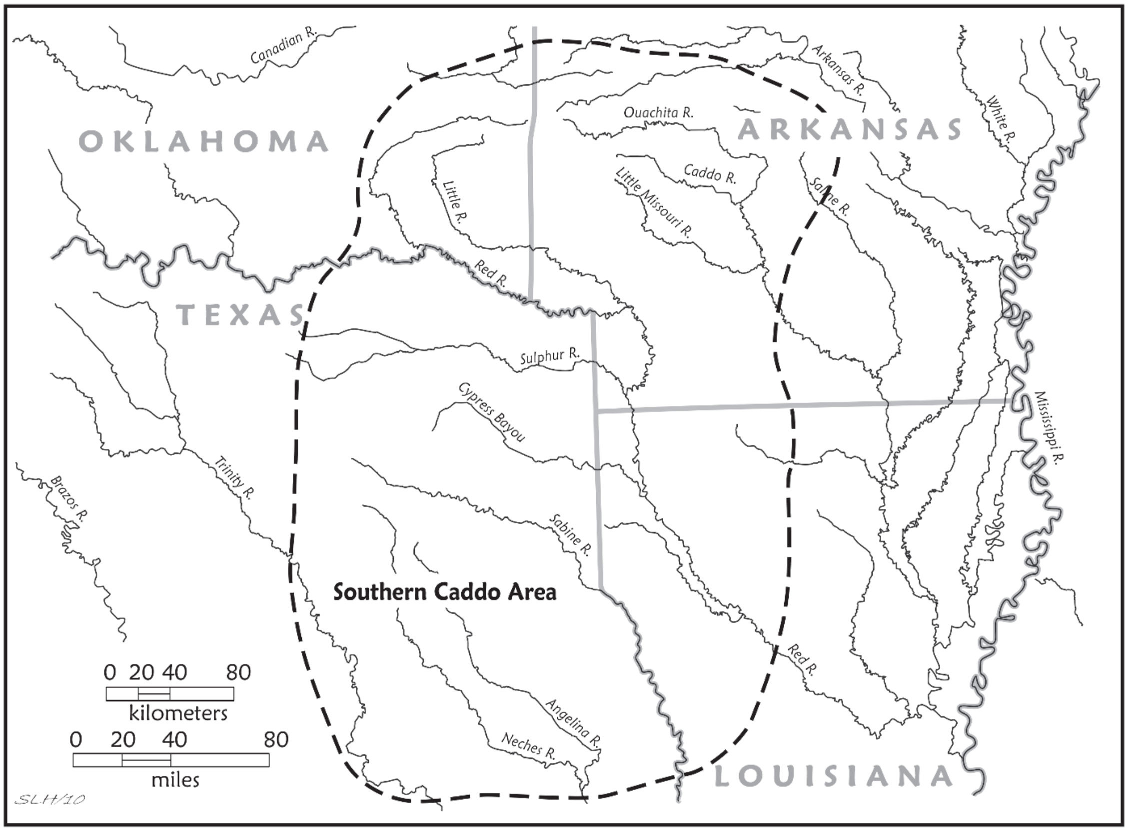

Figure 1.1. Map of the Southern Caddo Area.

Itself a hierarchically-nested typology, the MTS uses—as its' most basic element—the *component*, which McKern (1939:30) defines as "the manifestation of any given focus at a specific site." Within the framework of Krieger's efforts, the *component* was employed to substantiate the membership of a site within a larger *focus, aspect, phase,* or *pattern*, linking Caddo sites by diagnostic traits that included stylistic, technological, and functional attributes (e.g., Dunnell 1971; Perttula 1992). Using these initial findings, further affiliations were then explored between known sites.

At its' core, the *component* remains an integral part of modern archaeological endeavors within Caddo archaeology, and phases remain in use, despite rumblings that archaeologists should—instead—be exploring "[t]he actual relations between data points…instead of boxes of our own cryptic creation" (Dunnell 2008:64). Although a valid point, there remain numerous geographic areas within the Caddo area that lack the data needed to pursue this manner of exploration currently (Perttula 2012).

Among the best examples of modern comparative analyses in Caddo archaeology employing a similar methodological approach is that of the Pine Tree Mound site (Fields and Gadus 2012). Using the bulk of modern analytical techniques, Fields and Gadus (2012) produced data sets for attributes and iconography, INAA, and petrography to explore ceramic variation; analysis of attributes, metric data, and LA-ICP-MS to explore lithic variation; petrology and geochemistry of ear spools and pigments; as well as radiocarbon, macrobotanical, geophysical, and osteological data sets. Using this amalgam of archaeological evidence, Fields and Gadus (2012) identified the Pine Tree Mound site as contemporaneous with the Titus phase using radiocarbon data (Figure 1.3). They were also able to infer interaction with Titus phase communities based upon geography, as well as attribute and INAA ceramic data—identifying similarities even at the sherd level—and noting that the percentages of Ripley vessels/sherds recovered from mortuary contexts at

Pine Tree Mound (40%) were similar to those from the Mockingbird (42%) and Tuck Carpenter (54%) cemetery sites, and that a number of the decorative motifs occurring at Tuck Carpenter were also present at Pine Tree Mound. Fields and Gadus (2012:661) see these elements to be suggestive of "distinct, though related, groups."

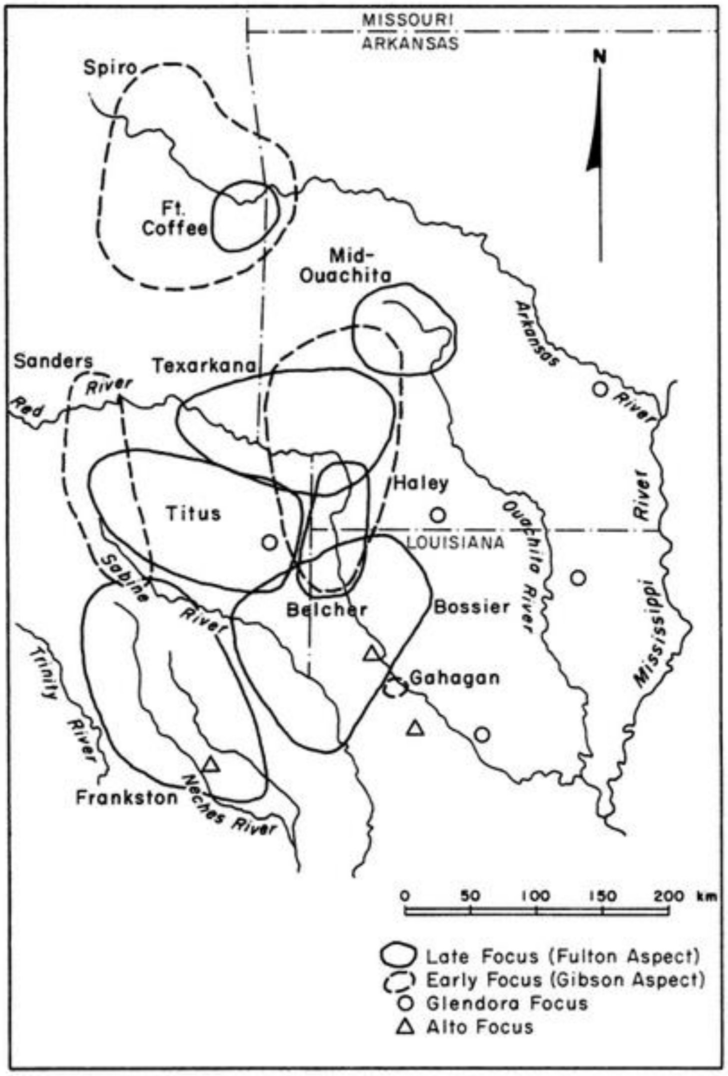

Figure 1.2. Distribution of Gibson and Fulton aspect foci defined by Krieger (1946). The triangles and circles represent individual components of the Alto and Glendora foci. Neither focus had a realistic spatial distribution when it was initially defined (Perttula 1992: Figure 9).

Through employing a hybrid of the century-old theoretical construct posited by Kroeber (1907), the *culture area*—a geographic region with relatively homogenous human activity or complex of activities—remains of substantive import within the framework of Caddo archaeology. In the context of exploring the material culture of the Caddo, Kroeber's *culture area* is augmented by both *culture history* and *processualism* to posit the temporal and spatial dynamics of Caddo sites via the totality of the archaeological assemblage (to include geoarchaeological, stratigraphic, and geographic contexts). It is from this theoretical baseline that discussions of inter-polity interaction (i.e., Fields and Gadus 2012) and commerce (see Appendix B) can, and are, being furthered.

The research presented in this dissertation is consistent with this theoretical archetype, and provides a novel method of exploring archaeological contemporaneity via radiocarbon, while also positing a landscape-level approach to the analysis of INAA. New methods of synthesizing large data sets will—no doubt—continue to increase in both size and research potential, and their interpretation owes much to the forerunners of Caddo archaeology who strove to make sense of the complex material culture that represents our ever-expanding intellectual toolkit. Through their guidance and ingenuity, we continue to progress toward increasingly substantive interpretations as we endeavor to refine and reshape current theoretical constructs aimed at comprehending the complexities and nuances in the material culture of the ancestral Caddo.

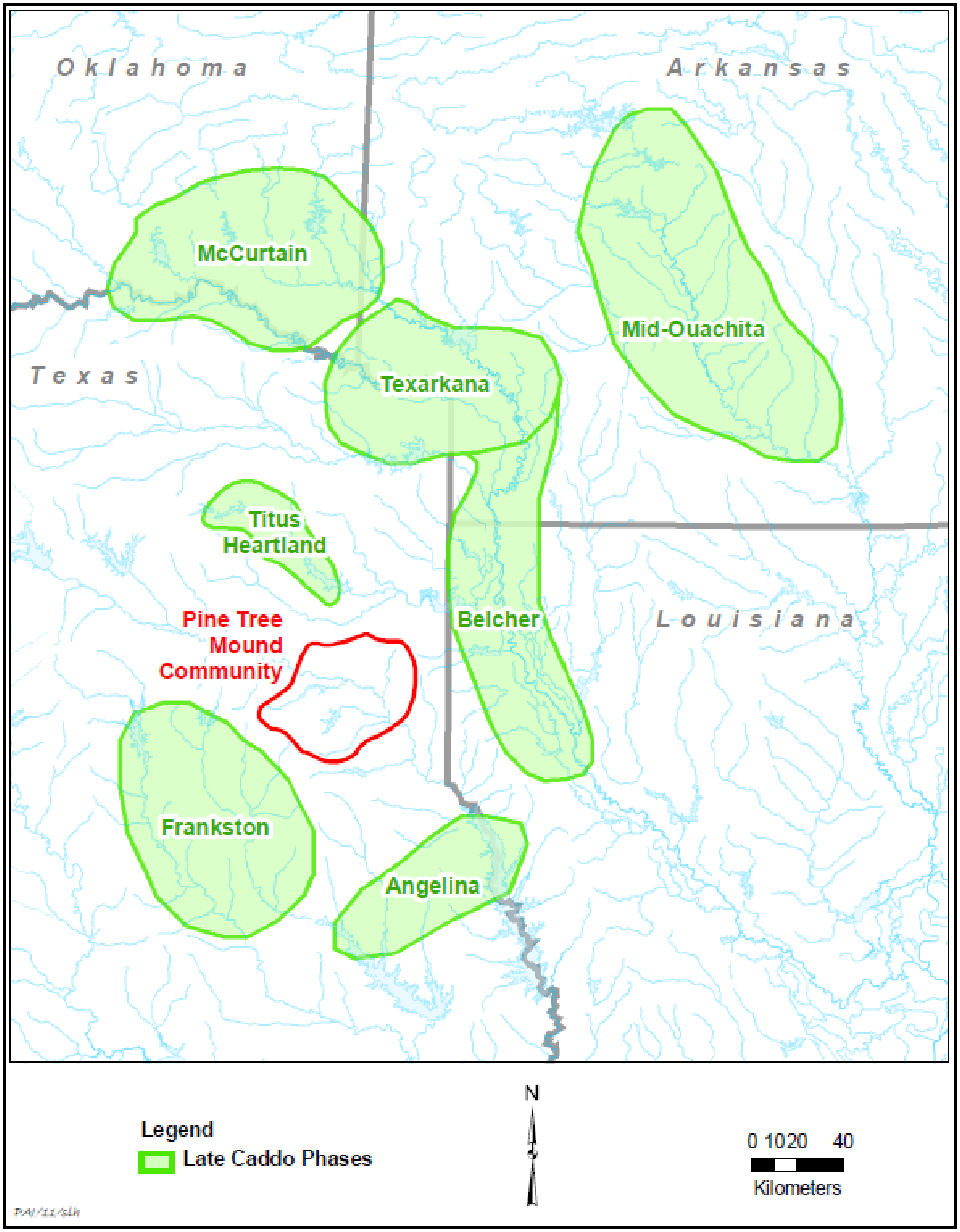

Figure 1.3. Map showing the location of the Pine Tree Mound community relative to the Late Caddo Belcher, Texarkana, McCurtain, Mid-Ouachita, Frankston, Angelina, and Titus (heartland only) phases (Fields and Gadus 2012: Figure 9.11).

Ethnohistorical Evidence

The Caddo were the most culturally complex aboriginal peoples living in the Trans-Mississippi South (e.g., Schambach 1988) at the time of European contact. They used fire to clear new and old fields, employing buffalo shoulder blades or wooden hoes, and cultivated five or six varieties of beans, squash, sunflower seed, corn, and tobacco, which were raised in abundance in all but the infrequent drought years. They were very successful agriculturalists, and supplied enough food to support an increasingly dense sedentary population at, and during, the contact period (Figure 1.4).

Caddo trade networks extended from Cahokia in the north (Smith 2005; Foster 2008), to the Pueblo villages of New Mexico in the west (Smith 2005), to the Acansa and Taensa Indians on the Mississippi and Arkansas rivers to the east (Foster 2008). Manufacturers of such sought-after items as bows constructed of Osage-orange (bois d'arc), decorated fine ware pottery, salt (LaVere 1998; Perttula 1992; Swanton 1996), and food products, the Caddo were able to place themselves comfortably within local and extended trade networks (Smith 2005).

Surplus food helped contribute to the Caddo's development of a sophisticated and well-defined hierarchy of political and religious systems governed by a hereditary elite (Smith 2005). The *caddi* exercised control at the individual tribal level, while the *xinesi* led a religious community consisting of several populations (Smith 2005). The *caddi* presided over a "well-defined chain of command," and were aided in their efforts by *canahas*, their principal aides, who were—in turn—aided by their assistants, known as *chayas* (Smith 1995:10).

Sedentary life was found to be fruitful for the Caddo, but it was also detrimental once Europeans entered the area, as epidemic diseases (smallpox, measles, plague, diphtheria, whooping cough, trachoma, and influenza [see Ewers 1973]) swept through the region, decimating large numbers of Caddo—an estimated 75% between 1687 and 1790 (Perttula 2001)—during the contact period (Foster 2008; LaVere 2004; Perttula 1992; Smith 1995, 1996, 2005). Within the Caddo area of Texas alone, eight epidemic event occurred between 1691 and 1816; equating to one every 15.6 years (Perttula 1992). The result of this was high sub-adult mortality; and for those individuals with no immunity—in this case children and young adolescents—a significant decrease in the population growth potential that might have been achieved (Perttula 1992).

Foster (2008:211-214) and Perttula (2001:81) identify (by name) a catalog of allies and the enemies of the Caddo during the contact period. Of Caddo enemies, the Osage were among the most feared during the contact period (Foster 2008), and in an effort to bolster their numbers against these enemies, the Caddo welcomed emigrant natives as allies to aid in their fights against the Osage (Smith 1995). Among the emigrants were growing numbers of Cherokee, who would eventually begin to lead war parties against the Osage. However, as the number of foreign emigrants increased—of the Cherokee in particular—the position of the Caddo groups became threatened, causing an increase in tension between the tribes (Smith 1995).

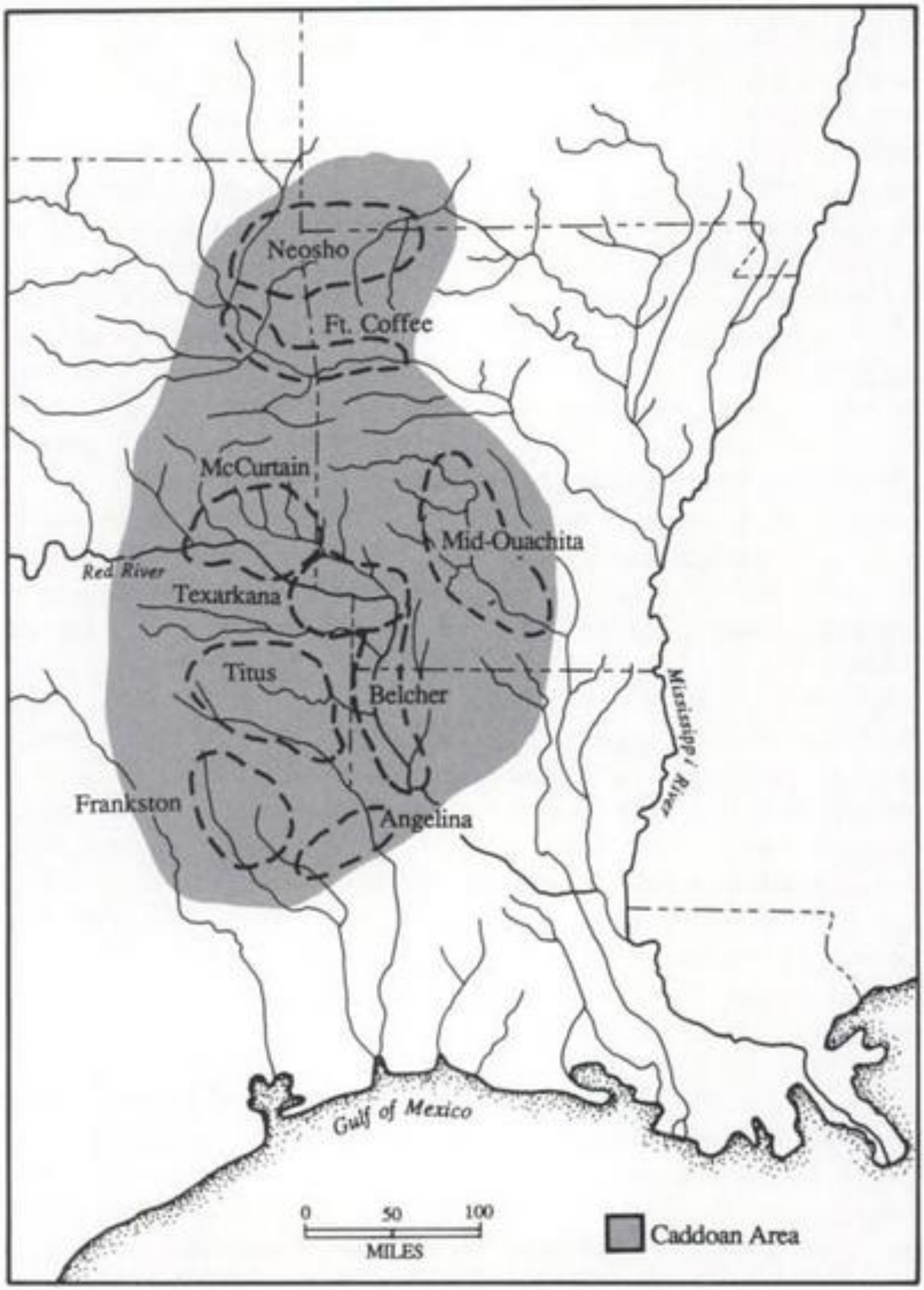

Figure 1.4. Distribution of Caddoan phases at initial contact with Europeans ca. 1520 (Perttula 1992: Figure 10).

The Caddo, along with other cultures that were largely agricultural, had matrilineal—rather than patrilineal—descent patterns; the latter was more prevalent in hunter-gatherer societies (LaVere 2004). While this approach to kinship organization was logical within the minds of the Caddo, it posed a rather significant cultural challenge for the Spanish, whom—upon their initial dealings—offended the Caddo greatly (Barr 2007). Although the Spanish would eventually return, they would never quite grasp the cultural nuances that the French had seemingly benefitted from (Barr 2007). The Caddo would continue in a position of power within the region until—during the Historic Caddo period (ca. 1680-1860+)—the imposition of other tribes, displaced by Andrew Jackson's Indian Removal Act, and the influx of American settlers, would drive the Caddo from their traditional territory in 1838, then onto the Brazos Reserve in 1854, and then to Oklahoma in 1859 (LaVere 2004; Smith 1995, 1996, 2005).

Research Approaches for Caddo Archaeology

In beginning a discussion of the theoretical underpinnings in the archaeological study of the Caddo region, chronology is an element of considerable import, providing evidence that underscores *when* and *where* different events occurred. These data can be useful within a variety of discussions ranging from Caddo origins (Girard 2009; Perttula 2009; Schambach 1998) and demographics (e.g., Surovell and Brantingham 2007; Surovell et al. 2009) to trade and exchange. This is aided by the delineation of sites that contain evidence for components that may be archaeologically contemporary.

Within the context of such investigations, much of the data necessary to begin this discussion is available, just not properly organized and synthesized. I accomplish that in this dissertation by identifying sites with occupational episodes (of a particular age and/or phase affiliation) that are archaeologically contemporary based upon radiocarbon dating measures.

Upon the identification of archaeological components from a series of sites that appear to have been inhabited simultaneously, efforts can then be made to identify specific occupational episodes within those sites by using multiple sources of data (radiocarbon, ceramics, lithics, etc.). Using such multi-scalar approaches, Caddo archaeologists can then engage in a meaningful dialogue regarding the networks that existed between groups (e.g., Allen et al. 1997; Brumfield and Earle 1987; Janetski 2002; Orton et al. 1983; Parsons and Price 1971), the ceramic economy (including its location, organization, and production) (e.g., Cobb 1993; Costin 1991, 1993, 2001, 2005, 2007; Earle 1982; Mills and Crown 1995; Rice 1987), technological and functional attributes (volume, firing, and contents) (e.g., Jeske 1992; Rice 1987), identity (regional traditions and regional and inter-regional interactions) (e.g., Costin 1998; Duff 2002), and social organization (Perttula 1992; Perttula and Walker 2012).

Radiocarbon

The initial goal of my work with radiocarbon was intended to address issues of Caddo demography (Surovell and Brantingham 2007; Surovell et al. 2009) across the traditional Caddo landscape, while making an effort to capitalize upon specific geographic occurrences within a temporal period (see Grove 2011). Perttula (1997a, 1997b) had assembled the majority of these data within the framework of previous endeavors, and thus the scope of that undertaking was manageable.

In archaeology, there is a lengthy history of manipulating dates or dated components, and some have interpreted those dates as representative of changes in human demographic trends based on "the simple and reasonable assumption that as the number of people increases, so does the strength of their archaeological signal" (Surovell and Brantingham 2007:1868). In their recent work, Surovell and Brantingham (2007) argue that caution should be used when employing summed probability distributions to infer demographic trends, to which Surovell et al. (2009) offer a formula to decrease the amount of bias introduced by sampling error. As an alternative, Peros et al. (2010) suggest the use of binning to look more closely at demographic trends within a more rigid and compartmentalized approach. Steele (2010) uses radiocarbon as a quantitative strategy to estimate the speed of a colonizing front along with their densities, and while it is a novel application of extracting meaningful data from radiocarbon trends, it was thrown into question by Buchanan et al. (2011). However, Buchanan et al. (2011) do not refute the usefulness of employing summed probability distributions for studies of Paleoindian demography; in fact, they use it themselves to explore Paleoindian demography to investigate the extraterrestrial impact hypothesis (Buchanan et al. 2008). While seemingly useful, this method of extracting demographic data does come with substantive warnings, particularly regarding the inclusion of additional data within the framework of this type of research question (Bamforth and Grund 2012; Surovell and Brantingham 2007).

While employing radiocarbon dates as data is not a novel endeavor (see Rick 1987), the magnitude of questions that are being asking of these data has increased dramatically. Many of these arguments appear logically sound, since the "when" and "where" components of archaeological research can have a fairly profound influence on the interpretation of archaeologically-recovered datasets. Examples of this can be seen in more macro-level analyses, like Kuzmin and Keates (2005), who were able to delineate Paleolithic settlement patterns in Siberia from radiocarbon dates, and in a more novel application of radiocarbon data and statistics, Grove (2008, 2009, 2011:1012) has developed a method he dubbed the "spatio-temporal kernel method," illustrating the variability of "prehistoric" land-use patterns temporally to identify active and inactive sites that were occupied contemporaneously.

My research arose out of concerns that Williams (2012) raised on the method of employing summed probability distributions in archaeology, and the bias that is often introduced by sites with large catalogs of dates that are geographically adjacent to sites with relatively few dates. Within that framework, Williams (personal communication, 2012) has often had to explain away peaks in his datasets "due to an overzealous archaeologist dating the same site umpteen times." After a fair amount of reading and learning how to use OxCal, date combination appears to be the appropriate chronological method to use to approach an understanding of time in Caddo archaeology.

The date combination process assumes that if all assays collected at a particular site draw carbon from the same reservoir, they should have the same underlying $F^{14}C$ value and can be combined prior to calibration (Bronk Ramsey 2008). The measurements have Gaussian uncertainty distributions, and X^2 can be used to test the assumption that all rations are the same to reveal whether compelling evidence exists—at the 95% confidence level—that dates cannot be related to the same event (Bronk Ramsey 2008).

One aspect of radiocarbon research that ought to be of considerable interest within Caddo archaeology is Bayesian analyses (Bayliss 2009; Bronk Ramsey 2009). Despite the claim that statistics commonly produce "instant mental paralysis in many otherwise competent archaeologists" (Fletcher and Lock 1991:viii), the potential return on the time invested to learn and employ the method is substantial. While Bayesian models are more often used within the chronological component of geomorphological models of river terrace development (see Chiverrell et al. 2008), Bayesian archaeological models have been used for over 48% of the samples submitted by English Heritage since 1993 (see Bayliss 2009). The chronological control produced by these models offer testable hypotheses (that can be confirmed or refuted by the addition of more radiocarbon dates) that can produce accurate chronologies at a resolution of less than a century (Bayliss 2009), and in some cases less than a decade (Bayliss 2009; Kidder, personal communication 2012).

Instrumental Neutron Activation Analysis

Instrumental Neutron Activation Analysis (INAA) is a technique pioneered by the archaeological chemistry community—although quickly adopted by geologists for lithic analysis—that represents one of a very few examples where the earth sciences adopted a technique from archaeology (Pollard et al. 2007). Using small samples (archaeologically-recovered ceramics in this instance), INAA can—with high precision—measure both very low and very high concentrations of a wide range of elements (Pollard et al. 2007). In endeavoring to explore the ceramic compositional data from East Texas Caddo sites—due to current difficulties with interpretations—the synthesis of these data is important in the broader study of ceramic provenance in the southernmost territory of the Southern Caddo, and this analysis provides a method that can be employed to identify geochemical signatures that may—through more in-depth analyses of specific areas—be linked to geologic groups or formations that occur within and across the different river basins in East Texas.

Correlating the INAA evidence with the bedrock geology of East Texas falls beyond the purview of this dissertation, but that approach is being explored within the framework of current CRM endeavors in this region.

Problems that emerged from this analysis are: (1) the inconsistent application of a calcium correction to either all or a prescribed percentage of the data (dependent upon the analyst), (2) the failure of the defined composition groups to render a reliable result with further sample analyses, and (3) the failure of the currently defined compositional groups to provide results of analytical value at the macro-level. In an effort to combat these problems, this dissertation has focused on the development of a landscape-level approach that illustrates areas of high and low elemental concentrations for each of the 33 rare earth elements identified by INAA, as well as composite groups of elements that have similar spatial trends across the larger traditional Caddo landscape. Furthermore, within that framework, the calcium correction is only applied to the shell and bone-tempered sherds, leaving the *other* (mostly grog) tempered sherds uncorrected since "such correction is unnecessary because the grog itself is made of clay, presumably the same clay that comprises the rest of the paste" (Steponaitis et al. 1996:559).

Law

An important aspect of Caddo archaeology is how it affects, and is affected by, living descendants, and one place where it may be possible to view the effects of this is within the practice of law. Although the Caddo have not pursued litigation for infractions under the current statutes and Executive Orders offering protections to their cultural property (see Cast and Perttula 2002), the Caddo have become more assertive in the protection of cultural resources in ancestral Caddo lands. However, the current federal legal system can be said to hinder the efforts of the Caddo by making it increasingly difficult to gain consistent application and interpretation of cultural resource legislation across the geographic area encompassing their traditional territory (see Figure 1.1).

Although geographically contiguous, the Caddo territory falls within the purview of three Federal Circuit Courts (5th, 8th, and 10th). Within that framework, the Caddo Tribal Historic Preservation Officer would have to travel to (1) New Orleans to assert any challenges within Texas or Louisiana, (2) to St. Louis to assert any challenges within Arkansas or Missouri, or (3) to Denver to assert any challenges within Oklahoma. Add to that equation that the majority of federal judges follow the active precedent for the geographic area (Circuit Court) to which they are assigned, and one begins to see where inconsistencies in the interpretation of legislation can be problematic.

When viewing the deviation from national averages, court cases filed in each of the Circuit Courts illustrate an interesting trend. Of those states now defined atop traditional Caddo territory, only Texas and Louisiana have a litigation record that remains equal to or above the national average. Oklahoma falls below the national average for the Archeological and Historic Preservation Act, National Historic Preservation Act, and the Abandoned Shipwreck Act. Arkansas falls below the national average for the National Historic Preservation Act and the Abandoned Shipwreck Act. Missouri also falls below the national average for the National Historic Preservation Act and the Abandoned Shipwreck Act.

For those statutes found to fall below the national average within the traditional Caddo territory, all are more closely related to the protection of historic preservation (i.e., architecture, landscapes, and shipwrecks) rather than the preservation of archaeological resources. Looking closer in this dissertation, of those statutes addressing shipwrecks, half (National Historic Preservation Act and the Abandoned Shipwreck Act) are predominantly litigated in Circuit Courts along the Eastern Seaboard and the Gulf of Mexico. The remaining statutes—each more closely geared toward the protection of archaeological resources—are more regularly prosecuted in the central and western areas of the U.S. Of the eight statutes, only the Archeological Resources Protection Act and the Native American Graves Protection and Repatriation Act were found to correlate well with archaeologically-related topics, and the principal reason for legal action in those cases was compliance.

Organization of the Volume

The primary goal of this dissertation is to create a foundation for a continuing research program employing radiocarbon (^{14}C) and INAA data and results from Cultural Resources Management (CRM) projects throughout the East Texas region. As a means of viewing these topics at a regional (^{14}C and INAA) and national (law) scale, databases have been created and made publicly available (see Selden and Bousman 2009; Perttula and Selden 2011) for use within present and future academic or CRM endeavors.

The ^{14}C articles (Chapters 2 and 3) employ OxCal's method of date combination (R_Combine) to reduce the amount of bias introduced by sites with substantial catalogs of dates. This method of analysis has refined the current probability distributions to the extent that individual ranges can be discussed as occupational events. Median Woodland-era dates indicate the probability of three temporal divisions: Early Woodland (500 B.C. – A.D. 0), Middle Woodland (A.D. 0 – 400), and Late Woodland (A.D. 400 – 800), while Caddo-era dates both confirm the current temporal divisions, but highlight the ability to identify occupational episodes within sites. These endeavors provide the initial step toward a better temporal understanding of the temporal and spatial relationships, population dynamics, and general use of the East Texas landscape by ancestral Woodland and Caddo inhabitants.

The INAA article and supporting appendices (Chapter 4 and Appendix A-B) synthesize the Caddo INAA database and supporting literature, and develop geographic representations of five composite chemical groups with similar geographic trends. This is augmented by the element by element results of the INAA analysis (Appendix A), illustrating elemental concentrations geographically, which is supported by a substantive bibliography (Appendix B).

The law article (Chapter 5) clarifies general temporal and spatial trends in federal cultural resources case law. This includes a higher rate of challenges to historic preservation laws (historic resources) nearer the east coast, and a higher rate of archaeological challenges (prehistoric resources) nearer the west coast. This chapter also illustrates the variable application of this legislation across the Caddo landscape (Texas, Louisiana, Arkansas, Oklahoma, and a small part of Missouri).

The volume concludes with a consideration of the broader theoretical framework of Caddo archaeology, as well as future analyses of radiocarbon and INAA databases. Caddo researchers should be able to gainfully utilize these results to enhance applicable theoretical arguments (Chapter 6). The results of this effort hold promise for multiple advances in theoretical, methodological, and practical applications within the Caddo area and abroad, and can be exported to research designs globally to aid in demarcating issues of contemporaneity, provenance, and the legal framework within which most—if not all—

archaeological research is currently conducted.

CHAPTER II

MODELING REGIONAL RADIOCARBON TRENDS: A CASE STUDY FROM THE EAST TEXAS WOODLAND PERIOD*

Overview

The work presented in this chapter was submitted and accepted to *Radiocarbon.* The East Texas Radiocarbon Database contributes to an analysis of tempo and place for Woodland era (ca. 500 B.C. - A.D. 800) archaeological sites within the region. The temporal and spatial distributions of calibrated radiocarbon (^{14}C) ages (n=127) with a standard deviation (ΔT) of 61 from archaeological sites with Woodland components (n=51) are useful in exploring the development and geographical continuity of the peoples in East Texas, and lead to a refinement of our current chronological understanding of the period. While the analysis of the dates produces less than significant findings due to sample size, they are used here to illustrate the method of date combination prior to the production of site and period-specific summed probability distributions. Through the incorporation of this method, the number of ^{14}C dates is reduced to 85 with a ΔT of 54. The resultant data set is then subjected to statistical analyses which conclude with the separation of the East Texas Woodland period into the Early Woodland (ca. 500 B.C. – A.D. 0), Middle Woodland (ca. A.D. 0-400), and Late Woodland (ca. A.D. 400-800) periods.

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Introduction

Archaeologists have a lengthy history of tinkering with the manipulation of ^{14}C data, and have made much progress since first advocating for a more flexible method of processing data through the employment of a punch-card data retrieval system (see Taylor et al. 1968). Through the advent and acceptance of novel methodological approaches, we continue to make significant progress in our understanding and manipulation of regional cultural chronologies (Bamforth and Grund 2012, Bever 2006, Hassan 1984, Wendorf et al. 1979).

Rick's (1987) innovative explanation and subsequent employment of ^{14}C dates as data garnered acceptance and use within studies of occupational patterns and population dynamics (see Kuzmin and Keates 2005), which use the number of occupations—in lieu of the number of ^{14}C dates—as a method to view the spatial and temporal dynamics of human distribution (Straus et al. 2000). To that end, this study includes the assumptions that (1) ^{14}C dates that can be combined via OxCal X-test represent a single occupational episode, (2) the summed probability distribution for archaeological sites with four or more ^{14}C assays illustrates the discrete or diffuse nature of occupational episodes, and (3) median dates represent the age of highest probability within each date range.

Through a variety of academic, avocational, and cultural resource management pursuits, archaeologists have obtained 127 ^{14}C dates from 51 Woodland period sites across East Texas (Tables 1 and 2). The bulk of these dates were collected with the intention of exploring locally-based research questions and are employed here within a discussion of macro-level trends, using a descriptive analysis of the results from date combination, summed probability distributions, and statistics to apprise the subsequent inferences (see

Bernard 2006). While the distribution of recognized Woodland sites (or components) is easily plotted spatially, this paper represents the first attempt to synthesize these combined data and illustrate the temporal relationships that exist between ^{14}C dates collected across the East Texas region over the last 40 years.

The ETRD represents a sizeable sample of dates produced within a relatively small geographic region on the southwestern border of the Woodland culture area. This research refines our current knowledge regarding the temporal complexities within the Woodland period, providing a snapshot of temporal trends extracted from an understudied sample of radiocarbon dates. The temporal and spatial distributions of calibrated radiocarbon ages are useful in exploring the development and geographic continuity of the Woodland peoples and lead to a better understanding of the current chronological framework. From these data, it is possible to establish temporal associations that correlate with site abandonment, decreases or increases in local populations, and an intensification of landscape usage throughout the Woodland period. These data are particularly helpful since paleoenvironmental models for East Texas are not able to be constructed due to highly acidic soils (Bryant and Holloway 1985).

The inductive methodology employed here informs a regional chronology for East Texas Woodland sites (DeWalt and Pelto 1985). The goals of this article are to explore the process of ^{14}C date combination from sites with four or more samples (n=11) to decrease sampling bias for statistical analysis and determine the modified summed probability distributions (see Bamforth and Grund 2012, Michczynska and Pazdur 2004, Williams 2012), and secondly to employ the resulting median dates within a statistical analysis of regional trends.

East Texas Radiocarbon Database

Story (1990) provided the first published compendium of ^{14}C dates from East Texas, and the extensive radiocarbon database from investigations at Cooper Lake (Fields et al. 1997: Appendix B) led to Perttula's (1997, 1998) initial efforts to synthesize these data. In its current form, the ETRD is comprised of 1248 radiocarbon dates from a total of 199 archaeological sites that range in age from Paleoindian through Historic. This is a substantial increase from the 520 dates previously published (Perttula 1997; Perttula and Selden 2011), and the vast majority of the radiocarbon dates in the database are the product of Cultural Resource Management (CRM) projects in East Texas.

Methods of Analysis

Radiocarbon dates used within this research were collected from CRM reports and publications, were synthesized, then recalibrated with OxCal using IntCal09 (Table 2.1) (Perttula and Selden 2011). The completed database was analyzed using a variety of statistical processes (histograms, barplots, boxplots, kernel density, and hierarchical cluster analysis) within version 2.15.1 of R, and SPDs were produced using OxCal. Statistical calculations were made using negative numbers to represent B.C. and positive numbers to represent A.D. (Sirkin 2006).

The 1248 corrected dates in the ETRD were calibrated utilizing OxCal 4.1.7 (Bronk Ramsey 2012) and IntCal09 (Reimer et al. 2009). With few exceptions where conventional radiocarbon ages were reported - to include older assays found to lack $\delta^{13}C$ date - value estimates were made for fractionation correction as suggested by Stuiver and Reimer

(1993:Table 1): -25‰ for nutshells and charcoal (C_3 plants), and -10‰ for charred maize (C_4 plants).

The Woodland sample was selected from the ETRD on the basis of median age. If the median age fell within the currently accepted temporal construct (ca. 500 B.C.-A.D. 800) for the Woodland period (see Story 1990, Perttula and Nelson 2004, Perttula 2008a), it was included. Dates from sites found to lack geographic coordinates, with a standard deviation greater than 200 years, or from non-archaeological contexts (i.e., geoarchaeological profile, backhoe trench, or cutbank not on a site), were removed from the sample. The remaining dates were combined and comprise the basis of the Woodland period statistical sample. Data fields from the ETRD include site name, trinomial (site number), assay number, raw age, $\delta^{13}C$, corrected ^{14}C age, 2σ age range, and median age (Table 2.2).

Within the distribution of Woodland ^{14}C assays (n=127) from the ETRD, 28 sites were found to have one radiocarbon sample, eight have two samples, four have three samples, three have four samples, one has five samples, three have six samples, two have seven samples, one has nine samples, and one has 13 samples. The assays from the 11 sites with four or more radiocarbon dates were combined via OxCal for two reasons: (1) to reduce the standard deviation and increase the accuracy of each site's temporal assignments and (2) to reduce sampling bias created by the number of samples during statistical analyses.

Once combined, a summed probability distribution (SPD) was produced for each of the 11 sites to illustrate the position of each within the period. The dates were plotted in a manner where the SPDs, the combined groups, and the individual assays that inform them can be viewed together. These efforts permit the SPD for the entirety of the Woodland period sample to be contrast with those produced for the 11 sites. This comparison demonstrates the impact that each site has upon the whole of the Woodland period radiocarbon sample, and allows for a discussion of regional trends within the temporal sample.

This expands the scholarly impact of existing ^{14}C dates through their integration within a regional chronology. By combining and recalibrating ^{14}C dates, and producing site-specific summed probability distributions, the most accurate temporal representation available for the Woodland period in East Texas has been developed. The investigation contrasts site-specific summed probability distributions for 11 sites against the summed probability distribution for the entirety of the Woodland period sample.

To facilitate the statistical analysis, median ages were used to calculate the frequency of samples within each of the five major river basins in East Texas, and that information was used to inform a discussion of the average median age of Woodland sites in each river basin. To conclude the statistical analysis, a kernel density plot was created to explore potential populations within the sample of median ages.

Subsequent modifications include the addition of the North American Datum, UTM zone, UTM northing, UTM easting, and river basin. The river basins used in the analysis are the Red River basin (RRB), Sulphur River basin (SRB), Cypress Creek basin (CCB), Sabine River basin (SaRB), and the Neches River basin (NRB), as currently defined by the Texas Natural Resources Information System (TNRIS 2012) (Figure 2.1).

Table 2.1. Data sources for the 51 archaeological sites examined in this study.

Trinomial*	***Source***
41AN38	Lohse et al. 2004; Perttula et al. 2007, 2011
41AN120	Perttula 1997
41BW692	Lohse et al. 2004
41CE19	Davis et al. 1992; Perttula 2010a, 2010b; Story 1990
41CP245	Nelson and Perttula 2006
41CP408	Sherman et al. 2004, Perttula and Ellis 2012
41DT6	Fields et al. 1993
41DT16	Fields et al. 1993
41DT62	Fields et al. 1993
41DT141	Fields et al. 1997
41HO216	Cooper and Cooper 2005; Perttula and Nelson 2006, 2007
41HP78	Doehner and Larson 1978
41HP106	Perttula 1999
41HP137	Fields et al. 1997
41HS15	Fields and Gadus, in press
41HS16	Webb et al. 1969
41HS231	Dockall et al. 2008
41HS843	Gadus et al. 2006
41HS844	Gadus et al. 2006
41LR152	Mahoney et al. 2001, 2002
41LR164	Mahoney et al. 2001, 2002
41LR297	Bruseth et al. 2009
41MX5	Brewington et al. 1995
41NA49	Corbin 1984, Corbin et al. 1984, Corbin and Hart 1998
41NA231	Perttula 2002, 2008b
41NA236	Perttula 2000, 2002, 2008b
41NA243	Perttula 2000, 2002
41NA244	Perttula 2000, 2002
41NA248	Perttula 2000, 2002
41NA264	Perttula 2000, 2002
41NA280	Perttula 2000, 2002
41NA285	Perttula 2000, 2002, 2008b
41NA290	Perttula 2000, 2002
41RK170	Perttula and Nelson 2003
41RK214	Rogers and Perttula 2004, Perttula and Rogers 2007
41RK222	Rogers et al. 2001

Table 2.1. Continued

*Trinomial**	*Source*
41RK328	Cliff et al. 2004
41RK468	Dixon et al. 2009
41RK558	Dockall and Fields 2011
41SM273	Perttula and Nelson 2001, 2004
41SY41	Perttula 1997
41TT370	Kotter et al. 1993
41TT372	Barnhart et al. 1997
41TT409	Kotter et al. 1993
41TT550	Dixon et al. 1997, Perttula et al. 1998
41TT653	Galan 1998, Perttula and Sherman 2009
41TT847	Hatfield et al. 2008
41TT865	Hatfield et al. 2008, Perttula et al. 2003
41UR77	Perttula and Ricklis 2005
41UR133	Parsons 1998
41WD495	Bruseth and Perttula 1981

*"Trinomial" refers to the Smithsonian trinomial numbering system where the state is indicated by a number ranging from 1-50, the county by two-three capitals, and the site within the county is represented by a number ranging from one- infinity.

Table 2.2. ^{14}C dates for the East Texas Woodland period.*

Trinomial**	***Assay No.***	***Raw Age***	***±***	δ^{13}C	***Corr ^{14}C Age***	***±***	***1σ Age Range***	***2σ Age Range***	***Median***
41AN038	Beta-236778	--	--	-26.2 ‰	1290	40	AD 670-722 (0.43), AD 741-770 (0.25)	AD 653-783 (0.91), AD 789-812 (0.03), AD 845-856 (0.01)	722
41AN038	Beta-236790	--	--	-25.8 ‰	1420	40	AD 604-655 (0.68)	AD 565-666 (0.95)	625
41AN038	Beta-236794	--	--	-24.3 ‰	1830	50	AD 126-244 (0.68)	AD 70-263 (0.87), AD 278-329 (0.08)	184
41AN120	SMU-669	1744	64		1744	76	AD 215-401 (0.68)	AD 83-434 (0.95), AD 495-505 (0.01)	290
41BW692	UGA-13420	1270	40	-24.7 ‰	1280	40	AD 676-729 (0.40), AD 736-772 (0.28)	AD 657-825 (0.93), AD 841-862 (0.03)	730
41CE019	Tx-1223	1290	80	--	1266	90	AD 665-826 (0.61), AD 840-863 (0.07)	AD 622-972 (0.95)	767
41CE019	Tx-919	1310	80	--	1286	90	AD 665-820 (0.63), AD 842-860 (0.05)	AD 602-901 (0.91), AD 917-966 (0.04)	751
41CE019	Tx-105	1120	90	--	1361	99	AD 582-775 (0.68)	AD 436-490 (0.03), AD 510-517 (0.00), AD 530-891 (0.92)	676
41CE019	Tx-674	1420	100	--	1396	108	AD 542-723 (0.61), AD 740-770 (0.07)	AD 425-877 (0.95)	639
41CE019	Tx-3312	1190	80	--	1431	90	AD 471-477 (0.01), AD 535-683 (0.67)	AD 422-773 (0.95)	606
41CE019	--	1630	40	-26.7 ‰	1600	40	AD 418-466 (0.31), AD 482-533 (0.37)	AD 382-560 (0.95)	473
41CE019	Tx-3695	1400	60	--	1641	72	AD 337-468 (0.49), AD 479-534 (0.18)	AD 240-570 (0.95)	411
41CP245	Beta-208773	1320	40	-27.5 ‰	1280	40	AD 676-729 (0.40), AD 736-772 (0.28)	AD 657-825 (0.93), AD 841-862 (0.03)	730
41CP245	Beta-208775	1730	40	-27.3 ‰	1690	40	AD 261-280 (0.11), AD 326-410 (0.58)	AD 249-426 (0.95)	353
41CP408	Beta-184988	1930	40	-25.9 ‰	1920	40	AD 29-38 (0.05), AD 51-128 (0.63)	20-13BC (0.01), 1 BC – AD 215 (0.95)	83
41DT006	Beta-51364	1270	60	-26.2 ‰	1250	60	AD 680-818 (0.62), AD 843-860 (0.06)	AD 657-895 (0.95), AD 927-935 (0.01)	768
41DT006	Beta-51366	1300	80	-25.0 ‰	1300	80	AD 649-782 (0.63), AD 790-809 (0.05)	AD 599-895 (0.95), AD 925-937 (0.01)	736
41DT006	Beta-51367	1370	80	-25.5 ‰	1370	80	AD 595-718 (0.59), AD 743-769 (0.10)	AD 536-876 (0.95)	663
41DT006	Beta-51368	1470	80	-25.8 ‰	1460	80	AD 470-478 (0.02), AD 535-660 (0.66)	AD 414-689 (0.95), AD 753-760 (0.00)	583
41DT006	Beta-51365	1790	100	-26.1 ‰	1770	100	AD 134-354 (0.65), AD 366-381 (0.04)	AD 27-41 (0.01), AD 48-442 (0.92), AD 455-460 (0.00), AD 484-532 (0.03)	258
41DT016	Beta-52241	1300	60	-25.5 ‰	1290	60	AD 663-775 (0.68)	AD 649-878 (0.95)	735
41DT016	Beta-51372	1300	80	-26.0 ‰	1290	80	AD 654-782 (0.60), AD 789-810 (0.06), AD 848-855 (0.02)	AD 606-897 (0.94), AD 923-941 (0.01)	744
41DT016	Beta-52242	1330	70	-25.9 ‰	1310	70	AD 652-776 (0.68)	AD 612-883 (0.95)	723
41DT016	Beta-52245	1520	60	-24.8 ‰	1530	60	AD 436-491 (0.28), AD 509-518 (0.04), AD 529-596 (0.37)	AD 416-641 (0.95)	525
41DT016	Beta-52244	1550	90	-24.8 ‰	1560	90	AD 415-592 (0.68)	AD 260-283 (0.02), AD 324-652 (0.94)	490
41DT016	Beta-51371	2090	90	-25.7 ‰	2080	90	336-331 BC (0.00), 203 BC - AD 21 (0.67)	365 BC-77 AD (0.95)	-112
41DT062	Beta-52605	1370	110	-24.8 ‰	1380	110	AD 556-773 (0.68)	AD 430-886 (0.95)	657
41DT141	Beta-17400	2100	70	--	2100	81	347-321 BC (0.06), 206-37 BC (0.58), 30-21 BC (0.02), 11-2 BC (0.02)	363 BC-AD 53 (0.95)	-134

Table 2.2. Continued

*Trinomial***	*Assay No.*	*Raw Age*	±	δ^{13}C	*Corr ^{14}C Age*	±	*1σ Age Range*	*2σ Age Range*	*Median*
41DT141	Beta-17401	2350	70	--	2350	81	733-691 BC (0.08), 662-650 BC (0.02), 545-359 BC (0.55), 276-259 BC (0.03)	761-682 BC (0.12), AD 671 -347 BC (0.69), 320-206 BC (0.14)	-465
41HO216	Beta-206843	1540	70	-26.5 ‰	1520	70	AD 435-491 (0.25), AD 509-518 (0.04), AD 529-606 (0.40)	AD 409-651 (0.95)	534
41HP078	SMU-1978	--	--	-26.4 ‰	1810	110	AD 81-339 (0.68)	46 BC-AD 436 (0.94), AD 490-510 (0.01), AD 517-529 (0.00)	212
41HP078	Tx-1961	2080	60	--	2080	72	196-20 BC (0.65), 12-1 BC (0.03)	357-285 BC (0.09), 255-249 (0.04), 234 BC-AD 67 (0.86)	-108
41HP106	Beta-82913	1730	100	-27.6 ‰	1710	100	AD 175-192 (0.03), AD 212-433 (0.65)	AD 85-547 (0.95)	325
41HP106	Beta-82914	1820	90	-25.4 ‰	1810	90	AD 86-106 (0.5), AD 120-264 (0.48), AD 276-332 (0.15)	AD 18-417 (0.95)	212
41HP106	Beta-82915	1820	50	-24.1 ‰	1840	50	AD 93-97 (0.02), AD 125-238 (0.66)	AD 62-260 (0.90), AD 282-324 (0.05)	175
41HP106	Beta-85866	1860	50	-24.6 ‰	1860	50	AD 86-109 (0.12), AD 117-220 (0.56)	AD 29-39 (0.01), AD 51-256 (0.93), AD 303-316 (0.01)	156
41HP106	Beta-82917	1880	90	-25.9 ‰	1870	90	AD 29-39 (0.02), AD 50-245 (0.66)	49 BC-AD 382 (0.95)	146
41HP106	Beta-85868	1910	50	-26.2 ‰	1890	50	AD 61-172 (0.61), AD 193-211 (0.07)	AD 5-240 (0.95)	118
41HP106	Beta-85867	2270	50	-26.7 ‰	2250	50	389-352 BC (0.23), 296-228 BC (0.40), 221-211 BC (0.05)	398-202 BC (0.95)	-287
41HP137	SMU-1966	--	--	-25.2 ‰	1460	60	AD 555-647 (0.68)	AD 434-493 (0.10), AD 507-520 (0.02), AD 527-666 (0.84)	592
41HP137	SMU-1917	--	--	-25.7 ‰	2090	30	164-129 BC (0.26), 121-88 BC (0.25), 78-55 BC (0.17)	196-42 BC (0.95)	-112
41HS015	Beta-242049	1450	40	-23.7 ‰	1470	40	AD 565-635 (0.68)	AD 467-481, AD 534-665 (0.99)	594
41HS016	Tx-483	1850	90	--	1850	99	AD 54-259 (0.63), AD 296-321 (0.05)	AD 47-406 (0.95)	169
41HS016	Tx-481	2150	100	--	2150	108	359-278 BC (0.21), 259-241 BC (0.04), 236-88 BC (0.39), 78-55 BC (0.05)	402 BC-61 AD (0.95)	-194
41HS016	Tx-484	2360	130	--	2360	136	752-686 BC (0.11), 667-636 BC (0.05), 623-614 BC (0.01), 595-357 (0.45), 283-257 BC (0.04), 246-235 BC (0.02)	802-159 BC (0.95), 134-116 BC (0.01)	-480
41HS231	Beta-236382	1300	40	-26.2 ‰	1280	40	AD 676-729 (0.40), AD 736-772 (0.28)	AD 657-825 (0.93), AD 841-862 (0.03)	730
41HS231	Beta-236383	1290	40	-25.4 ‰	1280	40	AD 676-729 (0.40), AD 736-772 (0.28)	AD 657-825 (0.93), AD 841-862 (0.03)	730
41HS231	Beta-236388	1470	40	-25.2 ‰	1470	40	AD 565-635 (0.68)	AD 467-481 (0.01), AD 534-655 (0.94)	594
41HS843	Beta-210245	1930	40	-25.3 ‰	1930	40	AD 27-42 (0.10), AD 48-125 (0.58)	BC 40-AD 170 (0.92), AD 150-170 (0.02), AD 195-210 (0.01)	72
41HS844	Beta-210247	1820	40	-25.6 ‰	1810	40	AD 136-243 (0.68)	AD 86-109 (0.03), AD 120-264 (0.80), AD 275-334 (0.13)	201
41LR152	Beta-153588	--	--	-28.7 ‰	1240	60	AD 688-827 (0.59), AD 840-864 (0.09)	AD 660-897 (0.94), AD 923-940 (0.02)	779
41LR164	Beta-153591	--	--	-21.0 ‰	2040	40	106 BC - AD 17 (0.68)	BC 168-AD 30 (0.92), AD 37-52 (0.03)	-50
41LR164	Beta-153593	--	--	-21.2 ‰	2180	40	356-286 BC (0.40), 234-177 BC (0.28)	379-154 BC (0.92), 137-114 BC (0.03)	-268

Table 2.2. Continued

*Trinomial***	*Assay No.*	*Raw Age*	*±*	δ^{13}C	*Corr ^{14}C Age*	*±*	*1σ Age Range*	*2σ Age Range*	*Median*
41LR164	Beta-153592	--	--	-20.6 ‰	2320	40	412-360 BC (0.63), 274-260 BC (0.05)	514-352 BC (0.79), 295-229 BC (0.16), 220-212 BC (0.01)	-391
41LR297	Beta-239524	1290	40	-25.9 ‰	1280	50	AD 671-774 (0.68)	AD 656-870 (0.95)	736
41LR297	Beta-237680	1480	40	-24.9 ‰	1480	40	AD 550-621 (0.68)	AD 441-484 (0.06), AD 532-652 (0.90)	586
41LR297	Beta-237677	1570	50	-24.9 ‰	1570	50	AD 430-540 (0.68)	AD 394-600 (0.95)	489
41LR297	Beta-237678	2340	50	-25.1 ‰	2340	50	511-371 BC (0.68)	736-689 BC (0.05), 663-648 BC (0.01), 548-352 BC (0.80), 296-228 BC (0.07), 221-211 BC (0.01)	-417
41MX005	Beta-52709	1790	90	--	1790	99	AD 126-350 (0.66), AD 368-379 (0.02)	AD 2-435 (0.94), AD 491-509 (0.01), AD 518-529 (0.00)	235
41NA049	Tx-4876	1280	100	--	1280	108	AD 656-870 (0.68)	AD 576-984 (0.95)	760
41NA231	Beta-136806	1700	40	-26.3 ‰	1680	40	AD 264-276 (0.06), AD 333-415 (0.62)	AD 245-434 (0.95), AD 495-505 (0.01)	363
41NA231	Beta-204778	1970	70	-25.9 ‰	1960	70	42 BC - AD 90 (0.60), AD 100-124 (0.08)	159-135 BC (0.02), 116 BC - AD 221 (0.93)	37
41NA236	Beta-183857	1280	60	-19.0 ‰	1380	60	AD 598-688 (0.68)	AD 558-773 (0.95)	651
41NA236	Beta-203667	1410	90	-24.6 ‰	1420	90	AD 537-689 (0.67), AD 753-760 (0.01)	AD 420-778 (0.95)	615
41NA236	Beta-204783	1470	40	-24.7 ‰	1470	40	AD 565-635 (0.68)	AD 467-481 (0.01), AD 534-655 (0.94)	594
41NA236	Beta-203666	1560	40	-24.8 ‰	1560	40	AD 434-495 (0.42), AD 504-543 (0.26)	AD 415-585 (0.95)	492
41NA236	Beta-204782	1830	40	-24.8 ‰	1830	40	AD 134-230 (0.68)	AD 80-258 (0.93), AD 300-318 (0.03)	182
41NA236	Beta-203669	1850	90	-24.9 ‰	1850	90	AD 61-256 (0.66)	39 BC-AD 385 (0.95)	169
41NA236	Beta-151097	1920	40	-25.4 ‰	1910	40	AD 31-37 (0.03), AD 52-132 (0.66)	AD 5-216 (0.95)	95
41NA236	Beta-203668	2000	60	-24.6 ‰	2010	60	91-70 BC (0.07), 60 BC - AD 65 (0.61)	174 BC-AD 90 (0.93), AD 100-124 (0.03)	-19
41NA236	Beta-151098	2370	40	-24.7 ‰	2370	40	510-436 BC (0.43), 426-393 BC (0.26)	735-690 BC (0.07), 663-649 BC (0.01), 546-382 BC (0.87)	-463
41NA243	Beta-154853	1770	70	-26.2 ‰	1750	70	AD 215-391 (0.68)	AD 86-106 (0.01), AD 121-428 (0.94)	285
41NA243	Beta-154854	2350	60	-25.3 ‰	2350	60	702-696 BC (0.01), 538-369 BC (0.67)	752-686 BC (0.10), 668-637 BC (0.03), 622-614 BC (0.00), 595-352 BC (0.74), 296-228 BC (0.07), 221-211 BC (0.01)	-454
41NA244	Beta-151102	1820	40	-23.6 ‰	1840	40	AD 130-226 (0.68)	AD 75-255 (0.95), AD 305-313 (0.01)	174
41NA248	Beta-151104	1670	40	-26.0 ‰	1650	40	AD 338-434 (0.65), AD 495-504 (0.03)	AD 260-284 (0.05), AD 323-520 (0.90)	400
41NA264	Beta-151105	2370	110	-26.7 ‰	2340	100	733-691 BC (0.08), 662-650 BC (0.02), 545-353 BC (0.47), 293-230 BC (0.11), 219-213 (0.01)	767-198 BC (0.95)	-451
41NA280	Beta-151107	1950	40	-24.8 ‰	1950	40	AD 3-85 (0.66), AD 110-115 (0.02)	41 BC-AD 129 (0.95)	50
41NA285	Beta-221421	1250	40	-25.5 ‰	1240	40	AD 690-752 (0.36), AD 761-783 (0.12), AD 788-815 (0.13), AD 844-859 (0.06)	AD 680-882 (0.95)	772
41NA285	Beta-201990	1240	40	-23.9 ‰	1260	40	AD 680-779 (0.68)	AD 668-870 (0.95)	744

Table 2.2. Continued

*Trinomial***	*Assay No.*	*Raw Age*	*±*	δ^{13}C	*Corr ^{14}C Age*	*±*	*1σ Age Range*	*2σ Age Range*	*Median*
41NA285	Beta-204786	1340	40	-25.6 ‰	1330	40	AD 652-695 (0.50), AD 701-707 (0.04), AD 748-765 (0.14)	AD 643-774 (0.95)	686
41NA285	Beta-221420	1560	40	-23.2 ‰	1590	40	AD 425-468 (0.30), AD 480-534 (0.40)	AD 392-562 (0.95)	480
41NA285	Beta-151112	2100	40	-25.7 ‰	2090	40	166-54 BC (0.68)	338-330 BC (0.01), 204 BC – AD 2 (0.95)	-113
41NA285	Beta-201989	2170	40	-26.1 ‰	2150	40	351-299 BC (0.24), 228-223 BC (0.02), 210-151 BC (0.32), 140-112 BC (0.11)	359-277 BC (0.30), 260-87 BC (0.62), 78-55 BC (0.04)	-196
41NA290	Beta-151116	1380	40	-24.5 ‰	1390	40	AD 617-665 (0.68)	AD 573-688 (0.95)	644
41RK170	Beta-166761	2110	40	-24.0 ‰	2130	40	342-326 BC (0.06), 204-94 BC (0.62)	355-290 BC (0.16), 232-46 BC (0.79)	-163
41RK214	B-107402**	1130	50	-18.4 ‰	1240	50	AD 689-753 (0.33), AD 760-822 (0.27), AD 842-861 (0.08)	AD 669-890 (0.95)	775
41RK214	Beta-81680	1810	60	-23.4 ‰	1830	60	AD 88-103 (0.05), AD 122-251 (0.63)	AD 55-343 (0.95)	186
41RK222	Beta-60093	1400	70	-24.3 ‰	1410	70	AD 568-671 (0.68)	AD 439-486 (0.04), AD 532-730 (0.87), AD 735-772 (0.05)	626
41RK222	Beta-60094	1840	100	-24.8 ‰	1840	100	AD 64-260 (0.60), AD 284-323 (0.09)	44 BC-AD 410 (0.95)	180
41RK222	Beta-72776	1880	80	-26.5 ‰	1850	80	AD 70-250 (0.68)	20-13 BC (0.00), AD 1-382 (0.95)	168
41RK222	Beta-72770	1840	60	-23.2 ‰	1870	60	AD 78-217 (0.68)	AD 3-259 (0.93), AD 295-322 (0.02)	145
41RK222	Beta-72778	1860	45	-22.0 ‰	1905	50	AD 26-139 (0.62), AD 158-166 (0.02), AD 196-209 (0.04)	19-14 BC (0.01), AD 1-235 (0.95)	102
41RK222	Beta-72771	1980	100	-24.6 ‰	1990	100	151-140 BC (0.02), 112 BC - AD 126 (0.66)	351-298 BC (0.03), 228-222 BC (0.00) 211 BC-AD 242 (0.92)	-4
41RK328	--	--	--	--	1610	40	AD 408-465 (0.35), AD 482-533 (0.33)	AD 348-369 (0.03), AD 379-547 (0.93)	463
41RK468	Beta-239710	2150	40	-26.5 ‰	2130	40	342-326 BC (0.06), 204-94 BC (0.62)	355-290 BC (0.16), 232-46 BC (0.79)	-163
41RK558	Beta-278035	1280	40	-25.9 ‰	1270	40	AD 682-774 (0.68)	AD 662-830 (0.89), AD 836-869 (0.06)	737
41SM273	Beta-157990	1270	40	-25.7 ‰	1260	40	AD 680-779 (0.68)	AD 668-870 (0.95)	744
41SM273	Beta-173089	1310	40	-26.0 ‰	1290	40	AD 670-722 (0.43), AD 741-770 (0.25)	AD 653-783 (0.91), AD 789-812 (0.03), AD 845-856 (0.01)	722
41SM273	Beta-154860	1400	60	-25.0 ‰	1400	60	AD 588-673 (0.68)	AD 540-721 (0.91), AD 741-770 (0.04)	634
41SM273	Beta-157989	1490	70	-25.7 ‰	1480	70	AD 469-479 (0.03), AD 534-650 (0.65)	AD 427-661 (0.95)	571
41SM273	Beta-173091	1520	40	-24.9 ‰	1520	40	AD 442-484 (0.19), AD 532-601 (0.49)	AD 430-617 (0.95)	546
41SM273	Beta-154857	1550	80	-26.0 ‰	1530	80	AD 433-497 (0.27), AD 503-599 (0.42)	AD 353-367 (0.01), AD 381-657 (0.95)	519
41SM273	Beta-173092	1590	90	-25.9 ‰	1570	90	AD 405-590 (0.68)	AD 259-295 (0.03), AD 322-648 (0.92)	482
41SM273	Beta-173095	1640	40	-26.9 ‰	1610	40	AD 408-465 (0.35), AD 482-533 (0.33)	AD 348-369 (0.03), AD 379-547 (0.93)	463
41SM273	Beta-173090	1680	40	-24.4 ‰	1690	40	AD 261-280 (0.11), AD 326-410 (0.58)	AD 249-426 (0.95)	353
41SM273	beta-157991	1710	40	-24.9 ‰	1710	40	AD 259-296 (0.23), AD 322-388 (0.45)	AD 241-415 (0.95)	332
41SM273	Beta-182401	1710	40	-25.1 ‰	1710	40	AD 259-296 (0.23), AD 322-388 (0.45)	AD 241-415 (0.95)	332
41SM273	Beta-173097	1720	40	-25.1 ‰	1720	40	AD 257-300 (0.28), AD 318-382 (0.40)	AD 235-414 (0.95)	321

Table 2.2. Continued

*Trinomial***	*Assay No.*	*Raw Age*	*±*	δ^{13}C	*Corr ^{14}C Age*	*±*	*1σ Age Range*	*2σ Age Range*	*Median*
41SM273	Beta-182402	1810	40	-25.0 ‰	1810	40	AD 136-243 (0.68)	AD 86-109 (0.03), AD 120-264 (0.80), AD 275-334 (0.13)	201
41SY041	Beta-97897	960	70	-6.0 ‰	1270	70	AD 664-782 (0.58), AD 789-810 (0.08), AD 848-855 (0.02)	AD 645-896 (0.94), AD 924-938 (0.01)	755
41TT370	Beta-48882	2140	100	--	2140	100	356-286 BC (0.18), 234-50 BC (0.50)	394 BC-AD 29 (0.95), AD 39-50 (0.01)	-183
41TT372	Beta-70994	1290	50	-26.4 ‰	1270	50	AD 670-778 (0.68)	AD 660-875 (0.95)	744
41TT372	Beta-71006	1330	60	-26.1 ‰	1310	60	AD 657-728 (0.46), AD 736-772 (0.22)	AD 635-876 (0.95)	718
41TT372	Beta-71000	1420	60	-26.8 ‰	1390	60	AD 595-682 (0.68)	AD 545-724 (0.89), AD 739-771 (0.06)	643
41TT372	Beta-70995	1800	60	-25.3 ‰	1800	60	AD 131-259 (0.58), AD 295-322 (0.10)	AD 81-382 (0.95)	220
41TT409	Beta-64984	1730	60	-30.4 ‰	1640	60	AD 340-442 (0.47), AD 454-461 (0.02), AD 484-533 (0.19)	AD 255-548 (0.95)	413
41TT409	Beta-64985	1710	60	-25.5 ‰	1700	60	AD 257-302 (0.21), AD 316-410 (0.47)	AD 172-193 (0.01), AD 211-465 (0.90), AD 482-533 (0.05)	340
41TT550	Beta-70989	2080	60	-27.0 ‰	2050	60	162-131 BC (0.12), 119 BC - AD 5 (0.56)	342-327 BC (0.01), 204 BC-AD 74 (0.94)	-70
41TT653	Beta-117272	1870	50	-23.2 ‰	1900	50	AD 29-38 (0.03), AD 51-140 (0.54), AD 151-170 (0.06), AD 194-210 (0.05)	AD 3-236 (0.95)	107
41TT847	Beta-242371	1360	40	-26.6 ‰	1330	40	AD 652-695 (0.50), AD 701-707 (0.04), AD 748-765 (0.14)	AD 645-772 (1.00)	686
41TT865	Beta-242373	2180	40	-26.9 ‰	2150	40	351-299 BC (0.24), 228-223 BC (0.02), 210-151 BC (0.32), 140-112 BC (0.11)	358-277 BC (0.31), 259-87 BC (0.65), 78-55 BC (0.04)	-196
41UR077	Beta-166910	1480	50	-25.5 ‰	1470	50	AD 558-640 (0.68)	AD 460-480, AD 520-660	589
41UR077	UGA-12983	1830	40	-24.4 ‰	1840	40	AD 130-226 (0.68)	AD 75-255 (0.95), AD 305-313 (0.01)	174
41UR077	UGA-12984	1840	40	-24.8 ‰	1840	40	AD 130-226 (0.68)	AD 75-255 (0.95), AD 305-313 (0.01)	174
41UR077	UGA-12971	2190	40	-25.1 ‰	2190	40	358-281 BC (0.42), 258-243 BC (0.06), 236-197 BC (0.20)	383-164 BC (0.95), 128-122 BC (0.01)	-278
41UR133	Beta-117743	--	--	--	2250	60	391-350 BC (0.21), 304-209 BC (0.47)	406-170 BC (0.95)	-288
41WD495	Tx-3045	1760	50	--	1760	64	AD 180-187 (0.02), AD 214-382 (0.66)	AD 93-97 (0.00), AD 125-417 (0.95)	275

*Missing values in the Assay No., Raw Age and δ^{13}C columns were not reported in technical reports.

**"Trinomial" refers to the Smithsonian trinomial numbering system where the state is indicated by a number ranging from 1-50, the county by two-three capitals, and the site within the county is represented by a number ranging from one- infinity.

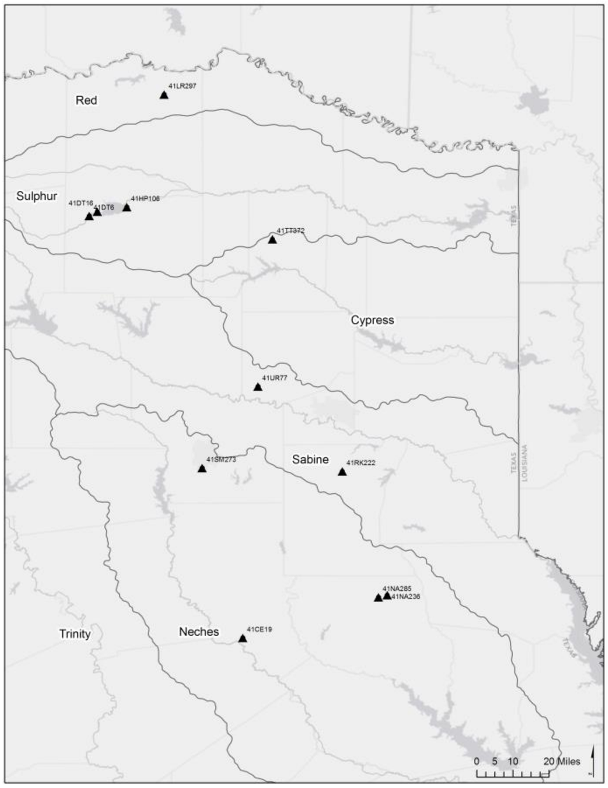

Figure 2.1. Map of East Texas river basins and the 11 Woodland period sites with four or more radiocarbon dates.

^{14}C Date Combination

The date combination process assumes that if all assays collected at a particular site draw carbon from the same reservoir, then they should have the same underlying F14C value and can be combined prior to calibration (Bronk Ramsey 2008). The measurements have Gaussian uncertainty distributions, and X^2 was used to test the assumption that all ratios are the same to reveal whether compelling evidence exists – at the 95% confidence level – that dates cannot be related to the same event (Bronk Ramsey 2008). Each site-specific figure provides the SPDs, calibrated age range for combined assays, and all dates utilized to inform these results.

Although ^{14}C determinations are most often represented in the form *A*±*E* where *A* is the radiocarbon estimate (B.P.) and *E* represents the standard deviation, the method of date combination can be used to create a new ^{14}C determination from multiple assays often with the ancillary benefit of a decrease in the standard deviation (Ward and Wilson 1978). To test whether a series of ^{14}C determinations are consistent, the pooled mean is calculated by way of A_p, where

$$A_p = \left(\sum_1^n A_i/E_i^2\right) / \left(\sum_1^n 1/E_i^2\right)$$

followed by the test statistic, *T*, where

$$T = \sum_1^n \left(A_i - A_p\right)^2 / E_i^2$$

the latter of which illustrates a chi-square distribution on *n* – 1 degrees of freedom under the null hypothesis (see Clark 1975:252; Ward and Wilson 1978:21).

Provided that the ^{14}C determinations are found not to be significantly different, they can then be combined with the pooled age as A_p given by (I), and the variance given by

$$V(A_p) = \left(\sum_1^n 1/E_i^2\right)^{-1}$$

(Ward and Wilson 1978:21), which is a process accessible in OxCal by way of the R_Combine function. Once combined with R_Combine, a new date range, standard deviation, and median age is provided for the combined samples (Figure 2.2). Within the framework of this study, the new date range replaces the combined dates and was employed within the revised summed probability distribution, while the new median date was used for statistical analyses.

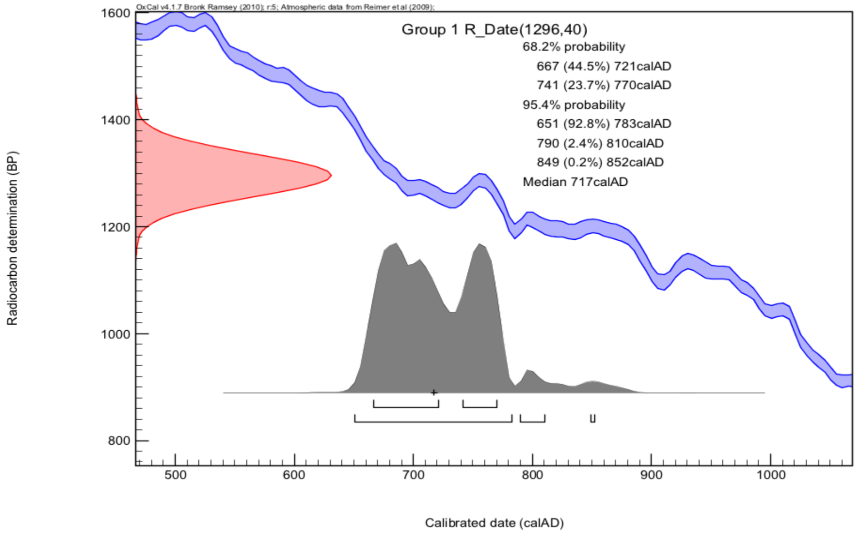

Figure 2.2. Calibrated results from the R_Combine function for 41DT16 Group 1.

Calibration Curve

Conventional ^{14}C dates used within the framework of this study were recalibrated using IntCal09 (Figure 2.3). The curve serves as the basis for date calibration and can aid the process of archaeological interpretation by highlighting temporal zones with reversals and plateaus. Within the span of time assigned to the East Texas Woodland period (500 B.C. – A.D. 800), the curve can be seen to have three notable reversals of varying degrees (370-220 B.C., A.D. 240-340, and A.D. 680-780). There are also three plateaus within the curve (500-420 B.C., A.D. 140-210, and A.D. 430-540). While this does not produce clues regarding human behaviors, it does help to clarify why—even after combination—some date ranges have longer spans of probability for the calibrated date range.

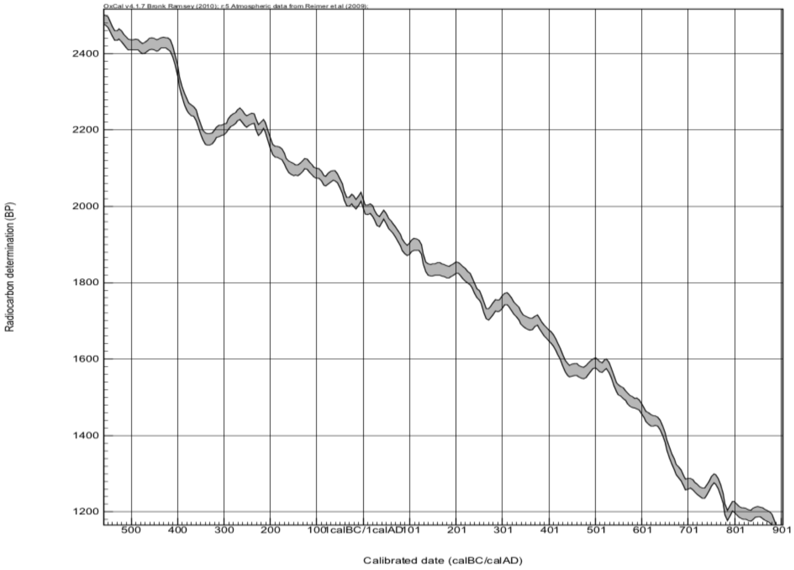

Figure 2.3. IntCal09 Radiocarbon calibration curve for the East Texas Woodland period.

The Woodland Sample

The Woodland sites with four or more ^{14}C assays include George C. Davis (41CE19), Tick (41DT6), Spike (41DT16), Hurricane Hill (41HP106), Stallings Ranch (41LR297), Naconiche Creek (41NA236), Boyette (41NA285), Herman Ballew (41RK222), Broadway (41SM273), 41TT372, and 41UR77. The number of ^{14}C samples from each site is heavily biased by the variable mitigation strategies and research designs used in archaeological practice. The ^{14}C samples from these sites are refined here through date combination, where the results of date combination replaced the original assays, and then incorporated with the remaining 42 samples used in this analysis.

41CE19 (George C. Davis Site)

The Woodland period ^{14}C dates for the George C. Davis site (n=7) have been combined into two groups (Figure 2.4). Group 1 consists of Tx-1223, Tx-919, Tx-105, Tx-674, and Tx-3312. Group 2 consists of Tx-3695 and a reported conventional ^{14}C age with an assay number that was not reported. The 2σ age ranges for the groups, A.D. 358-544 for Group 2 and A.D. 616-773 for Group 1, indicate a possible occupational hiatus of 72 ^{14}C years. Occupation periods for the two ^{14}C groups span 186 cal. ^{14}C years and 157 cal. ^{14}C years, respectively.

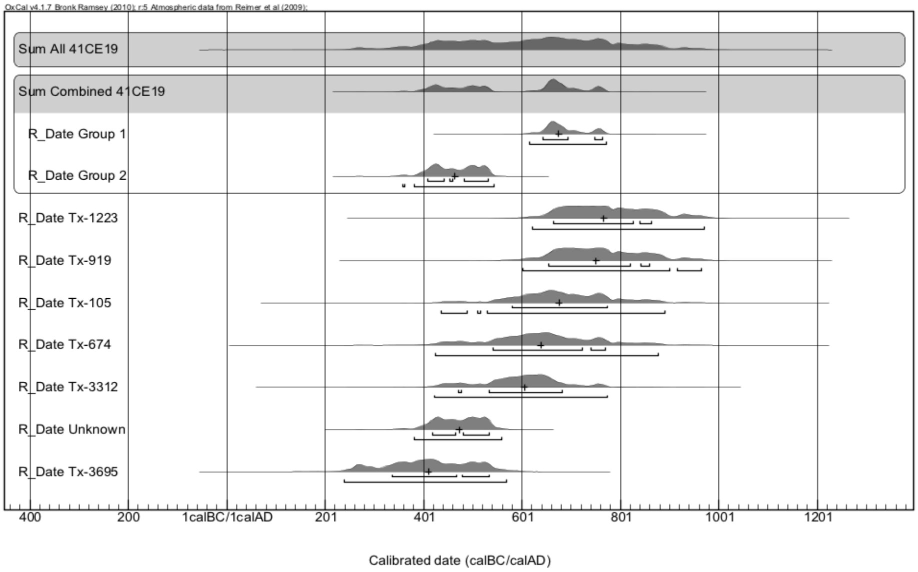

Figure 2.4. Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for radiocarbon dates from the George C. Davis site (41CE19).

41DT6 (Tick Site)

All ^{14}C dates from the Tick site (n=5) were unable to be combined via OxCal X-test (Figure 2.5). Only three assays (Beta-51364, Beta-51366, and Beta-51367) were combined into Group 1, leaving the remaining assays (Beta-51368 and Beta-51365) to populate the balance of the summed probability distribution. This site represents the singular example of overlapping occupations between A.D. 660-667, and the ^{14}C assays indicate a continuous, but probably episodic, occupation of 831 cal. ^{14}C years.

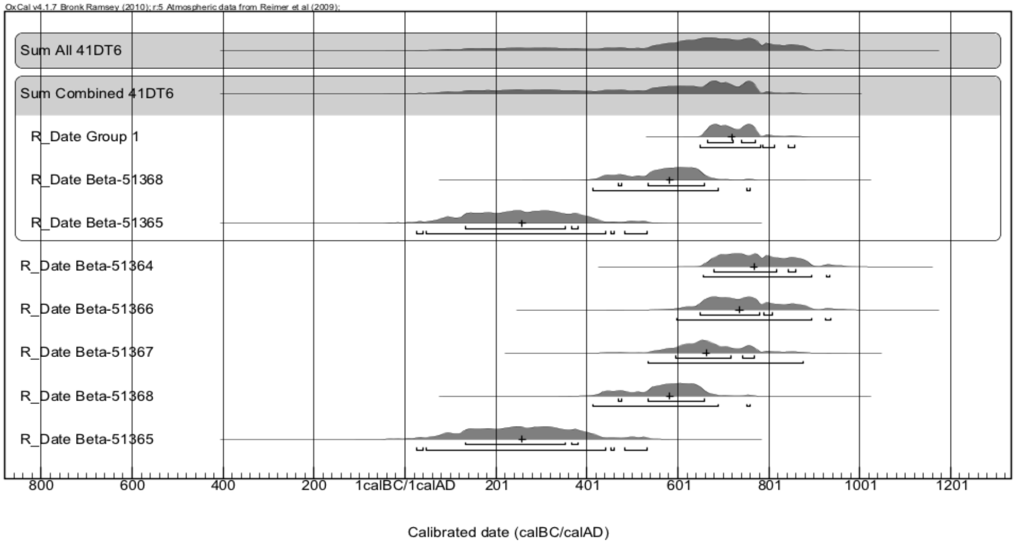

Figure 2.5. Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for radiocarbon dates from the Tick site (41DT6).

41DT16 (Spike Site)

There are six ^{14}C assays from the Spike site, three of which were combined, resulting in a final sample of three radiocarbon ages. Group 1 consists of Beta-52245 and Beta-52244, and Group 2 includes Beta-52242, Beta-52241, and Beta-51372 (Figure 2.6). Beta-

51371 was not able to be combined with the two other groups. Beta-51371 ranges from 336 B.C. – A.D. 21, the Group 2 range is A.D. 434-574, and Group 1 ranges from A.D. 667-770, indicating a temporal hiatus of 413 cal. ^{14}C years between Beta-51371 and Group 2, and 93 cal. ^{14}C years between Group 2 and Group 1. Occupational periods span 357 cal. ^{14}C years, 140 cal. ^{14}C years, and 103 cal. ^{14}C years, respectively.

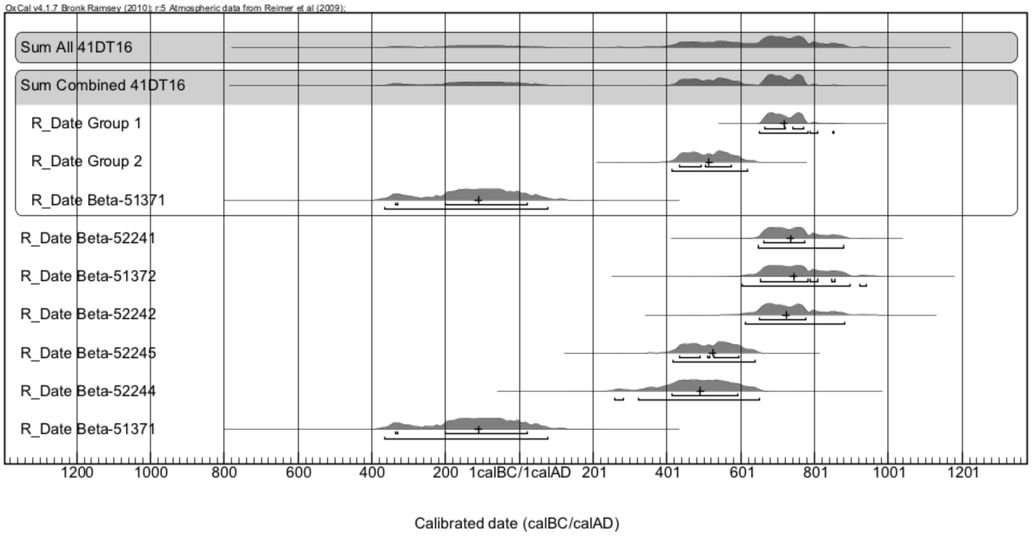

Figure 2.6. Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for radiocarbon dates from the Spike site (41DT16).

41HP106 (Hurricane Hill Site)

There are seven ^{14}C dates from the Woodland period occupation at the Hurricane Hill site. Six of these (Beta-82913, Beta-82914, Beta-82915, Beta-85866, Beta-82917, and Beta-85868) comprise Group 1, while a single and much earlier assay (Beta-85867) was unable to be combined with the other dates (Figure 2.7). The Beta-85867 date ranges from 398-202 B.C. and Group 1 dates indicate an occupation ranging from A.D. 85-235; there is a temporal hiatus of 287 cal. ^{14}C years between the two occupations. Occupational periods span 150 cal. ^{14}C years and 196 cal. ^{14}C years, respectively.

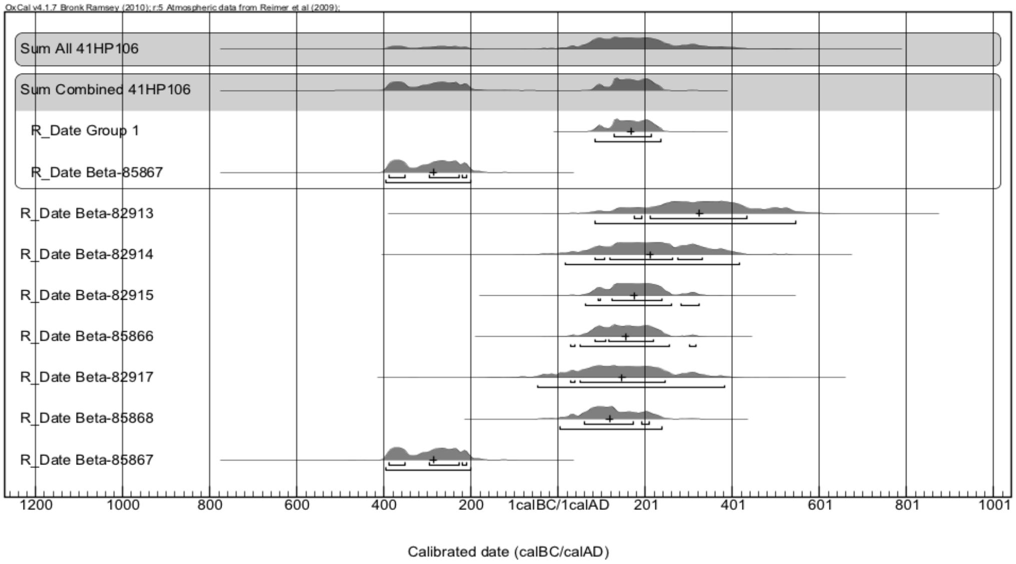

Figure 2.7. Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for radiocarbon dates from the Hurricane Hill site (41HP106).

41LR297 (Stallings Ranch Site)

Only two of the ^{14}C dates from the Stallings Ranch site (n=4) were combined. The assays with the latest (Beta-239524) and the earliest (Beta-237678) calibrated age ranges are plotted individually, and Group 1 consists of Beta-237680 and Beta-237677 (Figure 2.8). There are three possible occupations at Stallings Ranch, the first (Beta-237678) ranging from 736-211 B.C., with a peak distribution at 400 B.C., Group 1 from A.D. 432-619, and A.D. 656-870 for Beta-239524. This indicates a 643 cal. ^{14}C year hiatus between the first and second occupations, and a 37 cal. ^{14}C year hiatus between the second and third.

Occupational periods span 525 cal. ^{14}C years, 187 cal. ^{14}C years, and 214 cal. ^{14}C years, respectively.

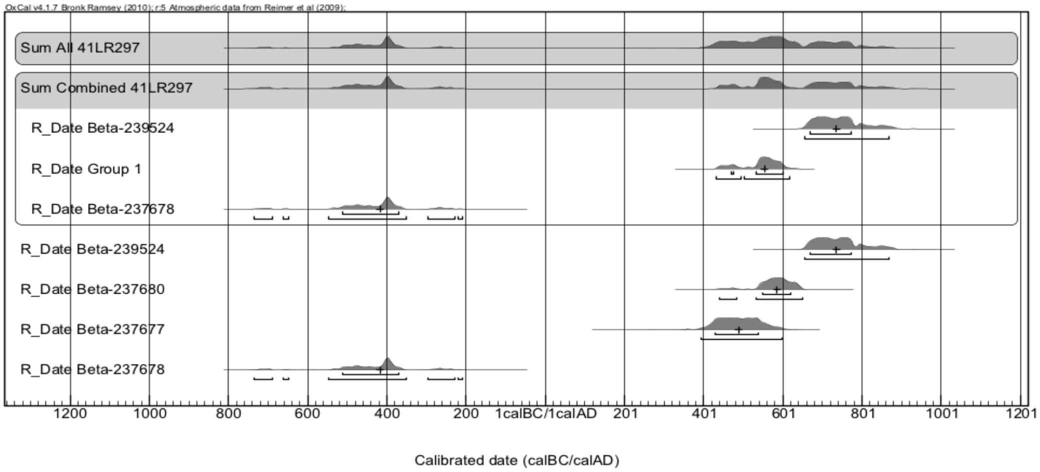

Figure 2.8. Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for radiocarbon dates from the Stallings Ranch site (41LR297).

41NA236 (Naconiche Creek Site)

The ^{14}C dates from the Naconiche Creek site (n=9) were combined into two groups, excluding only a single and older assay (Beta-151098) (Figure 2.9). Group 1 encompasses the Beta-183857, Beta-203667, Beta-204783, and Beta-203666 samples. Group 2 consists of the Beta-204782, Beta-203669, Beta-151097, and Beta-203668 samples. Beta-151098 spans the period from 735-382 B.C., Group 2 ranges from A.D. 56-214, and Group 1 extends from A.D. 541-636, indicating an occupational hiatus of 438 cal. ^{14}C years between the first and second occupations, and 327 cal. ^{14}C years between the second and third occupations. Occupational periods span 353 cal. ^{14}C years, 158 cal. ^{14}C years, 95 cal. ^{14}C years, respectively.

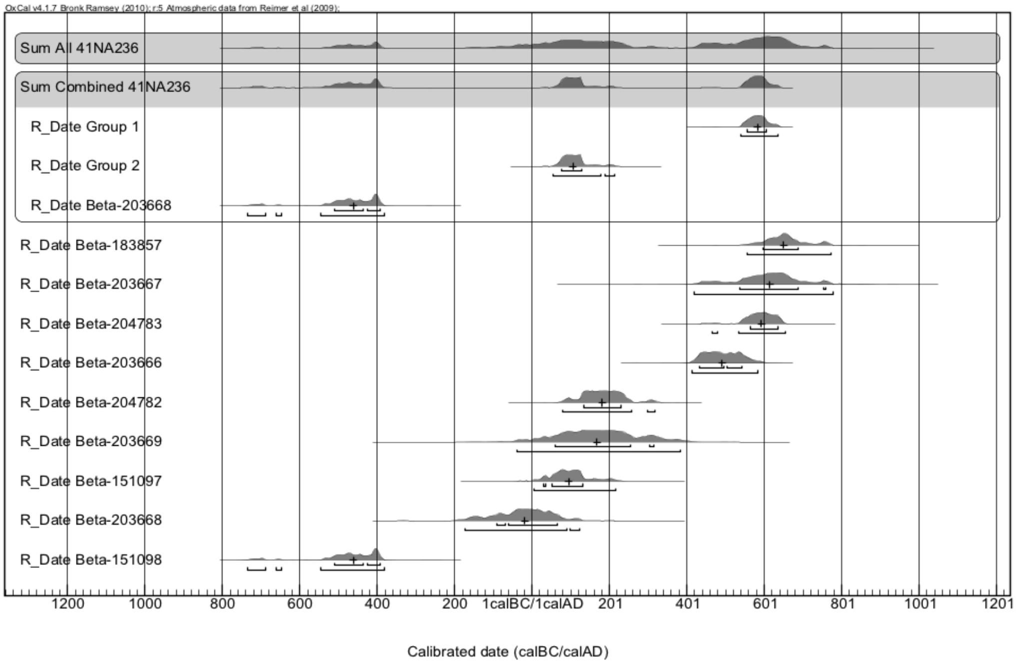

Figure 2.9. Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for radiocarbon dates from the Naconiche Creek site (41NA236).

41NA285 (Boyette Site)

Radiocarbon dates from the Boyette site (n=6) were combined into two groups with a single uncombined exception (Beta-221420) (Figure 2.10). Group 1 consists of three assays (Beta-221421, Beta-201990, and 204786), while Group 2 is comprised of two assays (Beta-151112 and Beta-201989). Group 2 dates from 197-107 B.C., Beta-221420 dates from A.D. 425-534, and Group 1 ranges from A.D. 685-770, indicating a temporal hiatus of 532 cal. ^{14}C years between Group 2 and Beta-221420, and 151 cal. ^{14}C years between Beta-221420 and Group 1. Occupational periods span 90 cal. ^{14}C years, 109 cal. ^{14}C years, and 85 cal. ^{14}C years, respectively.

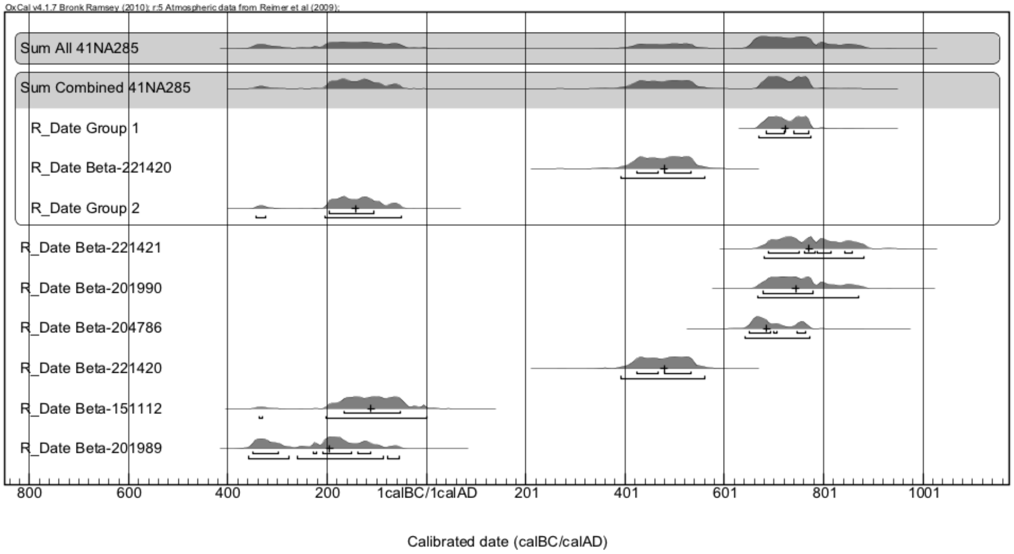

Figure 2.10. Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for radiocarbon dates from the Boyette site (41NA285).

41RK222 (Herman Ballew Site)

The ^{14}C dates from the Herman Ballew site (n=6) were combined into one group (n=5), excluding only a single and younger assay (Beta-60093) (Figure 2.11). Group 1 consists of Beta-60094, Beta-72776, Beta-72770, Beta-72778, and Beta-72771. The 2σ age range for Group 1 is A.D. 54-221, and A.D. 439-772 is the calibrated age range for the Beta-60093 assay. This indicates a possible hiatus of 218 cal. ^{14}C years between occupations. Occupational periods span 167 cal. ^{14}C years and 333 cal. ^{14}C years, respectively.

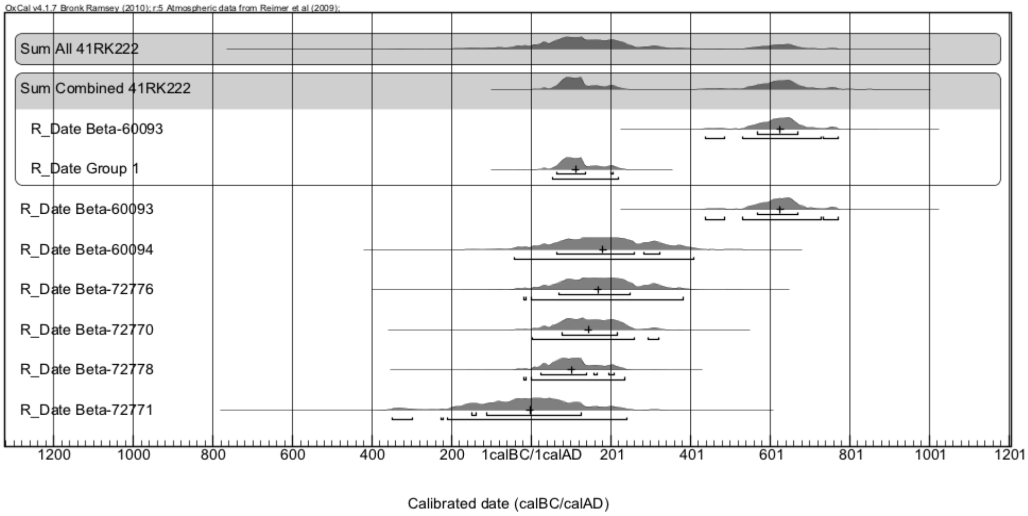

Figure 2.11. Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for radiocarbon dates from the Herman Ballew site (41RK222).

41SM273 (Broadway Site)

The 13 ^{14}C dates from the Woodland period occupation at the Broadway site were combined into three groups (Figure 2.12). Group 1 consists of two assays (Beta-157990 and Beta-173089), Group 2 has six assays (Beta-154860, Beta-157989, Beta-173091, Beta-154857, Beta-173092, and Beta-173095), and Group 3 has five assays (Beta-173090, Beta-157991, Beta-182401, Beta-173097, and Beta-182402). Group 3 dates from A.D. 257-344, Group 2 has an age range from A.D. 442-574, and Group 1 dates from A.D. 685-771, indicating a temporal hiatus of 98 cal. ^{14}C years between Group 3 and Group 2, and 111 cal. ^{14}C years between Group 2 and Group 1. Occupational periods span 87 cal. ^{14}C years, 132 cal. ^{14}C years, and 86 cal. ^{14}C years, respectively.

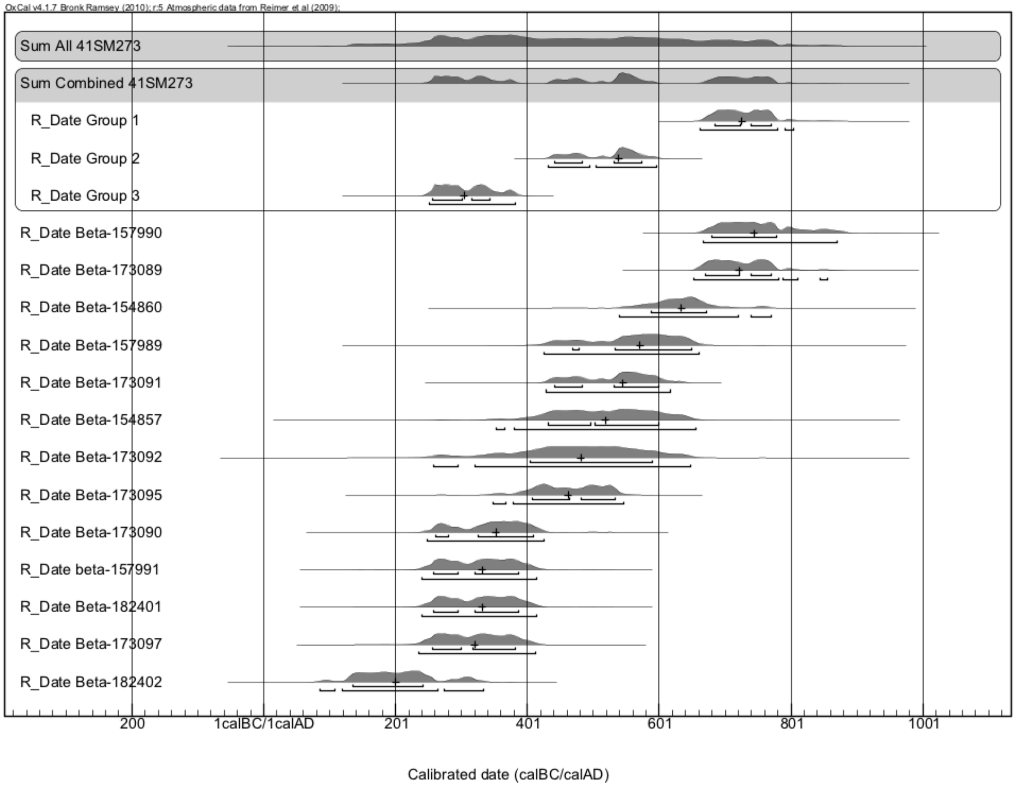

Figure 2.12. Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for radiocarbon dates from the Broadway site (41SM273).

41TT372

Radiocarbon dates for 41TT372 (n=4) were combined into a single group (n=3), excluding one earlier assay (Beta-70995) (Figure 2.13). Group 1 consists of Beta-70994, Beta-71006, and Beta-71000. The early assay (Beta-70995) ranges from A.D. 131-322, and Group 1 dates from A.D. 659-765, indicating a temporal hiatus of 337 cal. ^{14}C years between occupations. Occupational periods span 191 cal. ^{14}C years and 106 cal. ^{14}C years, respectively.

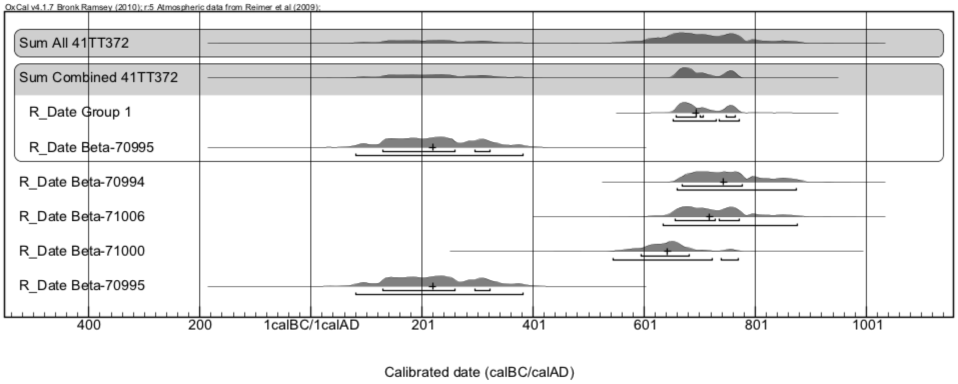

Figure 2.13. Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for radiocarbon dates from 41TT372.

41UR77

Radiocarbon dates from 41UR77 (n=4) were combined into a single group with two dates, and there are two younger and older exclusions (Beta-166910 and UGA-12971 respectively) that could not be grouped (Figure 2.14). Group 1 consists of UGA-12983 and UGA-12984. The 2σ age range for UGA-12971 is 358-197 B.C., for Group 1 it is A.D. 133-215, and for Beta-166910 the age range is A.D. 558-640. This indicates a temporal hiatus of 330 cal. ^{14}C years between the first and second occupations, and 343 cal. ^{14}C years between the second and third occupations. Occupational periods span 161 cal. ^{14}C years, 82 cal. ^{14}C years, and 82 cal. ^{14}C years, respectively.

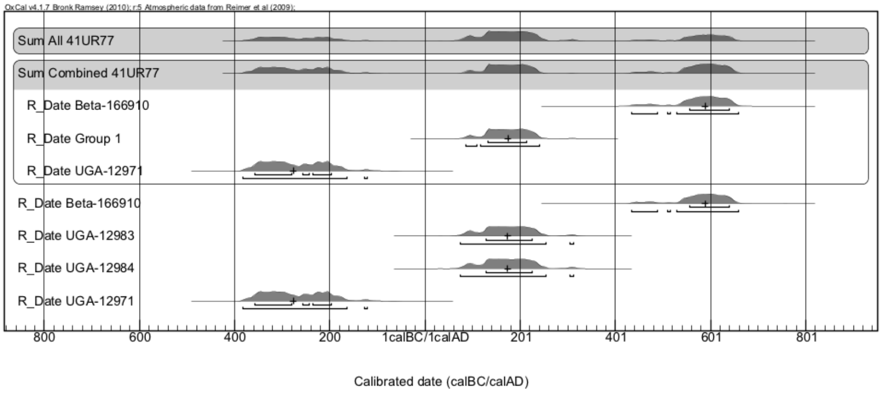

Figure 2.14. Combined 1σ and 2σ date ranges with median age illustrated, normal and combined summed probability distribution for radiocarbon dates from 41UR77.

Results

Through the date combination (R_Combine) process, the number of assays decreased from 127 to 85, which lowered the standard deviation for the combined group while reducing the number of median ages to be used in the statistical analysis. Summed probability distributions were then produced for each site with four or more dates to better illustrate when diffuse and discrete periods of occupation can be identified.

The SPD for the whole of the Woodland period was created using the revised (i.e., combined from sites with ≥4 ^{14}C assays) sample of 85 ^{14}C dates from 51 archaeological sites in East Texas (Figure 2.15). This representation of these data is not biased by sites with larger numbers of samples due to the date combination process. While not discussed here, those sites with <4 ^{14}C assays that conformed to methodological constraints were included in the Woodland SPD.

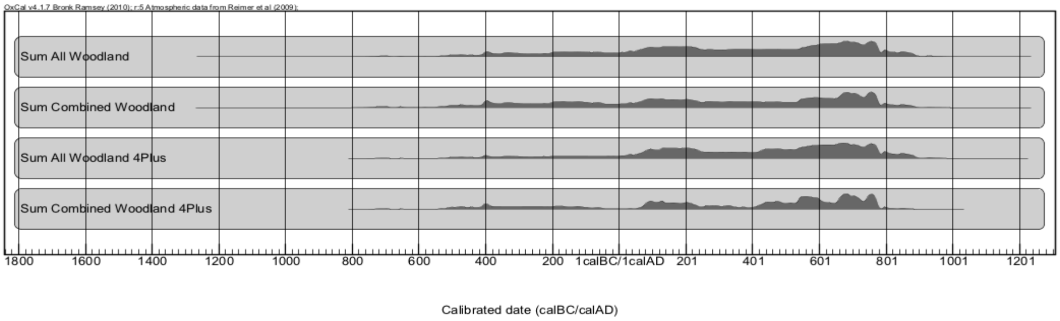

Figure 2.15. Summed probability distributions contrasting all and combined dates from the entirety of the sample, and from those sites with ≥4 ^{14}C dates.

Temporal Considerations

Incorporating these results into a revised Woodland sample reduces the number of ^{14}C assays from 127 to 85. The final sample represents Woodland components from 51 archaeological sites in the Red River (n=7 dates), Sulphur River (n=20), Cypress Creek (n=10), Sabine River (n=20), and Neches River (n=26) basins (Figure 16). The sample was sorted by median age, illustrating that the dates for Woodland period sites – when ordered by appearance – are oldest in the Red River basin (A.D. 134), followed by Cypress Creek (A.D. 202), Sulphur (A.D. 251), Sabine River (A.D. 296), and Neches River basins (A.D. 312) (Figure 2.16).

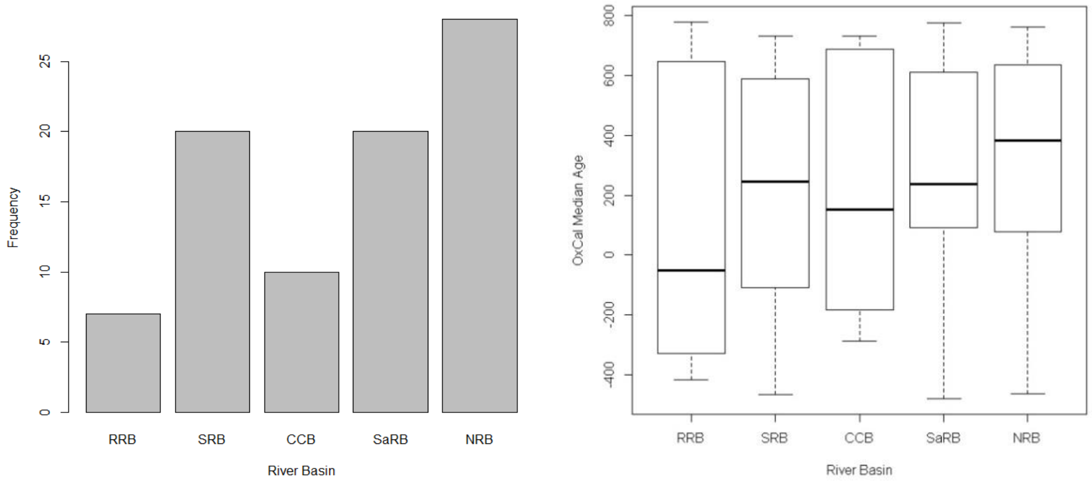

Figure 2.16. Frequency of samples and boxplot of median ages by river basin.

A summed probability distribution was calculated for the entirety of the Woodland period, and illustrates the temporal placement of Woodland components from key sites in East Texas (Figure 2.17). Although the number of sites is small, they highlight a possible temporal hiatus of nearly 400 years in the Red River basin, and another of nearly 200 years in the Cypress Creek basin, both of which appear here on the basis of data from one site in each river basin. The remaining peaks correlate with populations from the kernel density plot, and they illustrate a small peak in the Red River basin around 400 B.C. followed by slight increases in the dates from the Sulphur, Cypress, and Sabine basins around 200 B.C. This is prior to a 200-year peak in dates from the Sulphur and Sabine River basins for A.D. 50-220, after which a marked increase occurs in the number of dated Woodland sites for the Sulphur, Cypress, Sabine, and Neches River basins from A.D. 600-800.

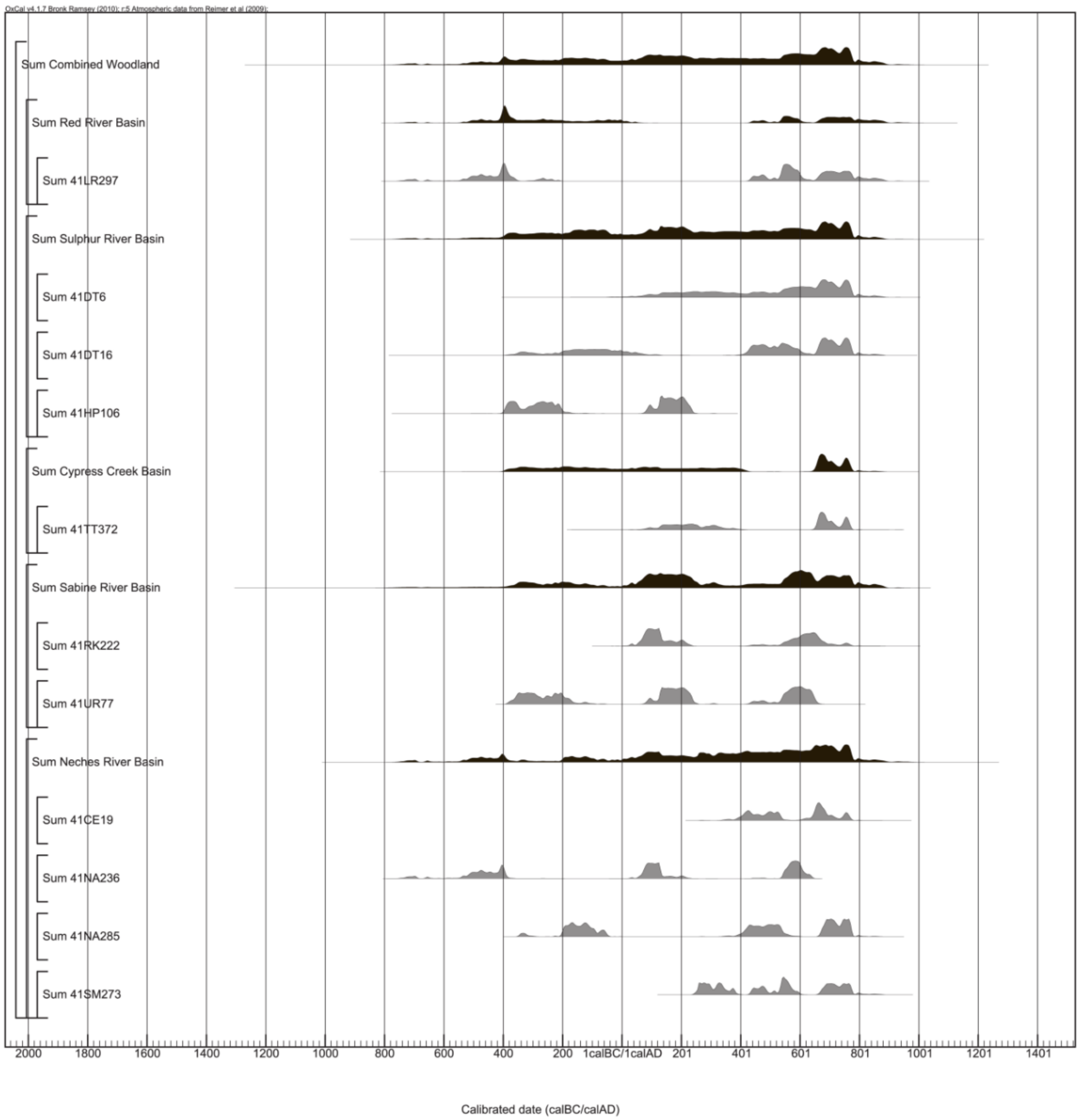

Figure 2.17. Summed probability distributions illustrating the impact of the 11 sites on the whole of the period, and upon the associated river basin.

The temporal character of Woodland occupations from the 11 sites has been dissected, and then reassembled to illustrate the temporal range of occupations and hiatuses for each (Table 2.3). The diversity of occupational length within the sample ranges from an average of 95-831 cal. ^{14}C years, with breaks of 0-382 cal. ^{14}C years. Of the 11 sites, one may have been continually - if episodically - occupied (41DT6), four have two discretely dated occupational events (41HP106, 41TT372, 41RK222, and 41CE19), and six have three discretely dated occupational events (41LR297, 41DT16, 41UR77, 41NA236, 41NA285, and 41SM273).

Table 2.3. Occupations and hiatuses by river basin for sites with ≥4 ^{14}C dates.

River Basin	***Site***	***O(1)***	***H(1)***	***O(2)***	***H(2)***	***O(3)***	***AOL***	***AHL***
Red	*41LR297*	525	643	187	37	214	309	340
Sulphur	*41DT6*	831	--	--	--	--	831	0
	41DT16	357	413	140	93	103	200	253
	41HP106	150	287	196	--	--	173	287
Cypress	*41TT372*	191	337	106	--	--	149	337
Sabine	*41RK222*	167	218	333	--	--	250	218
	41UR77	161	330	82	343	82	108	337
Neches	*41CE19*	186	72	157	--	--	172	72
	41NA236	353	436	158	327	95	202	382
	41NA285	90	532	109	151	85	95	342
	41SM273	87	98	132	111	86	102	105

O = Occupation
H = Hiatus
AOL = Average Occupation Length
AHL = Average Hiatus Length

Spatial Considerations

It has become increasingly apparent that there was no preference for river basin or natural region by this prehistoric population as they began to intensify upon the landscape within the Post Oak Savannah, Blackland Prairie, and Pineywoods of East Texas. In fact, Woodland period populations settled in all three natural regions within the Red, Sulphur, Cypress Creek, Sabine, and Neches River basins. While the great majority of Woodland sites fall within the Austroriparian biotic province (Blair 1950:98), some sites—those in the western Red River and Sulphur River basins—occur within the Texan biotic province. The western boundary of the Austroriparian is limited by moisture (Blair 1950:99), and rainfall amounts range from 44 inches on the western margin of the province to 56 inches on the eastern border of Texas (Window on State Government 2012). While this region boasts the highest annual rainfall for the state, it lies within the Region of Summer Drought as characteristically defined by Carr (1967:17), where he notes that,

> [o]ne abnormal climatologic occurrence which would have deleterious effects on East Texas would be the loss in April and May of the generous rainfalls which occur there during these months and again in November and December. These are the two peak rainfall periods before and after the summer-drought months. The loss of peak rainfalls during these months could result in a year-long drought—not merely a summer drought.

This cyclical pattern produces a winter surplus and summer deficiency of water for the region (see Carr 1967:Figure 7), and may be a factor in the geographic location of Woodland-period settlements. While impossible to determine from the record of radiocarbon dates alone, shifts in residential strategies of these semi-nomadic to semi-sedentary populations may have much to do with the variability in rainfall, since seasonal shortcomings could have caused a dramatic shift in the availability of regionally important ecological resources.

Another consideration of residential strategies is trade. This is defined by Perttula and Bruseth (1990:95) as “the movement of objects or materials to be used in the production of objects back and forth between different groups.” Archaeologically, participation in extra-local trade follows—virtually entirely—500 B.C. and continues to mature through the entirety of the Woodland period before fluorescing during the Caddo period in East Texas (ca. 800-1680) (Perttula and Bruseth 1990).

Through the analysis of median dates by way of kernel density and hierarchical cluster analysis, Woodland period median dates were found to encompass three potential divisions (Figure 2.18). Although the small sample size prevents these results from achieving the appropriate level of significance—750 by Michczynski and Pazdur (2004) and 500 by Williams (2012)—they do warrant mention here.

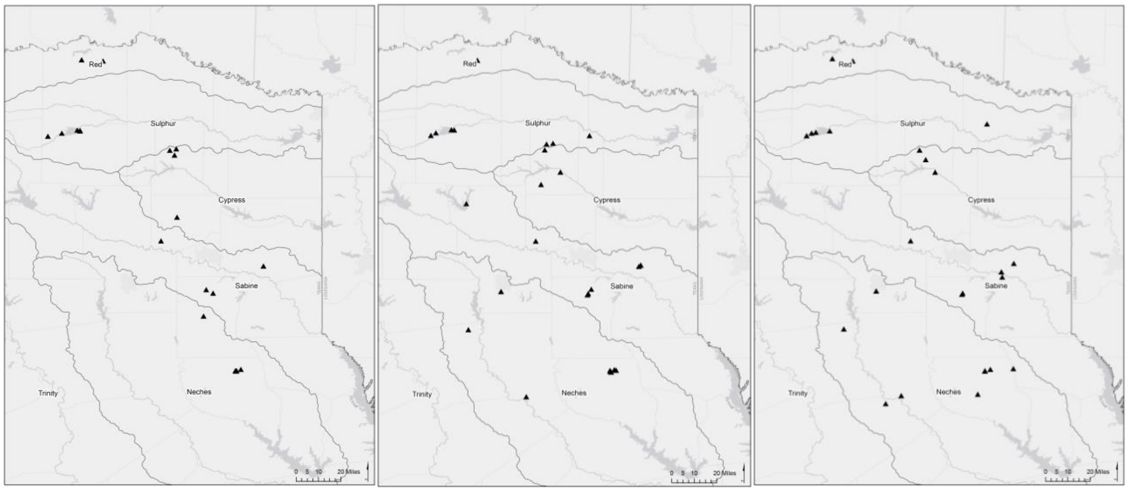

Figure 2.18. From left to right, Early Woodland (500 B.C. – A.D. 0), Middle Woodland (A.D. 0-400), and Late Woodland (A.D. 400-800) archaeological sites.

These temporal trends were manifest within the geographic boundaries for East Texas Woodland populations of the Fourche Maline (Schambach 1998, 2002), Mill Creek (Perttula and Nelson 2004), and Mossy Grove (Story 1990) culture areas, and appear to support Schambach's (1998:128) hypothesis that the Caddo culture developed "in situ in the Trans-Mississippi South." However, this observation appears true for all three currently defined culture areas in East Texas and is not limited to the Fourche Maline.

The demonstrated occupational episodes represent the cultural antecedents of the later prehistoric and protohistoric Caddo populations (ca. A.D. 800-1680) and the shift from a hunter-gatherer and horticultural economy to one dominated by agriculture within greater East Texas. While lacking in detailed temporal correlations with the material culture of the different Woodland culture areas, the 11 sites surveyed within this study illustrate a significant increase in site use during the period of A.D. 400-800.

The temporal distribution of occupational episodes for Woodland sites in East Texas (see Figure 2.17) increased exponentially after A.D. 400 and the associated hiatuses decreased in both frequency and duration. Prior to A. D. 400, only 13 occupational episodes occurred throughout an 800 cal. ^{14}C year period, while the number of occupational episodes increased to 16 during the last 400 cal. ^{14}C years of the Woodland period. This trend is indicative not only of a larger population, but possibly a more sedentary lifestyle, which may temporally demonstrate the cultural shift from hunter-gatherer to agriculturalist.

Discussion

Due to depositional and contextual issues and the wide variety of mitigation strategies and research designs employed throughout the region, the western boundary of the Eastern Woodlands remains one of the least well-known and explored periods in the greater Southeast. This can be seen plainly when the number of components from Woodland period sites is contrast against the much more robust representation of radiocarbon dates from the Archaic and Caddo periods. The fact that only 127 of the 1248^{14}C samples in the East Texas Radiocarbon Database are representative of this period speaks to the need for further research.

These results present a significant advancement in the manner by which ^{14}C assays may be manipulated for use within summed probability distributions. At the regional and sometimes local scale, most archaeologists have encountered at least one very well-dated site. These sites, while often incredibly informative at the micro-scale, are fairly detrimental to macro-level analyses due to the amount of bias they introduce. Through incorporation of date combination to studies of summed probability distribution, the amount of site-specific sample bias can be reduced.

Although not essential to this analysis due to sample size, consideration should be given to taphonomic loss (see Surovell and Brantingham 2007; Surovell et al. 2009; and Peros et al. 2010) and land-use patterns (see Grove 2008, 2009, 2011) once the sample size threshold is surpassed. When coupled with the method of date combination, these tools can further clarify much of the ambiguity encountered as we continue to move forward with our analyses of these data at the regional scale.

Summary and Conclusion

Regionally, statistical nuances within the data appear to illustrate the likelihood of three temporal divisions and an increase in occupational episodes post ca. A.D. 400. While more research needs to be completed to reveal the nature of the cultural shift from hunter-gatherer/part-time horticulturist to a more agriculturalist lifestyle, this investigation illustrates those sites with temporal components that would likely be more fruitful than others within the framework of that endeavor.

Subsequent efforts to refine the chronology of the material culture from these different components should take the form of case studies from specific Woodland period sites where artifacts were recovered in association with radiocarbon samples. As that effort expands, our knowledge of the temporal and spatial distributions of specific artifact classes, types, and assemblages can be enhanced. We are quickly approaching an era where typological assignments can be associated with radiocarbon samples in this same manner, but significant advances in correlating these data with specific aspects of archaeological assemblages still need to be made as we progress in our analyses of the Woodland period of East Texas.

This analysis represents only a small sample of ^{14}C dates from the ETRD, which remains a large and understudied amalgam of radiocarbon dates that is available for use within current cultural resource management endeavors. Through the systematic employment of this methodological approach, it is plausible that similar analyses would strengthen the arguments presented here (i.e., shorter hiatuses during the later and better-understood Caddo period, and longer hiatuses ranging from the Archaic through

Paleoindian periods), providing a productive medium through which dialogues regarding the material culture of East Texas can continue to be developed.

CHAPTER III

MODELING TEMPORAL AND SPATIAL DYNAMICS OF THE EAST TEXAS CADDO (ca. A.D. 800-1680)[2]

Overview

The work presented in this chapter has been submitted by the author and committee member Timothy K. Perttula to the journal *Southeastern Archaeology*, where it was subsequently accepted. Through the employment of radiocarbon (^{14}C) dates as data, we use the date combination process to refine site-specific summed probability distributions for 555 dates from Caddo sites (n=19) in East Texas with 10 or more ^{14}C dates. Summed probability distributions are then contrasted across river basins and natural regions with the remainder of the East Texas Caddo Radiocarbon Database (n=338 from 132 other Caddo sites), highlighting the temporal and spatial character of Caddo archaeological sites throughout East Texas.

Introduction

The Southern Caddo Area stretches across East Texas, Northwest Louisiana, Southwest Arkansas, and Southeast Oklahoma (Figure 3.1). While delineating the geographic extent of ancestral Caddo settlements across this broad area has been of considerable research interest since the early 1900s (see Brown et al. 1978; Early 1982, 2004;

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Girard 2010; Krieger 1946, 2009; Rogers and Sabo 2004; Schambach 1982; Story 1990), this article focuses on the temporal and spatial variability in Caddo native history that occurred in East Texas. Using radiocarbon (^{14}C) dates as data (e.g., Rick 1987), we combine ^{14}C assays from all sites with 10 or more dates in order to construct a temporal and spatial model of ancestral Caddo occupation by natural region and river basin. This effort represents the first phase of a larger research approach to focus on better understanding long-term trends in interaction between Caddo and non-Caddo cultural groups between ca. A.D. 850-1680 (Formative to Late Caddo periods).

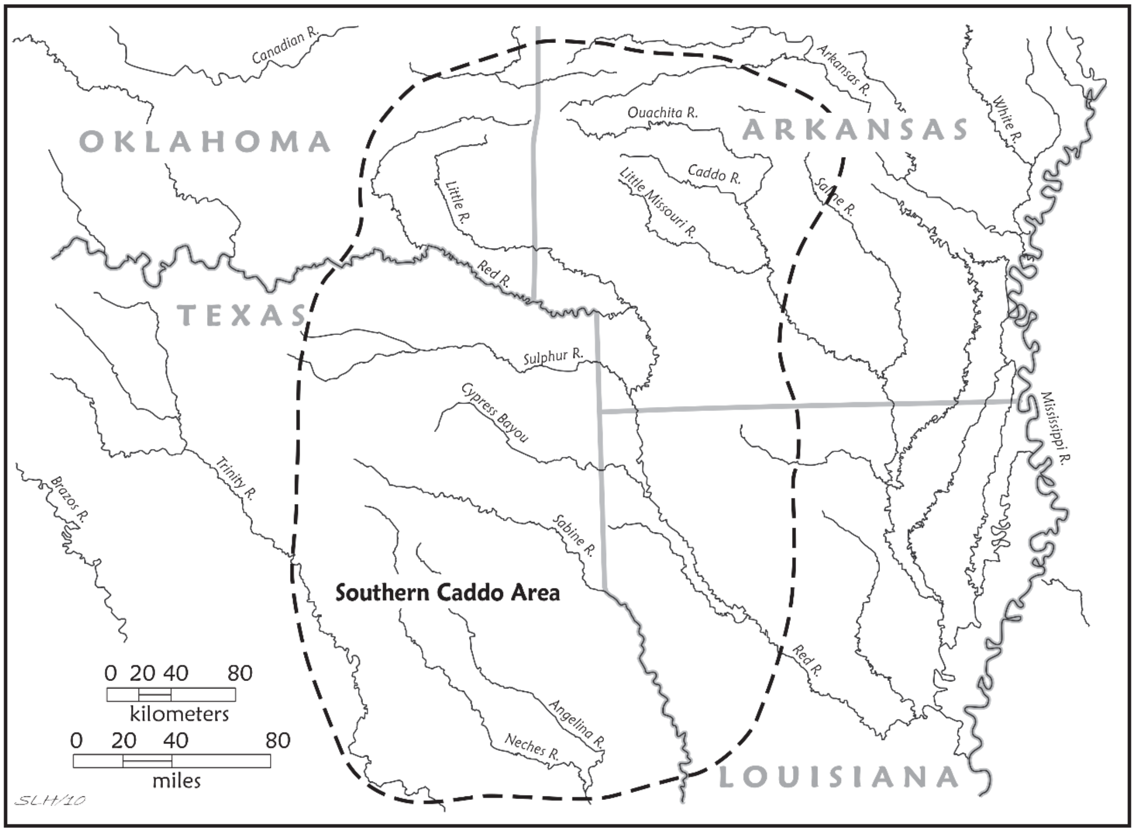


Figure 3.1. Southern Caddo Area.

To this end, it is important to identify those sites with occupational episodes (of a particular district/region/phase) that are archaeologically contemporary. Here we use detailed analyses of radiocarbon dates from East Texas Caddo sites to address the issue.

Problems with chronology and cultural taxonomies persist (Perttula 2012) in East Texas Caddo studies, but with the availability of the extensive East Texas Radiocarbon Database (Perttula and Selden 2011)there is hope that these problems will be replaced with new ideas regarding non-chronological issues in the archaeological record: technology, traditions, politics, religion, and rituals of the East Texas Caddo people. It is important to dig deeper into the cultural nuances and traditions of the Caddo people to investigate how human interaction influenced the creation of this socially powerful group of complex mound-building societies at the western edge of the Eastern Woodlands. Representative of the first step in furthering current dialogues, this article explores various avenues through which large data sets-such as the one employed herein-from the Caddo region can be used gainfully to address more pointed and focused research questions.

To us, the logical first step in addressing the temporal and spatial character of the East Texas Caddo tradition is through an analysis of the ^{14}C data. Although "deceptively simple" (Perttula 2012:12), the current chronology of the Caddo tradition (Table 3.1) embraces "no unstated assumption…that [these] periods represent linear or evolutionary views of regional developments or that archaeological developments within the East Texas Caddo area conform in any way from one region to another within the overall regional framework" (Perttula 1992:58).

Table 3.1. Caddo chronological framework (Perttula 2012: Table 1-1).

Period	Dates (A.D.)
Formative Caddo	800 – 1000
Early Caddo	1000 – 1200
Middle Caddo	1200 – 1400
Late Caddo	1400 – 1680
Historic Caddo	1680 – 1860+

Methods

Radiocarbon dates have been gathered from the East Texas Radiocarbon Database (ETRD) (Perttula and Selden 2011), which is an amalgam of ^{14}C dates collected from research and cultural resource management reports and publications spanning the last 50 or more years, synthesized, then recalibrated in version 4.1.7 of OxCal (Bronk Ramsey 2012) using IntCal09 (Reimer et al. 2009). These data were analyzed using a variety of statistical processes within version 2.15.1 of R (www.r-project.org), and summed probability distributions (SPD) were produced using OxCal. For older assays lacking $\delta^{13}C$ data, we used estimates for fractionation correction as suggested by Stuiver and Reimer (1993: Table 1): -25‰ for nutshells and charcoal (C_3 plants), and -10‰ for charred maize (C_4 plants) (Perttula 1998a, 1998b; Perttula and Selden 2011; Selden 2012). Once recalibrated, median ages were utilized to select the bulk of the Caddo sample, while others—those straddling the A.D. 800 or A.D. 1680 temporal boundaries—were selected on a case-by-case basis and were segregated based upon probability. Statistical calculations employ negative numbers to represent B.C. and positive numbers to represent A.D. (Sirkin 2006).

The raw sample of Caddo ^{14}C dates (n=893) exceeds the minimum number of dates needed for statistical significance—750 as suggested by Michczyńska and Pazdur (2004) and 500 by Williams (2012)—but the combined sample (n=405) does not. However, the distilled sample of 405 dates reduces probability bias introduced by sites with large numbers of ^{14}C dates, and provides a more accurate representation of the temporal character for Caddo sites with 10 or more ^{14}C dates.

The ^{14}C date combination process assumes that if all assays collected at a particular site draw carbon from the same reservoir, then they should have the same underlying $F^{14}C$ value and can be combined prior to calibration (Bronk Ramsey 2008). The measurements have Gaussian uncertainty distributions, and the calibration curve will have an expanded range of probability that broadens the temporal span within which the date of the event may be said to have occurred. Conversely, if the calibrated intercept occurs at a point in the curve with no plateaus or reversals, the resultant date range will be smaller. Thus, no matter how precise the sample, occurrences of prolonged (plateaus) and multi-modal probability distributions (reversals) occur across the sample. However, through an understanding of the nuances in the current ^{14}C calibration curve, samples that fall within temporal periods where plateaus and reversals occur can be more easily identified, and given a more critical analysis.

The Caddo sample was selected from the ETRD on the basis of median age. If the median age fell within the currently accepted temporal construct (ca. A.D. 850-1680) for the Caddo tradition prior to sustained European contact (see Story 1990; Perttula 2012), it was included. Data fields imported from the ETRD include site name, trinomial (site number), assay number, raw age, δ^{13}C, corrected ^{14}C age, 2-sigma age range, and median age.

There are 118 sites in the ETRD that have between one and five ^{14}C samples; 17 sites with 6-10 samples; seven sites with 11-20 samples; four sites with 21-30 samples; two sites with 31-40 samples; one site with 41-50 samples; and two sites with 91-115 samples. The assays from the 19 sites with 10 or more ^{14}C dates were combined via OxCal for two reasons: (1) to reduce the standard deviation and increase the accuracy of each site's temporal assignments and (2) to reduce sampling bias that was created by the number of samples during statistical analyses. Once combined, a SPD was produced for each of the 19 sites with more than 10 dates to illustrate the temporal position of each grouping at the site. The dates were plotted in a manner where the SPDs, the combined groups, and the individual assays that comprise them can be viewed together. These efforts permit the uncombined SPD for each site to be contrasted with the combined SPD and the combined groups that comprise it. This comparison demonstrates the impact that each site has upon the whole of the Caddo sample, and allows for a discussion of regional trends within the temporal sample.

Caddo sites with 10 or more ^{14}C dates are listed in bold in Table 2 and are geographically illustrated in Figure 3.2 (see also Table 3.2). The ^{14}C assays from these 19 sites are refined through date combination, and the subsequent results (combined dates) replace the original assays within the analysis of all East Texas Caddo dates. Radiocarbon samples from these sites were refined through date combination in an effort to create accurate site and temporally-specific summed probability distributions.

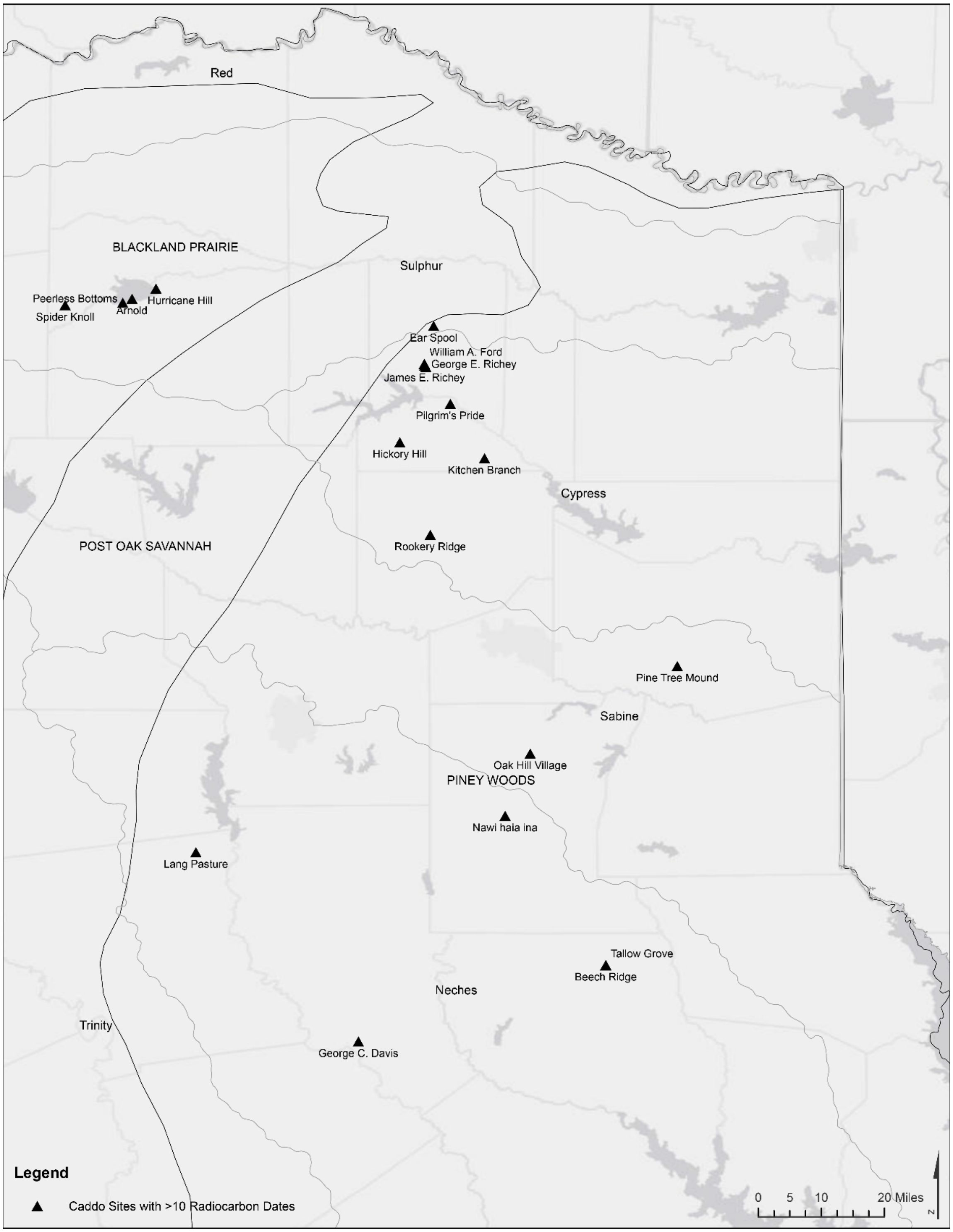


Figure 3.2. East Texas Caddo sites with 10 or more radiocarbon dates.

Table 3.2. Caddo sites in East Texas with radiocarbon dates.

Site Name	Site Trinomial	No. of ^{14}C dates
Emma Owens	41AN21	1
Fred McKee	41AN32	1
Pierce Freeman	41AN34	1
Lang Pasture	41AN38	22
Pace McDonald	41AN51	2
Ferguson	41AN67	1
Alcoa No. 1	41AN87	4
Hatchel	41BW3	8
Cranfill	41BW171	3
Dogwood Mound	41BW226	1
-	41BW553	4
Weaver Creek	41BW692	1
Solon Stanley	41CE3	1
A. H. Reagor	41CE15	1
George C. Davis	41CE19	115
-	41CE299	3
Kah-hah-ko-wha	41CE354	6
Tuck Carpenter	41CP5	1
Harold Williams	41CP10	1
Shelby Mound	41CP71	8
-	41CP88	5
Kitchen Branch	41CP220	17
Underwood	41CP230	1
Polk Estates	41CP245	2
Pilgrim's Pride	41CP304	29
-	41CP313	2
-	41CP316	2
Honey Suckle	41CP335	1
Hickory Hill	41CP408	27
Coker Mound	41CS1	1
Knight's Bluff	41CS14	2
-	41CS150	1
-	41CS151	4
-	41CS155	1
Tick	41DT6	1
Spider Knoll	41DT11	22
Spike	41DT16	7
L. O. Ray	41DT21	1
-	41DT50	1

Table 3.2. Continued

Site Name	Site Trinomial	No. of ^{14}C dates
Luna	41DT52	2
Johns Creek	41DT62	2
-	41DT63	3
Thomas	41DT80	5
Doctors Creek	41DT124	5
-	41DT141	2
New Hope	41FK107	1
Hardin-A	41GG69	2
Woldert	41HE80	1
-	41HE139	1
Winston	41HE245	2
-	41HE257	1
-	41HE343	2
Hargrove Lake	41HO150	1
Nabedache Azul	41HO214	1
Butler Branch	41HO216	1
Lawson	41HP78	2
Arnold	41HP102	11
Hurricane Hill	41HP106	11
-	41HP116	1
Finley Fan	41HP159	1
Peerless Bottoms	41HP175	11
Tuinier Farm	41HP237	2
Mound Pond	41HS12	2
Pine Tree Mound	41HS15	92
-	41HS231	5
-	41HS573	1
-	41HS574	1
-	41HS588	9
-	41HS843	1
-	41HS846	2
Mackin	41LR39	7
Ray	41LR135	8
Stallings Ranch	41LR297	5
-	41MX5	3
Chayah	41NA44	3
Washington Square	41NA49	7
Tallow Grove	41NA231	15
Foggy Fork	41NA235	5

Table 3.2. Continued

Site Name	Site Trinomial	No. of ^{14}C dates
Naconiche Creek	41NA236	8
Beech Ridge	41NA242	10
Stroddard	41NA243	1
Jas. Miles	41NA247	1
Miles Boundary	41NA248	2
Telesco	41NA280	3
Boyette	41NA285	6
Tom Moore	41PN149	1
-	41PN175	1
Hudnall-Pirtle	41RK4	4
Nawi haia ina	41RK170	11
Oak Hill Village	41RK214	32
Herman Ballew	41RK222	3
-	41RK342	1
-	41RK468	1
-	41RK557	5
-	41RK558	4
-	41RK562	1
Holdeman	41RR11	4
Fasken	41RR14	2
Sam Kaufman	41RR16	9
Rowland Clark	41RR77	2
Sawmill	41SA89	1
Blount	41SA123	1
P4	41SM53	1
Jamestown	41SM54	1
Bryan Hardy	41SM55	1
Henry Chapman	41SM56	1
Redwine	41SM193	2
Wolf	41SM195	1
Browning	41SM195A	1
Broadway	41SM273	7
Lindsey Park	41SM300	1
Leaning Rock	41SM325	6
-	41SM404	6
Buddy Hancock	41SY45	1
Tyson	41SY92	4
Keith	41TT11	1
-	41TT154	1

Table 3.2. Continued

Site Name	Site Trinomial	No. of ^{14}C dates
-	41TT372	4
-	41TT373	1
-	41TT406	1
-	41TT409	1
Mockingbird	41TT550	9
Ear Spool	41TT653	17
-	41TT670	1
-	41TT672	1
James Owens	41TT769	3
George E. Richey	41TT851	44
William A. Ford	41TT852	38
James E. Richey	41TT853	20
S. Stockade	41TT865	1
Harroun	41UR10	2
Dalton Mound	41UR11	1
Boxed Springs	41UR30	2
Seahorn	41UR105	1
Kelsey Creek Dam	41UR118	3
Verado	41UR129	2
Rookery Ridge	41UR133	10
Griffin Mound	41UR142	1
Camp Joy	41UR144	2
S. Lilly #4	41UR279	2
Henry Spencer	41UR315	2
Carlisle	41WD46	1
McKenzie	41WD55	8
Quitman Lake Burial Site	41WD60	3
Osborn	41WD73	1
Spoonbill	41WD109	5
-	41WD244	1
Turbeville	41WD382	1
Hines	41WD450	1
Taddlock	41WD482	4
Steck	41WD529	1

As an example of the date combination process, the Caddo period ^{14}C dates from the Lang Pasture site (n=23) (Perttula et al. 2011) were combined into four groups (Figure 3.3 and Table 3.3). Group 1 has three dates and ranges from A.D. 887-987, Group 2 has two dates ranging from A.D. 1264-1388, Group 3 has 12 dates ranging from A.D. 1320-1413, and Group 4 consists of three dates ranging from A.D. 1430-1610. Two dates from the site are unable to be combined (Beta-236788 and Beta-239847). There are six newly combined age ranges at the Lang Pasture site, two of which are represented by one ^{14}C sample each.

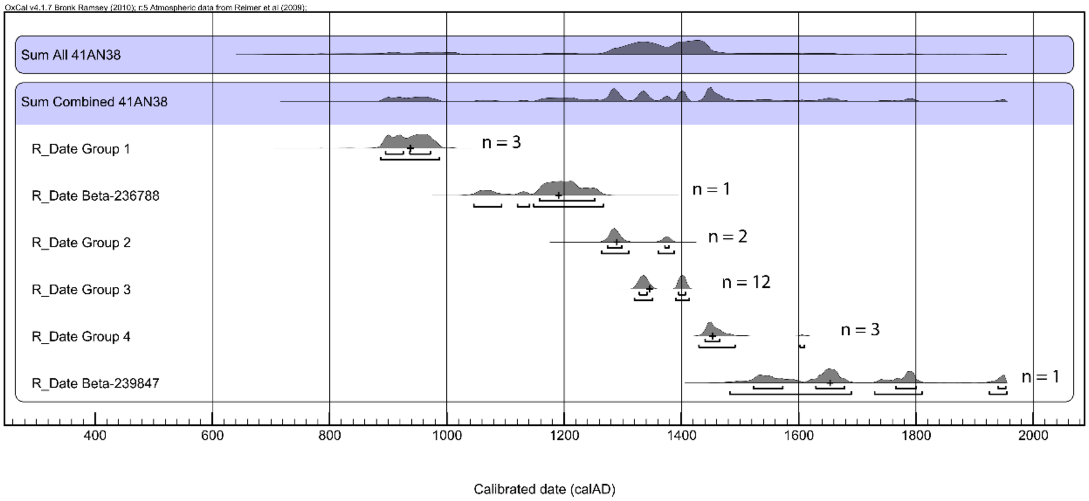


Figure 3.3 All and combined summed probability distributions for Caddo tradition dates from the Lang Pasture site (41AN38) with 1σ *and* 2σ *ranges*, median ages, and number of samples.

This process was followed for all sites with 10 or more dates, after which the assays were organized by river basin since there are known to have been temporal differences in the ancestral Caddo use of the major river basins, and the summed probability distribution was plotted for each (Figure 3.4 and Table 3.3). Combining the spatial and revised temporal data, Caddo sites of probable contemporaneity can be identified (Figure 3.5).

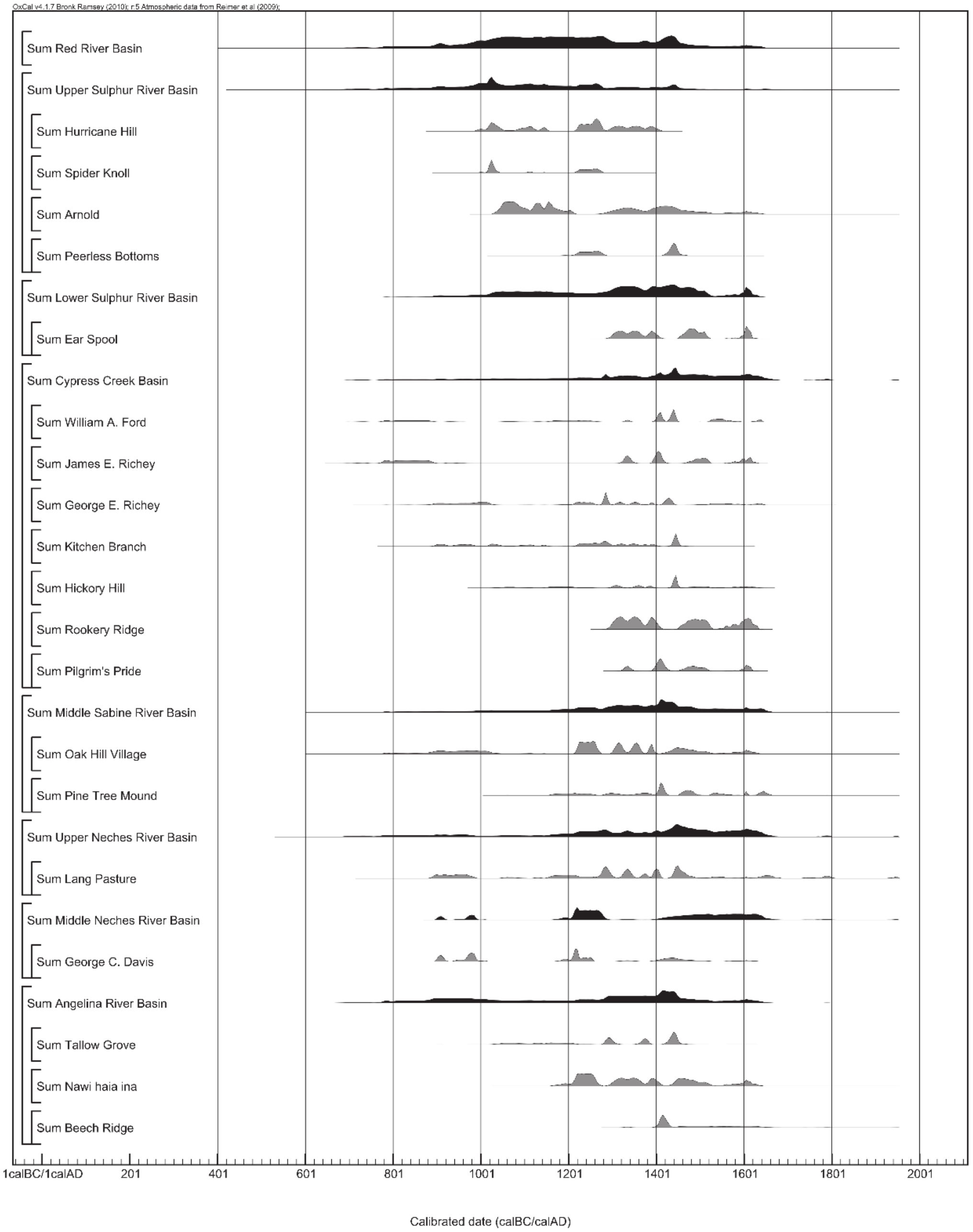


Figure 3.4. Summed probability distributions for each Caddo site with more than 10 radiocarbon dates contrast with the combined sum (from sites with less than 10 radiocarbon dates) of each river basin.

Table 3.3. Date ranges for sites with combined samples.

Site Name	Site Trinomial	Group/Assay No. of ^{14}C Dates	2σ Date Range (Probability)
Lang Pasture	41AN38	1 (n=3)	A.D. 887-987 (0.95)
	41AN38	Beta-236788	A.D. 1046-1093 (0.12), A.D. 1120-1141 (0.04), A.D. 1148-1267 (0.79)
	41AN38	2 (n=2)	A.D. 1264-1310 (0.73), A.D. 1360-1388 (0.22)
	41AN38	3 (n=12)	A.D. 1320-1351 (0.53), A.D. 1390-1413 (0.42)
	41AN38	4 (n=3)	A.D. 1430-1491 (0.93), A.D. 1602-1610 (0.02)
		Beta-239847	A.D. 1482-1690 (0.65), A.D. 1729-1810 (0.24), A.D. 1925-1955 (0.07)
George C. Davis	41CE19	1 (n=47)	A.D. 896-923 (0.31), A.D. 940-995 (0.64), A.D. 1006-1012 (0.01)
	41CE19	2 (n=66)	A.D. 1185-1258 (0.95)
	41CE19	3 (n=2)	A.D. 1310-1360 (0.10), A.D. 1386-1525 (0.74), A.D. 1557-1632 (0.12)
Kitchen Branch	41CP220	1 (n=3)	A.D. 894-988 (0.95)
	41CP220	Beta-322667	A.D. 993-1059 (0.46), A.D. 1068-1155 (0.50)
	41CP220	2 (n=2)	A.D. 1218-1273 (0.95)
	41CP220	Beta-319977	A.D. 1261-1310 (0.76), A.D. 1360-1388 (0.19)
	41CP220	3 (n=4)	A.D. 1303-1365 (0.74), A.D. 1383-1404.(0.21)
	41CP220	4 (n=6)	A.D. 1431-1461 (0.95)
Pilgrim's Pride	41CP304	1 (n=11)	A.D. 1323-1347 (0.22), A.D. 1392-1430 (0.73)
	41CP304	2 (n=18)	A.D. 1453-1522 (0.66), A.D. 1578-1581 (0.01), A.D. 1591-1620 (0.29)
Hickory Hill	41CP408	Beta-313943	A.D. 1035-1225 (0.95)
	41CP408	1 (n=8)	A.D. 1296-1325 (0.38), A.D. 1344-1395 (0.57)
	41CP408	2 (n=14)	A.D. 1434-1453 (0.95)
	41CP408	3 (n=4)	A.D. 1458-1528 (0.45), A.D. 1552-1634 (0.50)
Spider Knoll	41DT11	1 (n=16)	A.D. 995-1045 (0.87), A.D. 1099-1120 (0.07), A.D. 1142-1147 (0.01)
	41DT11	2 (n=6)	A.D. 1218-1277 (0.95)
Arnold	41HP102	1 (n=10)	A.D. 1037-1189 (0.93), A.D. 1198-1207 (0.03)
	41HP102	Tx-2049	A.D. 1280-1528 (0.85), A.D. 1552-1634 (0.11)

Table 3.3. Continued

Site Name	Site Trinomial	Group/Assay No. of ^{14}C Dates	2σ Date Range (Probability)
Hurricane Hill	41HP106	1 (n=4)	A.D. 989-1057 (0.52), A.D. 1076-1155 (0.44)
	41HP106	2 (n=4)	A.D. 1220-1279 (0.95)
	41HP106	(n=3)	A.D. 1294-1405 (0.95)
Peerless Bottoms	41HP175	1 (n=3)	A.D. 1189-1198 (0.02), A.D. 1207-1288 (0.94)
	41HP175	2 (n=8)	A.D. 1417-1464 (0.95)
Pine Tree Mound	41HS15	1 (n=2)	A.D. 1053-1080 (0.04), A.D. 1152-1269 (0.91)
	41HS15	Beta-217070	A.D. 1278-1398 (0.95)
	41HS15	2 (n=18)	A.D. 1397-1429 (0.95)
	41HS15	3 (n=69)	A.D. 1451-1495 (0.83), A.D. 1601-1612 (0.12)
	41HS15	4 (n=3)	A.D. 1520-1593 (0.48), A.D. 1619-1665 (0.46), A.D. 1786-1792 (0.01)
Tallow Grove	41NA231	1 (n=2)	A.D. 1033-1220 (0.95)
	41NA231	2 (n=7)	A.D. 1280-1310 (0.52), A.D. 1360-1388 (0.43)
	41NA231	3 (n=6)	A.D. 1419-1460 (0.95)
Beech Ridge	41NA242	1 (n=9)	A.D. 1333-1337 (0.01), A.D. 1397-1435 (0.94)
	41NA242	Beta-193131	A.D. 1442-1646 (0.95)
Nawi haia ina	41RK170	Beta-166767	A.D. 990-1185 (0.95)
	41RK170	1 (n=6)	A.D. 1185-1270 (0.95)
	41RK170	(n=3)	A.D. 1297-1410 (0.95)
	41RK170	Beta-164352	A.D. 1432-1527 (0.67), A.D. 1556-1633 (0.29)
Oak Hill Village	41RK214	Beta-107401	A.D. 775-1049 (0.91), A.D. 1085-1124 (0.03), A.D. 1137-1151 (0.01)
	41RK214	1 (n=12)	A.D. 1219-1268 (0.95)
	41RK214	2 (n=18)	A.D. 1299-1370 (0.77), A.D. 1380-1399 (0.18)
	41RK214	Beta-107400	A.D. 1415-1527 (0.71), A.D. 1555-1633 (0.25)
Ear Spool	41TT653	1 (n=3)	A.D. 1297-1407 (0.95)
	41TT653	2 (n=14)	A.D. 1452-1521 (0.68), A.D. 1591-1620 (0.28)

Table 3.3. Continued

Site Name	Site Trinomial	Group/Assay No. of ^{14}C Dates	2σ Date Range (Probability)
George E. Richey	41TT851	1 (n=2)	A.D. 880-990 (0.95)
	41TT851	Beta-305076	A.D. 898-920 (0.07), A.D. 948-1033 (0.88)
	41TT851	2 (n=4)	A.D. 1189-1197 (0.02), A.D. 1207-1264 (0.93)
	41TT851	3 (n=16)	A.D. 1276-1296 (0.95)
	41TT851	4 (n=12)	A.D. 1303-1365 (0.78), A.D. 1382-1399 (0.18)
	41TT851	5 (n=6)	A.D. 1415-1441 (0.95)
	41TT851	6 (n=3)	A.D. 1513-1601 (0.73), A.D. 1616-1645 (0.22)
William A. Ford	41TT852	Beta-300101	A.D. 720-742 (0.03), A.D. 769-898 (0.89), A.D. 921-944 (0.04)
	41TT852	Beta-242379	A.D. 1049-1085 (0.08), A.D. 1123-1138 (0.02), A.D. 1151-1271 (0.86)
	41TT852	1 (n=14)	A.D. 1328-1341 (0.12), A.D. 1395-1421 (0.84)
	41TT852	2 (n=10)	A.D. 1428-1449 (0.95)
	41TT852	3 (n=12)	A.D. 1521-1576 (0.73), A.D. 1582-1591 (0.03), A.D. 1623-1644 (0.19)
James E. Richey	41TT853	Beta-305110	A.D. 720-742 (0.03), A.D. 769-898 (0.89), A.D. 921-944 (0.04)
	41TT853	1 (n=4)	A.D. 1320-1350 (0.37), A.D. 1390-1422 (0.59)
	41TT853	2 (n=15)	A.D. 1470-1523 (0.53), A.D. 1573-1627 (0.43)
Rookery Ridge	41UR133	1 (n=4)	A.D. 1297-1407 (0.95)
	41UR133	2 (n=6)	A.D. 1454-1524 (0.53), A.D. 1558-1632 (0.42)

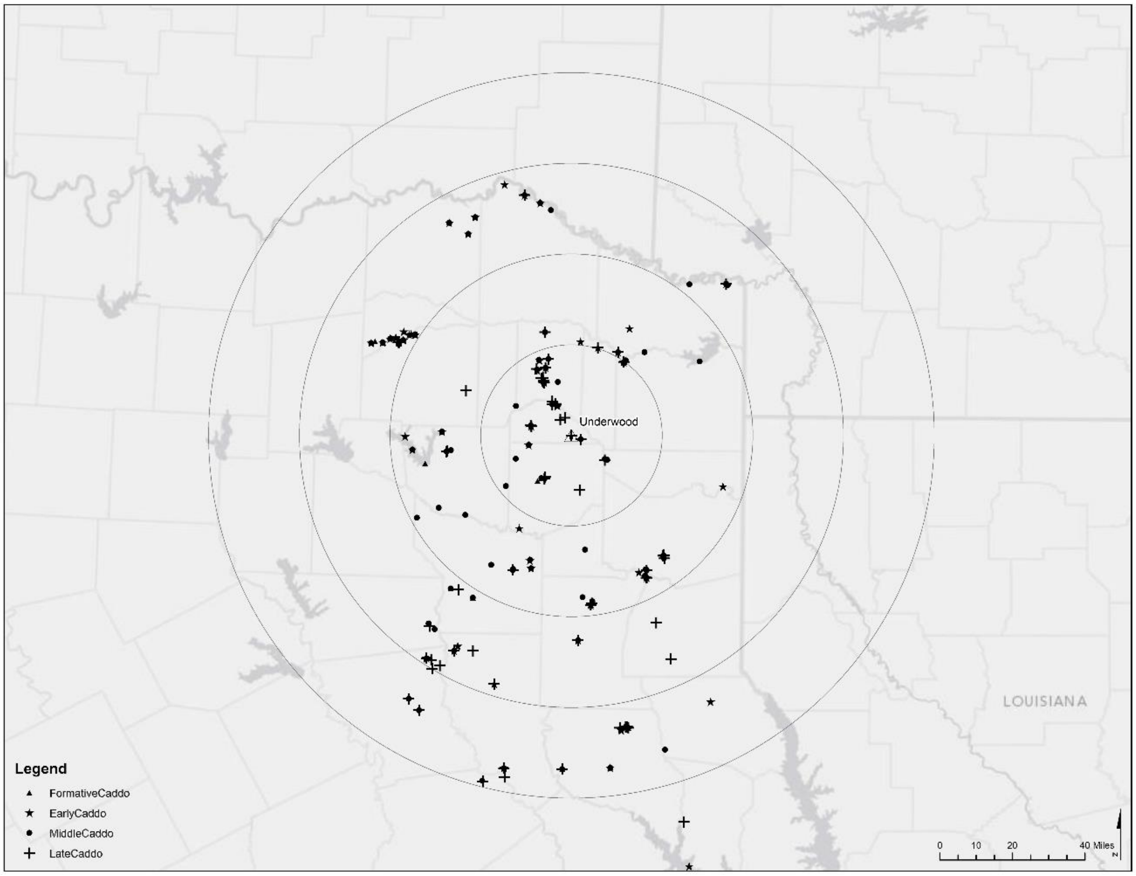


Figure 3.5. Spatial and temporal dynamics of East Texas Caddo sites surrounding the Underhill site.

Results

The use of OxCal's R_Combine process on the East Texas Caddo sites with more than 10 ^{14}C dates reduced the number of ^{14}C dates from 893 (with a standard deviation of 58) to 405 (with a standard deviation of 53), reducing probability bias from sites with large catalogs of ^{14}C dates, and providing a more accurate representation for the temporal character of the SPD for the entirety of the East Texas Caddo tradition. Subsequent to date combination, the combined ^{14}C assays replaced those assays used to create them. These data were then joined with the remaining assays from sites with less than 10 ^{14}C dates, and the

SPD across time were calculated for all the Caddo dates (Figure 6). This demonstrates the SPD for all Caddo ^{14}C dates before (All Caddo) and after (Combined Caddo) the date combination process. Further, those sites with 10 or more ^{14}C dates (Caddo 10Plus), were subject to the process of date combination, resulting in a decrease of bias in the associated probability distribution. In viewing the summed probability distribution for the sample of sites with ten or more dates in tandem with the dates from sites with fewer than 10 dates, it becomes clear that the 555 dates from sites with 10 or more ^{14}C dates heavily influence the probability distributions. Although the 67 dates from the R_Combine process still influence probability distributions for the larger sample, the probability bias from archaeological sites with a greater number of ^{14}C samples is decreased. (Figure 3.6)

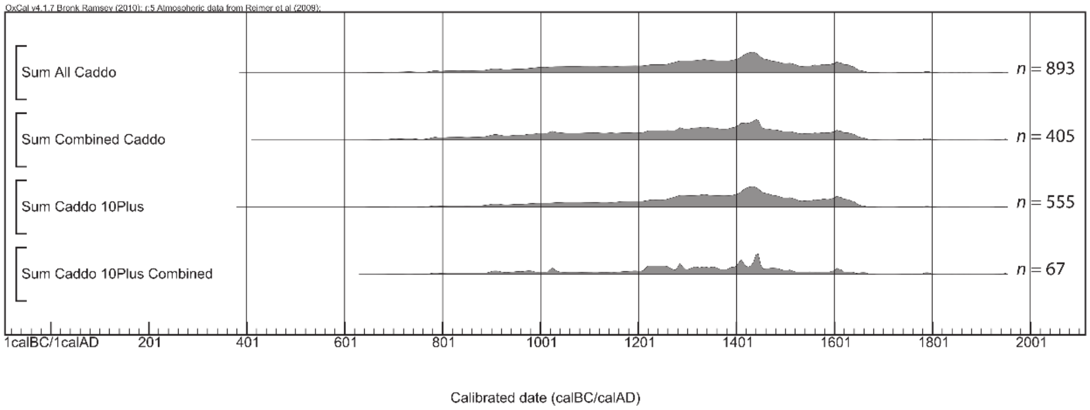


Figure 3.6. Summed probability distributions illustrating the effect of the date combination process upon the entirety of the Caddo tradition dates, and upon those sites with ≥10 ^{14}C samples.

One trend noted early in the study was that the number of ^{14}C dates increased through time; that is to say that there are fewer dates from Formative Caddo contexts than there are from Late Caddo contexts. This trend was also noted in research by Surovell and Brantingham (2007) and Surovell et al. (2009), which addressed concerns of taphonomic bias. In the context of those studies, taphonomic bias was defined as "the tendency for younger things to be over-represented relative to older things in the archaeological record due to the operation of destructive processes like erosion and weathering" (Surovell et al. 2009:1715). As a curative measure, Surovell and Brantingham (2007) modeled taphonomic bias as an exponential function to account for the proportion of archaeological sites that are lost (per year) to destructive processes. They subsequently refined that model (Surovell et al 2009). However, these models are most useful for discussions of deeper time than are covered within Caddo archaeology, and taphonomic correction of this dataset is not warranted (Todd A. Surovell, personal communication 2012).

Temporal Considerations

Efforts to analyze the temporal nature of Caddo occupations across the East Texas landscape utilizing ^{14}C dates assume that (1) ^{14}C dates combined via OxCal X-test decrease probability bias introduced by larger site-specific samples, (2) the summed probability distribution for archaeological sites with 10 or more ^{14}C assays illustrates the discrete or extended nature of ^{14}C date ranges, and (3) median dates represent the age of highest probability within each ^{14}C date range. Subsequent to date combination, the Caddo sample consists of 48 dates from the Red River basin, 25 dates from the lower Sulphur River basin, 46 dates from the upper Sulphur River basin, 89 dates from the Cypress Creek basin, 56 dates from the middle Sabine River basin, 42 dates from the upper Sabine River basin, 39 dates from the upper Neches River basin, six dates from the middle Neches River basin, and 59 dates from the Angelina River basin. The shift in sample size illustrates the reduction in the number of ^{14}C dates from each of the river basins for sites with 10 or more assays (Table 3.4).

Based on the radiocarbon data, Caddo sites dating after the early fifteenth century A.D. are uncommon in the upper Sulphur River basin, the upper Sabine River basin, the middle Neches River basin, and the Angelina River basin. Conversely, post-15th century A.D. Caddo sites are particularly well represented in the lower Sulphur River basin (Jelks 1961), the Cypress Creek basin (Perttula 2004), the middle Sabine River basin (Fields and Gadus 2012), and the upper Neches River basin (Perttula et al. 2011), where distinct regional polities had developed and were flourishing. These polities are marked by higher regional populations than was the case prior to ca. A.D. 1400, as well as dense but localized clusters of settlements, public architecture (i.e., earthen mounds), and associated family and community cemeteries. Most notably, these polities also have evidence for broad social and political hierarchies, led by religious and political leaders known ethnographically as the *Xinesi* and *Caddi* (see Story and Creel 1982).

Table 3.4. Radiocarbon dates by Caddo Period and stream basin.

Site Name	Site Trinomial	Dates by Period				
		FC	EC	MC	LC	N
Red River Basin						
Hatchel$_3$†	41BW3	-	2	3	2	7
Cranfill $_3$•	41BW171	-	-	3	-	3
Dogwood Mound$_3$†	41BW226	-	-	1	-	1
Mackin $_3$†	41LR39	1	5	1	-	7
Ray$_3$•	41LR135	2	4	2	-	8
Stallings Ranch$_2$•	41LR297	3	1	1	-	5
Holdeman$_3$†	41RR11	-	1	3	-	4
Fasken$_3$†	41RR14	-	2	-	-	2
Sam Kaufman$_3$†	41RR16	-	5	2	2	9
Rowland Clark$_3$•	41RR77	-	-	2	-	2
	Totals	*6*	*20*	*18*	*4*	*48*
	Blackland Prairie	*3*	*1*	*1*	-	*5*
	Post Oak Savannah	*3*	*19*	*17*	*4*	*43*
Lower Sulphur River Basin						
-$_1$•	41BW553	-	2	1	1	4
Weaver Creek$_1$•	41BW692	-	1	-	-	1
Coker Mound$_1$†	41CS1	-	-	1	-	1
Knight's Bluff$_1$•	41CS14	-	-	2	-	2
-$_1$•	41CS150	-	-	1	-	1
-$_1$•	41CS151	1	1	1	1	4
-$_1$•	41CS155	-	-	1	-	1
-$_1$•	41MX5	-	1	-	2	3
-$_1$•	41TT406	-	-	1	-	1
-$_1$•	41TT409	-	1	-	-	1
Ear Spool$_1$†	41TT653	-	-	4(1)	13(1)	17(2)
-$_3$•	41TT670	-	1	-	-	1
James Owens$_3$•	41TT769	-	-	1	2	3
	Totals	*1*	*7*	*13(10)*	*19(7)*	*40(25)*
	Pineywoods	*1*	*6*	*12(9)*	*17(5)*	*36(21)*
	Post Oak Savannah	-	*1*	*1*	*2*	*4*
Upper Sulphur River Basin						
Tick$_2$•	41DT6	1	-	-	-	1
Spider Knoll$_2$•	41DT11	7(-)	11(1)	4(1)	-	22 (2)
Spike$_2$•	41DT16	5	1	1	-	7
L. O. Ray$_2$•	41DT21	1	-	-	-	1
-$_2$•	41DT50	-	-	1	-	1
Luna$_2$•	41DT52	-	1	1	-	2
John's Creek$_2$•	41DT62	1	1	-	-	2
-$_2$•	41DT63	1	2	-	-	3

Table 3.4. Continued

Site Name	Site Trinomial	Dates by Period				
		FC	EC	MC	LC	N
Thomas $_2$•	41DT80	-	5	-	-	5
Doctors Creek$_2$•	41DT124	1	4	-	-	5
Lawson $_2$•	41HP78	-	2	-	-	2
Arnold$_2$•	41HP102	1	8(1)	2(1)	-	11(2)
Hurricane Hill$_2$•	41HP106	2	3(1)	6(2)	-	11(3)
-$_2$•	41HP116	-	-	1	-	1
Finley Fan$_2$•	41HP159	-	-	1	-	1
Peerless Bottoms$_2$•	41HP175	-	1	7(1)	3(1)	11(2)
Tuinier Farm$_3$•	41HP237	-	-	-	2	2
	Totals	*20(13)*	*39(20)*	*24(10)*	*5(3)*	*88(46)*
	Blackland Prairie	*20(13)*	*39(20)*	*24(10)*	*3(1)*	*84(44)*
	Post Oak Savannah	*-*	*-*	*-*	*2*	*2*
Cypress Creek Basin						
Tuck Carpenter$_1$°	41CP5	-	-	-	1	1
Harold Williams$_1$•	41CP10	-	-	-	1	1
Shelby Mound$_1$†	41CP71	-	-	4	4	8
-$_1$•	41CP88	-	1	-	4	5
Kitchen Branch$_1$•	41CP220	3(1)	1(1)	10(3)	3(1)	17(6)
Underwood$_1$•	41CP230	-	-	-	1	1
Polk Estates$_1$•	41CP245	-	1	1	-	2
Pilgrim's Pride$_1$†	41CP304	-	-	10(1)	19(1)	29(2)
-$_1$•	41CP313	-	-	1	1	2
-$_1$•	41CP316	-	-	-	2	2
Honey Suckle$_1$•	41CP335	-	-	-	1	1
Hickory Hill$_1$•	41CP408	-	1(1)	14(2)	12(1)	27(4)
New Hope$_1$•	41FK107	-	-	1	-	1
Mound Pond$_1$†	41HS12	-	2	-	-	2
Keith$_1$†	41TT11	-	-	1	-	1
-$_1$•	41TT154	-	1	-	-	1
-$_1$•	41TT372	-	1	3	-	4
-$_1$•	41TT373	-	-	-	1	1
Mockingbird$_1$•°	41TT550	1	3	1	4	9
-$_1$•	41TT672	-	-	-	1	1
George E. Richey$_1$•	41TT851	3(2)	1(-)	36(4)	4(1)	44(7)
William A. Ford$_1$•	41TT852	1(1)	-	22(3)	15(1)	38(5)
James E. Richey$_1$•	41TT853	1(1)	-	4(1)	15(1)	20(3)
S. Stockade$_1$•	41TT865	-	-	-	1	1
Harroun$_1$†	41UR10	-	-	2	-	2
Dalton Mound$_1$†	41UR11	-	-	1	-	1
Seahorn$_1$•	41UR105	1	-	-	-	1
Kelsey Creek Dam$_1$•	41UR118	-	-	-	3	3
Verado$_1$•	41UR129	1	-	1	-	2
Rookery Ridge$_1$†	41UR133	-	-	4(1)	6(1)	10(2)

Table 3.4. Continued

Site Name	Site Trinomial	Dates by Period				
		FC	EC	MC	LC	N
Griffin Mound$_1$•	41UR142	-	-	1	-	1
Camp Joy$_1$†	41UR144	-	-	-	2	2
S. Lilly #4$_1$•	41UR279	-	1	1	-	2
Henry Spencer$_1$°	41UR315	-	-	-	2	2
	Totals	*11(8)*	*13(12)*	*118(33)*	*103(36)*	*245(89)*
	Pineywoods	*11(8)*	*13(12)*	*118(33)*	*103(36)*	*245(89)*
Middle Sabine River Basin						
Hardin-A$_1$•	41GG69	-	-	2	-	2
Pine Tree Mound$_1$†	41HS15	-	-	27(3)	65(2)	92(5)
-$_1$•	41HS231	-	-	5	-	5
-$_1$•	41HS573	-	-	-	1	1
-$_1$•	41HS574	-	-	1	-	1
-$_1$•	41HS588	-	-	5	4	9
-$_1$•	41HS843	-	-	-	1	1
-$_1$•	41HS846	-	-	2	-	2
Tom Moore$_1$†	41PN149	-	-	-	1	1
-$_1$•	41PN175	-	-	-	1	1
Hudnall-Pirtle$_1$†	41RK4	-	4	-	-	4
Oak Hill Village$_1$†	41RK214	1(1)	4(-)	26(2)	1(1)	32(4)
Herman Ballew $_1$•	41RK222	2	-	-	1	3
-$_1$•	41RK342	-	-	1	-	1
-$_1$•	41RK468	-	-	1	-	1
-$_1$•	41RK557	1	-	3	1	5
-$_1$•	41RK558	-	2	1	1	4
-$_1$•	41RK562	-	-	1	-	1
Buddy Hancock$_1$•	41SY45	-	1	-	-	1
	Totals	*4(4)*	*11(11)*	*75(27)*	*77(14)*	*167(56)*
	Pineywoods	*4(4)*	*11(11)*	*75(27)*	*77(14)*	*167(56)*
Upper Sabine River Basin						
P4$_1$•	41SM53	-	1	-	-	1
Jamestown$_3$†	41SM54	-	-	1	-	1
Bryan Hardy$_1$†	41SM55	-	-	1	-	1
Henry Chapman$_1$•	41SM56	-	-	1	-	1
Redwine$_1$†	41SM193	-	-	1	1	2
Wolf$_1$•	41SM195	-	-	1	-	1
Browning$_1$•	41SM195A	1	-	-	-	1
Leaning Rock$_1$•	41SM325	-	1	5	-	6
Boxed Springs$_1$†	41UR30	-	2	-	-	2
Carlisle$_1$•	41WD46	-	-	1	-	1
McKenzie$_1$†	41WD55	-	-	8	-	8

Table 3.4. Continued

Site Name	Site Trinomial	Dates by Period				
		FC	EC	MC	LC	N
Quitman Lake Burial Site$_3$°	41WD60	-	-	2	1	3
Osborn$_3$•	41WD73	1	-	-	-	1
Spoonbill$_3$•	41WD109	-	2	3	-	5
-$_3$°	41WD244	-	-	-	1	1
Turbeville$_3$•	41WD382	-	-	1	-	1
Hines$_3$•	41WD450	-	1	-	-	1
Taddlock$_3$•	41WD482	-	3	1	-	4
Steck$_3$•	41WD529	-	-	1	-	1
	Totals	*2*	*10*	*27*	*3*	*42*
	Pineywoods	*1*	*4*	*18*	*1*	*24*
	Post Oak Savannah	*1*	*6*	*9*	*3*	*19*
Upper Neches River Basin						
Emma Owens$_1$•	41AN21	-	-	-	1	1
Fred McKee$_1$°	41AN32	-	-	-	1	1
Pierce Freeman$_1$°	41AN34	-	-	-	1	1
Lang Pasture$_1$•	41AN38	3(1)	1(1)	16(3)	2(1)	22(6)
Pace McDonald$_1$†	41AN51	-	-	2	-	2
Ferguson$_1$•	41AN67	-	-	-	1	1
Alcoa No. 1$_1$•	41AN87	-	-	2	2	4
Solon Stanley$_1$°	41CE3	-	1	-	-	1
A. H. Reagor$_1$°	41CE15	-	-	-	1	1
-$_1$•	41CE299	-	1	-	2	3
Kah-hah-ko-wha$_1$•	41CE354	-	1	1	4	6
Woldert$_1$•	41HE80	-	-	1	-	1
-$_1$•	41HE139	-	-	1	-	1
-$_1$•	41HE257	1	-	-	-	1
-$_1$•	41HE343	-	-	-	2	2
Lindsey Park$_1$°	41SM300	-	-	-	1	1
-$_1$•	41SM404	1	-	5	-	6
	Totals	*5(3)*	*4(4)*	*28(15)*	*18(17)*	*55(39)*
	Pineywoods	*5(3)*	*4(4)*	*28(15)*	*18(17)*	*55(39)*
Middle Neches River Basin						
George C. Davis$_1$†	41CE19	29(1)	54(-)	31(2)	1	115(3)
Hargrove Lake$_1$•	41HO150	-	-	-	1	1
Nabedache Azul$_1$•	41HO214	-	-	-	1	1
Butler Branch$_1$•	41HO216	-	-	1	-	1
	Totals	*29(1)*	*54(-)*	*32(2)*	*3*	*118(6)*
	Pineywoods	*29(1)*	*54(-)*	*32(2)*	*3*	*118(6)*

Table 3.4. Continued

Site Name	Site Trinomial	Dates by Period				
		FC	EC	MC	LC	N
Angelina River Basin						
Chayah$_1$•	41NA44	1	-	1	1	3
Washington Square$_1$†	41NA49	2	2	3	-	7
Tallow Grove$_1$•	41NA231	-	2(1)	12(2)	1	15(3)
Foggy Fork$_1$•	41NA235	-	-	4	1	5
Naconiche Creek$_1$•	41NA236	5	-	2	1	8
Beech Ridge$_1$•	41NA242	-	-	8(1)	2(1)	10(2)
Stroddard$_1$•	41NA243	-	1	-	-	1
Jas. Miles$_1$•	41NA247	-	-	1	-	1
Miles Boundary$_1$•	41NA248	-	-	2	-	2
Telesco$_1$•	41NA280	-	-	-	3	3
Boyette$_1$•	41NA285	2	2	2	-	6
Nawi haia ina$_1$•	41RK170	-	4(1)	6(2)	1(1)	11(4)
Sawmill$_1$•	41SA89	-	1	-	-	1
Blount$_1$•	41SA123	-	-	-	1	1
Broadway$_1$•	41SM273	5	-	2	-	7
Tyson$_1$•	41SY92	-	-	4	-	4
	Totals	*15*	*12(8)*	*47(26)*	*11(10)*	*85(59)*
	Pineywoods	*15*	*12(8)*	*47(26)*	*11(10)*	*85(59)*

$_1$=Pineywoods, $_2$=Blackland Prairie, $_3$=Post Oak Savannah; †=Mound Center, • Settlement, ° Cemetery; FC=Formative Caddo, ca. A.D. 800-1000; EC=Early Caddo, ca. A.D. 1000-1200; Middle Caddo, ca. A.D. 1200-1450; Late Caddo, ca. A.D. 1450-1680+; numbers in parentheses indicate results from the date combination process

Spatial Considerations

The spatial divisions of the nine river basins crosscut three natural regions: the Blackland Prairie, Post Oak Savannah, and the Pineywoods (see Figure 3.2). While no sites with 10 or more ^{14}C samples occur in the Post Oak Savannah, this natural region is well-represented by sites with less than 10 ^{14}C samples (see Table 3.4). Of the spatial divisions by stream basin, five occur only in the Pineywoods (Cypress Creek, middle Sabine River, upper Neches River, middle Neches River, and Angelina River basins), two in the Blackland Prairie and Post Oak Savannah (Red River and upper Sulphur River basins), and two in the

Pineywoods and Post Oak Savannah (lower Sulphur River basin and upper Sabine River basins) (Figure 3.7).

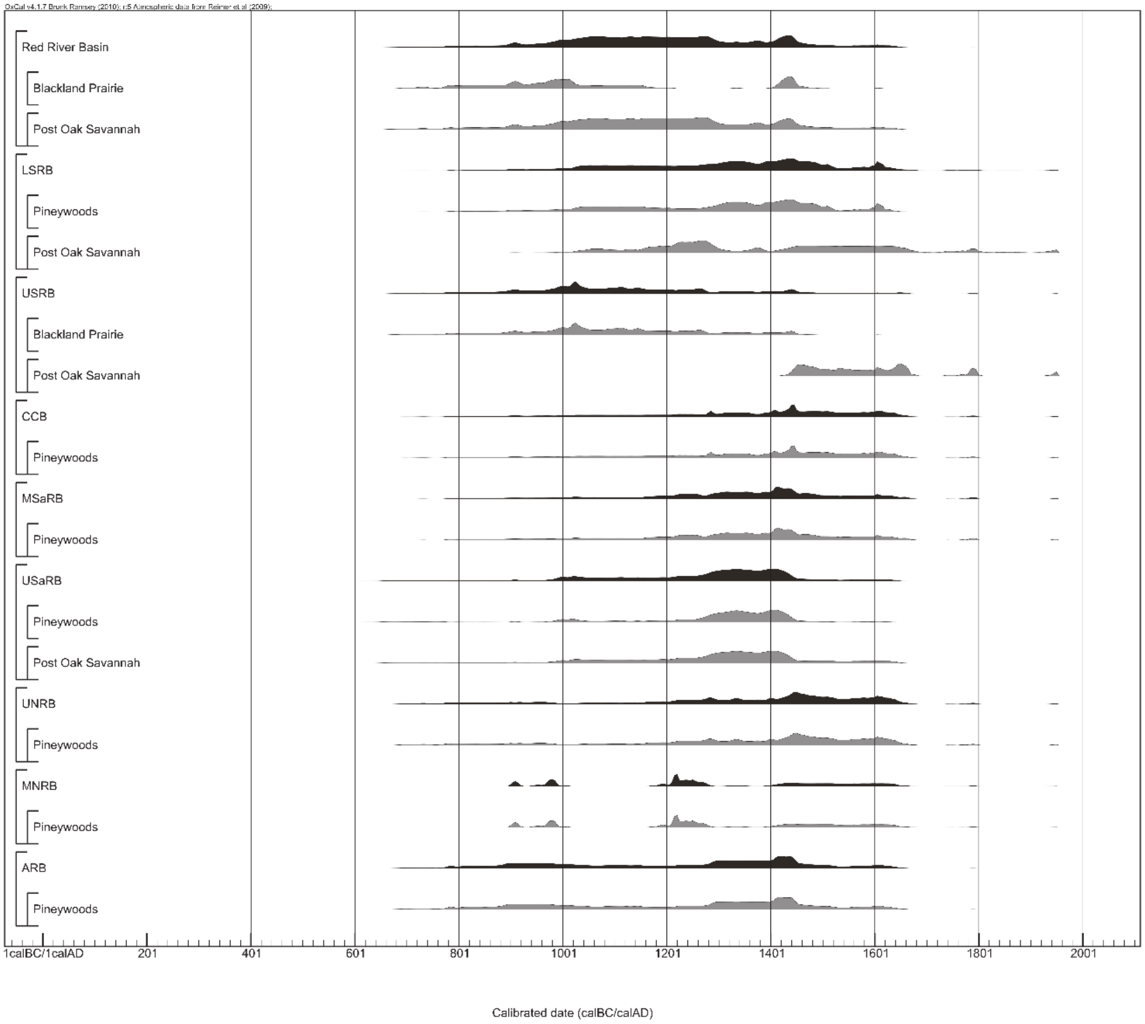


Figure 3.7. Summed probability distributions by spatial divisions and natural regions.

In most instances where dated archaeological sites occur in the Pineywoods, ^{14}C dates range from the Formative to the Late Caddo period, indicating a long-lasting continuity in settlements in this natural region. In the upper Sabine River and Angelina River basins, however, dated sites are rare after the early fifteenth century A.D. Perttula and

Rogers (2007) have suggested that drought-bearing climatic conditions beginning in the mid-fifteenth century may have led to the abandonment or lessened use of some parts of East Texas where agricultural economies were at risk. Sites in the Blackland Prairie are defined by a bimodal probability distribution in the Red River basin, and a more continuous probability distribution in the upper Sulphur River basin for Formative, Early and Middle Caddo periods. The natural region with the greatest amount of temporal variability in dated sites is the Post Oak Savannah. To better illustrate the differing settlement trends in this region (per ^{14}C dates), probability distributions are used to demonstrate that Formative Caddo (ca. A.D. 800-1000) settlements appear first in the Red River basin, followed by the Early Caddo (ca. A.D. 1000-1200) settlements in the lower Sulphur River basin, and Late Caddo (ca. A.D. 1450-1680) settlements in the upper Sulphur River basin (although only represented by only two ^{14}C dates) (Figure 3.8).

Conclusions

While the specifics of each probability range can be challenging to discern without the raw numbers, it is possible to manipulate a large sample of ^{14}C dates to create a regional model that highlights the temporal character of specific sites, where the cause of the differing temporal spans illustrated in the probability distributions associated with each episode can be correlated with the ^{14}C calibration curve (see also Bamforth and Grund 2012). The temporal analysis presented here effectively reduces bias introduced by sites with large numbers of ^{14}C dates, providing the means by which the number and character of the ^{14}C dates—in lieu of relative occupational episodes (see Rick 1987:56; Kuzmin and Keates 2005:780)—can be conveyed more meaningfully.

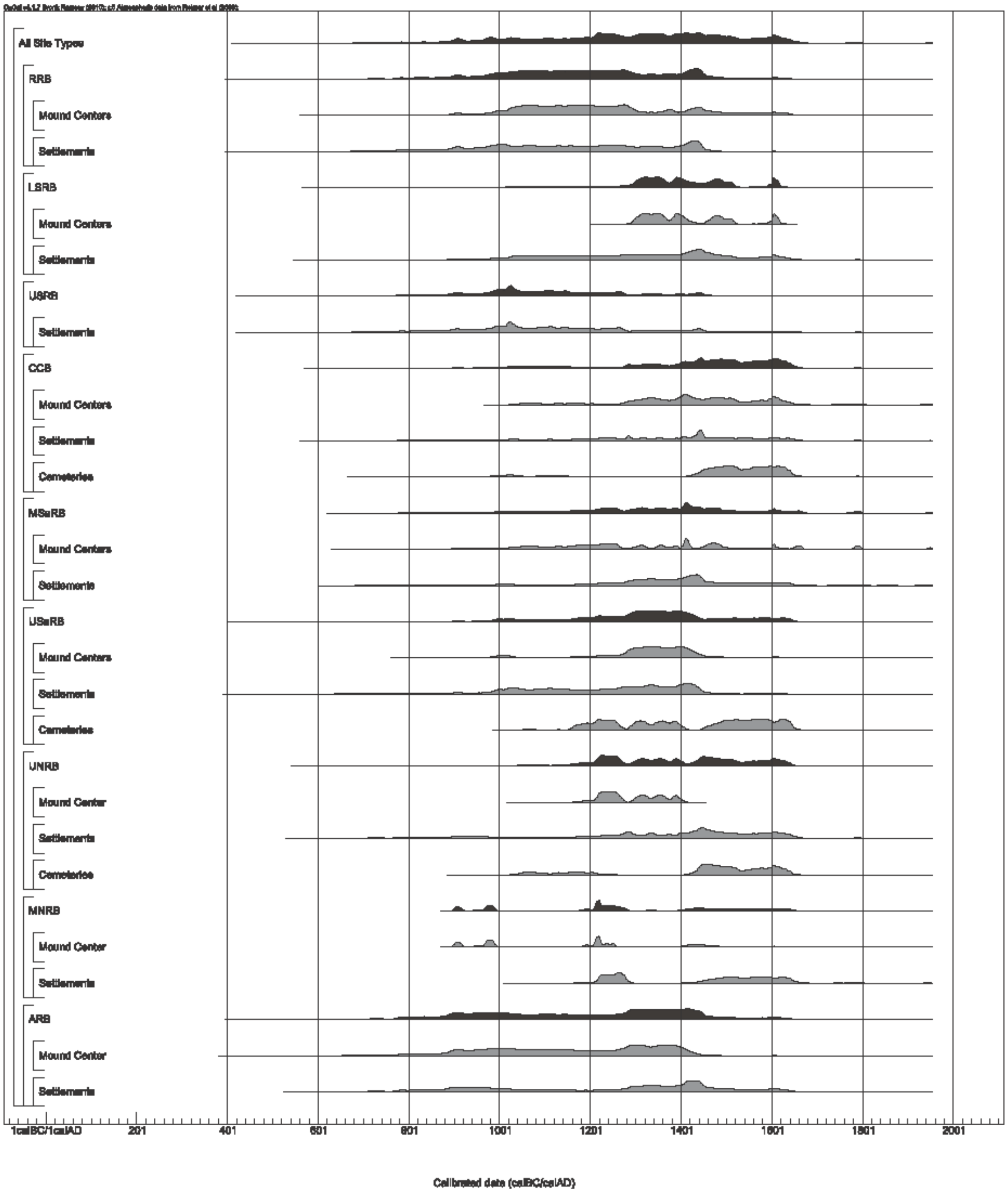


Figure 3.8. Summed probability distributions by site type.

This approach to the interpretation of ^{14}C data is fruitful, but whether it is capable of rendering accurate predictions regarding "occupation intensity" (see Rick 1987:67) or the "intensity of human occupation" (see Kuzmin and Keates 2005:773) warrants further consideration. In this instance, we consider the temporal dynamics of the East Texas Caddo radiocarbon database through site-specific analyses. Once refined through the date combination process, this approach provides a more accurate measure of regional occupation once a sufficient sample of well-dated Caddo sites throughout East Texas stream basins and environmental habitats is obtained. Certainly changes in the frequency of ^{14}C dates may be employed as a proxy for indicating population fluctuations (Peros et al. 2010), but it is best to remain skeptical as chronological models are continually refined (Bamforth and Grund 2012).

The date combination process, when paired with summed probability distributions for 19 important sites with 10 or more ^{14}C samples, has led to the establishment of more precise temporal ranges for specific Caddo occupations of East Texas. Within the context of an ongoing synthesis of research concerning all available Caddo radiocarbon dates in the four-state Caddo area, this method can be used to explore the temporal range of sites, and their combination can be a means of highlighting both temporal and spatial trends within the Caddo archaeological tradition (ca. A.D. 800-1680). Taken together and in combination with archaeological assemblage data, the analysis of Caddo radiocarbon dates can identify features and occupational events that are archaeologically contemporary across the larger region. The volume of ^{14}C dates from East Texas is fairly robust, and it is becoming easier to explore "[t]he actual relations between data points…instead of boxes of our own cryptic creation" (Dunnell 2008:64).

With the decreasing cost of attaining accurate ^{14}C determinations from much smaller samples, archaeologists are becoming more mindful of the research potential that ^{14}C dates can offer (see Kuzmin and Keates 2005; Rick 1987; Steele 2010; Williams 2012). One trend evidenced here and in other studies (see Surovell and Brantingham 2007; Surovell et al. 2009) is that the number of younger components outnumbers that of older components. This observation plays an integral role in the recent push toward highlighting fluctuations in prehistoric demography via radiocarbon (Bamforth and Grund 2012; Buchanan et al. 2008; Faught 2008; Hinz et al. 2012; Peros et al. 2010), and the curative methods advanced to correct for taphonomic bias (Surovell and Brantingham 2007; Surovell et al. 2009).

Advances in combining the analysis of ^{14}C with data from other sources—stratigraphic contexts (Bronk Ramsey 1995, 2007; Michczynski and Pazdur 2003), phases (Buck et al. 1991; Ziedler et al. 1998), architecture (Bayliss et al. 2007; Whittle et al. 2011), palaeoenvironmental records (Gearey et al. 2009), tephrochronology (Buck et al. 2003), climate (Kidder 2006), and ceramics (Buck et al. 1992)—provide an integral toolkit for exploring potential associations between ^{14}C determinations and archaeological datasets, providing testable hypotheses that can be validated or falsified with the addition of more data (Bayliss and Ramsey 2004). Bayesian analyses of radiocarbon data have been employed for over 15 years in Great Britain (Bayliss 2009; Bronk Ramsey 2008, 2009; Buck et al. 1996) with great success. Within the context of Caddo archaeological studies, further analysis of the trends highlighted here will aid in the development of more substantive and empirically-supported hypotheses and theories of culture change in East Texas and the larger Caddo area.

While it is certain that more ^{14}C dates are needed to identify more specific temporal and spatial patterns that characterize the Caddo tradition, this synthesis of data from the ETRD represents the initial undertaking in that endeavor. More attention should be given to the appearance and temporal character of specific types of sites in the future (i.e., mound centers, settlements, cemeteries, etc.), as well as for better known sites within regions whose material culture assemblages (particularly ceramic vessels and sherds) are becoming increasingly well known. This will serve to further elucidate the temporal progression or abandonment of East Texas Caddo communities through the detailed consideration of micro-stylistic changes in ceramic assemblages (see Girard 2012) that can be associated with suites of calibrated radiocarbon dates.

CHAPTER IV

EPISTEMOLOGY AND SYNTHESIS: INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS OF ANCESTRAL CADDO CERAMICS

Overview

The work presented in this chapter will be submitted to the *Journal of Archaeological Science*. Ceramic provenance studies remain the basis of worldwide archaeological research concerned with reconstructing exchange networks, tracing migrations, and informing upon local and regional ceramic economy. Due to the vagaries of Texas geology, traditional geochemical techniques (instrumental neutron activation analysis in particular) have not achieved the degree of success in Texas as within other regions. This paper presents a synthesis of Caddo INAA research, highlighting the results of analyses and positing future directions for endeavors that remain focused upon the provenance of ceramic vessels within the ancestral Caddo territory.

Introduction

Paradigms—as defined by Kuhn (1962:viii)—are "…universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners." That being the case, Caddo archaeology has passed through a number of theoretical paradigms in the last 80 years. The early years spawned a wealth of knowledge in the form of Culture History, and while standing philosophically on the shoulders of Kroeber (1919) and Childe (1932), this represents the basis of Sayles' (1935) synthesis of

Texas archaeology, Krieger's (1944, 1946) horizons and chronology-building of the Caddo archeological record, and Swanton's (1942) source material, as well as two subsequent landmark contributions that represent the foundations of our current typological understanding of Caddo—and Texas—material culture (Suhm et al. 1954; Suhm and Jelks 1962). The 1960s marked a significant turning point in the discipline, focusing upon the development of archaeology as a science. The principal arbiter of this new way of thinking was Lewis Binford, who began to vehemently question the efficacy of the historical (i.e., Culture History) approach (Binford 1968).

The "new archaeology" helped to shape much of the practice of archaeological research, and its impact can be seen in a large number of archaeological contributions spanning the 1970s through the present. Since adopting a more or less processual perspective (Shafer 1973, 2011), not much has changed within the realm of Caddo theory; however, this is not to say that there were no efforts made to pull Caddo archaeology toward and into other theoretical debates. Schambach's (1998) discussion of pre-Caddoan cultures, and Brooks' (1996) "revisionists perspectives," tried to do just that.

Holding true to the processual approach in vogue within the region, instrumental neutron activation analysis (INAA) has been employed in the context of ceramic studies focused upon the Caddo tradition since 1995 in an effort to generate probable zones of ceramic manufacture and use (Ferguson 2007; Perttula and Ferguson 2010). This article provides a general synthesis of the results of INAA endeavors in the ancestral Caddo territory over the past 17 years, and possible avenues for future research.

Thanks to significant assistance from several Caddo archaeologists, the geochemical data from all previous Caddo INAA endeavors has been assembled, and is used as the basis for this endeavor. Those data include 1281 assays from 171 archaeological sites across the traditional Caddo landscape of southwest Arkansas, northwest Louisiana, east Texas, and southeast Oklahoma. Included within the current database are an additional 57 assays of Caddo ceramics recovered from 17 sites in Central Texas that fall beyond the geographic extent of the Southern Caddo Area (Figure 4.1).

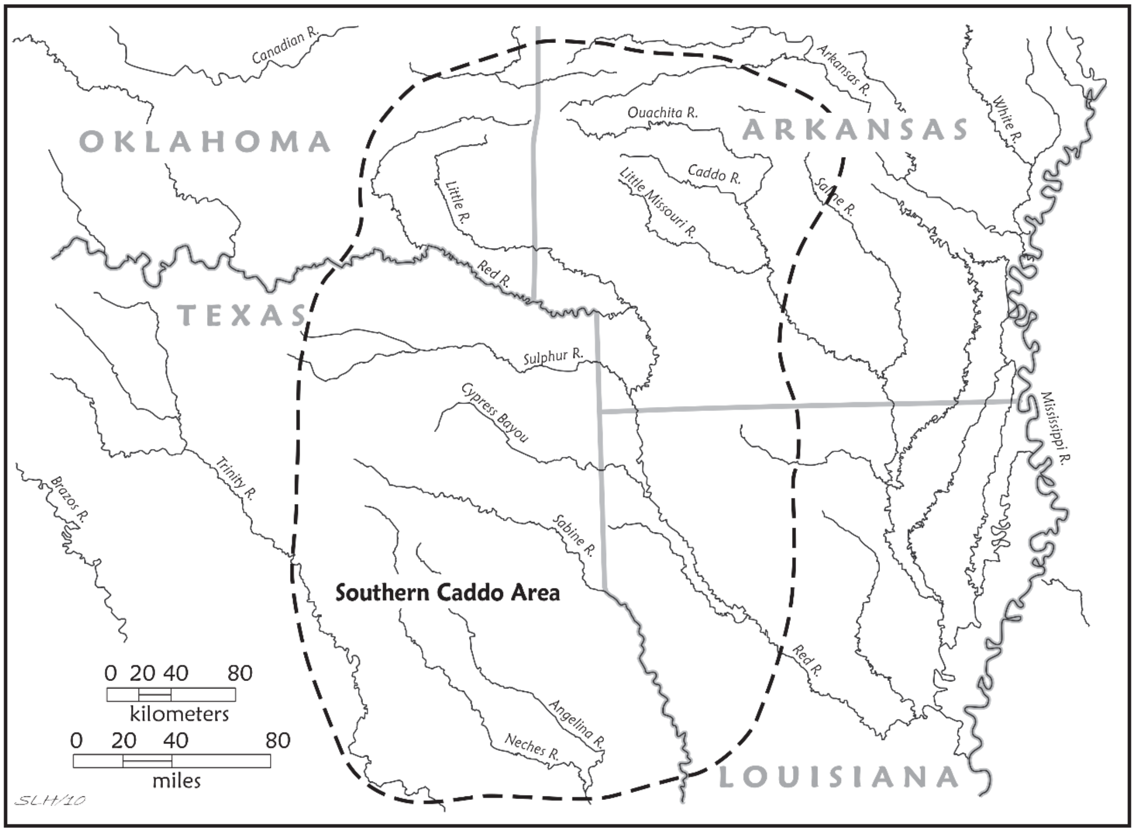


Figure 4.1. Geographic extent of the Southern Caddo Area.

Archaeological Epistemology of Caddo INAA Research

When viewing the current geochemical data set, it is hard to believe that the foundation of Woodland and Caddo-based INAA research began with only 22 samples processed by the National Institute of Standards and Technology (Steponaitis et al. 1996). Within that initial analysis, dominant clay minerals from each of several defined provinces in Eastern North America were identified (see Steponaitis et al. 1996:Figure 5), forming the core of the first region-based discussion (Steponaitis et al. 1996:555-557). Ceramic sherds from a few Caddo sites were assigned to the Western geographic area based upon the analysis of geochemical elements (Steponaitis et al. 1996:Figure 4), which appeared to segregate the sample based upon two clay-mineral provinces, the Western Gulf (dominated by smectite, illite and kaolinite), and the Ouachita-Ozark (dominated by kaolinite, illite and chlorite) (Steponaitis et al. 1996). While the Western Gulf province was relatively well-defined, the Ouachita-Ozark was represented only by ceramics from Spiro, a number of which were more chemically similar to the Eastern geographic area than that of the Ouachita-Ozark (Steponaitis et al. 1996). However, it was the calcium correction formula developed by Steponaitis et al. (1996:559) that proved to be their most valuable contribution from that initial undertaking. This correction (1) was undertaken due to the large amount (75.8%) of that initial sample that was found to be shell-tempered (Steponaitis et al. 1996:557).

$$e' = \frac{10^6 e}{10^6 - 2.5c}$$

Caddo INAA Research in the 1990s

The analysis of 40 ceramic samples from the Hurricane Hill (41HP106) site with Woodland, Early, and Middle Caddo period ceramic components represents the initial effort to incorporate the study of INAA in cultural resources management endeavors. This analysis was also significant in that it signaled the entrance of the University of Missouri's

Research Reactor Center (MURR) into the realm of Caddo research. While this report highlighted two potential source zones—one of which was deemed non-local-- the raw data from the 40 vessels analyzed were also presented and later synthesized (Neff et al. 1998; Perttula et al. 1998) with 10 sherds from the Mockingbird site (41TT550) and 16 sherds from the Middle Caddo occupation at the Oak Hill Village site (41RK214).

Prior to embarking upon the quantitative analysis, MURR noted that Neodymium (Nd), Nickel (Ni), and Zirconium (Zr) were not determined for those samples from the NIST sample, and they were eliminated from the analysis of the Mockingbird analysis for this reason (Neff et al. 1998:256-257). MURR also eliminated calcium (Ca) and strontium (Sr) due to the presence of shell-tempered sherds within the Hurricane Hill specimens, noting large analytical errors in Sr that limits the usefulness of this element even for those sherds without shell temper (Neff et al. 1998:257). While not employed within the framework of that endeavor, Cogswell et al. (1998:71) point out that freshwater mussel shell has the capacity to introduce significant amounts of Ca, Sr, Sodium (Na) and Manganese (Mn) to the ceramic paste, and the resulting values can be corrected more readily with mathematical equations rather than by chemical means. However, this study did not employ the calcium correction, but it was the first—in terms of Caddo INAA—to employ a measure of Mahalanobis distance to identify the probability of group membership for each specimen.

$$D^2_{y,X} = [y - \bar{X}]^t \, I_x [y - \bar{X}]$$

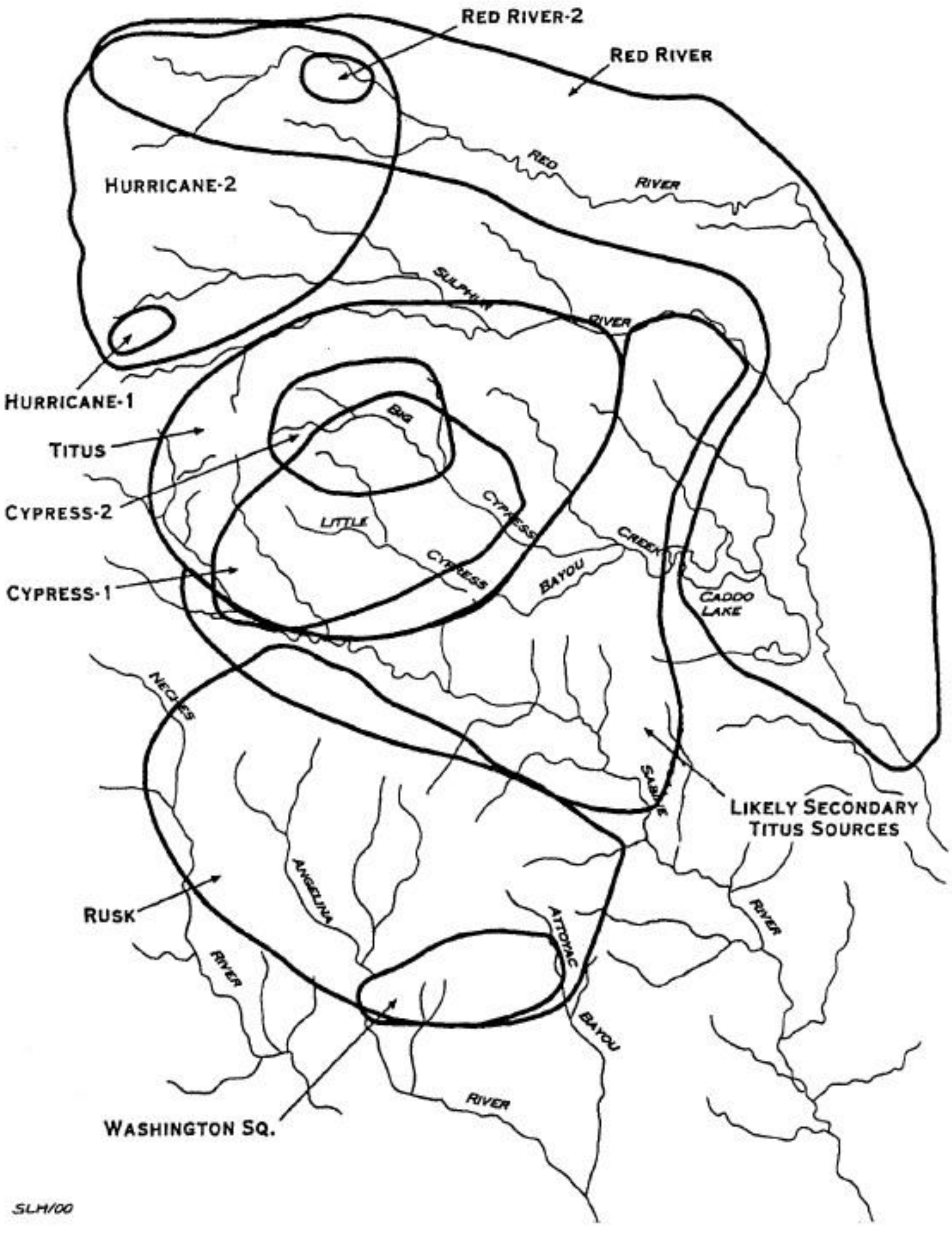
A subsequent analysis (Cogswell et al. 1998:66) of shell-tempered pottery replicates found that only Ca, Sr, Mn, and sodium (Na) "approached or exceeded the values in Ohio Redart clay and the southeastern Missouri clays" that were used in their experiment. They concluded that while elemental values for freshwater mussel shell lack the variability necessary to demarcate between mussel species, they do add significant amounts of those elements mentioned above.

Caddo INAA Research, 2000-2002

Due to the potential success of INAA in demarcating probable sources of ceramic raw materials and highlighting specific instances of what could be described as trade or exchange, Perttula (1999) submitted and was subsequently awarded by MURR a mini-NSF grant in an effort to expand the scope of this endeavor. The mini-grant allowed sherds submitted to MURR to be analyzed by INAA at a low NSF-subsidized rate, not the normal contract rate. By the year 2000, more than 220 samples of Caddo ceramics had been analyzed using INAA, but the volume of sherds submitted and analyzed soon increased dramatically, and Perttula's efforts proved remarkably fruitful. The first of the reports on these INAA results emerged in February of 2000 (Perttula 2000a, 2000b), and included sherds from the Audrey (11GE20) site in Illinois, as well as the Tom Moore (41PN149), Hardy (41SM55), and Redwine (41SM193) sites in Northeast Texas. Within these reports was the initial INAA-based discussion of trade and exchange for Caddo ceramics (Perttula 2000a:1, 2000b:4). The Holly Fine Engraved sherd submitted from the Audrey site (dating ca. A.D. 1050) was found to be manufactured in Northeast Texas, and thus was considered a product of trade between the Caddo and Illinois-based Mississippian groups (Perttula 2000a:1). Ceramics in the same compositional group (Titus, as named by MURR based on the county where the group seemed most frequent) were traded or exchanged within the Sulphur and Red River areas of the Caddo region. Those sherds from the Tom Moore, Hardy, and Redwine sites in Northeast Texas were found to primarily illustrate local manufacture, with some instances of inter-group trade among the Caddo (Perttula 2000b:4) (Figure 4.2).

The third report based on the NSF mini-grant surfaced in March of 2000, and was composed of an analysis of seven shell-tempered sherds from two Walnut Focus sites—Shrope (14CO331) and Radio Lane (14CO385)—in Cowley County, Kansas (Perttula 2000c:1). Sherds from the engraved vessels were found to have been manufactured by McCurtain phase Caddo groups in Northeast Texas and Southeast Oklahoma, indicating trade or exchange with prehistoric and protohistoric Wichita groups living on the Southern Plains (Perttula 2000c:4). The red-slipped sherd was assigned to the Red River 2 group, which was defined on the basis of ca. A.D. 1500 shell-tempered sherds originating at the Sam Kaufman-Roitsch site (41RR16) (Perttula 2000c:4).

Three subsequent reports (one on July 14, and two on July 17) divulged findings from the Helm (3HS449) site in Arkansas, and the Washington Square Mound (41NA49), Mast (41NA157), Guadalupe del Pilar (41NA223), Mission Dolores de los Ais (41SA125), 41SY45, Tyson (41SY92), and Henry M (41NA60) sites in Northeast Texas (Perttula 2000d, 2000e, 2000f). The sherds from the Helm site indicated manufacture by Caddo groups in Northeast Texas and trade with other Caddo groups in southwestern Arkansas (Perttula 2000d:1). All of the sherds from the Northeast Texas sites were found to have been the product of local manufacture (Perttula 2000e:2, 2000f:2).



Chemical Compositional Groups Defined for Caddo Ceramics in East Texas.

Figure 4.2. Caddo ceramic chemical groups in Northeast Texas (Perttula 2001: Figure 1).

In December of 2000, a report of Woodland and Caddo-era sherds from sites in Cherokee (41CE19), Smith (41SM54, 41SM56, 41SM87, 41SM144, 41SM197, 41SM213, and 41SM223), and Wood (41WD524) counties emerged (Perttula 2000g). Of the sherds submitted for analysis, 13 of 18 were assigned to the Titus group, and only one from the George C. Davis site (41CE19)—the Titus group sherd—was found to have been a potential trade vessel (Perttula 2000g:3). The only other trade vessel within this sample was the sherd from the Arnold Glenn site (41WD524) (Perttula 2000g:3).

In an effort to synthesize his findings, Perttula (2000h) offered a discussion of five Lower Walnut focus (ca. A.D. 1400-1700) sites—Larcom-Haggard (14CO1), Arkansas City Country Club (14CO3), Shrope (14CO331), Living the Dream (14CO382), and Radio Lane (14CO385)—near Arkansas City, Kansas. Of note is that Perttula's synthesis also employed the use of point-count data (200 points per thin-section) from the Lower Walnut focus sherds in a petrographic database (more than 250 sherds at that time) used in Northeast Texas (Perttula 1999). In this report, Perttula (2000h:10) reiterates that the geochemical evidence points to regular interaction between late prehistoric and protohistoric Wichita groups from the Walnut River area of south central Kansas and southern Caddo populations in the Red River, Big Cypress Creek, and Sabine River basins of Northeast Texas ca. A.D. 1300-1700 (Perttula 2000h:10).

In 2001, Perttula (2001) published a request in *Caddoan Archeology* to colleagues for more INAA samples to be submitted for INAA. Within that request, he appealed to professional and avocational archeologists to "identify sites and collections worthy of INAA," noting that "[l]uckily, almost any collection of Caddo sherds will suffice" (Perttula 2001:24). At that point in time—through the use of the NSF mini-grant—INAA had been conducted on 12 sherds from two sites in southwestern Arkansas, 19 sherds from eight sites in northwestern Louisiana, 38 sherds from four sites in southeast Oklahoma, and 481 sherds from 103 sites in northeast Texas, as well as those previously mentioned sherds from Illinois and Kansas (Perttula 2001:21). Despite that request, no Caddo archeological colleagues provided additional sherds for INAA.

The next of the NSF mini-grant analytical efforts was released in November 2002 (Perttula 2002a). This report was focused upon sherds from U.S. Forest Service lands of Northeast Texas in Houston (41HO150), Sabine (41SB157), Shelby (41SY43), and Walker (41WA218) counties (Perttula 2002a). Of the sherds submitted, those from 41HO150 and 41WA218 may have been trade vessels, the latter of which may have been manufactured by a Caddo group in the Neches-Angelina river basin (Perttula 2002a:7-10).

In his 2002 synthesis that highlights the long-distance exchange of Caddo ceramic vessels (Figure 4.3), Perttula (2002b) illustrates that none of the Kansas trade vessels associated with the Caddo were from contexts suggesting that they were prestige goods, but some have evidence of maintenance, which may indicate that these vessels were highly valued (Perttula 2002b:95). Nearly two-thirds of the Central Texas sample were potentially manufactured by Caddo potters in the Sabine and Big Cypress Creek basins, the remainder being attributed to different Caddo potters from the southern Sabine and Neches-Angelina river basins (Perttula 2002b:96). Perttula (2002b:100) mentions that Caddo ceramics made by the Red River groups were not traded heavily to the hunter-gatherers of Central Texas, suggesting that differing traditions and trade networks may have existed for different purposes. He also mentions the Caddo connection with Illinois in reviewing the evidence for the Holly Fine Engraved vessel from the Audrey site (11GE20), which was found to have been manufactured in Northeast Texas (Perttula 2002b:97).

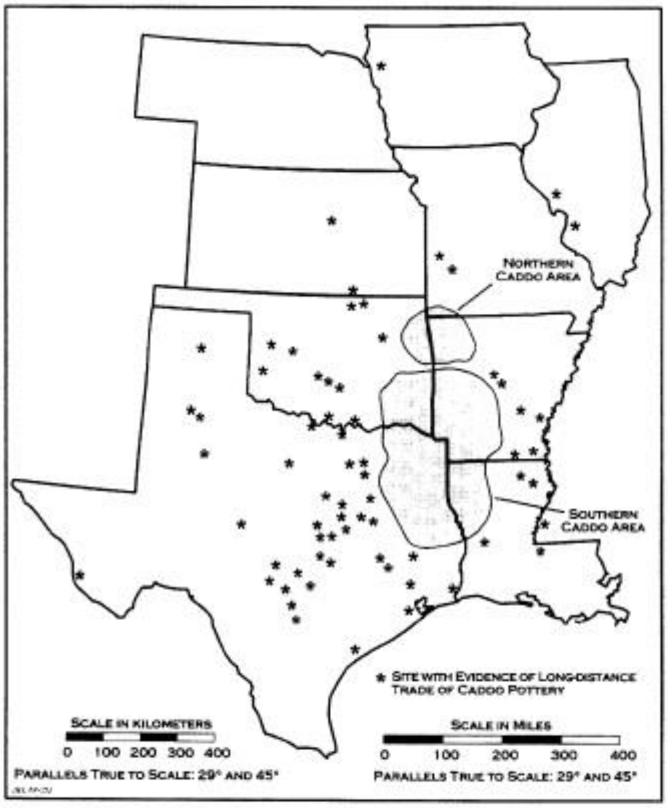


Figure 4.3. The southern and northern Caddo area and sites with evidence of the long-distance trade of Caddo ceramics (Perttula 2002b:Figure 5.1).

Caddo INAA Research, 2003-2006

In their appraisal of the ceramic sherds from the Hatchel site (41BW3), Speakman and Perttula (2003a:162) concluded that all of the samples—including Keno Trailed, Hodges Engraved, and Simms Engraved sherds—were locally manufactured. Three sherds were unable to be assigned to the current chemical compositional groups, but the rest were attributed to the Red River and Titus groups (Speakman and Perttula 2003a:162).

It was the report from the Alex Justiss site (41TT13) that marked a shift in method where MURR began to employ a search of their comparative database to identify compositionally similar specimens using the average Euclidean distance:

$$ED_{a,b} = \frac{\sqrt{\sum_{i=1}^{m}(a_i - b_i)^2}}{m}$$

where *a* and *b* are vectors containing *m* elemental concentrations for the two individual specimens being compared (Speakman and Glascock 2003:4). This report also marked a fundamental shift in which the discussion of ceramic provenance shifts from one of trade, exchange, and commerce, to one of local versus non-local production (see Speakman and Glascock 2003:5). It is also the first of many reports to return with a smaller number of sherds assigned to the established groups than the unassigned category (i.e., three assigned to Titus group, five unassigned), foreshadowing the forthcoming breakdown in the interpretation of this dataset, which would ultimately force a reconsideration of the efficacy of the groups initially defined by Neff et al. (1998) (see Speakman and Glascock 2003:12). Of those three sherds assigned to the Titus group, all were determined to have been of local manufacture (Speakman and Glascock 2003:5).

As of July 22, 2003, there were 785 INAA samples in the MURR database (Speakman 2003). In his analysis of the 10 sherds from the Hatchel site (41BW3), Speakman (2003) assigned one to the Titus group, five to the Red River Reference group, and the remaining four remained unassigned.

In his report on September 3, 2003, Descantes (2003a) identified two new compositional groups that included the Grog group (characterized by low potassium [K] concentrations), and the SM273 group (characterized by high arsenic [As] concentrations, and based on sherds from the Broadway site [41SM273]) in his analysis of 161 new INAA samples from East Texas sites. Within that sample were 45 sherds that were unable to be assigned to the current groups that were ultimately found—based upon the previously mentioned measure of Euclidean distance—to be compositionally similar to those from the Ohio Valley (n=1), Central Texas (n=1), Mississippi (n=3), Unknown (n=16), and Local (n=24); local context is defined by Descantes (2003a:4) as Northeast Texas or Northwest Louisiana based upon the current sample from the Caddo region.

This is the first report from MURR to request the addition of raw clay samples from the Caddo area in an effort to identify resource zones to better answer questions of clay procurement and ceramic production through time (Descantes 2003a:39). Descantes (2003a:4) also helped to clear up misconceptions regarding the Sandy Paste group that was defined by Neff (2001), adding that quartz sand can act as an intert dilutent. Perhaps more importantly, Descantes (2003a:39) mentioned that:

> [w]e believe we have reached a point of diminishing returns with the ceramic samples because the pastes in the ceramic samples originate from alluvial clays and ompositionally fit into the continuum predominated by the Titus, Red River, and Rusk groups.

At this time, there were 145 unassigned samples within the whole of the Caddo INAA database (Descantes 2003a).

Three months later (November 17, 2003), Descantes (2003b:1) dissolved the Grog group, noting that the Grog and Cypress-1 group overlapped on every projection with the exception of titanium (Ti). The SM273 group was renamed "Mud Creek," but was subsequently merged with the Smith group, effectively dissolving it as well (Descantes 2003b:2). He also points out that the Cypress-2 group has a tendency to be enriched with aluminum (Al), antimony (Sb) and scandium (Sc), while Hurricane-2 is enriched in tantalum (Ta) and Ti (Descantes 2003b:2). Of particular note is that Descantes (2003b:18) recants his previous remark regarding the potential for diminishing returns with INAA, mentioning that "more samples may…help refine existing chemical composition groups that have few members."

Following this, Perttula (2003a) reported on 31 sherds from the Festervan (16BO327), Mounds Plantation (16CD12), Onion Island (16CD218), Pace (16DS268), Robleau (16DS380), and Black Lake Bayou (16NA587) sites in northwestern Louisiana. In that report he points out that sherds from the Cypress-1 group have been found on both Middle and Late Caddo sites in the Big Cypress Creek basin of northeastern Texas, and within areas of Central Texas "where they must have been traded/exchanged with non-Caddo hunter-gatherers" (Perttula 2003a:5). Those sherds originating from the Onion Island and Pace sites that were assigned to the Titus chemical group may demonstrate the prehistoric use of two discrete clay sources (Perttula 2003a:6).

The last of the NSF mini-grant Caddo INAA projects at MURR was from the Los Adaes (16NA16) site, also in northwestern Louisiana (Perttula 2003b). Of the two sherds that indicated possible trade or exchange with Northeast Texas Caddo groups, one came from a Patton Engraved vessel from the Mud Creek compositional group, and the other came from a parallel incised bone-tempered sherd that was likely produced in the Neches-Angelina river basin (Perttula 2003b:5).

In a successive effort, Perttula (2003c) reports the findings of INAA at the Nawi haia ina (41RK170) site in northeastern Texas. While two of the sherds could not be assigned to ceramic compositional groups (see Descantes 2003a), the remainder of the sample was assigned to the Titus group, which was defined on the basis of Caddo ceramics from the Big Cypress and Sabine River basins (Perttula 2003c:335). The sherds within the Titus group sample contain enough variability (based upon Mahalanobis distance calculations) to infer the possible use of two different clay sources (Perttula 2003c:335).

Dr. Darrell Creel and Dr. Samuel Wilson from the University of Texas then submitted 50 samples from the George C. Davis (41CE19) site for analysis via INAA (Descantes et al. 2003, 2004). Using the standard suite of multivariate statistics employed at MURR, 39 (78%) of the samples were assigned to the Smith compositional group, and two were assigned to Titus (Descantes et al. 2003:5). In a comparison of ceramics from the Davis and Washington Square Mound (41NA49) ceramics mentioned earlier, they found that—while having similar geochemical compositions—the Wasington Square and Smith groups can be shown to separate statistically, and they illustrate this with a bivariate plot of scandium (Sc) and Mn (Descantes et al. 2003:8). In the first published report of Caddo INAA results since Perttula's (2002b) synthesis, Descantes et al. (2003:126) discuss the elephant in the room, pointing out that:

> No clear chemical discriminations exist between these [Red River, Rusk and Titus] compositional groups, although Red River members tend to be

> enriched in transition metals and Rusk members tend to have higher rare earth (or Lanthanide) concentrations.

The fact that the overwhelming majority of ceramics from the Davis site were assigned to the Smith group—which is chemically distinct from all other compositional groups—brushed aside concerns regarding the overlap in those groups mentioned above for this analysis. In the end, they found that the majority of ceramic sherds from the Davis site were locally produced from alluvial clays in the Neches River basin, but point out that this hypothesis should be tested with the addition of raw clay samples from this and other major drainages in Northeast Texas (Descantes et al. 2004:132).

Excavations at the Broadway (41SM273) site in Northeast Texas resulted in an additional 21 INAA specimens (Perttula 2004). Of those, 13 were assigned to the Mud Creek group, five to the Titus group, one to Smith, and the remaining two were unassigned (Perttula 2004:416). The abundance of Mud Creek assignments led Perttula to interpret that the chemical components in the Mud Creek sherds pointed to local manufacture, which Perttula also posits for the single sherd from the Smith chemical group (Perttula 2004:417). Based on the measure of Mahalanobis distance, Perttula (2004:417) infers non-local production and the possibility of four different non-local clay sources, two of which most likely originate from the Big Cypress Creek or Sabine River areas. Perttula (2004:417) also concludes that the Caddo population at the Broadway site exhibited no clear preference with regard to clay source based upon the geochemical data.

A synthesis of chemical variation in Northeast Texas (Cogswell et al. 2004) was then put forth employing sherds from the Hurricane Hill (41HP106), Mockingbird (41TT550), Oak

Hill Village (41RK214), Holdeman (41RR11), Fasken (41RR14), Sam Kaufman-Roitsch (41RR16), Salt Well Slough (41RR204), as well as the comparative dataset employed by Steponaitis et al. (1996) (where appropriate). While this piece reiterates the need for a raw materials survey within the region, it also draws inferences to trade and exchange from the current sample of sherds. Within that discussion is a particularly interesting observation regarding ceramic pipes from the Oak Hill Village site. Of the five pipe samples submitted for analysis, only one was found to have been produced locally, indicating that these artfacts may have been a highly mobile commodity (Cogswell et al. 2004:319). There is also evidence for exchange between Caddo groups in the Red River valley, and those in Titus and Rusk counties (Cogswell et al. 2004:319). Additionally, Cogswell et al. (2004:319) found no evidence to support the potential exploitation of different clay sources between the Early and Late Caddo periods.

The 2006 analysis of 57 ceramic vessel and seven raw clay samples from archaeological sites in Arkansas (3LA1), Louisiana (16NA16, 16SA212), and Texas (41RK200, 41NA231, 41NA235, 41NA236, 41NA285, 41SM193, 41SM325) resulted in 26 sherds being assigned to the Titus group, 11 to the Smith group, and one to the Red River group; the remaining sherds were unassigned, and none of the raw clay samples plotted within any of the established groups (Ferguson and Glascock 2006:7-8). However, the three raw clay samples from Louisiana were found to be closer to the archaeological sample than any of the Texas clays, and more clay sampling was recommended (Ferguson and Glascock 2006:8). These samples allowed for the refinement of the current compositional groupings to allow for statistical separation between the groups (Mahalanobis distance calculations).

Caddo INAA Research, 2007-2010

Perhaps the most damning evidence for the current chemical groupings was produced in a report of Caddo ceramics from 10 sites (41AN1, 41AN8, 41AN14, 41AN23, 41AN32, 41AN38, 41CE3, 41CE4, 41CE8 and 41CE17) in the upper Neches River basin in northeastern Texas (Ferguson and Glascock 2007). This was the first of the analyses to apply the calcium correction to the entirety of the data set instead of only to those sherds with >1% Ca (Ferguson and Glascock 2007:3). Out of the 100 samples submitted for analysis, only 16% (n=16) sherds were found to belong to any of the established chemical groups, concluding that "[a]t this point we cannot see any differences in the composition between the samples from 41AN38 and those from the other sites" (Ferguson and Glascock 2007:9).

In his discussion of compositional studies from the Mississippi valley and its periphery, Neff (2008:234) cites none of the technical literature advancing the study of Caddo INAA since 2002 (even though he was listed as an author on one of those [see Cogswell et al. 2004]), but he does hit the highlights for the pre-2002 studies. These include the gradual north-to-south decrease in potassium (K) and rubidium (Rb), and the correlation of several sherds from abroad (Kansas and Illinois) with likely areas of production within the ancestral Caddo territory (Neff 2008:234).

While currently unpublished, Ferguson (2007) produced the preliminary results of his reanalysis of the Caddo INAA database. Within the framework of that undertaking, he had attempted an approach employed by Glowacki (2006:87) using K-Means to generate new groups, but was discouraged by the "resounding failure" of this approach to discriminate the ceramic samples into more well-defined groupings (Ferguson 2007:1). In an effort to extract potentially useable information for anthropological research, Ferguson posited that the problem may be the scale of the current analysis, and Perttula and Ferguson subsequently divided the ancestral Caddo landscape into geographically and archeologically distinct regions (Ferguson 2007:1-2; 2010:3) (Figure 4.4). To correct for missing data (due to measurement error or values below NAA detection limits), Ferguson (2007:3) assumed each to be half of the lowest measured value for that element, and used all elements (with the exception of Ca and Sr, which were deleted after the entire dataset was calcium corrected) in his analysis. In Region 7, Ferguson (2007:15-16) noticed a possible gradient in chromium (Cr) within the Sabine drainage, and suggested that it might be useful to combine samples on a drainage-by-drainage basis to explore the existing compositional variability. The downstream increase in Cr levels may also be evidenced by those sherds in Regions 3 and 10 (Ferguson 2007:18, 20). In Ferguson's (2007:24) comparison with the old Caddo groups, he notes that "all of the old groups, with the exception of Titus and Cypress-2 are largely contained in a single new group." However, a large amount of overlap still existed among the new chemical groups with the exception of the northern part of Northeast Texas (i.e., the Red River basin), and while these new groups may have "great potential," there is still much work to be done (Ferguson 2007:25) as the final reanalysis of the Caddo dataset remains to be published.

Twenty sherds and two clay samples from the Leaning Rock (41SM325) site in Northeast Texas produced results that were probably not surprising. Of the 20 sherds submitted for analysis, 15 were assigned to the Titus group and five were unassigned, while neither of the two clay samples fit within any of the established groups (Ferguson et al. 2008:54). While these results do not reflect those potential new groupings proposed by

Ferguson (2007), this is due to this analysis being completed prior to/during the preparation of those groups.

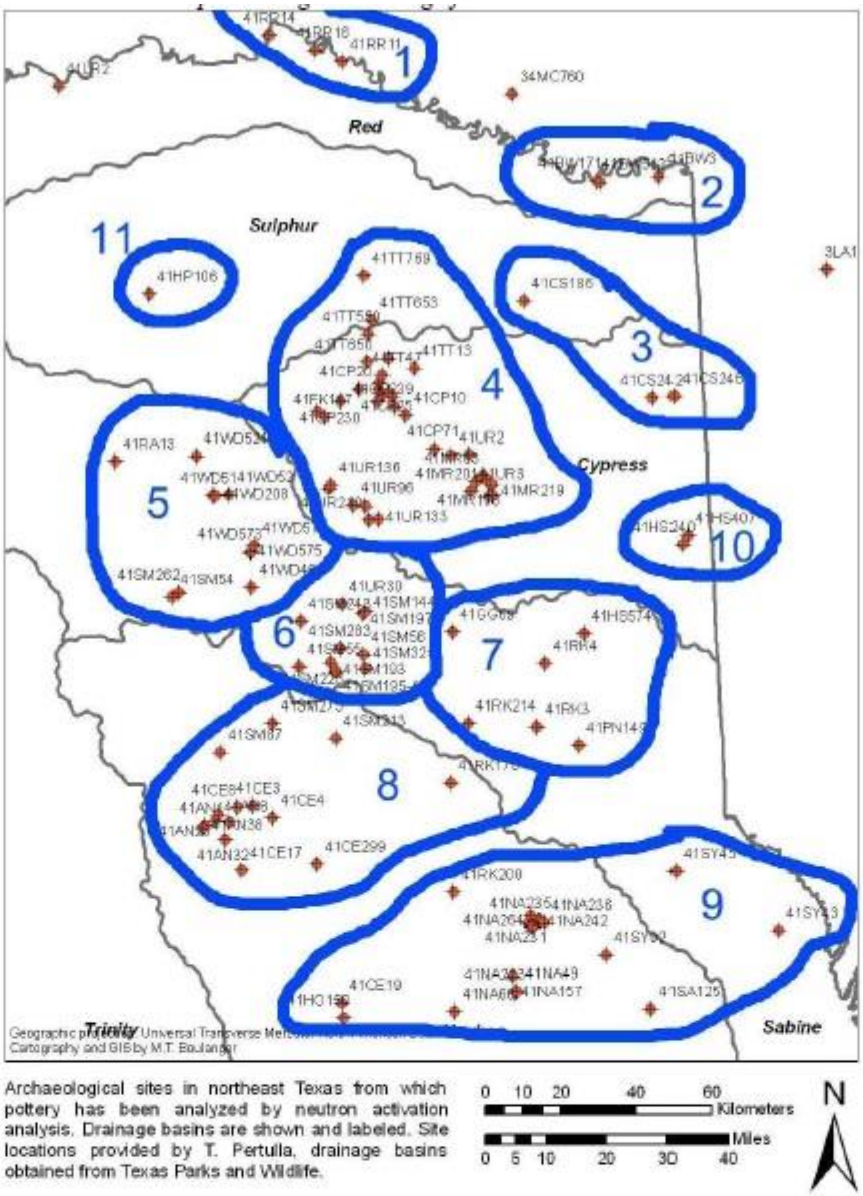
In the first test of these new groups, Ferguson (2009) analyzed 38 Caddo ceramics from 41CE354, 41FT549, 41HO67, 41HO211, 41HP237, 41LN436, 41LN465, 41WD244, Pine Snake, Pendulum, and Blue Branch sites. Within that analysis, Ferguson (2009:2) discusses the possible deletion of the outlier group as currently defined within Region 4. This sample also included sherds from the Trinity River basin (further south), and these sherds were found to have low probabilities of membership in core groups for Subregions 1 and 7, but high probabilities of membership within those core groups of adjacent regions (notably Regions 4, 5, 6, 8, and 9) (Ferguson 2009:5).

Analysis of sherds from 41BQ285 in Central Texas (Ferguson and Glascock 2009a; Perttula et al. 2010) found—through the incorporation of both INAA and ceramic petrography—that Caddo pottery that was manufactured within greater Northeast Texas was occasionally traded or exchanged with hunter-gatherer groups whose ranges included the central Brazos River basin (Perttula et al. 2003). What Perttula et al. (2010) suggest is the local production of pottery reflecting Caddo style that was manufactured locally in Central Texas. Incorporating the results from the petrographic analysis, one engraved sherd and two other sherds are believed to have been locally manufactured in Central Texas based upon point count data indicating a more substantial composition of hematite within those samples (Perttula et al. 2010:100).

Fifteen ceramic sherds and two daub samples from the Ear Spool (41TT653) site were analyzed in 2009 (Ferguson and Glascock 2009), combining that sample with an additional six samples from the same site that were previously analyzed by Hector Neff in 1999

(Ferguson and Glascock 2009:Appendix C). This report was rather unconventional, if for no other reason than Ferguson and Glascock (2009:270) assigned these new samples to the previously defined groups, and did not incorporate these results within the framework of Ferguson's proposed new groups (which were published subsequent to this analysis). Of the analyzed sherds, eight were assigned to the Titus group, one to the Cypress 2 group, and the remaining eight were unassigned (Ferguson and Glascock 2009:Table 11-1). Like the raw clay samples previously submitted to MURR (see Ferguson and Glascock 2006), the daub samples did not fit within any of the previously established groups (Ferguson and Glascock 2009:274).

During the course of eligibility testing for the National Register of Historic Places (Sherman et al. 2011), INAA was conducted on sherds from 41CP28 (Ferguson and Glascock 2010) and 41CP88 (Ferguson and Glascock 2009). With their findings from 41CP88, two sherds were found to match the current core groups from the region, and three others neither matched the current Caddo groups, nor any of those identified in Central Texas, and MURR recommended the use of ceramic petrography on these sherds to identify potential variations in temper and natural inclusions within the ceramic paste (Ferguson and Glascock 2009:8). Five sherds were analyzed at 41CP28, four of which were found to have been locally produced, but one evidenced a high probability of group membership within the Central Texas sample (Ferguson and Glascock 2010:9).



Archaeological sites in northeast Texas from which pottery has been analyzed by neutron activation analysis. Drainage basins are shown and labeled. Site locations provided by T. Perttula, drainage basins obtained from Texas Parks and Wildlife.

Figure 4.4. Plot of Texas Caddo regions defined for the 2007 reanalysis of Caddo INAA.

On the Current State of Caddo INAA Research

After Perttula voiced legitimate concerns with regard to the upper Neches River study where only 16% (n=16 of the 100 sherds submitted) were able to be assigned to current chemical compositional groups (later published as Ferguson and Glascock 2011), Ferguson (2010:2) “began to question the utility of a compositional group structure that could not assign a large percentage of new samples and continued to remove previously assigned samples from the compositional groups in order to maintain statistical separation of the groups.” As a whole, the Caddo region ranks within the top three with regard to the number of INAA samples that have been analyzed (only surpassed by the Valley of Mexico and the Mimbres region of the American Southwest), but due to the dominance of similar alluvial clays within the region it presents something of a statistical conundrum (Ferguson 2010). In their report of 36 samples submitted for analyses from the Hickory Hill site (41CP408), Ferguson and Glascock (Ferguson and Glascock 2011:6) point out that even after Ferguson’s reanalysis (cited as Ferguson et al. 2008)—due to statistical overlap within the current database of Caddo INAA—determining potential locations of ceramic production has become increasingly difficult, expounding upon a number of deficiencies that were identified by Perttula and Ferguson (2010) one year earlier.

While their recent work has focused upon the analysis of these data at a smaller scale (see Fields and Gadus 2012), the evolution of MURR’s methodological approach to Caddo INAA is difficult to document without access to technical and letter reports, and the proprietary nature of geochemical datasets produced by MURR (although Perttula [2010] published his) has made it a challenge to replicate their findings. Couple that with inconsistent exclusions/inclusions of different elements (zirconium, for instance) that are listed as “not determined” in the vast majority of reports, but included as one of the 12 “most precise” geochemical elements in the analysis of the largest sample from a single site (41HS15 – Pine Tree Mound) raises questions of methodological consistency (see Ferguson

2010; Fields and Gadus 2012; Perttula and Ferguson 2010:46). Surprisingly, the language in those reports generated by MURR recently changed from stating that the reanalysis of the Caddo INAA database remains incomplete and unpublished (Ferguson and Glascock 2007:1; 2009:7; 2010:6; 2011:593) to one that cites the same academic poster mentioned during reanalysis (Ferguson et al. 2008) as the completed product of those efforts. Additionally, in their final reports of ceramics from 41PN175 and the Pine Tree Mound site (41HS15), Ferguson and Glascock (2012a:6; 2012b:778) deemed that same (Ferguson 2007; Ferguson et al. 2008) reanalysis as only "moderately successful," mentioning the significant overlap between core groups as their basis for a lack of confdence in assigning the unknown assays to likely production groups, with the exception of some limited success in the area of the Red River (see Ferguson and Glascock 2012:9).

Further developments in Caddo INAA groupings (Perttula 2010: Article 3) illustrate the potential for provenance diversity (Figure 4.5), but issues arise when viewing the number of samples analyzed. Of the 171 sites where INAA has been employed, 104 have a sample size of five or less sherds, and 82 have three or fewer INAA samples. While the small sample size stems from the majority of INAA analyses being funded by only a few dedicated Caddo archeologists (whether because of financial constraints, or lack of interest, or both), the issue of statistical significance (or lack thereof) cannot be overlooked.

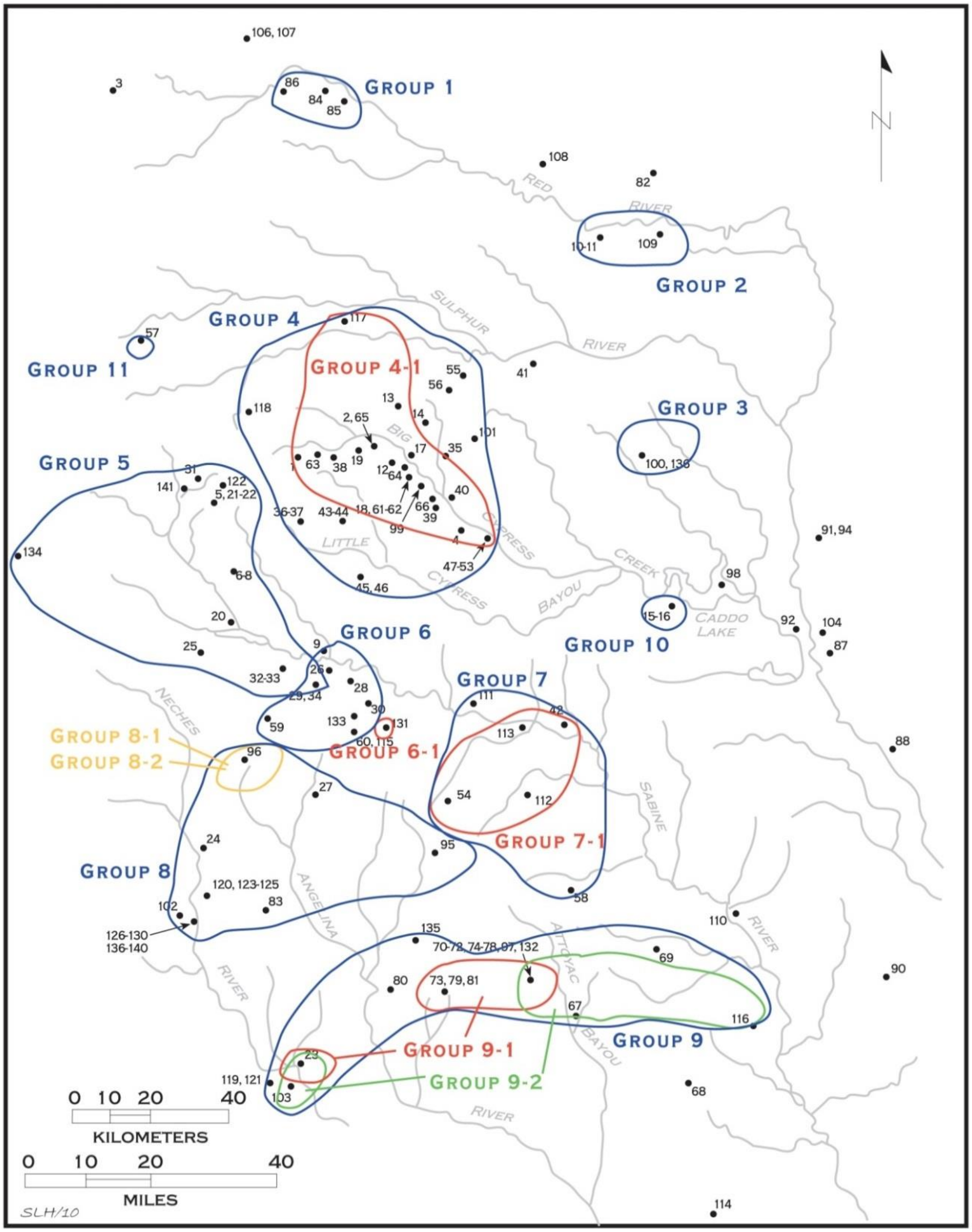


Figure 4.5. Current Caddo INAA groupings (Perttula and Ferguson 2010: Figure 1).

Reevaluating Caddo INAA

In an attempt to better illustrate the changes in geochemical signatures across the southern Caddo landscape, and to highlight general trends that appear within the data, the INAA results for 1192 sherds from 164 sites are employed within the subsequent discussion (Table 4.1). After assembling the dataset, two tables were used—one with geochemical data, one with site data—to catalog the sample. In reviewing the database, all of the shell and bone-tempered sherds were noted, but in lieu of applying the calcium correction to the entirety of the dataset, the calcium correction was only applied to the 4% (n=47) of samples known to be shell-tempered (Figure 4.6).

This analysis deviates from MURR's current method of applying the calcium correction (Steponaitis et al. 1996:559) to the whole of the Caddo INAA dataset (see Ferguson 2007:4, 2010:6; Ferguson and Glascock 2006:3; 2007:3; 2009a:3; 2009:266; 2010:93; 2012:3; Perttula and Ferguson 2010:11), and since the number of shell-tempered sherds remains small (4%), that process is found to be unwarranted due to the overwhelming majority of Caddo sherds being grog-tempered, and "such correction is unnecessary because the grog itself is made of clay, presumably the same clay that comprises the rest of the paste" (Steponaitis et al. 1996:559).

The correction was applied in version 2.15.2 of R, after which those sherds were recombined with the bone and other-tempered sherds, and the log-10 value of each element was calculated, adding a value of one to each sherd/element in the database, modifying any missing values to a zero.

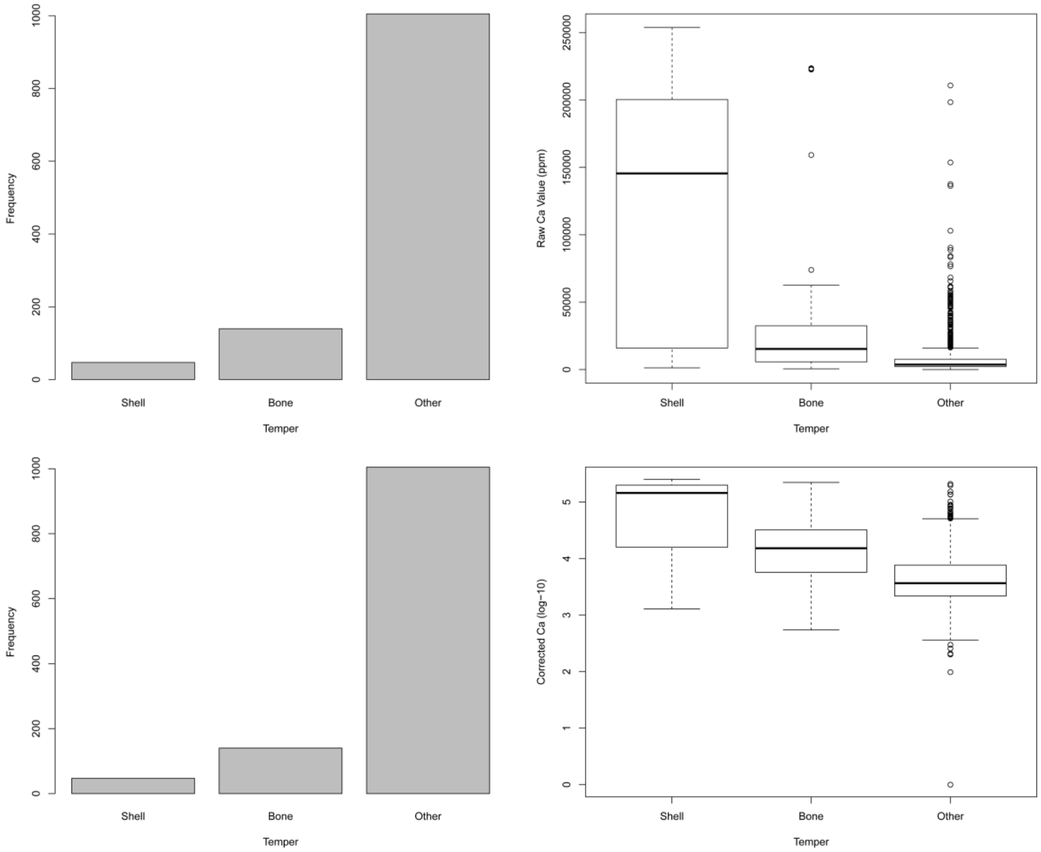


Figure 4.6. Frequency and uncorrected Ca values for shell, bone, and other tempers (top), and frequency and corrected Ca values for shell, bone, and other tempers (bottom).

The calcium correction was applied to shell-tempered sherds in version 2.15.2 of R,after which those sherds were recombined with the bone and other-tempered sherds, and the log-10 of each element was calculated, adding a value of one to each sherd/element in the database, effectively replacing all missing values with a zero. Subsequently, the Getis-Ord Gi* statistic in ArcGIS10 was employed to calculate a z-score for each log-10 value, illustrating the spatial distribution and z-score values for each site using the formula:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}\, x_j - \bar{X} \sum_{j=1}^{n} w_{i,j}}{s \sqrt{\frac{\left[n \sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}} \tag{4}$$

where x_j is the attribute value for feature j, $w_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of features and:

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n} \tag{5}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2} \tag{6}$$

The G_i^* statistic is a z-score so no further calculations are required (ESRI 2012).

Following the calculation of log-10 values for each element, these data were then used to calculate the deterministic statistic of inverse distance weighted (IDW) in ArcGIS10 for each element to better illustrate whether discrete geochemical signatures exist close to one another, or in the same location (see Appendix B:Figures B.2-B.34).

While initially an issue due to sample size, deletion of neodymium (Nd) and zirconium (Zr) from the dataset is no longer necessary. While comparisons to the original NIST sample should still follow this method, when dealing with the MURR dataset, the contribution of these elements needs to be further explored and not disregarded on the basis of their absence from 22 sherds analyzed at NIST (see Steponaitis et al. 1996).

Table 4.1. Caddo sites with INAA Samples.

Site Name	Site Trinomial	Samples
Helm	3HS449, H	2
Battle Mound	3LA1	2
Vanceville Mound	16BO7	2
Werner	16BO8	1
-	16BO175	2
-	16BO186	1
McLelland	16BO236	2
Festervan	16BO327	5
Mounds Plantation	16CD12	6
Onion Island	16CD218	5
Jamis Pace	16DS268	10
-	16DS389	1
Los Adaes	16NA16	40
Lambre Point	16NA544	2
-	16NA587	5
-	34CH43	1
Hugo Dam	34CH112	7
Mahaffey	34CH113	16
-	34MC760	14
-	41AN1	2
Cecil	41AN8	8
Isibell-Gene Donell	41AN14	3
A.C. Saunders	41AN19	3
-	41AN23	9
Fred McKee Farm	41AN32	6
Lang Pasture	41AN38	50
-	41BQ285	4
Hatchel	41BW3	10
Cranfill	41BW171	6
Indian Springs #2	41BW512	5
Solon Stanley	41CE3	6
J.W. Blackburn	41CE4	8
-	41CE8	6
George C. Davis	41CE19	53
-	41CE299	1
Kah-hah-ko-wha	41CE354	2
Williams	41CP10	2
Horton	41CP20	4
-	41CP21	10

Table 4.1. Continued.

Site Name	Site Trinomial	Samples
Peach Orchard Overlook	41CP25	10
Shelby	41CP71	17
-	41CP220	20
Underwood	41CP230	8
Lake Bob Sandlin	41CP239	3
Polk Estates	41CP245	4
-	41CP257	1
Pilgrim's Pride	41CP304	18
-	41CP313	1
-	41CP366	1
-	41CS186	3
-	41CS242	5
-	41CS246	1
-	41CV41	2
-	41CV48	1
-	41CV92	1
-	41CV174	3
-	41CV344	3
New Hope	41FK107	5
Edwards Creek	41FT549	3
Hardin A	41GG69	5
-	41HI105	2
-	41HO67	2
Hargrove Lake	41HO150	6
Nebadache Blanco	41HO211	1
Hurricane Hill	41HP106	40
Tuinier Farm	41HP237	5
Pine Tree Mound	41HS15	142
Harrison Bayou	41HS240	3
-	41HS407	4
Coleman Farm	41HS574	2
-	41LN436	2
-	41LN465	2
Sanders	41LR2	7
Chupik	41ML44	4
Asa Warner	41ML46	4
-	41MR122	3
-	41MR174	5
-	41MR178	1

Table 4.1. Continued.

Site Name	Site Trinomial	Samples
-	41MR201	1
-	41MR219	3
-	41MX57	2
Washington Square Mound	41NA49	2
Henry M.	41NA60	2
Mast	41NA157	1
-	41NA223	1
Tallow Grove	41NA231	12
Foggy Fork	41NA235	16
Naconiche Creek	41NA236	28
Beech Ridge	41NA242	1
Stroddard	41NA243	3
Cedar Branch	41NA244	1
-	41NA261	1
P. Wilson	41NA264	1
Telesco	41NA280	1
Boyette	41NA285	19
Tom Moore	41PN149	2
-	41PN175	10
Gilbert	41RA13	3
Millsey Williamson	41RK3	4
Hudnall-Pirtle	41RK4	2
Nawi-haia-ina	41RK170	10
Mission Nasoni	41RK200	5
Oak Hill Village	41RK214	84
Dan Holdeman	41RR11	3
Fasken	41RR14	2
Roitsch	41RR16	21
Salt Well Slough	41RR204	10
-	41SA125	1
Devils Ford Creek	41SB157	5
Jamestown Mound	41SM54	2
Bryan Hardy	41SM55	2
Henry Chapman Farm	41SM56	2
-	41SM87	1
-	41SM144	2
Redwine	41SM193	5
Browning	41SM195-A	2
Langford	41SM197	1

Table 4.1. Continued.

Site Name	Site Trinomial	Samples
-	41SM213	1
-	41SM223	1
Lake Clear	41SM243	1
-	41SM262	1
Broadway	41SM273	31
Holmes	41SM282	1
-	41SM283	1
Leaning Rock	41SM325	23
-	41SY43	7
Buddy Hancock	41SY45	2
Tyson	41SY92	3
Alex Justiss	41TT13	8
-	41TT47	2
Mockingbird	41TT550	10
Crabb	41TT650	5
Ear Spool	41TT653	6
-	41TT718	10
-	41TT730	2
James Owens	41TT769	16
-	41UR2	3
Southall	41UR3	4
Boxed Springs	41UR30	3
-	41UR96	1
-	41UR99	2
Rookery Ridge	41UR133	3
-	41UR136	4
Griffin Mound	41UR142	5
Camp Joy	41UR144	1
-	41UR210	2
Storm	41WA218	13
Carlisle	41WD46	7
-	41WD51	7
M.W. Burks	41WD52	8
Goldsmith	41WD208	3
-	41WD244	3
-	41WD524	2
-	41WD573	2
Audrey E. Allen-Smith	41WD575	3
Thomas Moody	41WD577	10

Table 4.1. Continued.

Site Name	Site Trinomial	Samples
Barker	41WM71	1
Rowe Valley	41WM437	4
Blue Branch	-	5
Pendulum	-	6
Pine Snake	-	5

Geochemical Variation in the Ancestral Caddo Territory

The resultant geographic illustrations affirm Ferguson's (2007:15-16) assertion regarding an apparent gradient in the Sabine River drainage for Chromium, an observation which might now be extended to all but the Red River drainage in East Texas, and Neff and Glascock's (2000; see also Neff 2008:234) notice of a north-to-south gradient for both potassium (K) and rubidium (Rb) (see Appendix B: Figures B.8, B.14 and B.21).

Spatial Trends in the Chemical Composition Data

Composite 1. A general northeast (high)—to—southwest (low) gradient occurs for aluminum (Al), calcium (Ca), chromium (Cr) (as mentioned previously), potassium (K) (also mentioned previously), manganese (Mn), sodium (Na), rubidium (Rb) (also mentioned previously), scandium (Sc), strontium (Sr), and tantalum (Ta). While the dynamics of the distributions for each of these elements does differ, the general trend—a decrease (substantial in some cases) that is evident from the Red River basin (high) to the Trinity River basin (low)—remains the same (Figure 4.7). There is a single case (antimony [Sb]) for which this trend is reversed, and high values occur in the southwest with low values in the northeast.

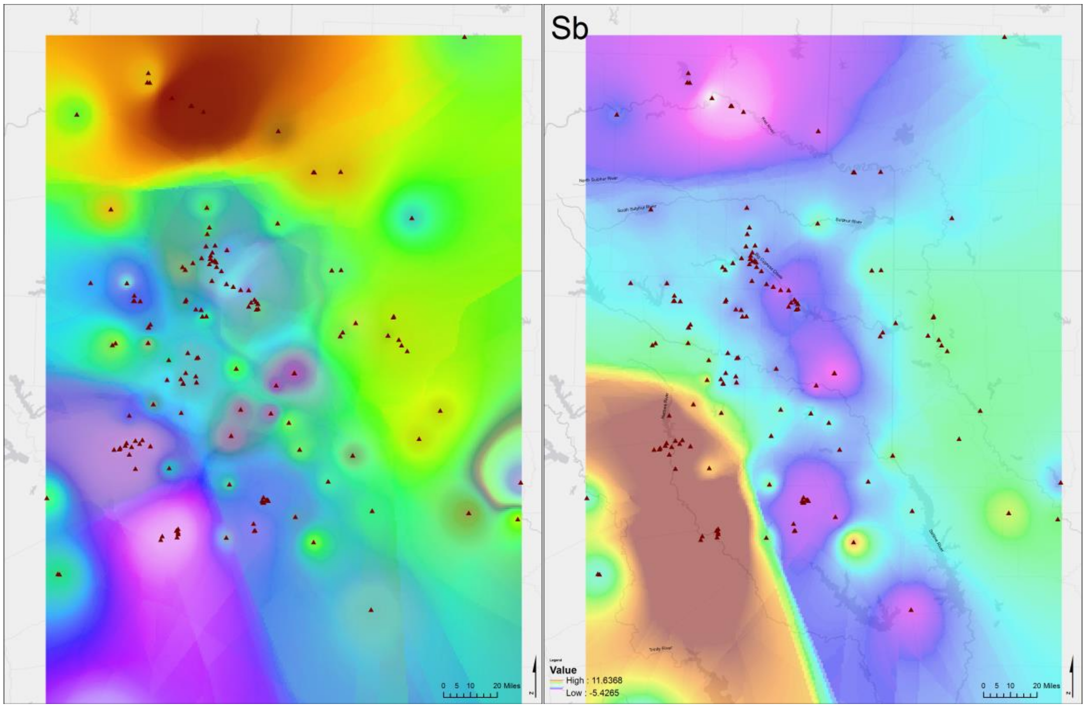


Figure 4.7. Composite 1 (left) contrast with antimony (Sb) (right).

Composite 2. While it could be combined with the previous group, cesium (Cs) illustrates a stronger north-to-south dynamic with those areas of the Angelina, middle Neches, lower Sabine and lower Trinity River basins, which highlights a strong contrast with those sites to the north (Figure 4.8). The opposite is true for hafnium (Hf) and zirconium (Zr), for which the lowest values occur in the Cypress, Sulphur and Red River basins.

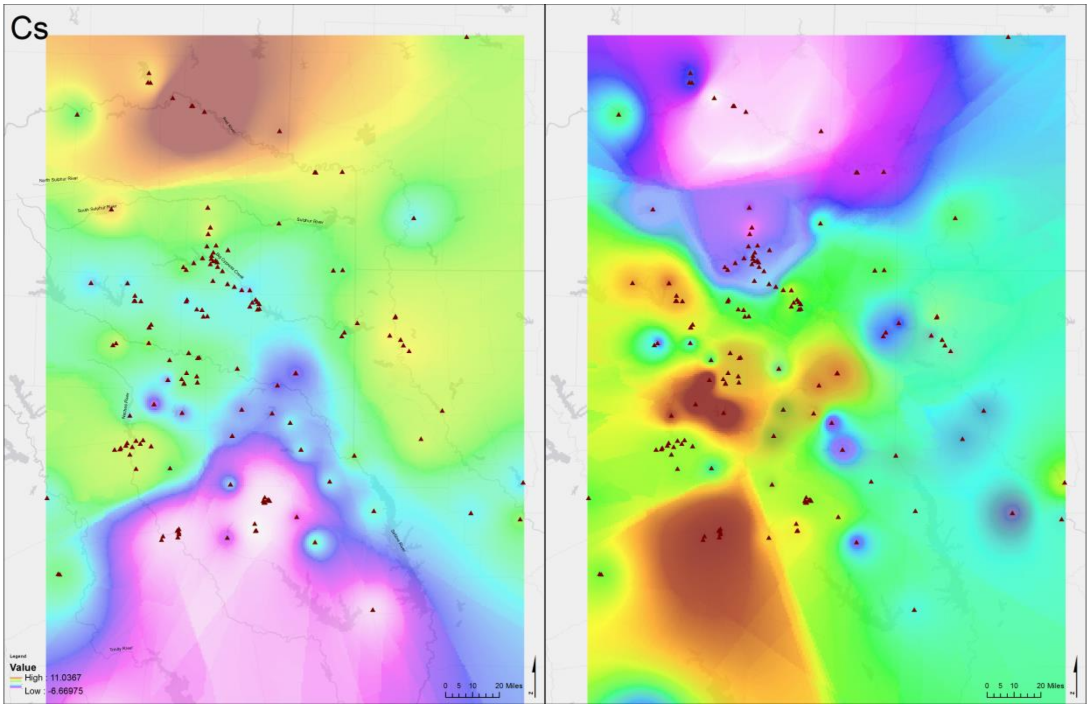


Figure 4.8. Cesium (Cs) (left) contrast with Composite 2.

Composite 3. Arsenic (As), iron (Fe) and vanadium (V) appear have similarly amorphous spatial dynamics that are—for the most part—confined to Texas, where a region of low chemical concentration occurs in the Sulphur, Cypress and upper Sabine River basins that border a neighboring region to the south where high concentrations appear in the Angelina, Neches, and Trinity River basins (Figure 4.9). Again, these distributions are not identical, but do have recognizably similar distributions across the ancestral Caddo landscape.

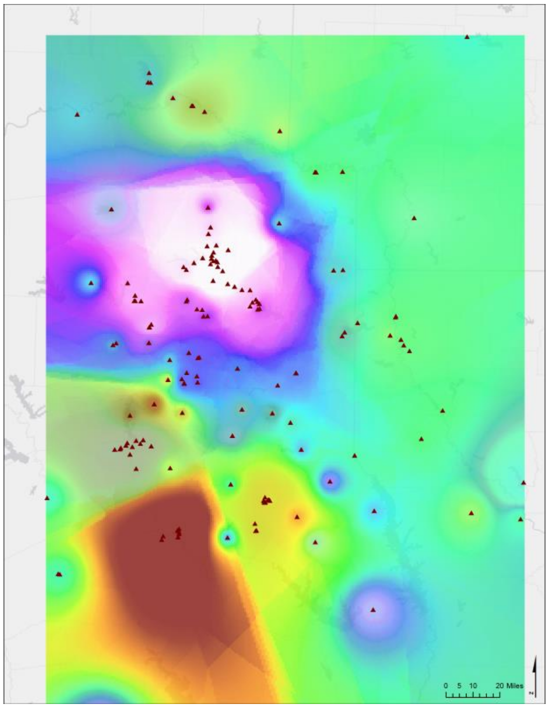


Figure 4.9. Composite 3.

Composite 4. Cobalt (Co), thorium (Th), uranium (U), and zinc (Zn) have an area of low value that runs northwest—to—southeast that is flanked on the northeast and southwest by areas of high value (Figure 4.10). There is one element—barium (Ba)—that illustrates an inverse distribution where an area of high value runs northwest—to—southeast that is flanked on the northeast and southwest by areas of low value.

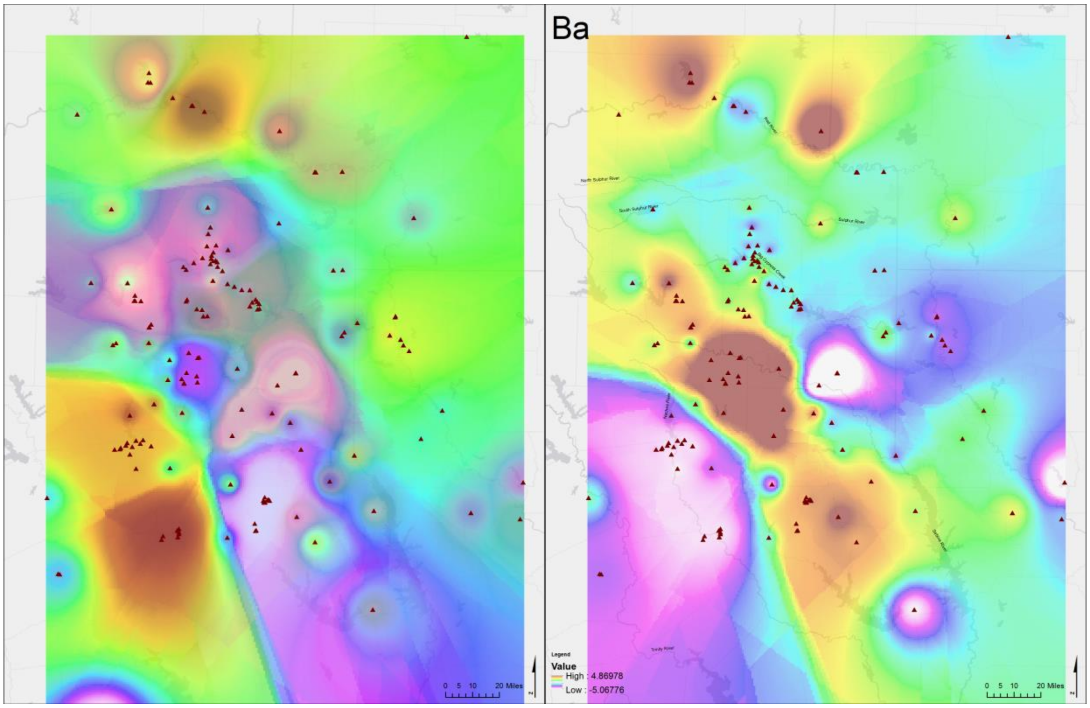


Figure 4.10. Composite 4 (left) contrast with barium (Ba) (right).

Composite 5. For cerium (Ce), dysprosium (Dy), europium (Eu), lanthanum (La), lutetium (Lu), neodymium (Nd), samarium (Sm), terbium (Tb) and ytterbium (Yb) there is a contrasting dynamic among the northern sites with an area of high value in the northeast and one of low value immediately to the southwest (Figure 4.11). Farther south, the dynamics change where chemical concentrations highlight a west (high)—to—east (low) dichotomy.

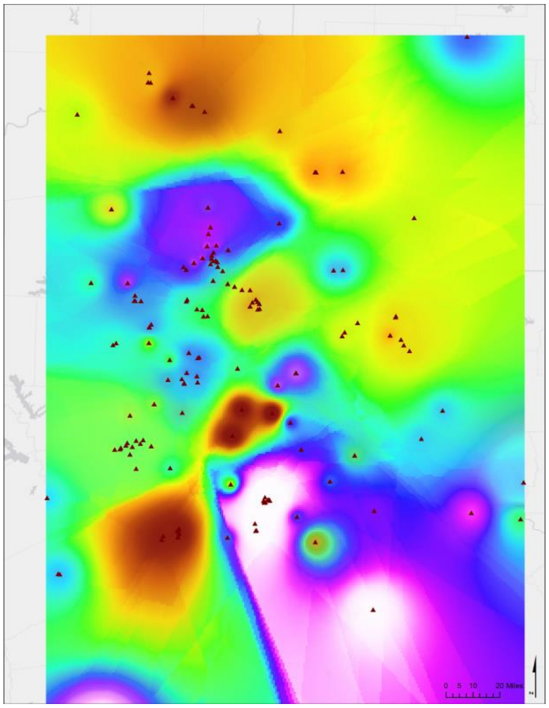


Figure 4.11. Composite 5.

Neither nickel (Ni) (which is deleted from most analyses) nor titanium (Ti) has spatial patterns similar to any of the five groups mentioned previously, and both illustrate unique spatial patterns across the ancestral Caddo territory (Figure 4.12). For titanium, there are two discrete areas of low values, one surrounding of Lake O' the Pines in Northeastern Texas, and the other near Clear Lake in Northwestern Louisiana.

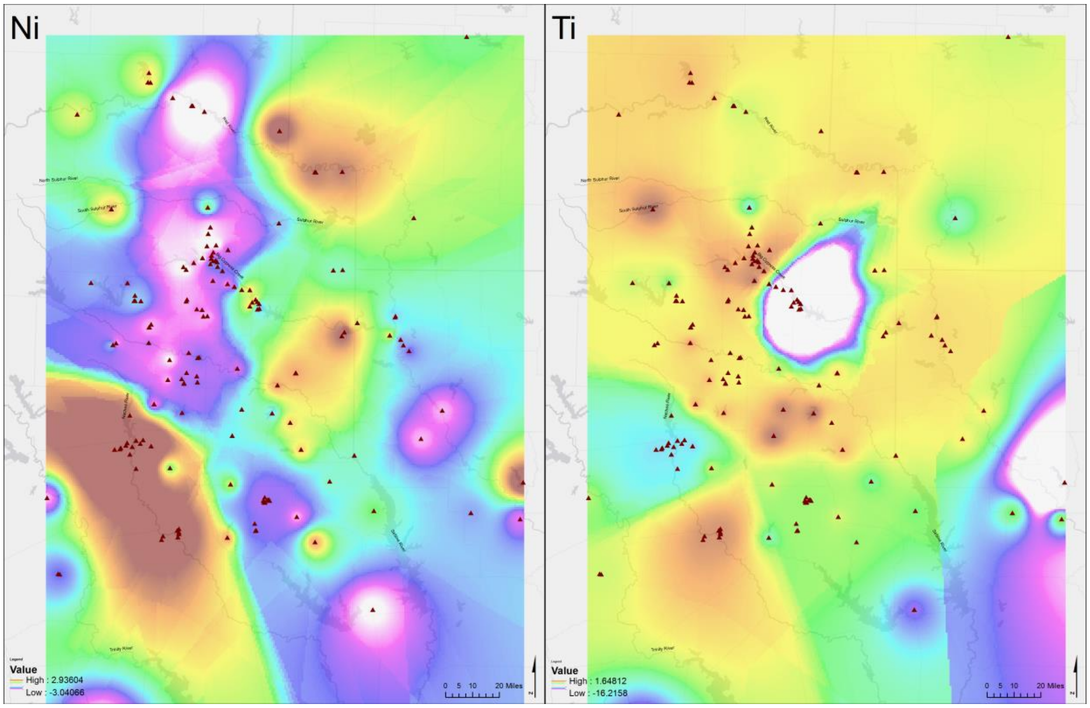


Figure 4.12. Nickel (Ni) (left) and titanium (Ti) (right).

The identification of the spatial dynamics associated with INAA data from Caddo sites increases its' explanatory power when it comes to issues of defining possible ceramic provenance, for which these illustrations provide meaningful clues to expand the current dialogue.

Summary and Conclusion

The employment of INAA-based research within the Caddo region will continue to aid in clarifying issues of provenance currently evident within the dataset, and this analysis contributes five unique geospatial patterns that may help to further future discussions of possible ceramic provenance for ancestral Caddo ceramics. It is becoming increasingly apparent that we cannot rely upon MURR to expound any further upon the diversity and increasing variability of this sample. Therefore, we must take it upon ourselves to investigate and identify potential areas of vessel provenance within the Caddo region that can be consistently employed as this substantial dataset continues to increase in magnitude.

Due to recent dialogues concerning lines of effective demarcation between local and non-local ceramics via INAA (Shrarer et al. 2006; Stoltman et al. 2005; Stoltman and Mainfort 2000), and the complex nature of ceramic chemical composition based upon the addition of temper and the process of diagenesis (Glascock 2002; Neff et al. 2006), it is recommended that petrographic analyses augment the analysis of INAA data in an effort to clarify and expound upon issues of probable vessel provenance and regional geochemical variability. It is noteworthy that more petrographic analyses were carried out in East Texas during the 1990s (Ferring and Perttula 1987; Reese-Taylor 1993, 1997; Skokan and Perttula 1997; Skokan Switek 1997, 1998; Iruegas 1999) than at any other time, and this practice steadily decreased in frequency within cultural resource management studies and academic literature aimed at Caddo ceramics until fairly recently (Cecil 2012a, 2012b, 2012c; Perttula and Rogers 2007; Rogers and Perttula 2004).

Employed in tandem, INAA and petrography have been found to complement one another, and often yield substantive clues that assist in clarifying issues of provenance. Additionally, once areas of possible ceramic provenance have been defined by INAA and petrographic methods, an exploration of ceramic petrofacies can exponentially increase the scope and utility of studies aimed at identifying possible manufacturing locales for specific ceramic vessels. By noting the relative abundance of local sands, petrofacies models provide a high-definition method of assigning ceramic provenance (see Miksa and Heidke 1995;

2001). This can assist in facilitating the production of increasingly complex research questions, and provide the spatial and temporal resolution needed to begin a more detailed discussion of manufacture and use, ceramic economy, migration, exchange networks, and temporal trends.

While combining these approaches may serve to elucidate further trends within these data, making sense of this complex amalgam of INAA samples remains paramount. Sample sizes must be increased within the currently analyzed sample and to further current dialogues regarding possible provenance determinations within the ancestral Caddo territory. In order to consistently identify local and non-local sherds as well as possible zones of production, a minimum of 30 sherds should be submitted for INAA from each site, making it possible to create a site-specific correspondence matrix from which an exploration of statistical similarities and differences can assist in the identification of clays found in the ceramics used at each site.

The maps presented here represent an important new addition to the analysis of the Caddo INAA database. The results of this analysis illustrate that the chemical composition of ceramics associated with ancestral Caddo populations were diverse and highly variable across East Texas and surrounding states, further hinting at the potential successes in ceramic provenance identifications for more robust (>33) samples of sherds from sites within this region.

CHAPTER V

TEMPORAL AND REGIONAL DYNAMICS OF CULTURAL RESOURCE CASE LAW[3]

Overview

The work presented in this chapter has been submitted by the author and colleague C. Britt Bousman to the *International Journal of Cultural Property*. Eight statutes comprise the basis of our exploration of cultural resource legislation in the United States. Since the passage of the American Antiquities Act in 1906, 1086 cases have been tried in U.S. courts under these statutes. We investigate temporal and regional patterns in the case law to establish if these laws are uniformly prosecuted throughout the U.S. Our findings suggest that case law is complex and controlled by many factors, including unequal application.

Introduction

Numerous articles and books contribute great detail to the discourse surrounding the various U.S. federal cultural resource laws offering insightful views regarding the interpretations and impacts of the individual statutes (see Hutt et al. 1999, 2004; King 2008). There have been 1086 adjudicated cases through December 2010, but since virtually nothing has been published that considers patterning for the case history of statutes aimed at the protection of cultural resources, we investigate the national application of cultural resource litigation through a spatial and temporal analysis of the case law for selected

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legislation aimed at cultural resource management.

Several questions emerge in a review of the case law, and the most prominent is that of consistent application. Are all federal cultural resource laws prosecuted to the same degree throughout the U.S. Circuit Courts? While the answer to this question would require book-length treatment and lies beyond the scope of this article, an initial examination is certainly warranted. This was recently made evident with the issue of warrants and subsequent arrests of 23 individuals in Utah for looting on federal and tribal lands. In noting his concern for the matter, Secretary of the Interior Ken Salazar noted, "[t]here have been times when the U.S. government looked the other way" (Johnson 2009).

The unequal distribution of cultural resources in the U.S. suggests that some bias should be expected. The spatial nature of archaeology requires consideration of varying artifact densities across broad cultural landscapes. For example, the archaeological record of the Southeast U.S. encompasses large and complex Mississippian ceremonial sites, mound complexes, and extensive prehistoric mortuaries that differ greatly from the dense distribution of well-preserved farming communities of the American Southwest or the widely dispersed rock shelters associated with hunter-gatherers in the Great Basin. Thus, the character of the cultural resources themselves demands some degree of flexible legal treatment.

The location and control of federal lands across the United States adds to the complexity of interpretation, and is evidenced through the distribution of national parks, in terms of number and size, that also vary from state to state. For historic reasons, the National Park Service (NPS) has the largest and most well-trained cultural resources staff of the federal agencies since its mission is aimed directly at preserving cultural resources. Other

Federal agencies (i.e., the U.S. Forest Service, Bureau of Land Management, and Department of Defense) have differing priorities and smaller cultural resource staffs as a result.

Native American populations and the location of tribal lands are equally important, and the application of laws like the American Indian Religious Freedom Act should reflect the distribution of the native people and their resources. The distribution of federal lands, when coupled with the actions of the controlling agency, has an enormous impact on the enforcement of this legislation.

Additionally, the variable manner by which archaeologists practice their profession affects the spatial patterning of the record. In the last century, the Works Progress Administration projects and River Basin Surveys helped to establish the foundation for much of our understanding of North American archaeology. Another of many examples can be seen throughout the last 30 years with a systematic increase in the application of geoarchaeological methods, which has dramatically altered the methodology of site discovery and interpretation. Archaeological research undertaken prior to this development produced very different views of American prehistory than what was previously known of the archaeological record.

These and many other biasing factors must be considered when analyzing the results presented in this paper. Nevertheless, the question remains, does equal prosecution of cultural resource laws exist, and if not, what other factors are causal?

Methods

Relevant cultural resource management laws were identified (National Park Service 2006; King 2008; Hutt and Tarler 2006, 2007, 2008, 2009; United States Army Environmental Command 2011), then a listing of individual cases was created through the use of LexisNexis and Westlaw. Data fields include case name, date, disposition of the resource (i.e., archaeology, architecture, landscape, and other), reason for legal action (i.e., compliance, taking, and other), State, case summary and holdings, U.S. Circuit Court district[1], and final ruling (see Author and Author 2010). This database comprises the foundation of the resulting analysis.

Temporal distributions for each statute were plotted alongside the total number of cases. The contingency table was created utilizing the numerical distribution of case law organized by statute and Federal Circuit Court district. Adjusted residuals[2] were calculated to measure deviation from average values, hereafter called national averages (Everitt 1977; Haberman 1978). Patterns identified within the statistical analysis were then plotted spatially.

The disposition of the resource (archaeology, architecture, landscape, shipwreck, and other) and the reason for legal action (compliance, taking, and other) were recorded for each case, and used to demonstrate the nationally variable application of the legislation. These data are coupled with temporal and spatial distributions to explore the national trends.

The Legal Basis

The case law for eight prominent cultural resource statutes was examined for this study. These include the American Antiquities Act, Historic Sites Act, National Historic Preservation Act, Reservoir Salvage Act, American Indian Religious Freedom Act, Archeological Resources Protection Act, Abandoned Shipwreck Act, and the Native American Graves Protection and Repatriation Act. These eight cultural resource laws have been amended a combined total of 45 times.

American Antiquities Act

The American Antiquities Act (AAA) was signed into law on June 8, 1906 by Theodore Roosevelt, has been amended once, and encompasses 34 Stat. 225 and 16 U.S.C. 431-433. The AAA developed out of concern for archaeology on public lands due to commercial looting and haphazard mining. This Act grants the power to the President to designate landmarks, structures, and objects as National Monuments (National Park Service 2006), and its passage marks the beginning of historic preservation laws in the United States. The first challenge to the American Antiquities Act was *Ramming Real Estate Co. v. U.S.* (122 F.2d 892 [1941]) on October 13, 1941, 35 years and four months after being signed into law.

Historic Sites Act

The Historic Sites Act (HSA) was signed into law on August 21, 1935 by Franklin D. Roosevelt, has been amended eight times, and encompasses 49 Stat. 666 and 16 U.S.C.

461-467. This statute makes preservation of historic lands, properties, and objects a national policy. The HSA grants authority to the Secretary of the Interior to obtain any information needed regarding archaeological sites, and established the National Park System Advisory Board (16 U.S.C. 463) (National Park Service 2006). The HSA was adjudicated twice prior to *Ramming Real Estate Co. v. U.S.* (122 F.2d 892 [1941]); once in March 1937 (*Balter v. Ickes*, 67 App.D.C. 112, 89 F.2d 856 [1937]), then in January 1939 (*Barnidge v. U.S.*, 101 F.2d 295 [1939]).

Reservoir Salvage Act (Archeological and Historic Preservation Act)

The Reservoir Salvage Act (now known as the Archeological and Historic Preservation Act [AHPA]) was signed into law on June 27, 1960 by Dwight D. Eisenhower, and has been amended six times. The statute was originally called the Reservoir Salvage Act, and has also been known as the Moss-Bennett Act and the Archeological Recovery Act before being renamed the Archeological and Historic Preservation Act in 1974 (National Park Service 2006). This statute includes a clause that forces federal agencies to accept responsibility for actions resulting in damage to archaeological sites.

National Historic Preservation Act

The National Historic Preservation Act (NHPA) was signed into law on October 15, 1966 by Lyndon B. Johnson, has been amended 23 times, and encompasses Public Law 89-665 and 16 U.S.C. 470 et seq. (National Park Service 2006). This Act established several well-known entities for both historic and archaeological preservation, including the Advisory Council on Historic Preservation (ACHP), the State Historic Preservation Office (SHPO) (adding the Tribal Historic Preservation Office [THPO] with the Amendments of

1992), the National Register of Historic Places, and the Section 106 review process.

American Indian Religious Freedom Act

The American Indian Religious Freedom Act (AIRFA) was signed into law on August 11, 1978 by Jimmy Carter, and encompasses Public Law 95-341 and 42 U.S.C. 1996 and 1996a (National Park Service 2006). The AIRFA was conceived through an internal investigation by Congress in which the government was found to have had an adverse impact upon the practice of Native American religions. The AIRFA protects the right of American Indians to practice native religions without significant interference from the federal government, and was amended in 1994 to allow American Indians access to peyote for use as a religious sacrament.

Archeological Resources Protection Act

The Archeological Resources Protection Act (ARPA) was signed into law on October 31, 1979 by Jimmy Carter, has been amended four times, and encompasses Public Law 96-95 and 16 U.S.C. 470aa-mm (National Park Service 2006). The ARPA provides civil and criminal penalties (felony and misdemeanor), and in some cases provides a reward for information. The statute was authored in a manner that establishes U.S. ownership of artifacts unearthed on federal lands or on private lands if the project uses federal dollars.

Abandoned Shipwreck Act

The Abandoned Shipwreck Act (ASA) was signed into law on April 28, 1988 by Ronald Reagan, has not been amended, and encompasses Public Law 100-298 and 43 U.S.C. 2101-2106 (National Park Service 2006). This statute establishes government ownership of shipwrecks, which are subsequently transferred to the state where the vessel is located. This piece of legislation is aimed at protecting shipwrecks in United States waters that are threatened by treasure salvors and looters.

Native American Graves Protection and Repatriation Act

The Native American Graves Protection and Repatriation Act (NAGPRA) was signed into law on November 16, 1990 by George H. W. Bush, has been amended twice, and encompasses Public Law 101-601 and 25 U.S.C. 3001 et seq. (National Park Service 2006). It requires the return of human remains from burials as well as associated and unassociated funerary objects to affiliated tribal entities recognized by the United States.

Temporal Distribution of Litigation

The temporal distribution of litigated cases provides a unique view of the legal system by illustrating the role that cultural resource statutes have and continue to play in our society. Until the early 1970s, cultural resource laws had been the source of very few cases, a trend that shifted greatly following the passage of the National Historic Preservation Act.

American Antiquities Act

The AAA comprises 7.7% (n=85) of the court cases compiled for this analysis. There have been four Supreme Court decisions regarding the AAA (*Cappaert v. U.S.* 426 U.S. 128, 96 S.Ct. 2062, 48 L.Ed.2d 523, 6 Envtl. L. Rep. 20,540 [1976]; *U.S. v. California* 436 U.S. 32, 98 S.Ct. 1662, 11 ERC 1651, 56 L.Ed.2d 94 [1978]; *Maine v. Thiboutot* 448 U.S. 1, 100 S.Ct. 2502, 65 L.Ed.2d 555 [1980]; *Southern Utah Wilderness Alliance v. Bureau of Land*

Management 545 U.S. 75, 125 S.Ct. 2137 [2005]).

The AAA was enacted to protect valuable cultural resources; however, integration of these preservation goals into our legal system appears to have occurred slowly. Over time, the AAA has fluctuated in use. These fluctuations are a recurring pattern noted in this legislative analysis. Since the 1970s, the frequency of case law has neither decreased nor increased; rather, it displays a pattern of consistent use.

Historic Sites Act

The Historic Sites Act (HSA) comprises 3.5% (n=39) of the case law compiled for this analysis. While the HSA was the first litigated statute aimed at the protection of cultural resources, investigation of its temporal distribution reveals a low but consistent pattern of use with several temporal gaps. The largest gap (12 years) is from 1957 to 1969; but shorter gaps also occur from 1948 to 1953 and from 1995 to 2000. The absence of cases in the 1960s appears odd as this was one of the few cultural resource laws available during the activist years, yet legal activity remained dormant.

National Historic Preservation Act

The National Historic Preservation Act (NHPA) comprises 60.6% (n=676) of the case law compiled for this analysis. Within NHPA, Section 106 litigation represents 15.5% (n=105) of the total number of cases. There have been eight Supreme Court decisions concerning this Act (*Penn Cent. Transp. Co. v. City of New York* 438 U.S. 104, 98 S.Ct. 2646, 11 ERC 1801, 57 L.Ed.2d 631, 8 Envtl. L. Rep. 20,528 [1978]; *Weinberger v. Romero-Barcelo* 456 U.S. 305, 102 S.Ct. 1798, 17 ERC 1217, 72 L.Ed.2d 91, 12 Envtl. L. Rep. 20,538 [1982];

I.N.S. v. Chadha 462 U.S. 919, 103 S.Ct. 2764, 77 L.Ed.2d 317, 13 Envtl. L. Rep. 20,663 [1983]; *Marek v. Chesny* 473 U.S. 1, 105 S.Ct. 3012, 38 Fair Empl.Prac.Cas. [BNA] 124, 37 Empl. Prac. Dec. P 35,396, 87 L.Ed.2d 1, 53 USLW 4903, 1 Fed.R.Serv.3d 1297 [1985]; *Lyng v. Northwest Indian Cemetery Protective Ass'n* 485 U.S. 439, 108 S.Ct. 1319, 99 L.Ed.2d 534, 56 USLW 4292, 18 Envtl. L. Rep. 21,043 [1988]; *West Virginia University Hospitals, Inc. v. Casey* (499 U.S. 83, 111 S.Ct. 1138, 55 Fair Empl.Prac.Cas. [BNA] 353, 55 Empl. Prac. Dec. P 40,606, 113 L.Ed.2d 68, 59 USLW 4180, 67 Ed. Law Rep. 37, Med & Med GD (CCH) P 39,109 [1991]; *State of N.J. v. State of N.Y.* Not Reported in S.Ct., 1997 WL 291594 [1997]; and *U.S. v. White Mountain Apache Tribe* 537 U.S. 465, 123 S.Ct. 1126, 155 L.Ed.2d 40, 71 USLW 4125, 71 USLW 4139, 03 Cal. Daily Op. Serv. 1903, 2003 Daily Journal D.A.R. 2393, 16 Fla. L. Weekly Fed. S 106 [2003]).

Twenty-three amendments have been made to the NHPA, and some of the largest increases in the number of prosecuted cases litigated followed the passage of amendments in 1992, 2000, and 2004; however, not all amendments appear to have influenced the case law in this manner. For instance, the NHPA amendment of 1980 did not yield a similar result.

American Indian Religious Freedom Act

The American Indian Religious Freedom Act (AIRFA) comprises 9.6% (n=106) of the case law compiled for this analysis. There have been three Supreme Court decisions for the AIRFA (*Lyng v. Northwest Indian Cemetery Protective Ass'n, Employment Div.,* 485 U.S. 439, 108 S.Ct. 1319, 99 L.Ed.2d 534, 56 USLW 4292, 18 Envtl. L. Rep. 21,043 [1988]; *Dept. of Human Resources of Oregon v. Smith* 494 U.S. 872, 110 S.Ct. 1595, 52 Fair Empl.Prac.Cas.

(BNA) 855, 53 Empl. Prac. Dec. P 39,826, 108 L.Ed.2d 876, 58 USLW 4433, Unempl.Ins.Rep. (CCH) P 21,933 [1990]; *Rice v. Cayetano* 528 U.S. 495, 120 S.Ct. 1044, 145 L.Ed.2d 1007, 68 USLW 4138, 00 Cal. Daily Op. Serv. 1341, 2000 Daily Journal D.A.R. 1881, 2000 CJ C.A.R. 898, 13 Fla. L. Weekly Fed. S 105 [2000]). However, none of these decisions deal directly with archaeology or historic preservation. In 30 years, the number of prosecuted cases involving AIRFA has surpassed all other statutes compiled for this study with the exception of the NHPA.

Archeological Resources Protection Act

The Archeological Resources Protection Act (ARPA) comprises 5.4% (n=60) of the case law compiled for this analysis. There has been one Supreme Court decision involving the statute (*Lyng v. Northwest Indian Cemetery Protective Ass'n* 485 U.S. 439, 108 S.Ct. 1319, 99 L.Ed.2d 534, 56 USLW 4292, 18 Envtl. L. Rep. 21,043 [1988]), although the role of ARPA in this case was marginal at best. The ARPA has the potential to yield substantive legal protection for archaeological resources, yet only 60 cases have been litigated using ARPA through 2010.

Abandoned Shipwreck Act

The Abandoned Shipwreck Act comprises 4.2% (n=47) of the compiled case law. There has been only one Supreme Court decision involving this statute (*California v. Deep Sea Research, Inc.* 523 U.S. 491, 118 S.Ct. 1464, 1998 A.M.C. 1521, 140 L.Ed.2d 626, 98 Cal. Daily Op. Serv. 3000, 98 Daily Journal D.A.R. 4083, 98 CJ C.A.R. 1919, 11 Fla. L. Weekly Fed. S 460 [1998]).

Native American Graves Protection and Repatriation Act

The Native American Graves Protection and Repatriation Act (NAGPRA) comprises 6.7% (n=74) of the compiled case law. There has been one Supreme Court decision regarding this Act (*Rice v. Cayetano,* 528 U.S. 495, 120 S.Ct. 1044, 145 L.Ed.2d 1007, 68 USLW 4138, 00 Cal. Daily Op. Serv. 1341, 2000 Daily Journal D.A.R. 1881, 2000 CJ C.A.R. 898, 13 Fla. L. Weekly Fed. S 105 [2000]). The most prominent case to date was that of Kennewick Man, and a large number of journal and newspaper articles have been published on the topic of this single high profile incident (Chatters 2000; Owsley and Jantz 2001; Jelderks 2002; Bruning 2006).

Spatial Dynamics of Litigation

The distribution of cases by Federal Circuit Court districts (Figure 5.1) was evaluated through contingency table analysis and a chi-square goodness-of-fit test (Table 5.1). The results (^{2}=544.333, df=12, $p<0.0000001$) show that there is a non-random distribution of court cases by Federal Circuit Court districts. The total number of cases by U.S. Circuit Court districts is illustrated in Figure 5.2. The average number of cases per district is 90.5 and the range varies greatly. In the discussion below, the number of litigated cases is described as greater, lesser, or equal to the national averages as defined by the adjusted residuals[2] (Everitt 1977; Haberman 1978). This analysis demonstrates that the western half of the United States has supported the largest case load, with the 2nd Circuit Court and D.C. Circuit Courts close behind (Figure 5.2).

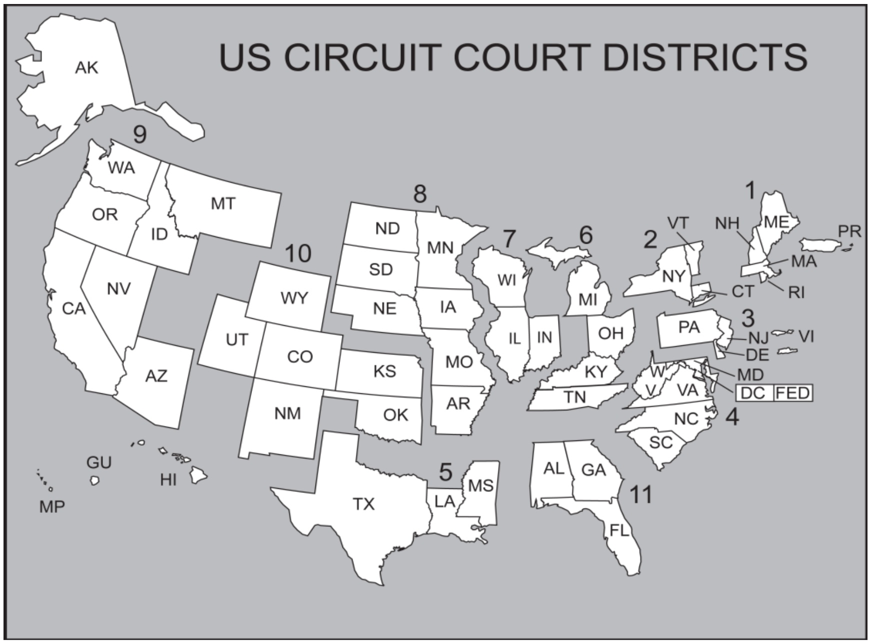

Figure 5.1. U.S. circuit court districts.

American Antiquities Act

The distribution of AAA cases displays larger frequencies than the Southern, Midwest and Western districts (7th, 8th, 10th, and 11th Circuits), as well as the Federal Circuit (Figure 5.3). However, it also reveals fewer than expected cases on the eastern seaboard, western Gulf Coast, western seaboard, and D.C. Circuit Court. Twenty-nine States have utilized this legislation, while the remaining 25 States and Territories have not.

Historic Sites Act

Use of the HSA is concentrated in the Northern Plains, Midwest, Eastern Seaboard, Gulf Coast (3rd - 4th, 6th - 8th and 11th circuits) and Federal Circuit courts (Figure 5.3). The 1st, 5th, 9th and 10th circuit court districts had many fewer HSA cases than predicted by the national average.

National Historic Preservation Act

The litigation pattern in AAA cases is the inverse of NHPA cases, where the highest number of cases occurred within the East and Gulf Coast Circuit Courts (1st -5th Circuits) and the D.C. Circuit, but in fewer than expected numbers in Circuits 7, 8, and 10 (Figure 5.3). Of the 627 litigated NHPA cases, 105 deal directly with the Section 106 process. Of these, 24 occurred in the DC Circuit Court, followed by Louisiana (5th Circuit) with eight cases, Pennsylvania (3rd Circuit) with seven cases, and California and Arizona (both 9th Circuit) with six cases each.

American Indian Religious Freedom Act, Archeological Resources Protection Act and Native American Graves Protection and Repatriation Act

Three statutes display a consistent regional pattern; those are AIRFA, ARPA, and NAGPRA (Figure 5.3). The 8th, 9th and 10th Circuits experienced a higher than expected pattern of use, and the 5th Circuit illustrates a high frequency of ARPA cases. This pattern is not surprising, since Native American populations are large and land ownership is great in the western states.

Abandoned Shipwrecks Act

The ASA has a higher than expected use rate that is statistically significant in the 3rd, 4th, 6th, 7th, and 11th Circuits (Figure 5.3). The highest frequency of ASA use was in the Great Lakes (n=16). Four cases and one Supreme Court decision *(California v. Deep Sea Research, Inc.)* were litigated on the west coast. A total of 15 cases have been litigated along the Eastern Seaboard and the eastern half of the Gulf of Mexico.

Litigation of Cultural Resources

In reviewing the history of litigation, resource-specific trends illustrate the highly variable use of these eight statutes (Figure 5.4). Legislation was correlated using the highest frequency of challenges by resource (Archaeology, Architecture, Landscape, Shipwreck, and Other) to demonstrate the resource most frequently protected by each statute. In sum, two statutes were found to correlate with archaeology (ARPA and NAGPRA), three with architecture (HSA, AHPA and NHPA), one with landscapes (AAA), one with shipwrecks (ASA), and one with other (AIRFA). In the case of the AIRFA, other is most frequently correlated with religion.

Archaeology

For archaeological resources, ARPA and NAGPRA evidence the highest number of litigated cases, followed by "other," landscapes, architecture, then shipwrecks (Figure 5.5). The reason for legal action followed the same trend, illustrating that the largest number of cases was focused upon issues of compliance, followed by Other and Taking (Figure 5.6).

The application of ARPA and NAGPRA correlates well with archaeology and landscape, but the number of cases in the category of other was unexpected. For ARPA, this category is comprised of litigation ranging in use from wrongful termination of mineral leases (327 Mont. 306, 114 P.3d 1009, 60 ERC 1869, 2005 MT 146 [2005]) and illegal fishing activities (Slip Copy, 2006 WL 3735654 [2006]) to importation of ozone-depleting

Table 5.1. Contingency table of number of litigated cases by regions and statute. Observed/values /adjusted residuals presented in each cell with row and column totals and percents. Adjusted residuals = ((Oi-Ei)/Ei)/Vari for cell i. Where O is observed value in cell i, E is expected value in cell i and Var is variance for cell i. Expected values (Ei) = column total x row total ÷ grand total. Variance = (1-(row total/grand total)) x (1-(column total/grand total)).

LAW		1st Circuit Boston	2nd Circuit New York	3rd Circuit Philadelphia	4th Circuit Richmond	5th Circuit New Orleans	6th Circuit Cincinnati	7th Circuit Chicago	8th Circuit St. Louis	9th Circuit San Francisco	10th Circuit Denver	11th Circuit Atlanta	D.C. Circuit Washington	Federal Circuit Washington	TOTAL
AAA	Count	3	2	0	2	3	4	4	8	15	17	11	7	8	84
	Adjusted Residual	-.66	-1.76	-2.39	-1.31	-1.29	-.21	.29	1.15	-1.79	3.40	3.80	-.80	5.97	
AIRFA	Count	4	2	2	2	6	5	2	9	53	17	1	3	0	106
	Adjusted Residual	-.65	-2.20	-1.85	-1.72	-.58	-.26	-1.23	.85	5.86	2.32	-1.91	-2.81	-1.38	
ARPA	Count	1	2	2	0	7	1	2	8	22	7	2	6	0	60
	Adjusted Residual	-1.24	-1.17	-.88	-1.92	1.44	-1.28	-.33	2.19	1.90	.53	-.50	-.24	-1.02	
ASA	Count	2	3	4	5	1	8	12	0	7	0	5	0	0	47
	Adjusted Residual	-.27	-.20	.76	1.57	-1.34	3.68	7.49	-1.85	-1.79	-2.29	1.98	-2.45	-.90	
HSA	Count	1	3	3	3	1	2	1	8	8	0	2	4	1	37
	Adjusted Residual	-.67	.23	.57	.70	-1.05	.04	-.45	3.77	-.64	-2.02	.22	-.03	.53	
NAGPRA	Count	0	5	1	0	3	1	2	9	37	9	0	6	0	73
	Adjusted Residual	-2.06	-.13	-1.73	-2.15	-1.04	-1.56	-.65	2.02	4.82	.75	-1.97	-.81	-1.14	
NHPA	Count	42	63	53	49	52	39	21	33	139	49	31	94	9	674
	Adjusted Residual	2.03	3.39	3.20	3.02	1.01	.90	-2.10	-2.67	-5.06	-3.27	-.16	3.77	-.89	
AHPA	Count	1	0	0	0	1	0	0	1	1	0	1	0	0	5
	Adjusted Residual	1.52	-.62	-.56	-.54	1.13	-.53	-.47	1.22	-.31	-.73	1.63	-.79	-.29	
TOTAL	Count	52	80	65	61	74	60	44	84	282	99	53	120	20	1086

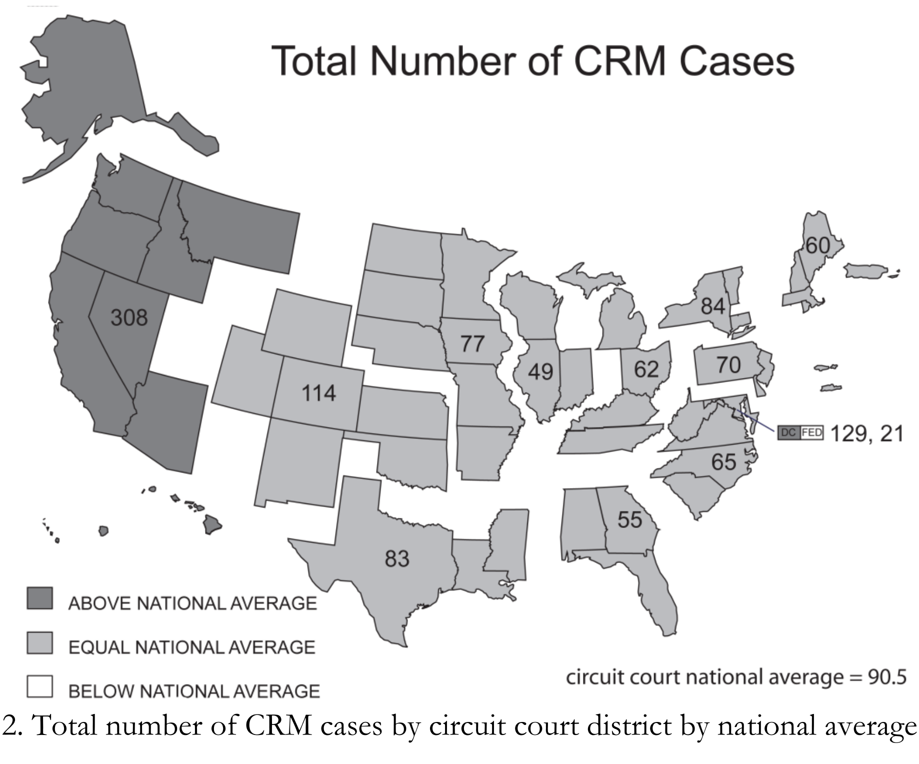

Figure 5.2. Total number of CRM cases by circuit court district by national average.

substances (517 F.3d 1179, 08 Cal. Daily` Op. Serv. 2583, 2008 Daily Journal D.A.R. 3178 [2008]). For NAGPRA, the same category ranged from a Supreme Court case focused upon voter qualification for trustees at the Office of Hawaiian Affairs (528 U.S. 495, 120 S.Ct. 1044, 145 L.Ed.2d 1007, 68 USLW 4138, 00 Cal. Daily Op. Serv. 1341, 2000 Daily Journal D.A.R. 1881, 2000 CJ C.A.R. 898, 13 Fla. L. Weekly Fed. S 105 [2000]) to a challenge by a non-native Hawaiian minor alleging that the admissions policy of a private school violated civil rights law (295 F.Supp.2d 1141, 184 Ed. Law Rep. 315 [2003]).

Architecture

The AHPA, HSA, and NHPA represent the statutes with the largest number of litigated cases focused upon architecture, followed by landscape, then (for HSA and NHPA only) other, archaeology, and shipwreck (Figure 5.5). The reason for legal action revealed differing patterns for each statute, but the category with the largest number of litigated cases—compliance—remained the same throughout all three (Figure 5.6). In the case of the AHPA, compliance-based litigation comprised the entirety of this category. For the HSA, compliance is followed by Taking, then Other, and by Other, then Taking, for the NHPA.

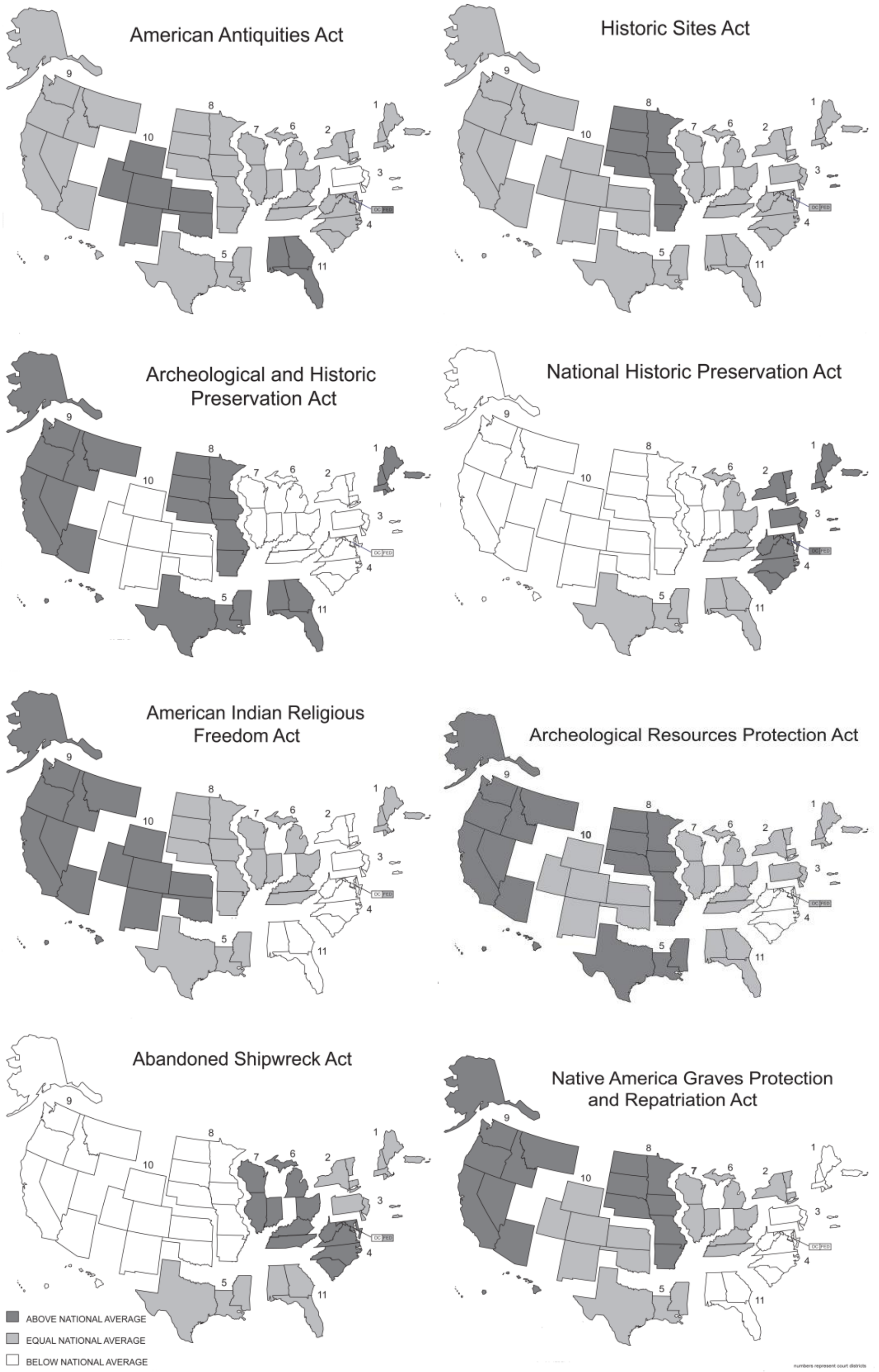

Figure 5.3. Distribution of American Antiquities Act, Historic Sites Act, Archeological and Historic Preservation Act, National Historic Preservation Act, American Indian Religious Freedom Act, Archeological Resources Protection Act, American Shipwreck Act, and Native American Graves Protection and Repatriation Act cases by circuit court district.

compared to the national averages.

Of the four cases litigated under the AHPA, none were found to correspond directly with archaeological issues and this law appears to be of little value in pursuing substantive protection for cultural resources on federal lands. It was not unexpected that architecture and landscape would be the primary recipient of legal protections under the NHPA, and that compliance-based litigation comprised the bulk of the case law. For the NHPA, the other category contains three Supreme Court cases that include the suspension of deportation (462 U.S. 919, 103 S.Ct. 2764, 77 L.Ed.2d 317, 13 Envtl. L. Rep. 20,663 [1983]), recovery of attorney's fees (473 U.S. 1, 105 S.Ct. 3012, 38 Fair Empl.Prac.Cas. (BNA) 124, 37 Empl. Prac. Dec. P 35,396, 87 L.Ed.2d 1, 53 USLW 4903, 1 Fed.R.Serv.3d 129 [1985]), and recovery of hospital fees related to Medicaid reimbursement (499 U.S. 83, 111 S.Ct. 1138, 55 Fair Empl.Prac.Cas. (BNA) 353, 55 Empl. Prac. Dec. P 40,606, 113 L.Ed.2d 68, 59 USLW 4180, 67 Ed. Law Rep. 37, Med & Med GD (CCH) P 39,109 [1991]). The other category of the HSA contains cases ranging from the appealed conviction of traffic regulations within a national seashore (364 F.3d 1266, 17 Fla. L. Weekly Fed. C 379 [2004]) to a sheriff's department employee seeking judicial review of her termination based upon misconduct involving pay vouchers (139 Idaho 5, 72 P.3d 845 [2003]).

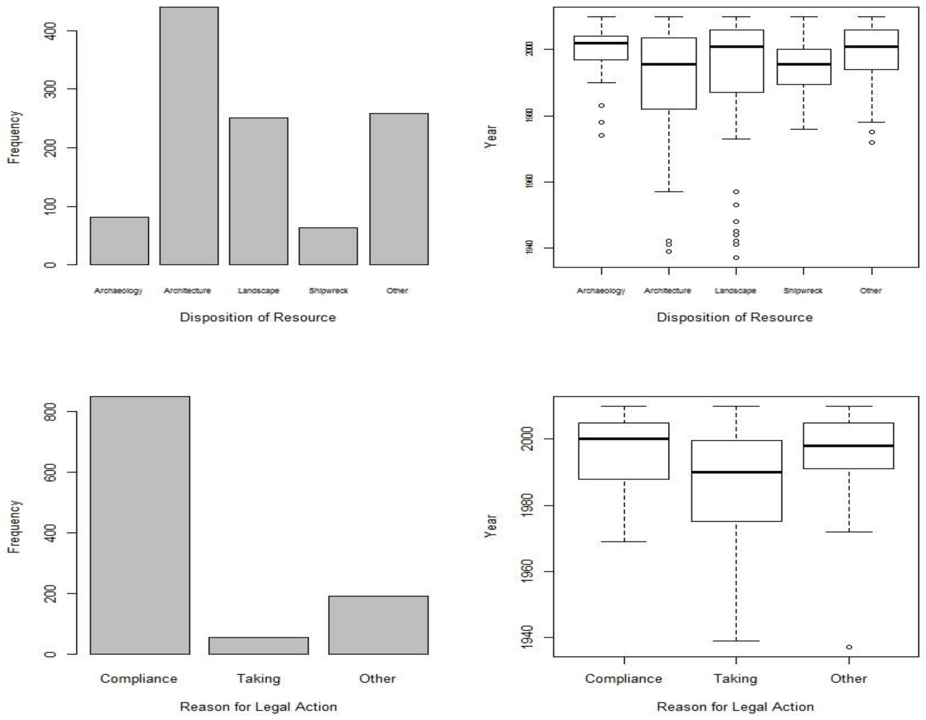

Figure 5.4. Overview of resource-based litigation.

Landscape

For landscape resources, the AAA has the highest frequency of litigated cases, followed by other, architecture, shipwreck, and archaeology (Figure 5.5). The reasons for legal action, when ordered by frequency, are compliance, other, and taking (Figure 5.6).

Challenges in the other category range from a prisoner that alleged constitutional violations while incarcerated in a private prison (352 F.3d 1351, 25 ITRD 1865 [2004]) to the conviction for receipt and concealment of state-owned stolen property valued at over $500 (137 Mich.App. 480, 358 N.W.2d 615 [1984]). There is a single Supreme Court decision in the other category where the AAA was used to recover retroactive benefits and attorney fees in a civil rights trial (448 U.S. 1, 100 S.Ct. 2502, 65 L.Ed.2d 555 [1980]).

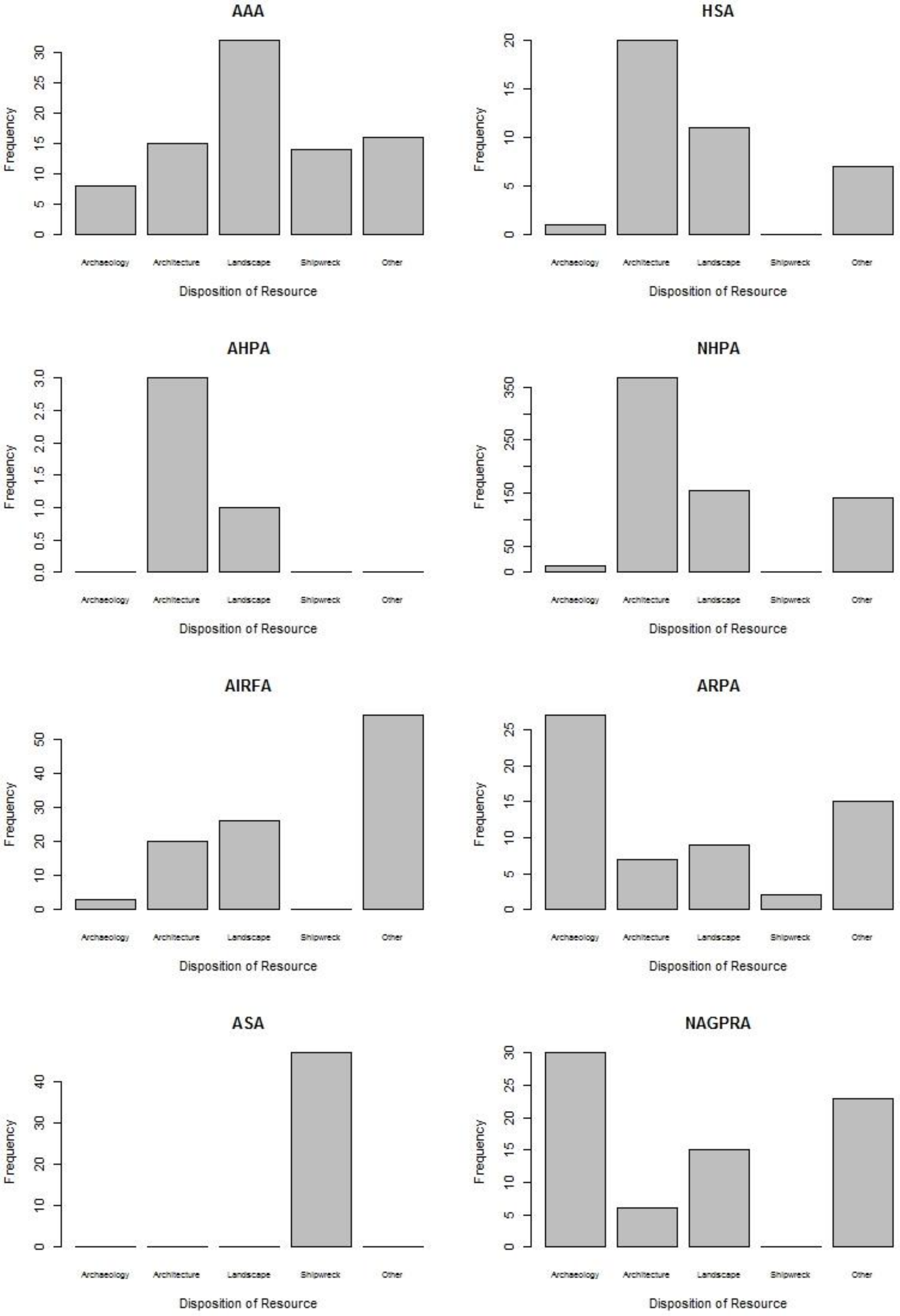

Figure 5.5. Disposition of resource by frequency.

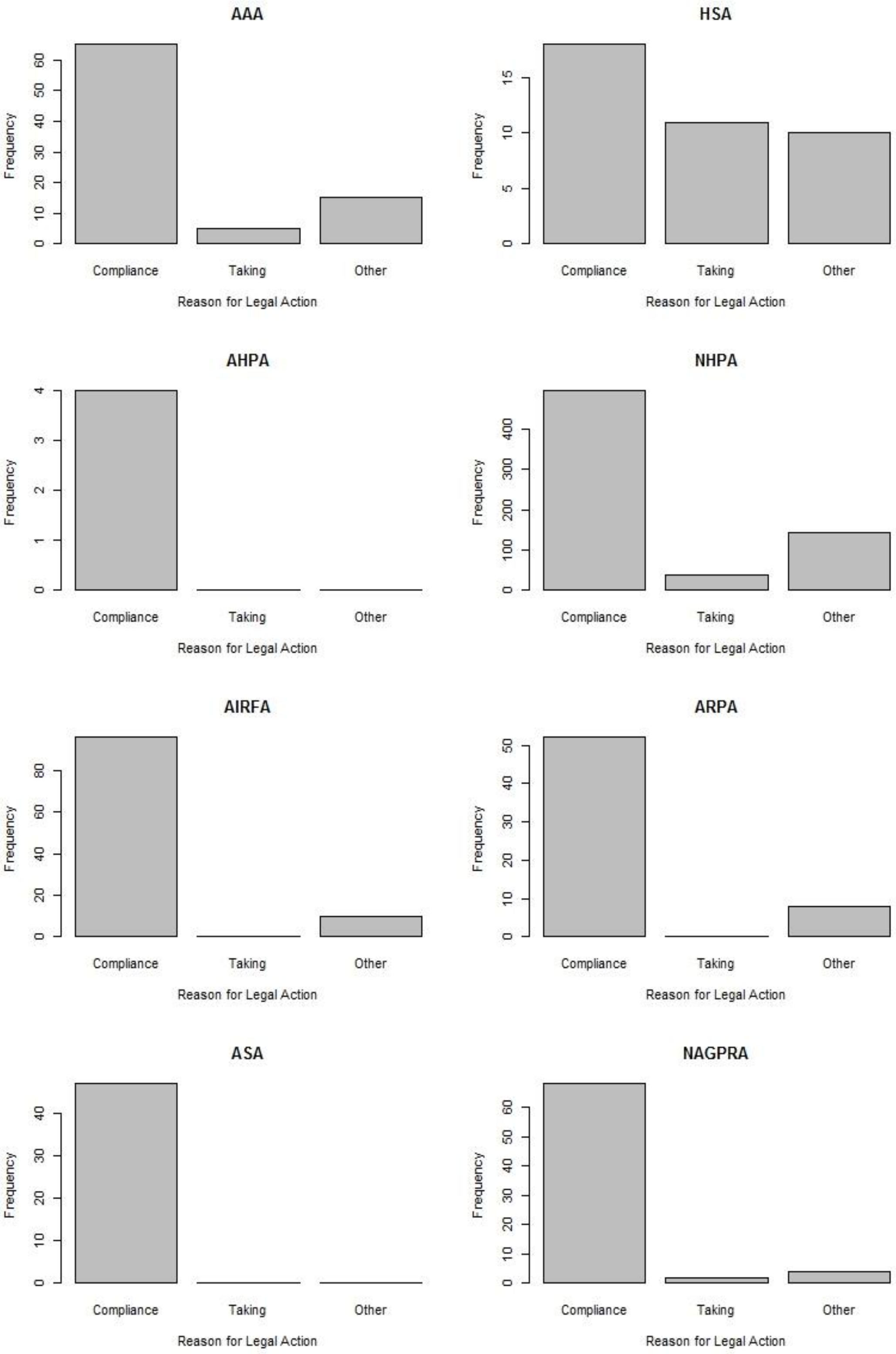

Figure 5.6. Reason for legal action by frequency.

Shipwrecks

Not surprisingly, the ASA represents the bulk of litigated cases concerning shipwrecks (Figure 5.5). The reason for legal action in the case of the ASA is purely compliance-based (Figure 5.6). The great majority of case law was filed seeking declaration of ownership for sunken vessels. The single Supreme Court case was centered upon the issue of acquiring salvage rights for an 1865 wreck that sank off the coast of California, and in the majority opinion Justice O'Connor wrote that "the Eleventh Amendment does not bar the jurisdiction of a federal court over an in rem admiralty action where the res is not within the state's possession" (523 U.S. 491, 118 S.Ct. 1464, 1998 A.M.C. 1521, 140 L.Ed.2d 626, 98 Cal. Daily Op. Serv. 3000, 98 Daily Journal D.A.R. 4083, 98 CJ C.A.R. 1919, 11 Fla. L. Weekly Fed. S 460 [1998]).

Other

The AIRFA represents the statute with the largest number of litigated cases associated with the category of other, followed by landscape, architecture, and archaeology (Figure 5.5). The reason for legal action is most commonly associated with compliance, then other (Figure 5.6).

The AIRFA case law in the category of other includes the conviction of individuals cultivating marijuana that failed to pay the drug tax (71 F.Supp.2d 1098 [1999]), an allegation that prison grooming regulations violated civil rights (10 Fed. Appx. 466, 2001 WL 294324, not selected for publication in the Federal Reporter [2001]), and even first degree murder (502 F.3d 931, 07 Cal. Daily Op. Serv. 10,677, 2007 Daily Journal D.A.R. 13,801 [2007]). The remainder of this category is focused upon the protection of religious freedoms, and was most famously used in the case of a review of determination by the Supreme Court regarding the use of peyote in the context of religious use (494 U.S. 872, 110 S.Ct. 1595, 52 Fair Empl.Prac.Cas. [BNA] 855, 53 Empl. Prac. Dec. P 39,826, 108 L.Ed.2d 876, 58 USLW 4433, Unempl.Ins.Rep. [CCH] P 21,933 [1990]). That challenge was made by two individuals who were dismissed from employment at a drug rehabilitation clinic due to their use of peyote. This offense was considered misconduct, preventing the plaintiffs from attaining unemployment compensation subsequent to termination. The case eventually reached the Supreme Court where Justice Scalia held that "(1) [the] free exercise clause did not prohibit application of Oregon drug laws to ceremonial ingestion of peyote, and (2) thus state could, consistent with free exercise clause, deny claimants unemployment compensation for work-related misconduct based on use of drug" (494 U.S. 872, 110 S.Ct. 1595, 52 Fair Empl.Prac.Cas. [BNA] 855, 53 Empl. Prac. Dec. P 39,826, 108 L.Ed.2d 876, 58 USLW 4433, Unempl.Ins.Rep. [CCH] P 21,933 [1990]).

Conclusion

These trends in major cultural resource laws indicate the disparate application of legislation associated with cultural resources. While a single piece of legislation, the ASA, appears to offer protection to only one kind of cultural resource, the remaining seven statutes have been employed within each of the resource categories, indicating the multifaceted nature of legal challenges. The flexible nature of these statutes and endless attempts by lawyers to apply them to widely ranging problems regarding cultural resources provides unique litigation-based signatures for each of the U.S. Circuit Courts.

In all, 1097 litigated cases comprise the foundation of this study. Though each is unique, the combined case law provides a tool to analyze the legislation and document the evolution of legal practices. Our findings highlight the variable and unequal application of the eight statutes across the national landscape, emphasizing the need for further research to explore the intricacies within these patterns.

Many of these laws have attempted to provide greater legal access and authority to Native Americans. The last decade has seen yet another increase in litigation, which has continued for most of the new century. Though not included within this study, the National Environmental Policy Act (NEPA) has the highest frequency of use (>4000 cases), but most involve environmental issues with no implications for cultural resources. Nevertheless, NEPA warrants investigation and analysis.

This study demonstrates the diverse practical application of these eight statutes. Knowing that these laws exist to protect the past is not enough. Only by following the evolutionary progress revealed in part by this study may we begin to truly comprehend the current impact of cultural resource laws upon the practice of archaeology. This analysis ends not only with a plea for additional analyses, but for the education of our legal counterparts regarding legislation that protects cultural resources, and the consistent prosecution and enforcement of cultural resource laws since, to a large degree, the nature of research focused upon cultural resources in the United States is influenced by the enforcement of these statutes.

Notes

1. The distribution of cases uses the 11 circuit courts, which includes both the District of Columbia (D.C.) and Federal Circuit jurisdictions. Judicial practice places U.S. Territories within specific regional circuit districts. For example, the Northern Mariana Islands and Guam are grouped with the 9th Circuit (Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, Oregon, and Washington), the Virgin Islands are incorporated with the 3rd Circuit (Delaware, New Jersey, and Pennsylvania), and Puerto Rico is placed with the 1st Circuit (Maine, Massachusetts, New Hampshire and Rhode Island). The other districts are made up of only states. For example, the 2nd Circuit is comprised of Connecticut, New York, and Vermont. The 4th Circuit contains Maryland, North Carolina, South Carolina, Virginia, and West Virginia. The 5th Circuit is made up of Louisiana, Mississippi, and Texas. Kentucky, Michigan, Ohio, and Tennessee constitute the 6th Circuit. The 7th Circuit consists of Illinois, Indiana, and Wisconsin. Arkansas, Iowa, Missouri, Minnesota, Nebraska, North Dakota, and South Dakota form the 8th Circuit. Colorado, Kansas, New Mexico, Oklahoma, Utah, and Wyoming are the states constituting the 10th Circuit, while Alabama, Georgia, and Florida comprise the 11th Circuit.

2. In the contingency table analysis, a chi-square test of independence and adjusted residuals were calculated (Everitt 1977; Haberman 1978). Adjusted residuals measure the difference between observed and expected values in individual contingency table cells, and converts this difference to the equivalent of a z-score in a normal distribution. Adjusted residuals with a value of 1.96 or greater, or –1.96 or less, are considered significant at a 0.05

level of confidence. Adjusted residual values between 1.96 and -1.96 do not deviate enough from the expected values to be considered significantly different from the expected values. Details of the actual calculations are presented in Table 5.1.

CHAPTER VI

SUMMARY AND FUTURE DIRECTIONS

> The weapon of criticism cannot, of course, replace criticism by weapons, material force must be overthrown by material force; but theory also becomes a material force as soon as it has gripped the masses (Marx 1997 [1844]:93)

This concluding chapter offers potential future directions concerning avenues of gainful research within the Caddo region that are easily exportable to global contexts. To be sure, it has been my goal to aim a critical lens to issues of temporal control and ceramic provenance; however, the methods and approaches employed herein can be used to bolster archaeological arguments using databases composed of regionally-specific data garnered from archaeological investigations anywhere in the world.

Summary

Within the preceding pages, I have attempted to convey both the scope and breadth of radiocarbon dating, instrumental neutron activation analysis (INAA), and legally-based research questions that can be addressed by the corpus of data available in the pages of Cultural Resources Management (CRM) reports and legal databases. The synthesis of this data provides a substantial platform from which to build upon as Caddo archeologists and the Caddo peoples strive to learn more regarding the materials, identities, and lifeways of ancestral Caddo populations.

Through the use of radiocarbon, this investigation revealed three divisions within the Woodland period that represent the Early Woodland (ca. 500 B.C. – A.D. 0), Middle Woodland (A.D. 0 – 400), and Late Woodland (A.D. 400 – 800) occupations of East Texas. Using the same method, radiocarbon dates were used to explore the variation within the ancestral Caddo tradition (ca. AD 800 – 1680+) of East Texas, in which variable use through time of Texas' natural regions was evidenced, and the differing site types (Cemeteries, Mound Centers, and Settlements) were set in contrast with their temporal and spatial contexts.

Although buried deep within the gray literature, collecting and assembling the INAA data proved to be a time consuming process. Taking almost two years to gather, this represents the first attempt to synthesize these data for reanalysis outside of the various approaches taken by the University of Missouri Research Reactor (MURR) since the late 1990s. The product of this analysis is the landscape-level consideration of geochemical diversity across the Caddo region. At the conclusion of this analysis, five composite groups have been identified, each with differing geographic distributions that may hold clues to furthering the analysis of this complicated dataset.

The legal framework employed by the United States Circuit Courts provides a challenging platform from which the Caddo Nation must address their concerns and grievances regarding the violation of both statutes and Executive Orders. Positioned within the geographic limits of three different Circuit Courts, the Caddo must hope for consistent interpretation of federal mandates across current political boundaries. Fiscal limitations play a large part in their pursuit of violations, and may be the principal reason for the complete absence of litigation for cases in which their cultural property had been illegally procured (i.e., stolen and/or looted). Within each of the three research domains included in this dissertation, the analysis provides more questions than answers. It is my hope that the combining of these datasets will lead to an improved understanding of what it was to be a member of Caddo society. Of the most conceivably fruitful endeavors yet to be explored is the development of a novel and complementary theoretical dialogue, which must begin to evolve if Caddo archaeology is to continue to expand the boundaries of our current base of knowledge and remain relevant in the coming decades.

While not a central focus of this study, these results demonstrate the capacity for significant research gains from repository or library-based efforts. These methods illuminate promise in many forms.

Future Directions

Temporal Considerations

With the decreasing cost of attaining accurate ^{14}C determinations from increasingly small samples, archaeologists are becoming ever more mindful of the research potential that ^{14}C dates can offer (see Kuzmin and Keates 2005; Rick 1987; Steele 2010; Williams 2012). One trend evidenced here—and in other studies (see Surovell and Brantingham 2007; Surovell et al. 2009)—is that the number of younger components outnumbers that of older components. This observation plays an integral role in the recent push toward highlighting fluctuations in prehistoric demography via radiocarbon (Bamforth and Grund 2012; Buchanan et al. 2008; Faught 2008; Hinz et al. 2012; Peros et al. 2010), and the curative methods advanced to correct for taphonomic bias (Surovell and Brantingham 2007; Surovell et al. 2009).

Recent technological and statistical advances have made it less complicating to remove investigator bias from the process of delineating sites with simultaneous temporal occupations (see Grove 2008, 2009, 2010). Hypothetically, because of an increase in chronological precision, the development of a regional model of Caddo trade and exchange ought to occur at an appropriate scale to begin a discussion of cultural transmission—whether vertical (Shennan and Steele 1999:376), oblique (Shennan 2002:49), master/apprentice (Epstein 1998:688-693; Silver 1981:43-44), or horizontal (Cavalli-Sforza and Feldman 1981)—which might be further evidenced in innovative ceramic decorations (Hosfield 2011). Within that context, variation and transmission become important mechanisms of ceramic traditions along with their differential persistence in the archaeological record (Neff 1996).

Advancements in combining the analysis of ^{14}C and data from other sources—stratigraphic (Bronk Ramsey 1995, 2007; Michczynski and Pazdur 2003), phases (Buck et al. 1991; Ziedler et al. 1998), architecture (Bayliss et al. 2007; Whittle et al. 2011), palaeoenvironmental records (Gearey et al. 2009), tephrochronology (Buck et al. 2003), climate (Kidder 2006), and even ceramic data (Buck et al. 1992)—can provide an integral toolkit for exploring potential associations between ^{14}C determinations and archaeological datasets, providing testable hypotheses that can be validated or falsified with the addition of more data (Bayliss and Ramsey 2004). Bayesian models of radiocarbon have been employed for over 15 years in Great Britain (Bayliss 2009; Bronk Ramsey 2008, 2009; Buck et al. 1996), and are widely employed there with great success (e.g., Bayliss 2009; Bayliss et al. 2005; Buck et al. 1994).

However, until archaeologists incorporate Bayesian analyses of radiocarbon dates on a more regular basis, we should at least endeavor to use these data to identify those sites with probable components of archaeological contemporaneity. This can be done by highlighting sites with overlapping date ranges, and extending the spatial scope outward at regular increments (perhaps at 25, 50, 75 and 100 miles) to better illustrate and consider archaeological sites that contain elements (ceramics, lithics, features, etc.) that can increase our understanding of potential networks, interactions, and cultural transmission at particular temporal intervals. While beyond the scope of this endeavor, those data could—and should—be used to explore the possible range in the structure of communities and the potential political and social alliances and networks that may have been operating within these areas.

Ceramic Provenance

The employment of INAA-based research in the Caddo area will continue to aid in clarifying issues of ceramic provenance evident in the dataset, and this analysis contributes five unique geospatial patterns that may help to further future discussions of ceramic provenance for ancestral Caddo ceramics. It is becoming increasingly apparent that we cannot rely upon MURR to expound any further upon the diversity and increasing variability of this sample. Therefore, we must take it upon ourselves to investigate and identify potential areas of vessel provenance within the Caddo area that can be consistently employed as this substantial dataset continues to increase in magnitude.

Due to recent dialogues concerning lines of effective demarcation between local and non-local ceramics via INAA (Shrarer et al. 2006; Stoltman et al. 2005; Stoltman and Mainfort 2000), and the complex nature of ceramic chemical composition based upon the addition of temper and the process of diagenesis (Glascock 2002; Neff et al. 2006a, 2006b), it is recommended that petrographic analyses augment the analysis of INAA data in an effort to clarify and expound upon issues of probable vessel provenance and regional geochemical variability. While combining these approaches may serve to elucidate further trends within these data, making sense of this complex amalgam of INAA samples remains paramount. Sample sizes must be increased within the currently analyzed sample of sites and to further current dialogues regarding possible provenance determinations within the ancestral Caddo territory. In order to consistently identify local and non-local sherds as well as possible zones of production, I recommend that a minimum of 30 sherds should be submitted for INAA from each site under consideration, making it possible to create a site-specific correspondence matrix from which an exploration of statistical similarities and differences can assist in the identification of clays found in the ceramics used at each site.

Employed in tandem, INAA and petrography have been found to complement one another, and often yield substantive clues that assist in clarifying issues of provenance. Additionally, once areas of possible ceramic provenance have been defined by INAA and petrographic methods, an exploration of ceramic petrofacies may exponentially increase the scope and utility of studies aimed at identifying possible manufacturing locales for specific ceramic vessels. By noting the relative abundance of local sands, petrofacies models can provide a high-definition method of assigning ceramic provenance (see Miksa and Heidke 1995; 2001).

In archaeological application, petrofacies can be thought of as “temper resource procurement zones whose sand compositions are distinct from one another at a relevant scale of investigation" (Miksa et al. 2004). Petrofacies models have been employed successfully in archaeological contexts of the San Pedro Valley (Miksa et al. 2004), Tonto basin (Miksa and Heidke 2001, Stark and Heidke 1998), Tucson basin (Lombard 1987, Miksa et al. 2004), Perry Mesa and Agua Fria (Castro-Reino 2004), Tanque Verde Wash (Lavayen 2011), and the Gila and Phoenix basins (Miksa et al. 2004), but this technique has not been exported east of Arizona, most likely due to the time investment needed at the outset of such an endeavor. Through employment of this method in East Texas, it should be possible to ask increasingly complex questions about Caddo ceramic sherds and vessels. The three-dimensional nature of ceramic provenance (x = longitude, y = latitude, z = time) adds to the complexity and value of the research. Data resulting from the construction of an actualistic petrofacies model in East Texas can provide the necessary foundation for expanding upon the current dialogue regarding the provenance of ceramic vessels utilized by Woodland and Caddo populations.

The lower Angelina River basin in East Texas provides an ideal locality for a test of the petrofacies model within a prehistoric coastal environment. The lack of systematic sampling for raw materials and the apparent homogeneous chemical signatures within the INAA data have led to challenges with interpretations offered by MURR (Ferguson and Glascock 2012). Although superficially homogenous at the elemental scale (per MURR), the geologic variability within the lower Angelina River basin is ample, and provides promise for a substantial increase in the resolution of ceramic provenance studies. Within the basin, latitudinal variability occurs at a higher frequency than its longitudinal counterpart due wholly to the nature of the coastal geology in which deep sands were deposited incrementally as sea level dropped. Although longitudinal homogeneity in the prehistoric coastline might be seen as a limiting factor, sand samples collected within the peripheral drainages could reveal that the petrofacies identifications defined within the Angelina River basin can be exported for use in the neighboring Neches and Sabine River basins due to similarities in longitudinal geologic composition.

Within the Angelina River basin, Woodland and Caddo (ceramic-bearing) occupations would provide the cultural framework for such an endeavor. The sample of ceramic sherds that could be employed for such a project would provide a representative cross-section needed to explore variation in ceramic composition from archaeological sites across the area.

The use of petrofacies exponentially increases the scope and utility of ceramic petrography. By noting the relative abundance of local sands instead of only ubiquitous materials, petrofacies models provide a high-definition method of assigning ceramic provenance (Miksa and Heidke 1995). This can facilitate the production of increasingly complex research questions, and provide the spatial and temporal resolution needed to begin a more detailed discussion of manufacture and use, ceramic economy, migration, exchange networks, and temporal trends.

With regard to the litigation aimed at the protection of archaeological and historical resources, it is recommended that future analyses proceed within the framework of statute-specific investigations aimed at exploring the question of *why* litigation for each of these statutes can be said to pattern in these various ways. Also of benefit to further analyses would be the inclusion of local, state, and federal law enforcement and lawyers within a larger discussion aimed at informing and educating those charged with the protection of these resources. The most productive of these would be the establishment of a Continuing Legal Education (CLE) course that meets the standards set out by the state in which the CLE is proposed. Another avenue of worthwhile pursuit would be the creation and dissemination of public service announcements aimed at informing the public of the laws protecting cultural resources on private lands.

Theoretical Perspectives on Caddo Archaeology

The contribution of theoretically-inspired concepts to the archaeological study of the Caddo people is a valuable approach at arriving at a better understanding of Caddo native history, but it is an approach that needs more attention. Put plainly, theory is one of the least expensive and most powerful tools that we possess in archaeology, and the regular incorporation of theoretical contributions to present and future Caddo archaeological endeavors ought to assist in the development of competing/complementary theories and hypotheses concerning all aspects of Caddo culture change over more than a millennium.

Early's (2012) agency-based discussion of Caddo pottery-making trajectories and the decision-making processes certainly stand out as a useful example of how this might be achieved. Subsequent to her discussion of ceramics, Early (2012:45) enlists the use of structural principles and cultural categories within several cultural domains, where "the relationships among cultural categories comprising pairs or contrast sets (e.g., human: superhuman, phenomenal: numinous, junior: senior, etc.) were structured according to a principle of hierarchy rather than opposition (Sabo 1998:167). Early's (2012) argument stands out as one of the better examples of what might be called hierarchically-nested

Caddo theory in that she constructs her own theoretical viewpoint, subsequently couching that supposition within Sabo's (1998) theoretical construct. It continues to be the case that within the realm of theory, Caddo archaeology possesses both the largest amount of promise, and the smallest number of practitioners.

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APPENDIX A

INSTRUMENTAL NEUTRON ACTIVATION ANALYSES IN THE ANCESTRAL CADDO TERRITORY[4]

Revisiting the Caddo INAA Dataset

The work presented in this appendix has been submitted to the *Caddo Archeology Journal*. In an attempt to better comprehend the geochemical composition of ceramic sherds across the traditional Caddo landscape, the INAA results for 1192 sherds from 164 sites are employed within this discussion (not included in this sample are sherds from sites recovered in central Texas). After assembling the dataset, two tables were used—one with geochemical data, one with site data—to catalog the sample. The shell and bone-tempered sherds were noted, but the calcium correction (see Steponaitis et al. 1996:559) was only applied to the 4% (n=47) of samples known to be shell-tempered (see Figure 2.1).

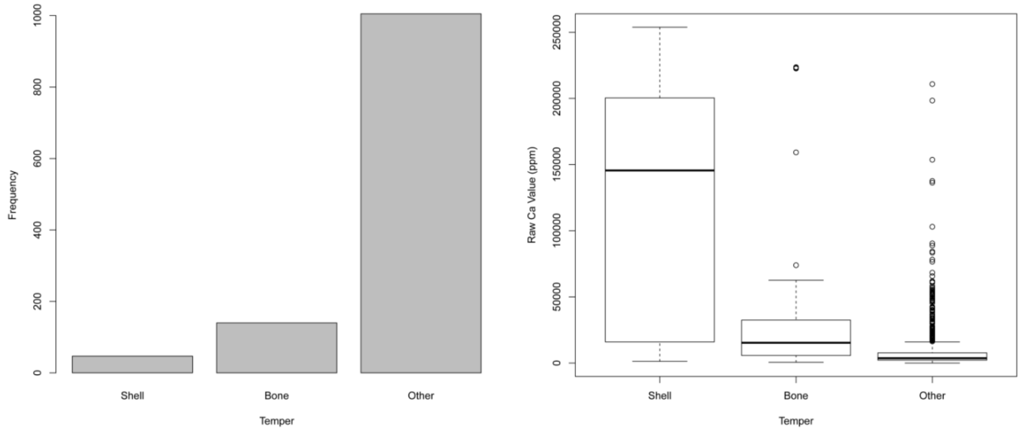

Figure A.1. Frequency and uncorrected Ca values for shell, bone and other tempers in the Caddo INAA dataset.

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The calcium correction was applied to these 47 sherds in version 2.15.2 of R, after which those sherds were recombined with the bone and other-tempered sherds, and the log-10 of each element was calculated, adding a value of one to each sherd/element in the database, effectively replacing all missing values with a zero. Subseqently, the Getis-Ord Gi* statistic in ArcGIS10 was employed to calculate a z-score for each log-10 value, illustrating the spatial distribution and z-score value for each element using the formula:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}\, x_j - \bar{X} \sum_{j=1}^{n} w_{i,j}}{s \sqrt{\frac{\left[n \sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}}$$

where x_j is the attribute value for feature $j, w_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of features and:

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2}$$

The G_i^* statistic is a z-score so no further calculations are required (ESRI 2012).

Following the calculation of log-10 values for each element, these data were then used to calculate the deterministic statistic of inverse distance weighted (IDW) in ArcGIS10 for each element to better illustrate whether discrete geochemical signatures exist close to one another, or in the same location (see Mitchell 2005; ESRI 2004). Pulling from these results, the geographic illustrations seem to clarify much, but can also be used to clarify and expand upon assertions made in previous analyses. For instance, the geographic distribution of chromium (Cr) appears to support Ferguson's (2010:16-17) assertion regarding an apparent gradient in the Sabine River drainage, an observation which might now be extended to all but the Red River drainage in East Texas. What follows are the geographic illustrations created through this process, which document the spatial diversity and variability for each of the reported elements (Figures A.2-A.34).

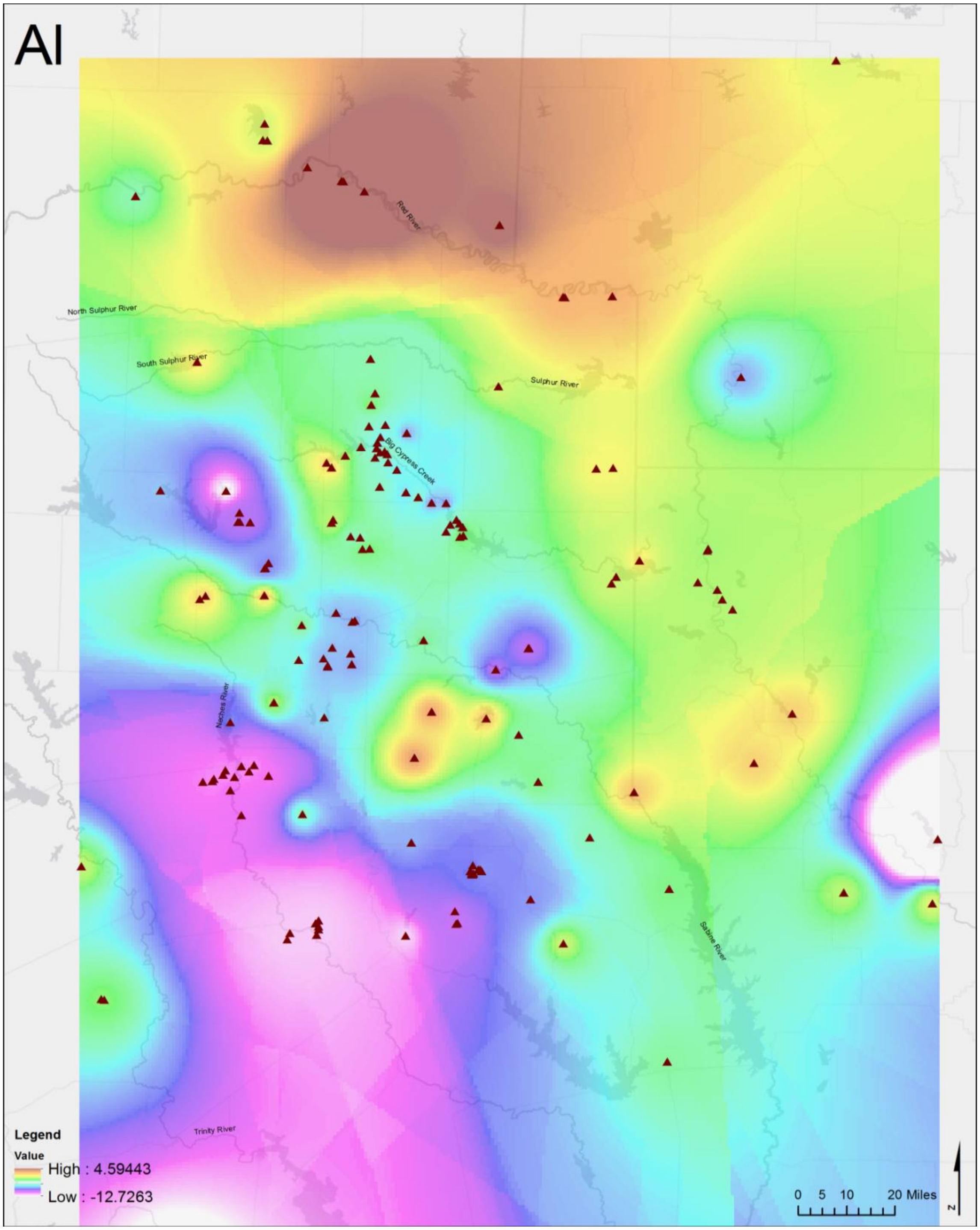

Figure A.2. Variation in aluminum (Al) concentrations for INAA of Caddo ceramics.

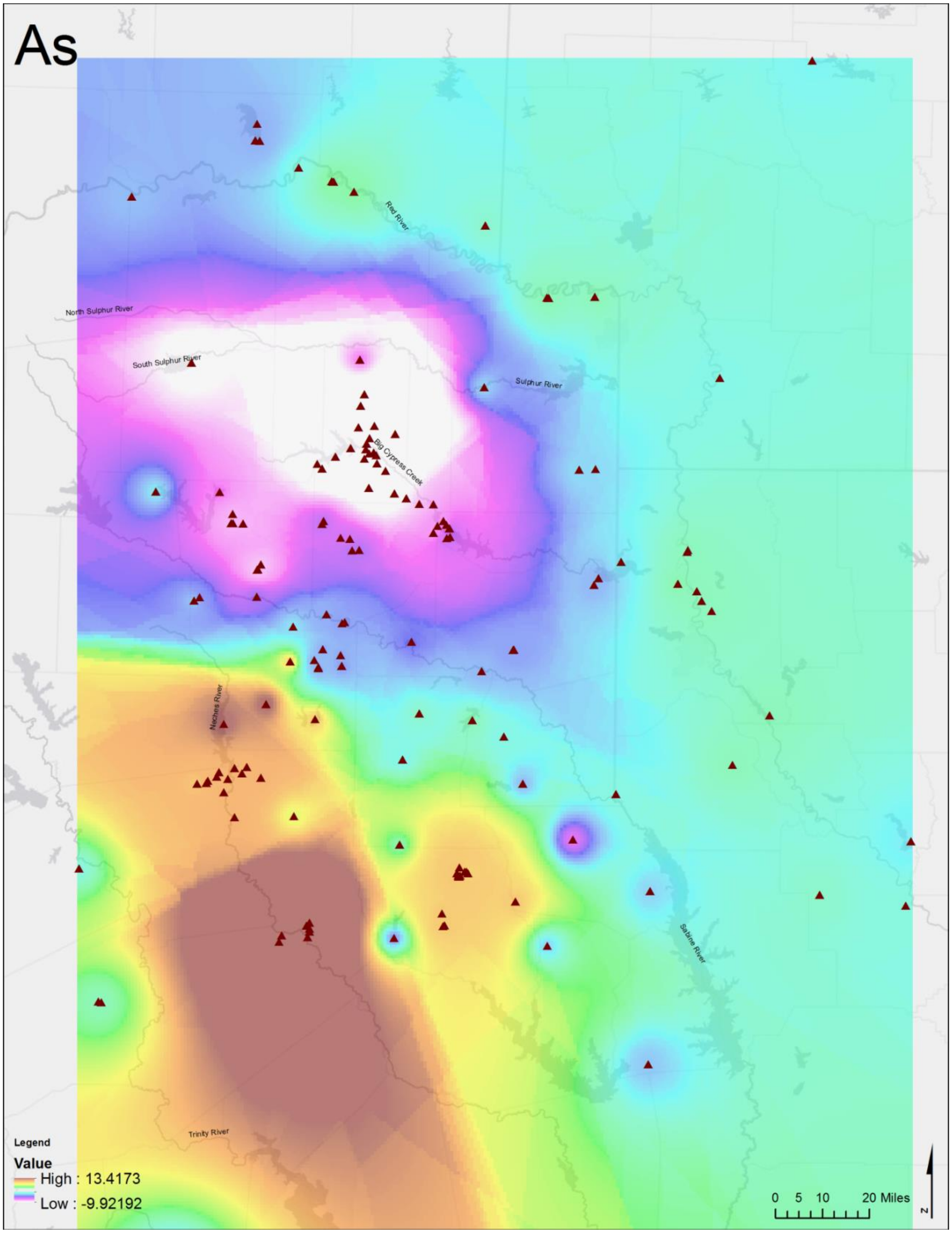

Figure A.3. Variation in arsenic (As) concentrations for INAA of Caddo ceramics.

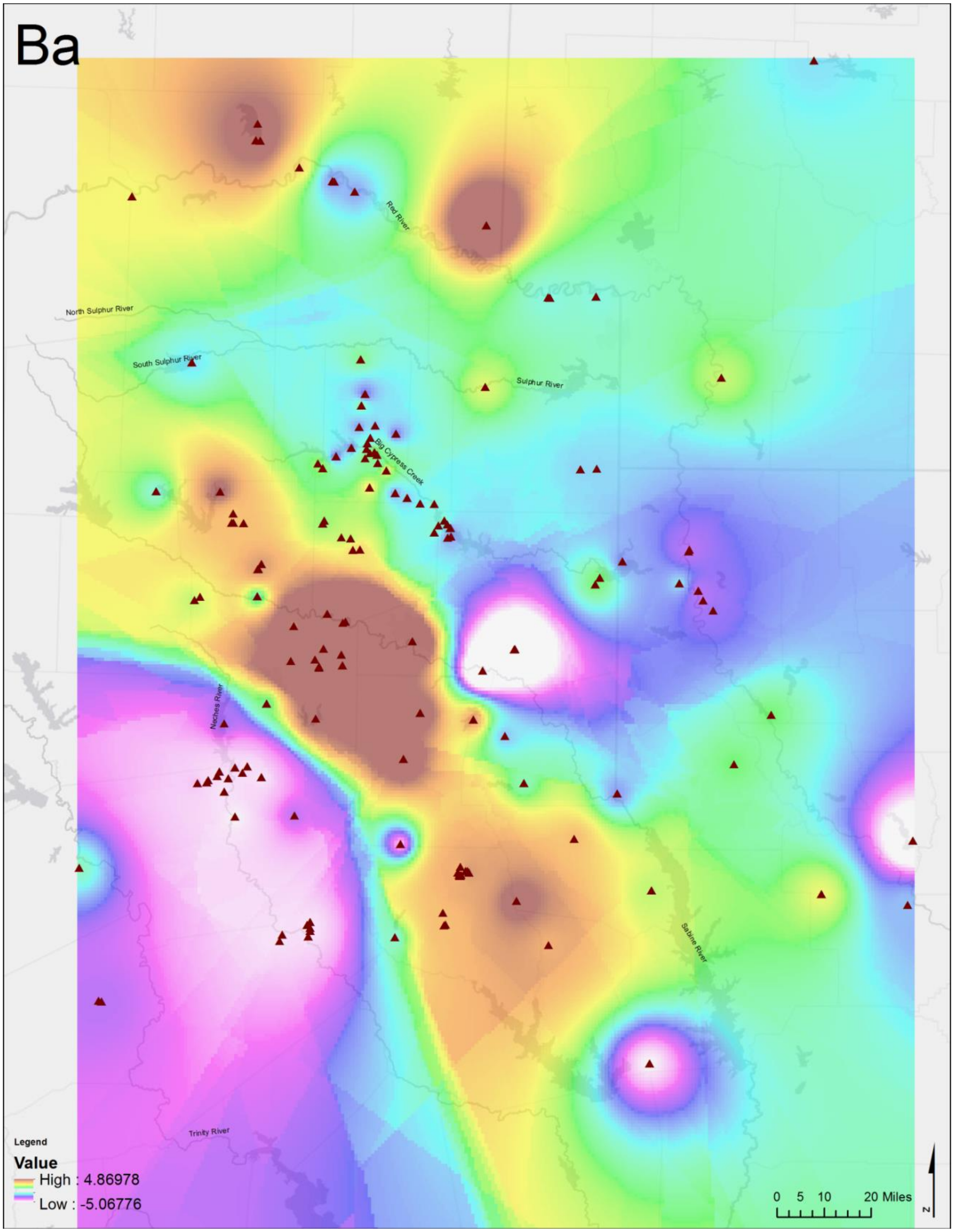

Figure A.4. Variation in barium (Ba) concentrations for INAA of Caddo ceramics.

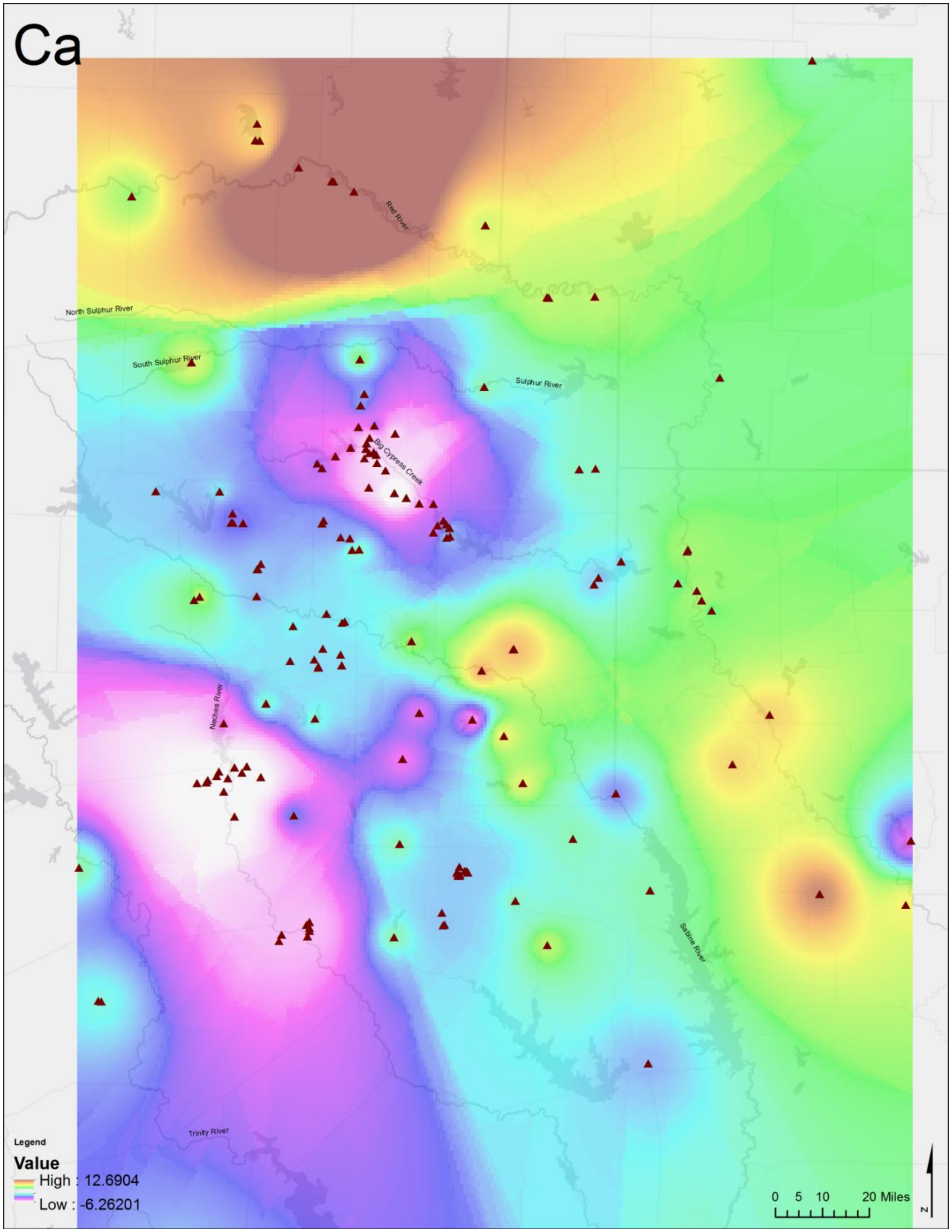

Figure A.5. Variation in calcium (Ca) concentrations for INAA of Caddo ceramics.

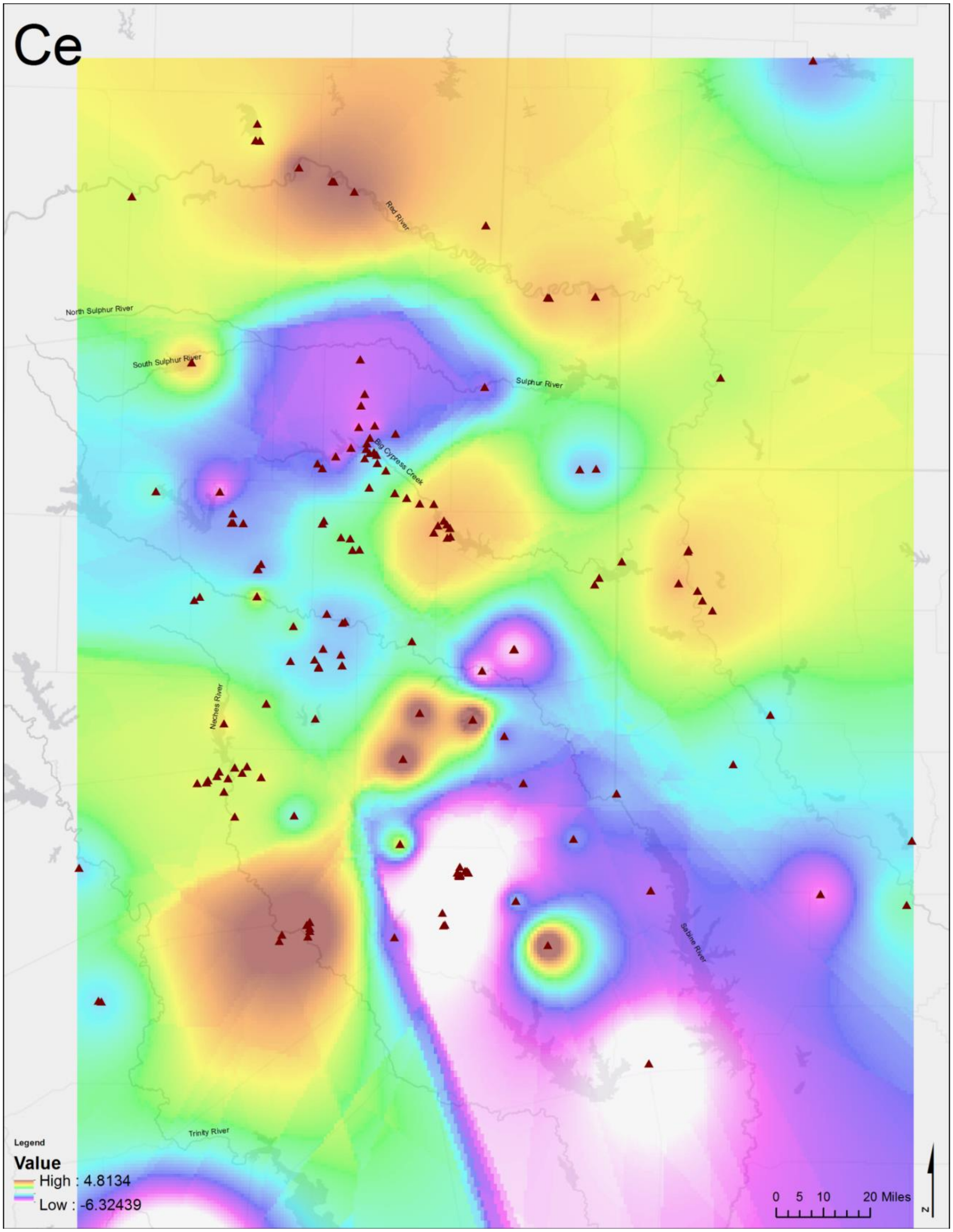

Figure A.6. Variation in cerium (Ce) concentrations for INAA of Caddo ceramics.

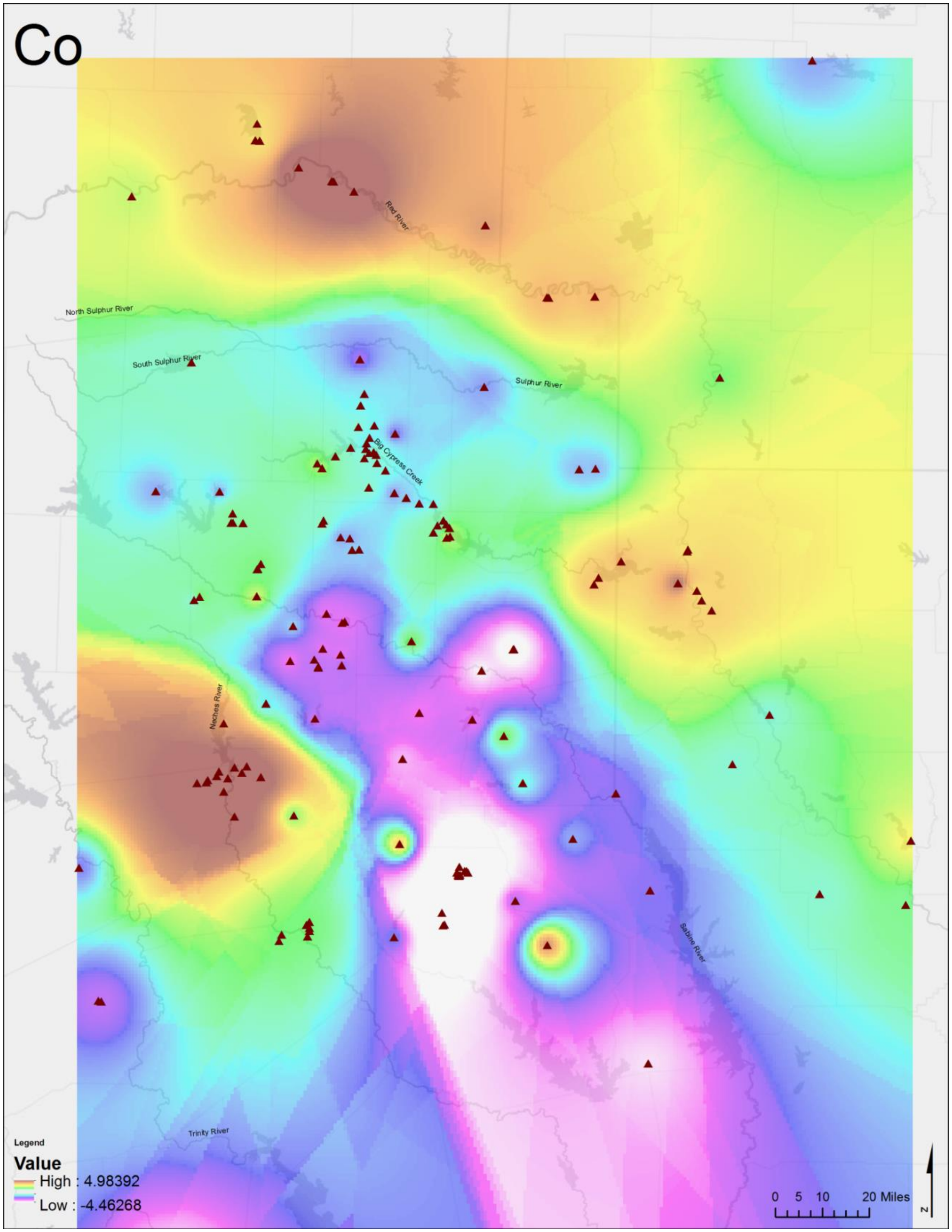

Figure A.7. Variation in cobalt (Co) concentrations for INAA of Caddo ceramics.

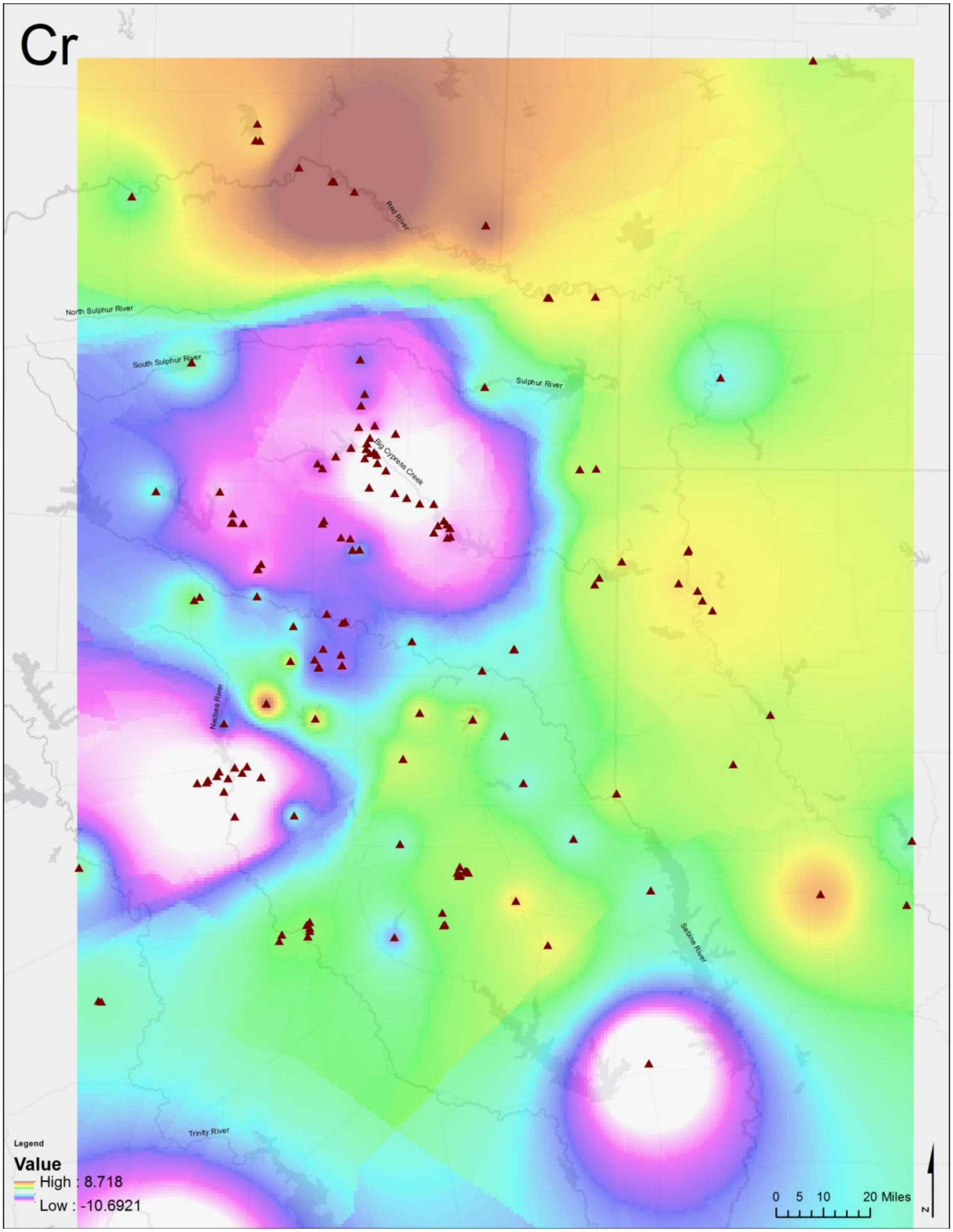

Figure A.8. Variation in chromium (Cr) concentrations for INAA of Caddo ceramics.

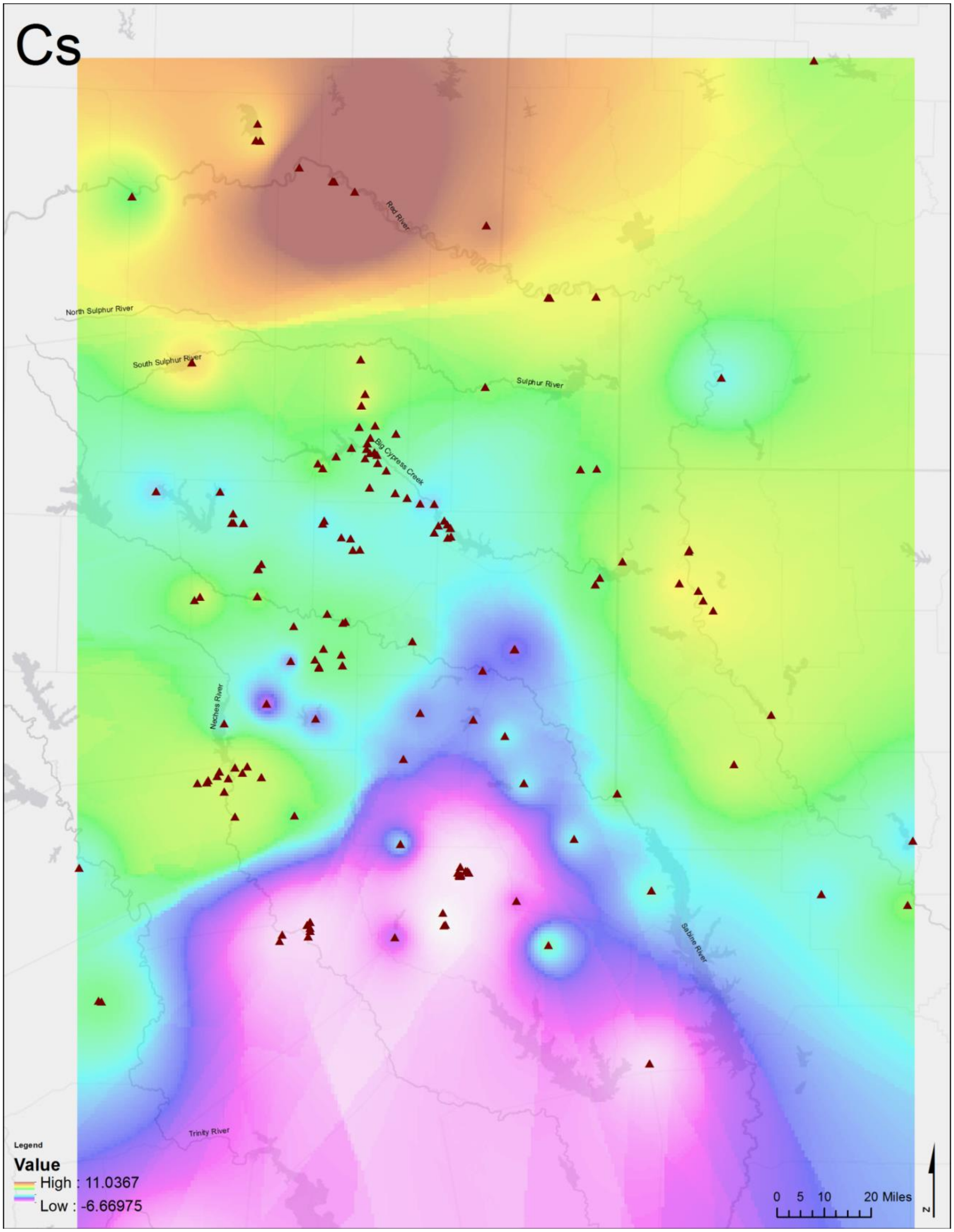

Figure A.9. Variation in cesium (Cs) concentrations for INAA of Caddo ceramics.

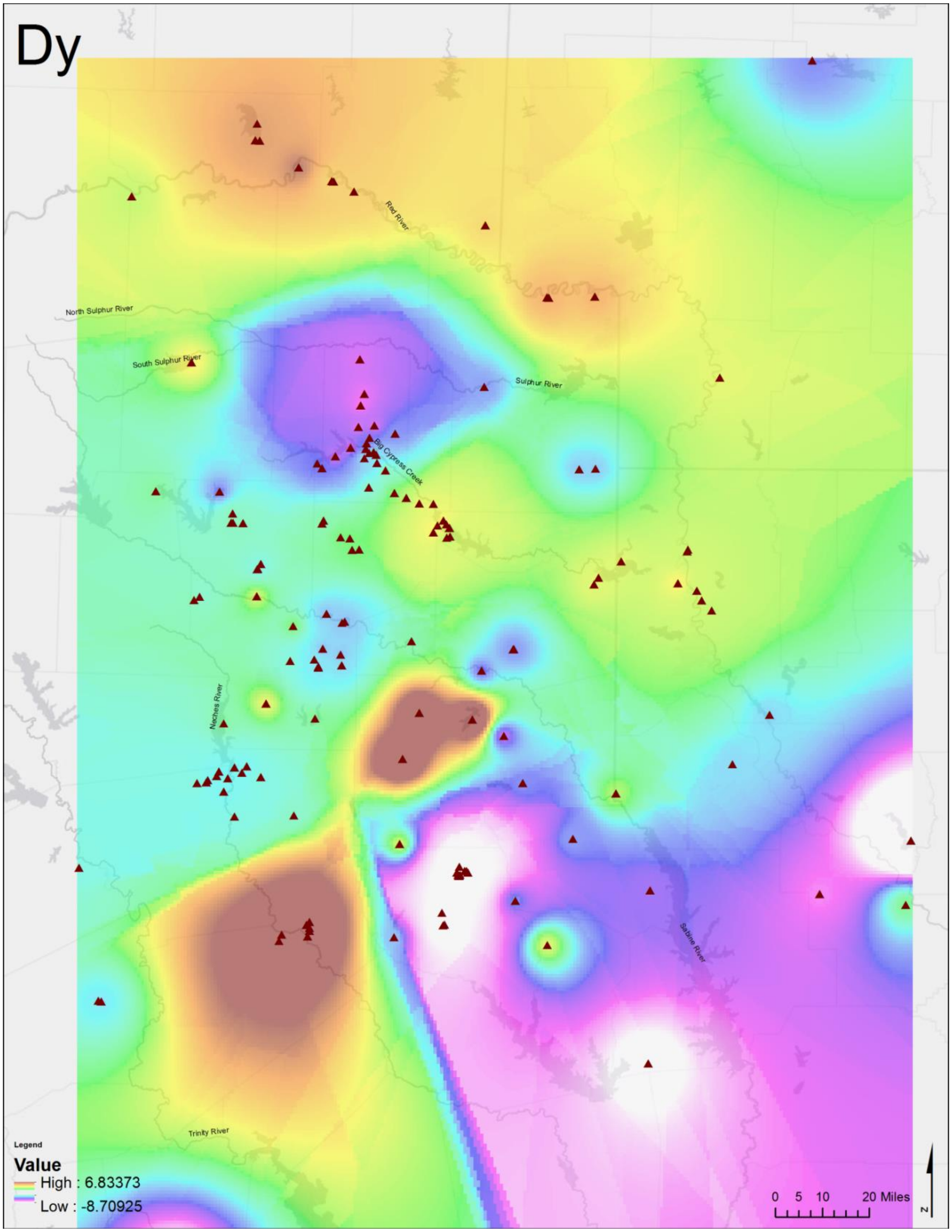

Figure A.10. Variation in dysprosium (Dy) concentrations for INAA of Caddo ceramics.

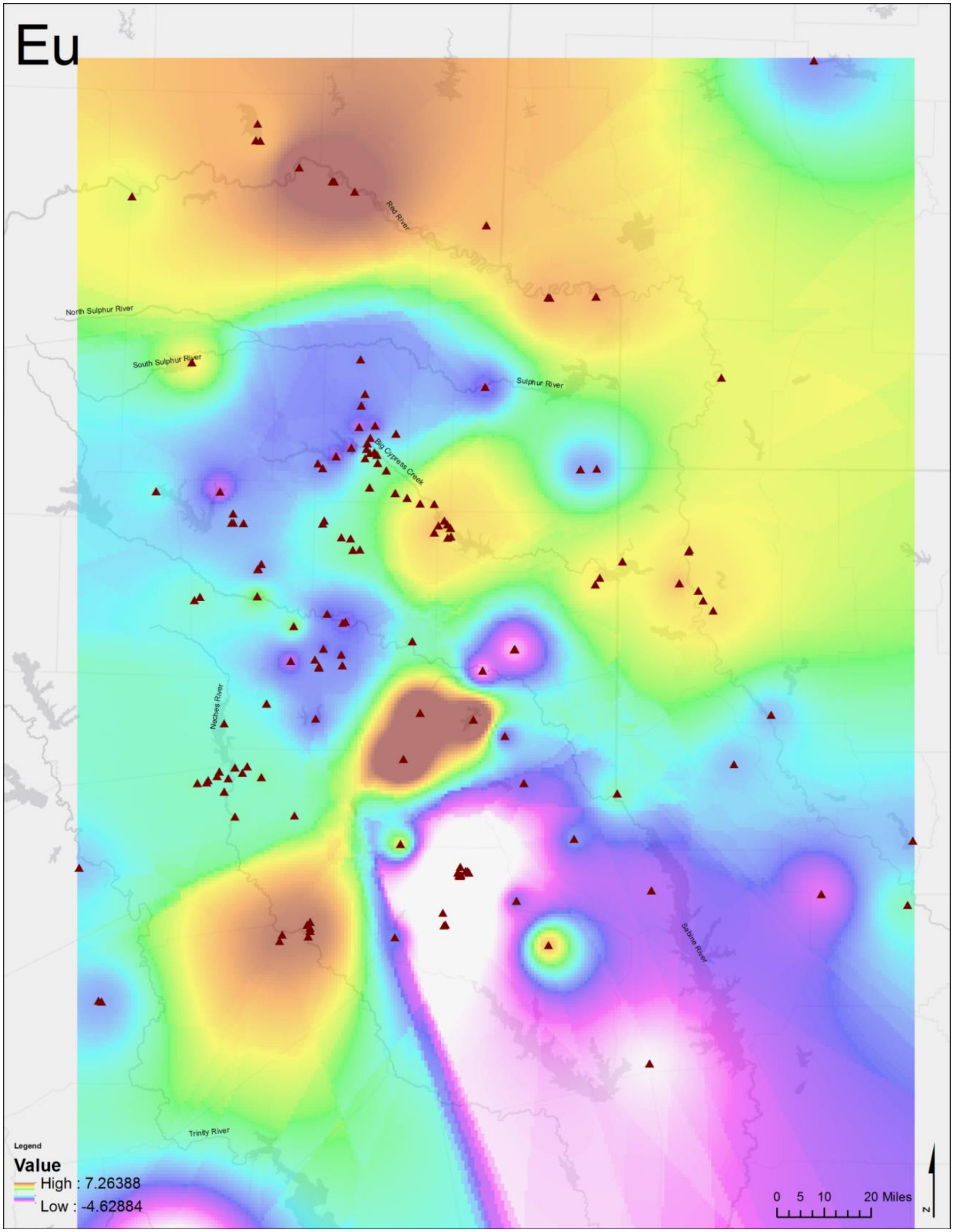

Figure A.11. Variation in europium (Eu) concentrations for INAA of Caddo ceramics.

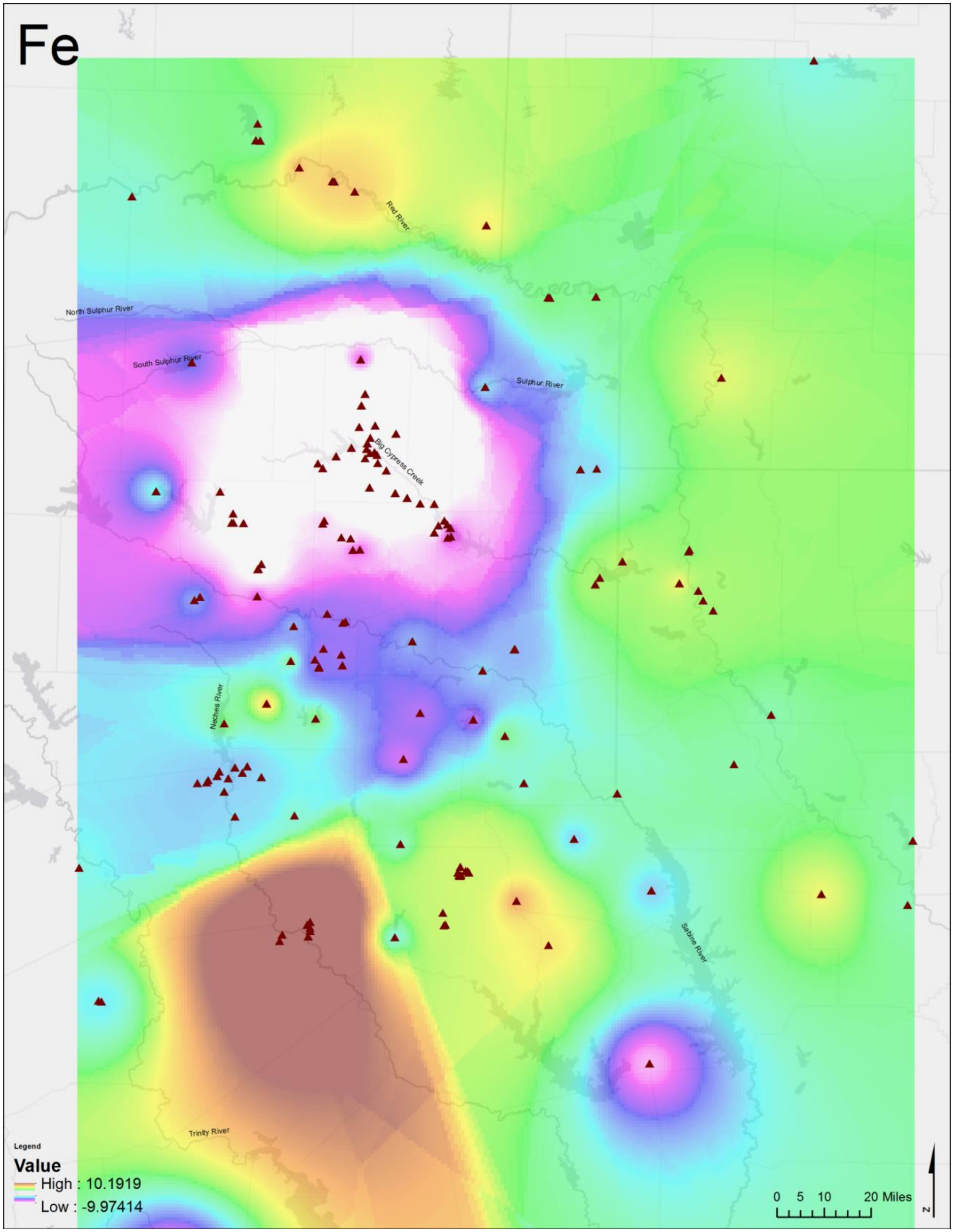

Figure A.12. Variation in iron (Fe) concentrations for INAA of Caddo ceramics.

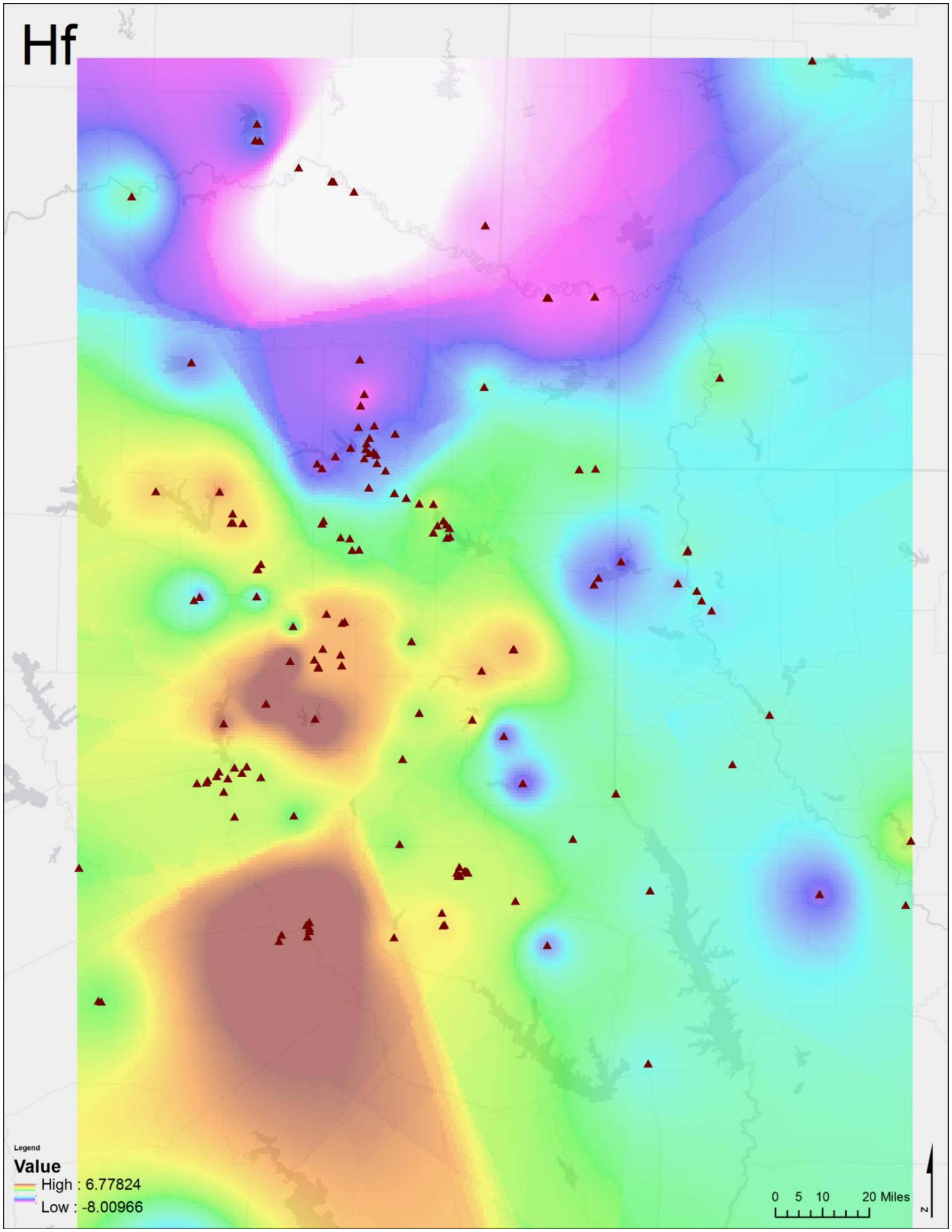

Figure A.13. Variation in hafnium (Hf) concentrations for INAA of Caddo ceramics.

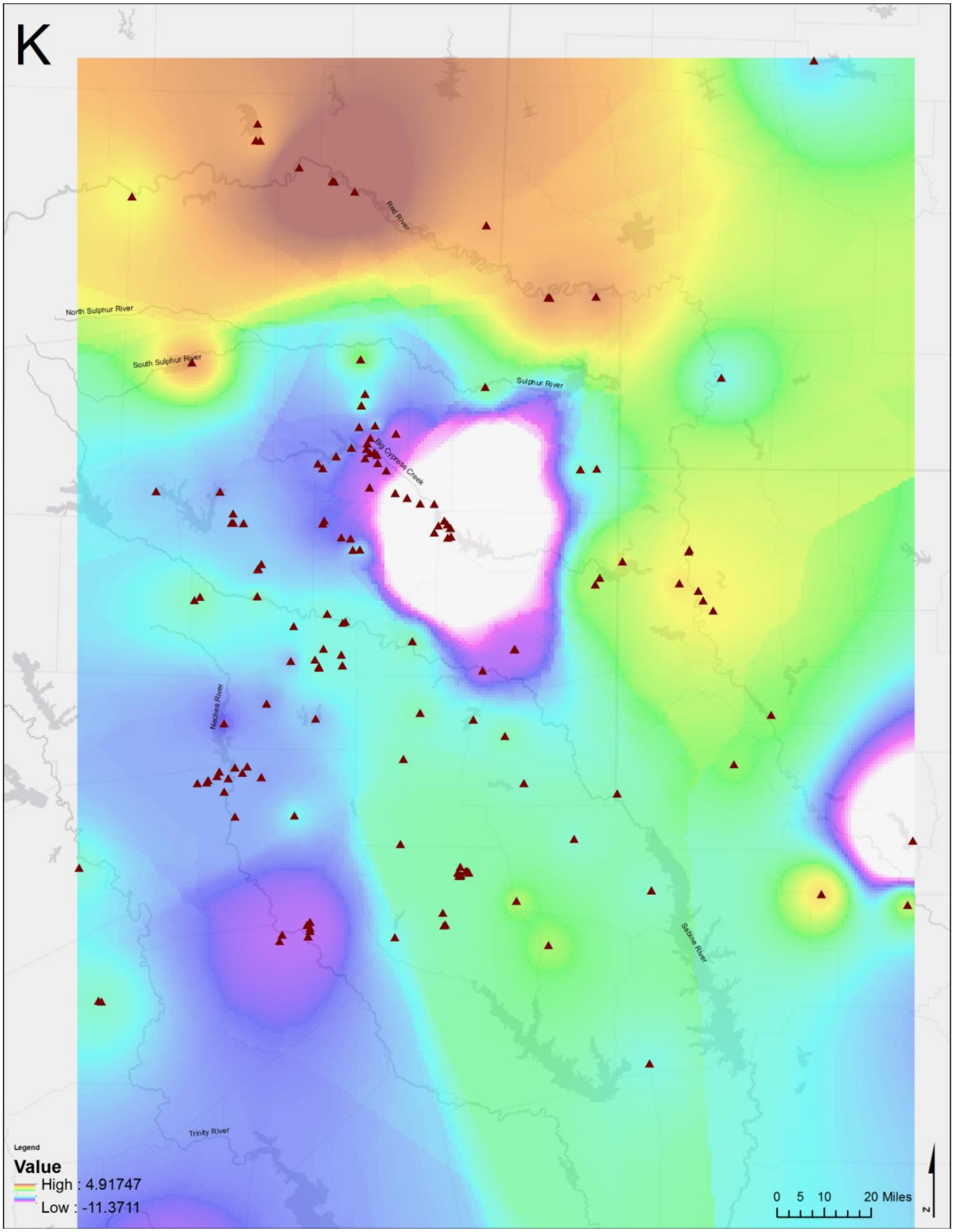

Figure A.14. Variation in potassium (K) concentrations for INAA of Caddo ceramics.

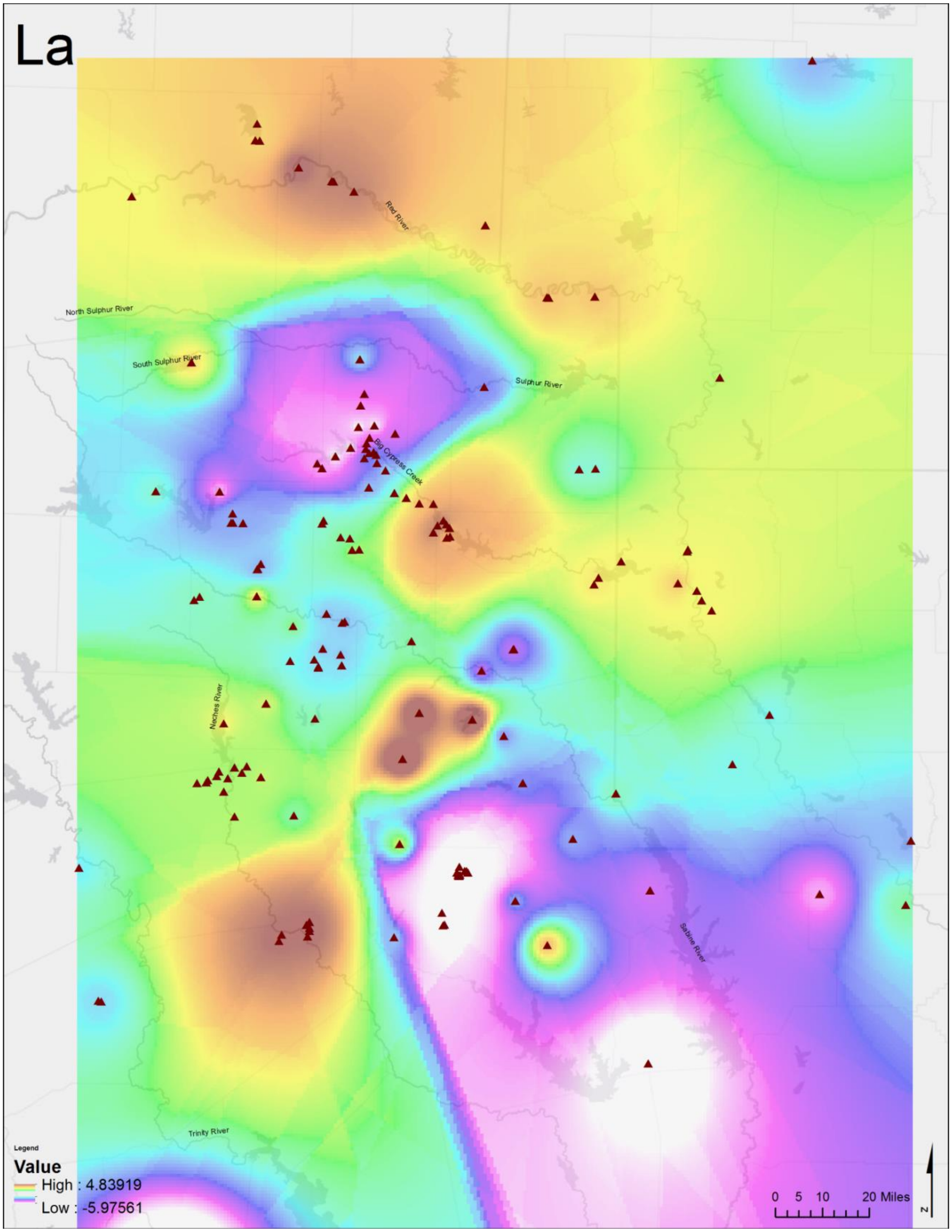

Figure A.15. Variation in lanthanum (La) concentrations for INAA of Caddo ceramics.

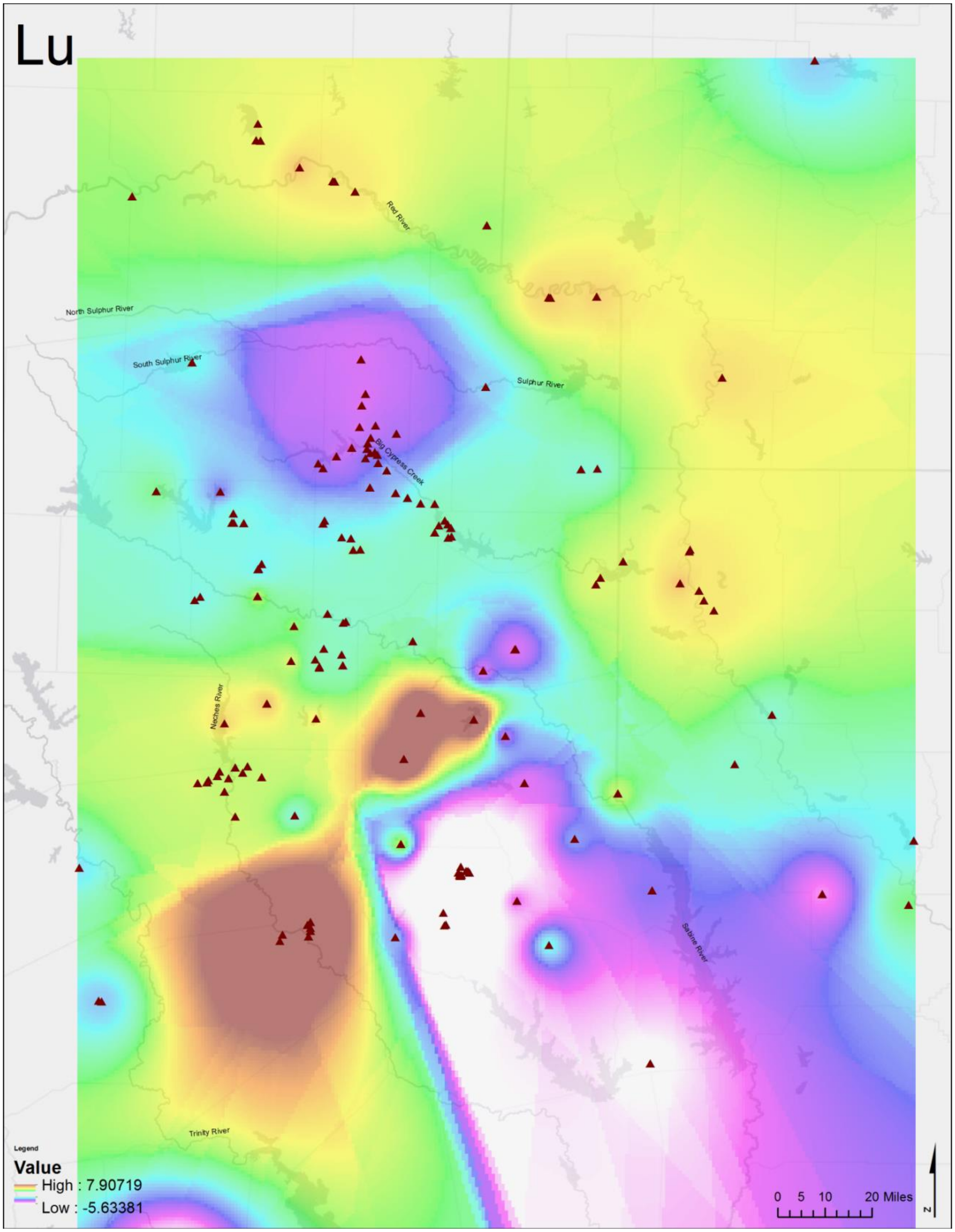

Figure A.16. Variation in lutetium (Lu) concentrations for INAA of Caddo ceramics.

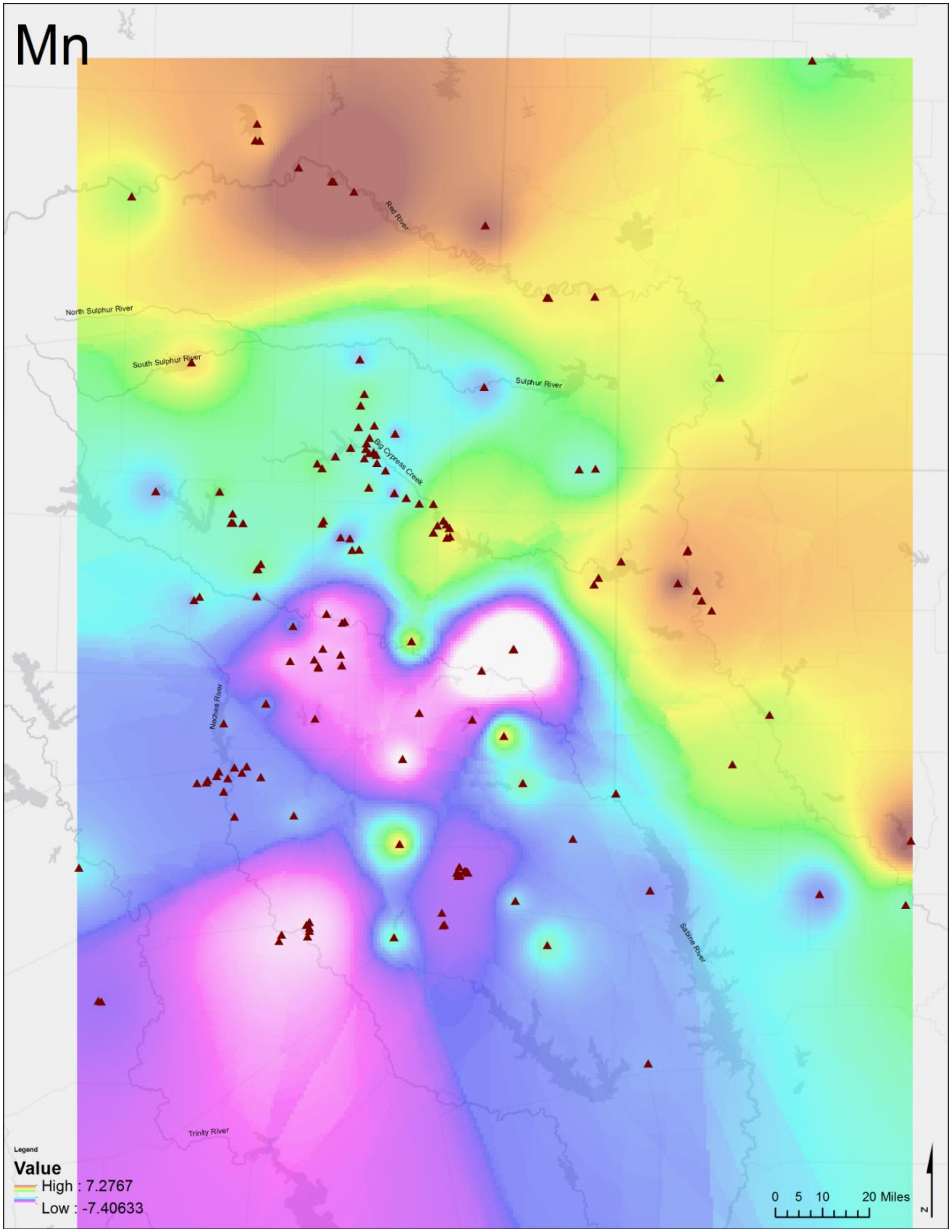

Figure A.17. Variation in manganese (Mn) concentrations for INAA of Caddo ceramics.

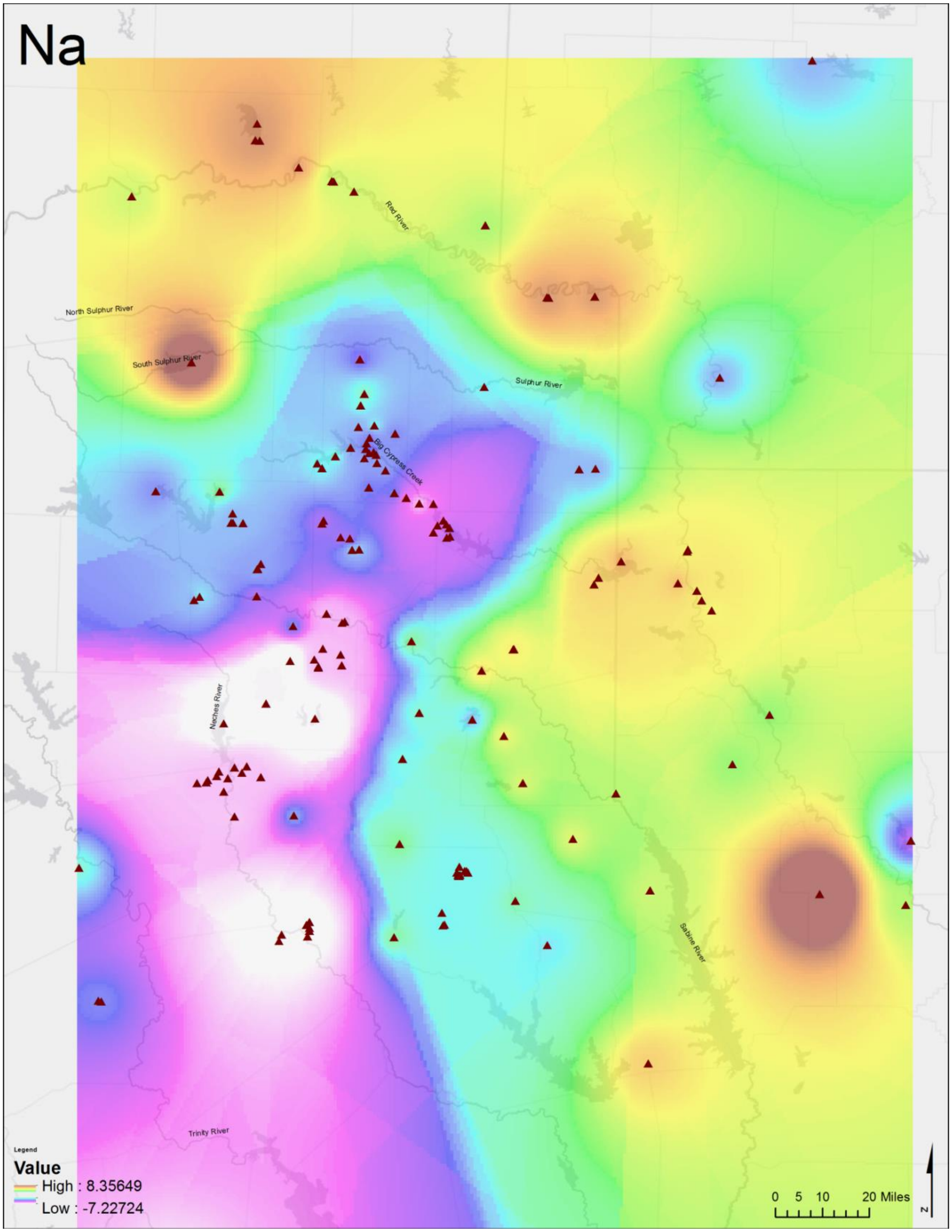

Figure A.18. Variation in sodium (Na) concentrations for INAA of Caddo ceramics.

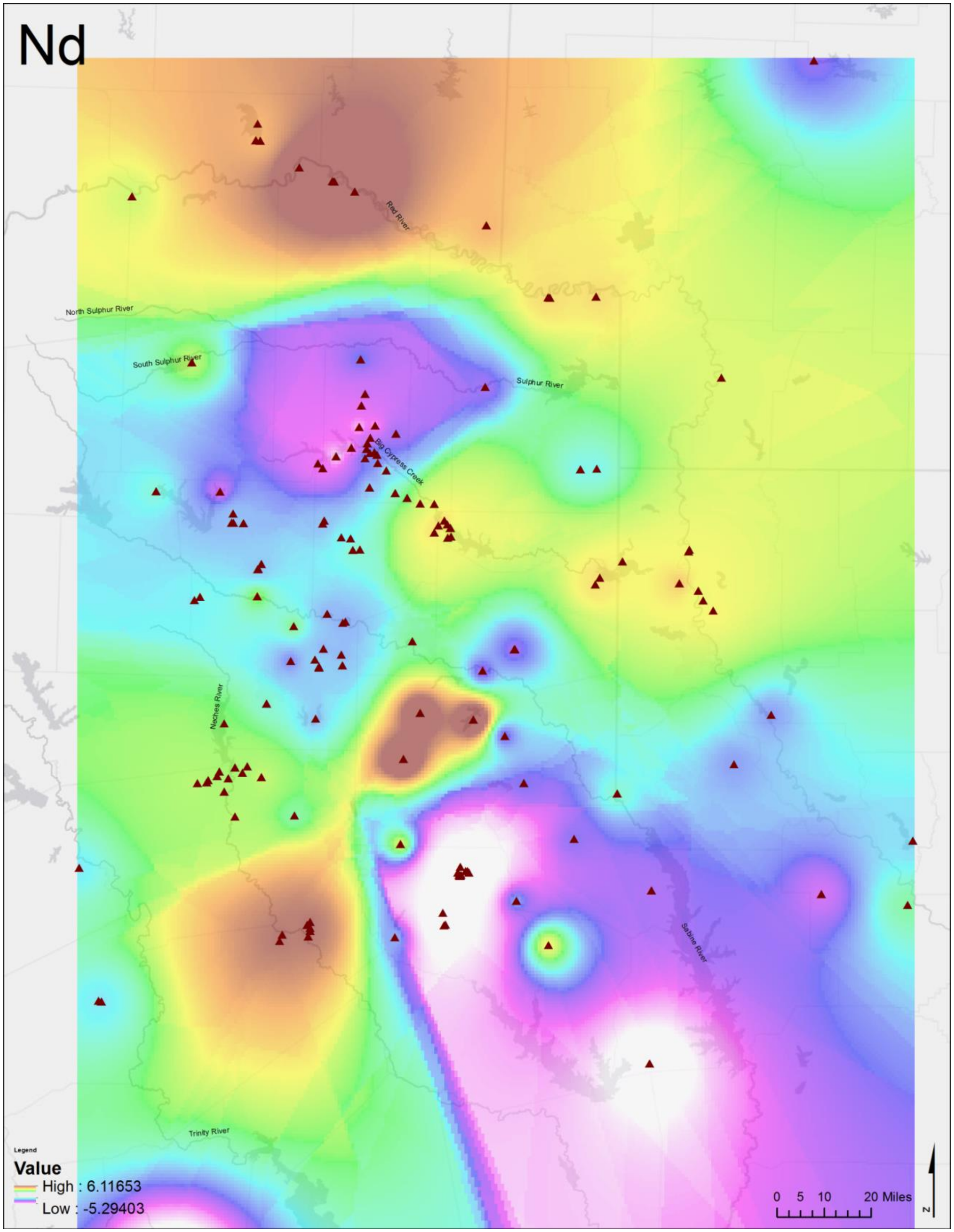

Figure A.19. Variation in neodymium (Nd) concentrations for INAA of Caddo ceramics.

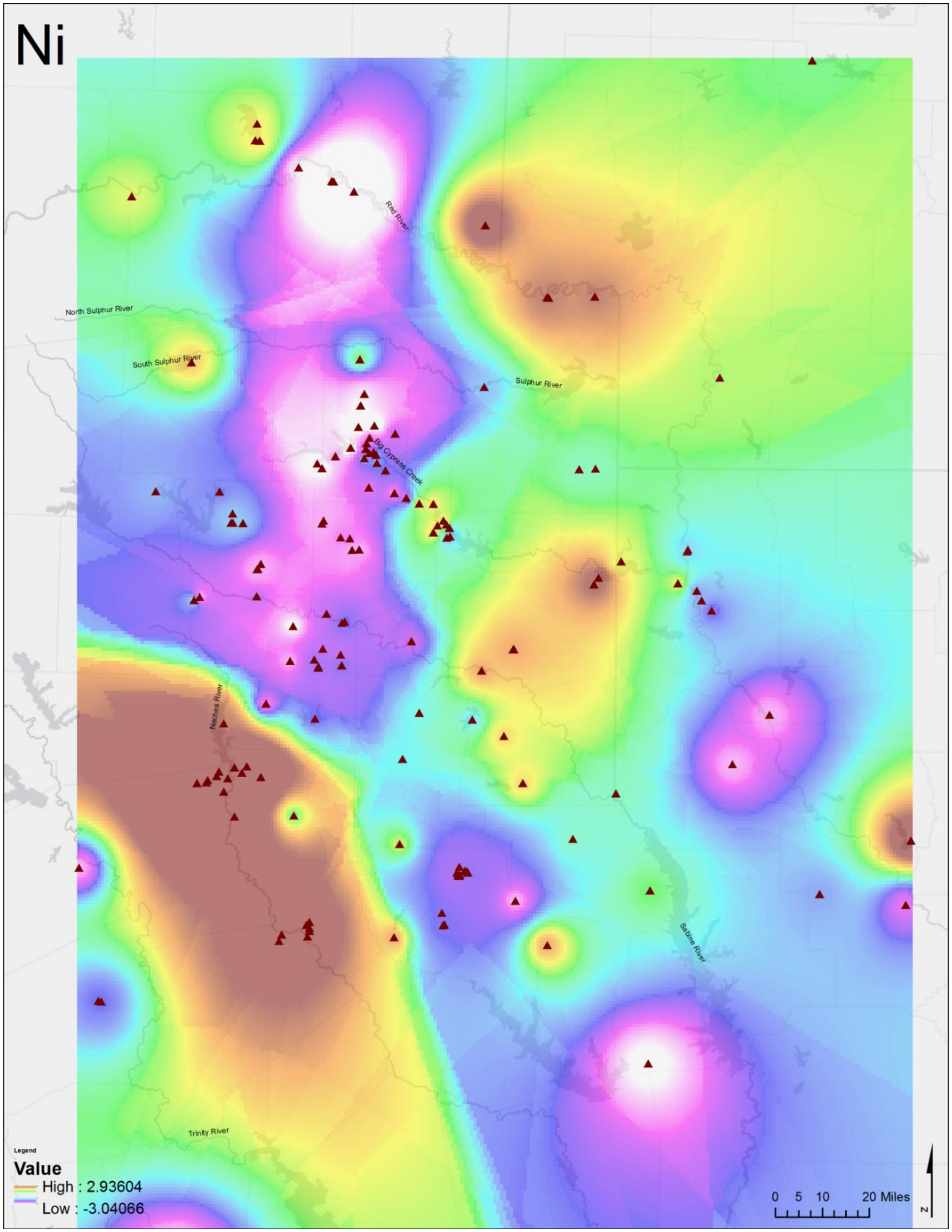

Figure A.20. Variation in nickel (Ni) concentrations for INAA of Caddo ceramics.

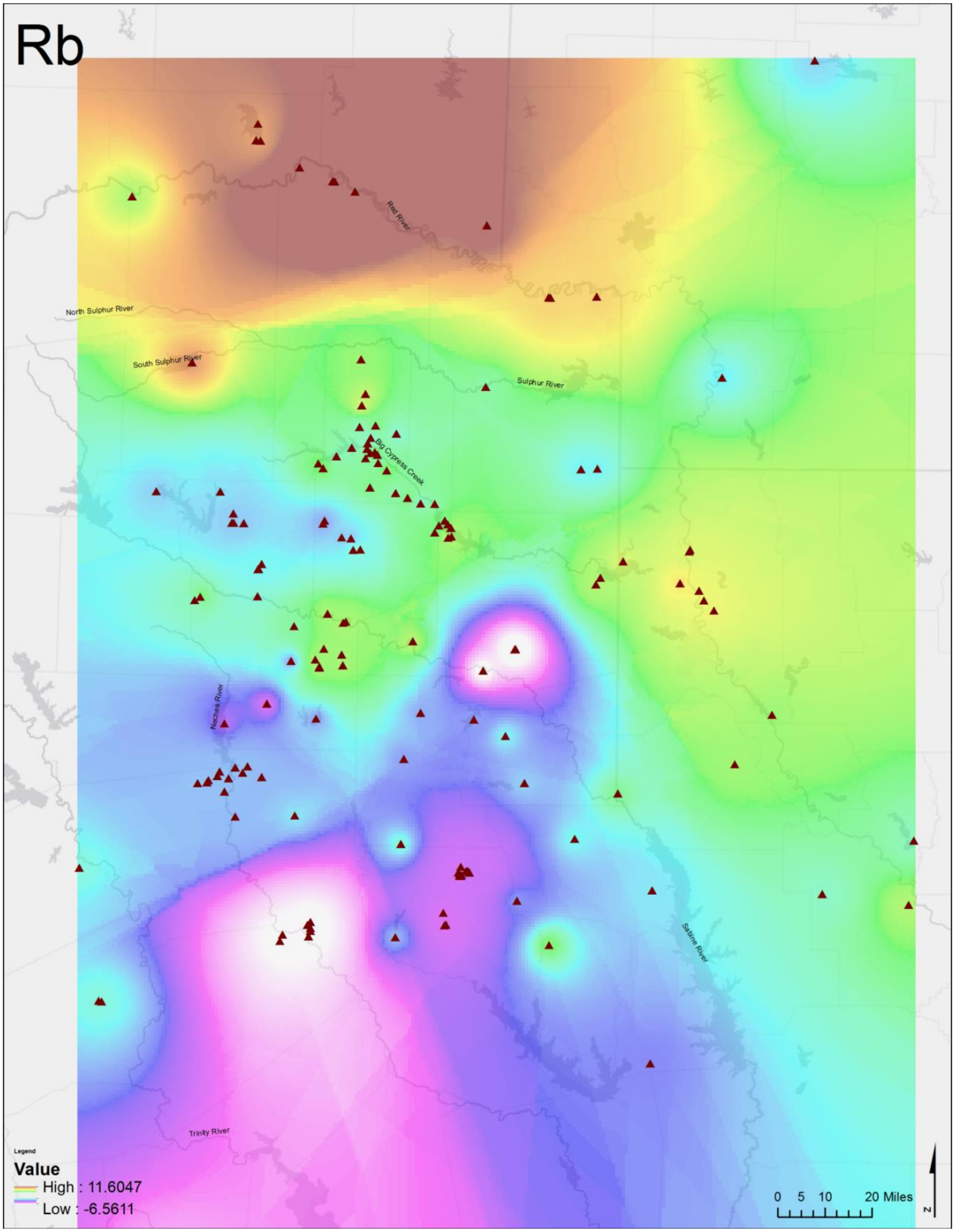

Figure A.21. Variation in rubidium (Rb) concentrations for INAA of Caddo ceramics.

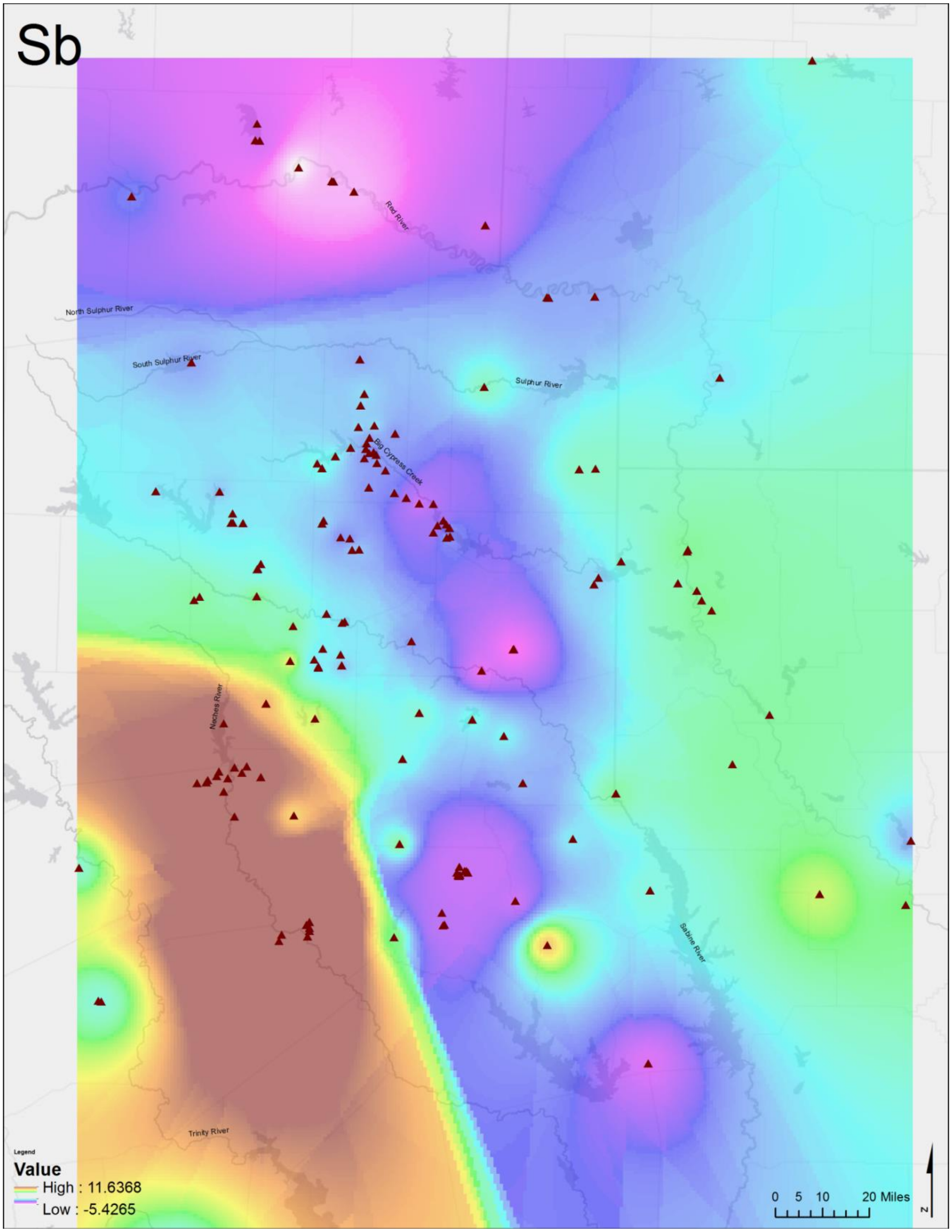

Figure A.22. Variation in antimony (Sb) concentrations for INAA of Caddo ceramics.

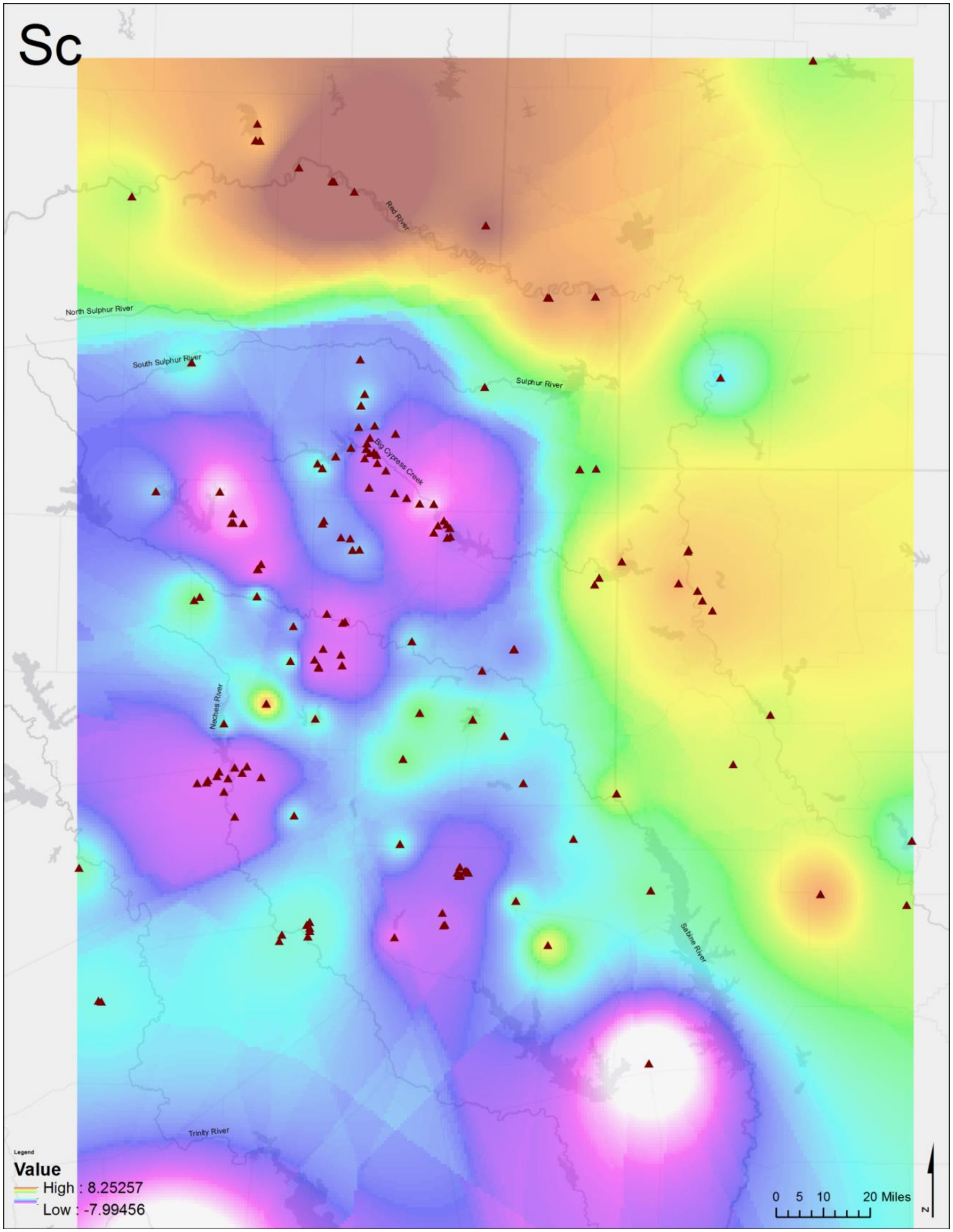

Figure A.23. Variation in scandium (Sc) concentrations for INAA of Caddo ceramics.

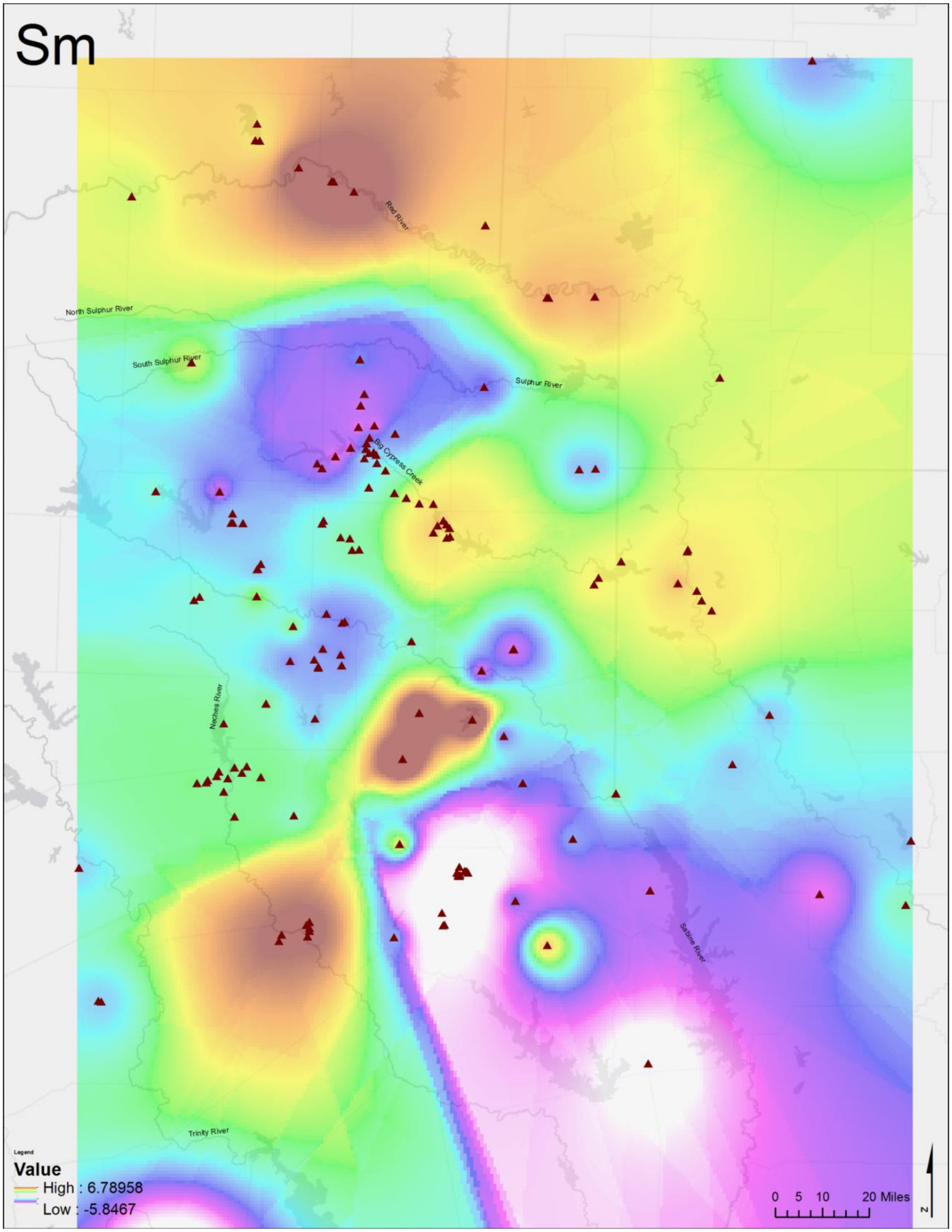

Figure A.24. Variation in samarium (Sm) concentrations for INAA of Caddo ceramics.

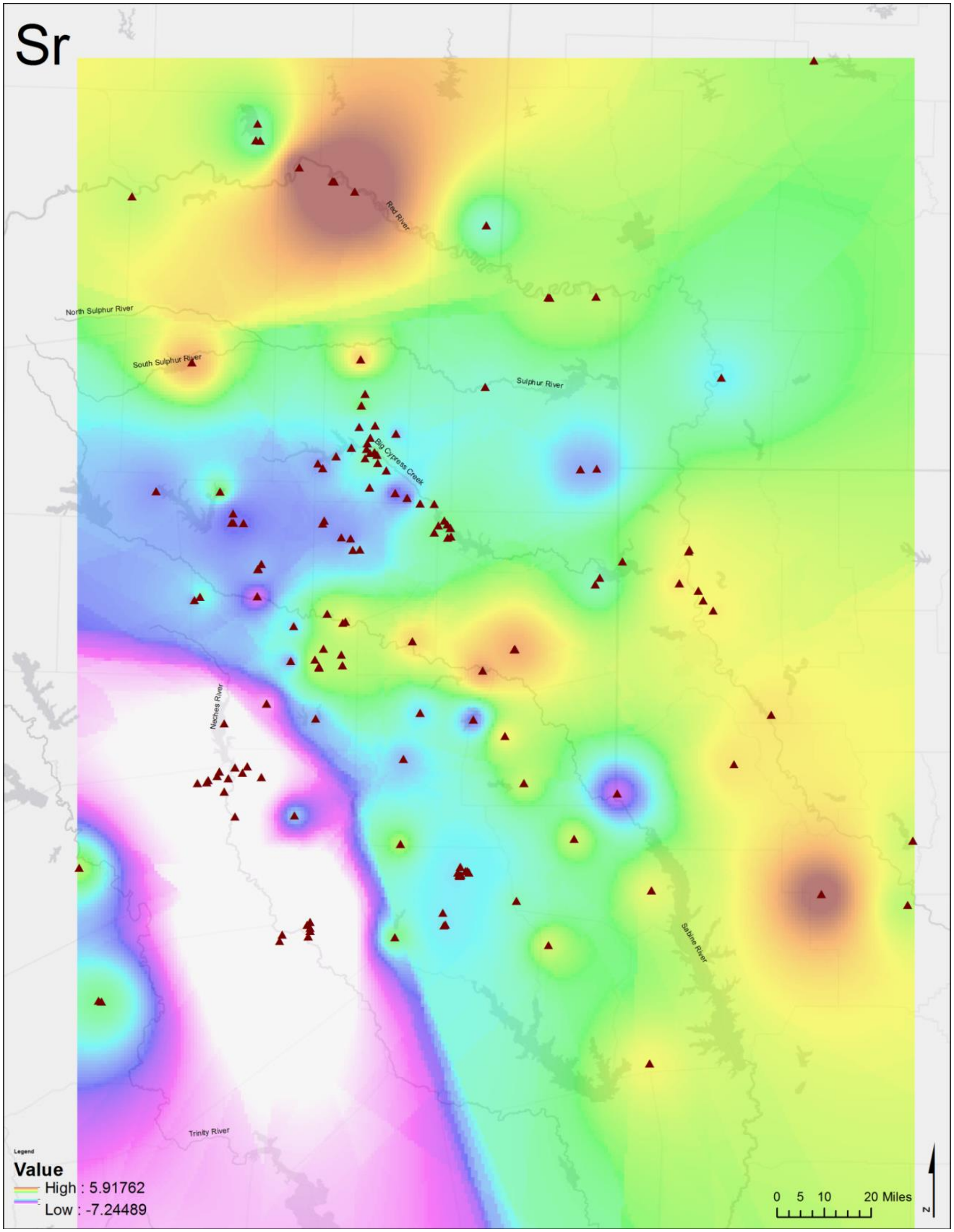

Figure A.25. Variation in strontium (Sr) concentrations for INAA of Caddo ceramics.

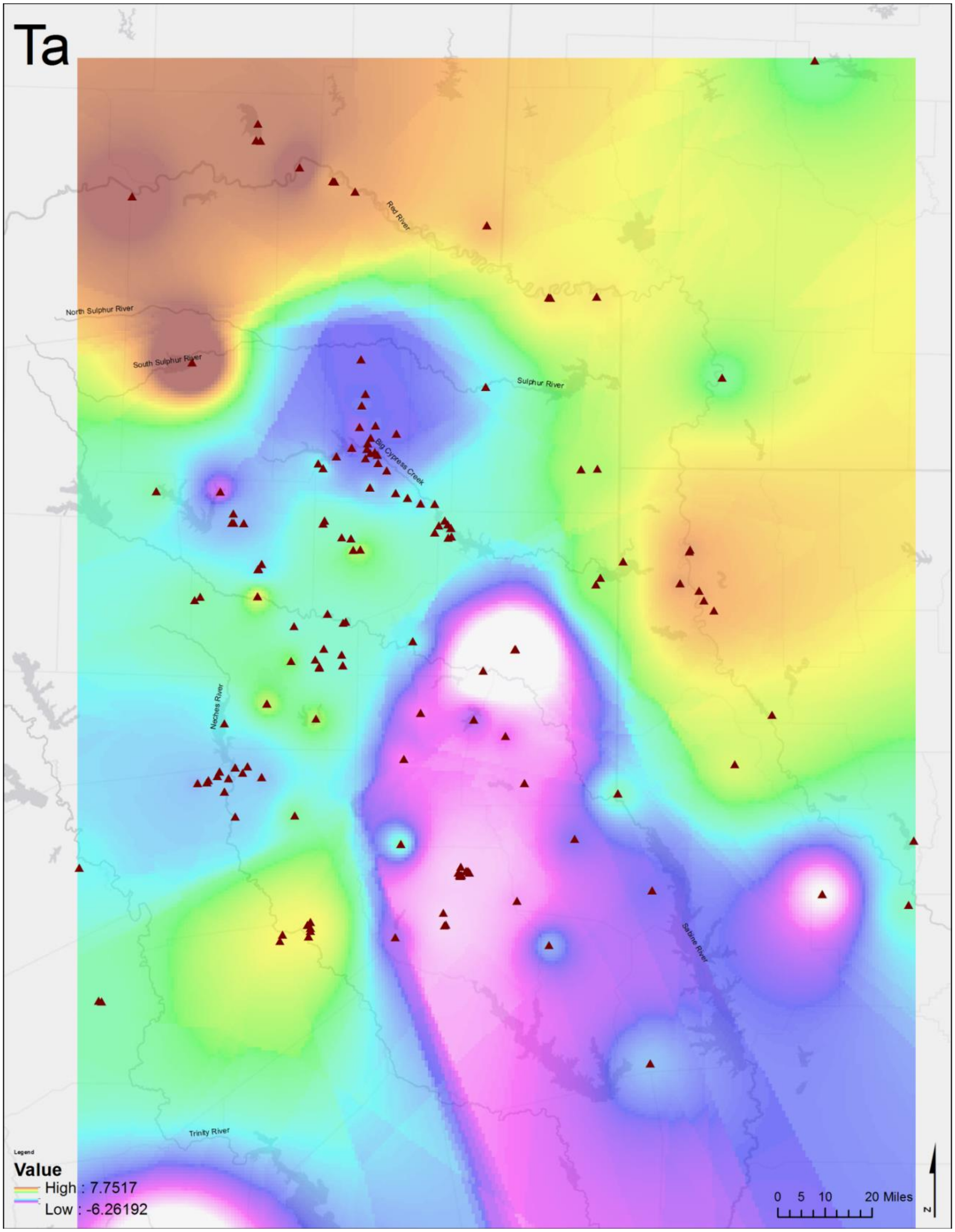

Figure A.26. Variation in tantalum (Ta) concentrations for INAA of Caddo ceramics.

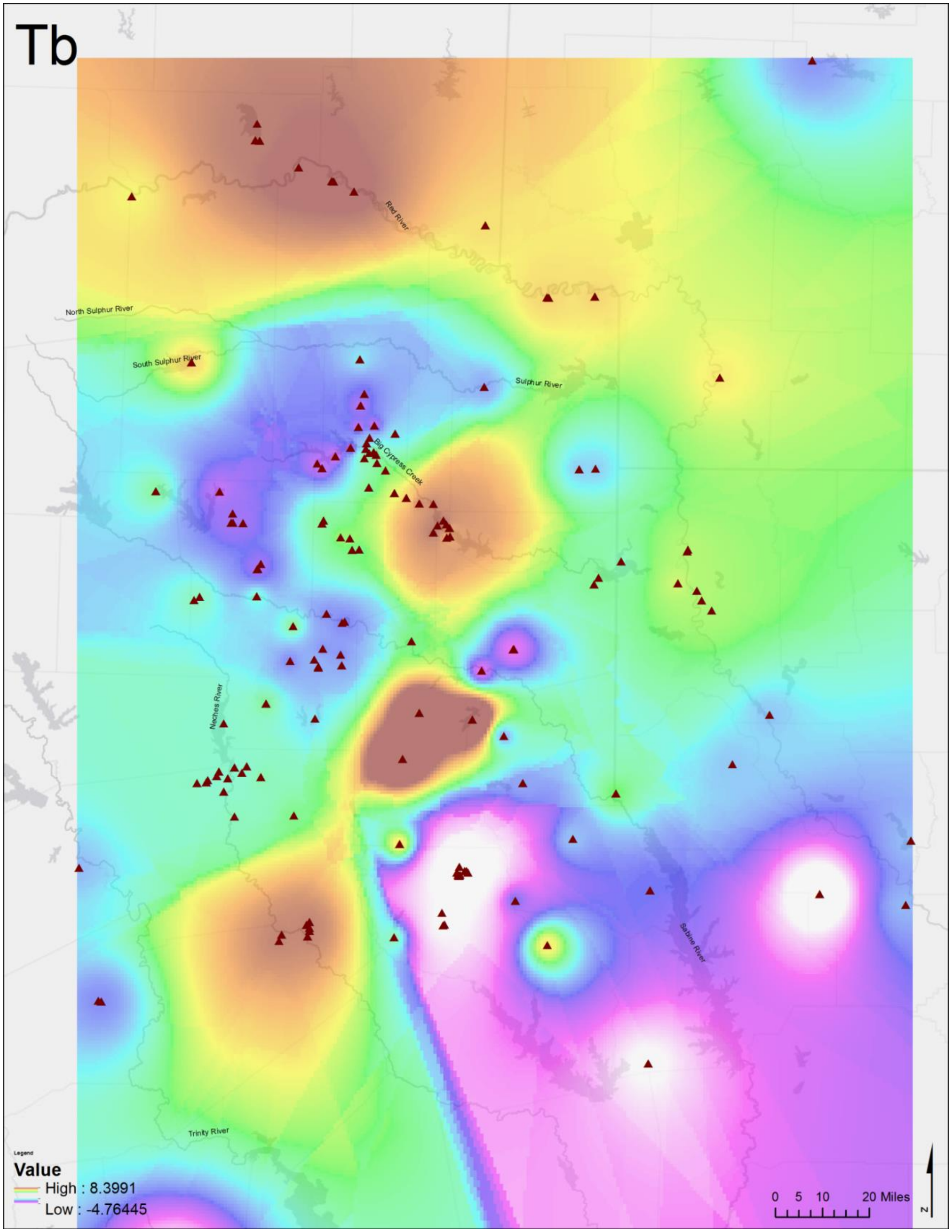

Figure A.27. Variation in terbium (Tb) concentrations for INAA of Caddo ceramics.

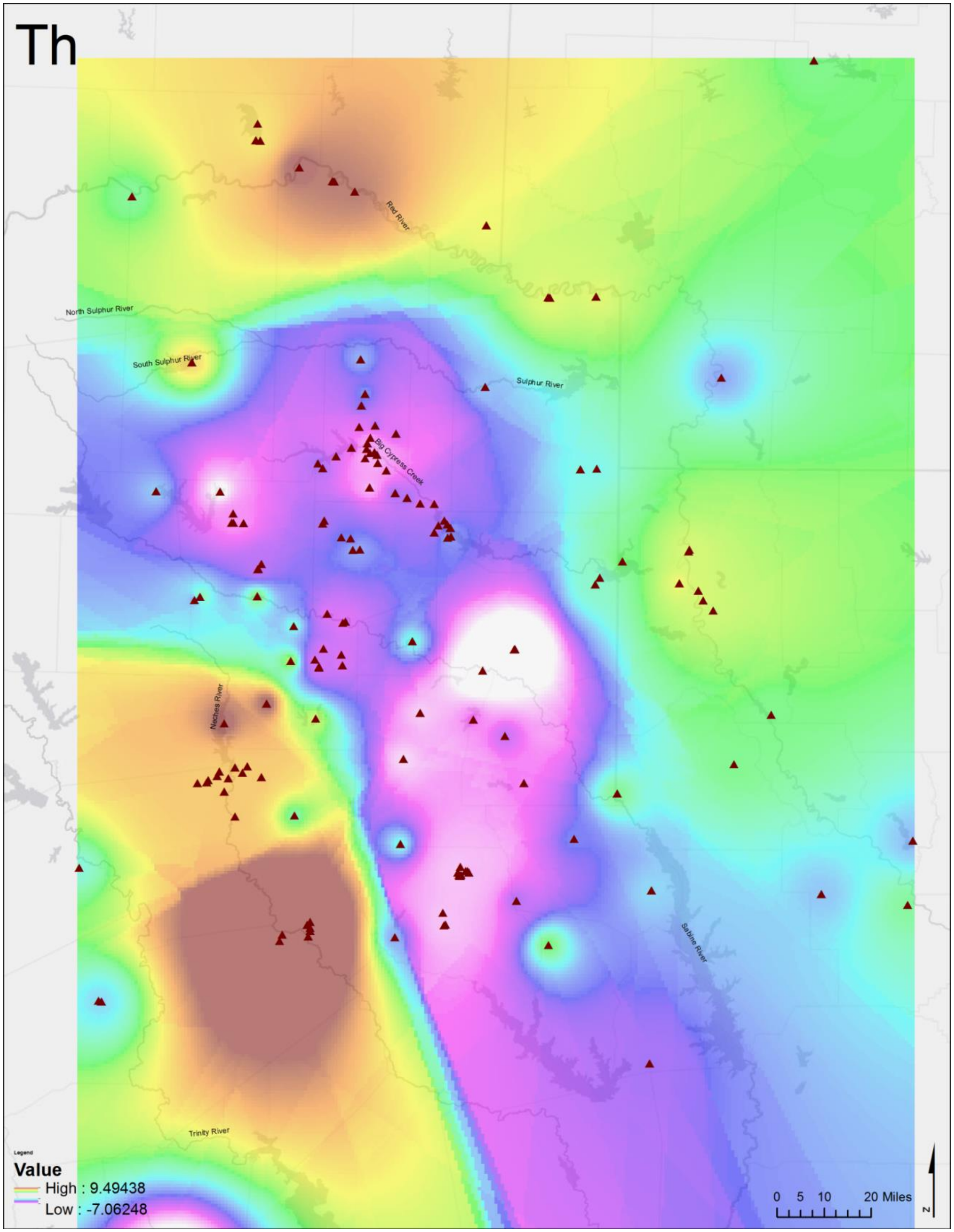

Figure A.28. Variation in thorium (Th) concentrations for INAA of Caddo ceramics.

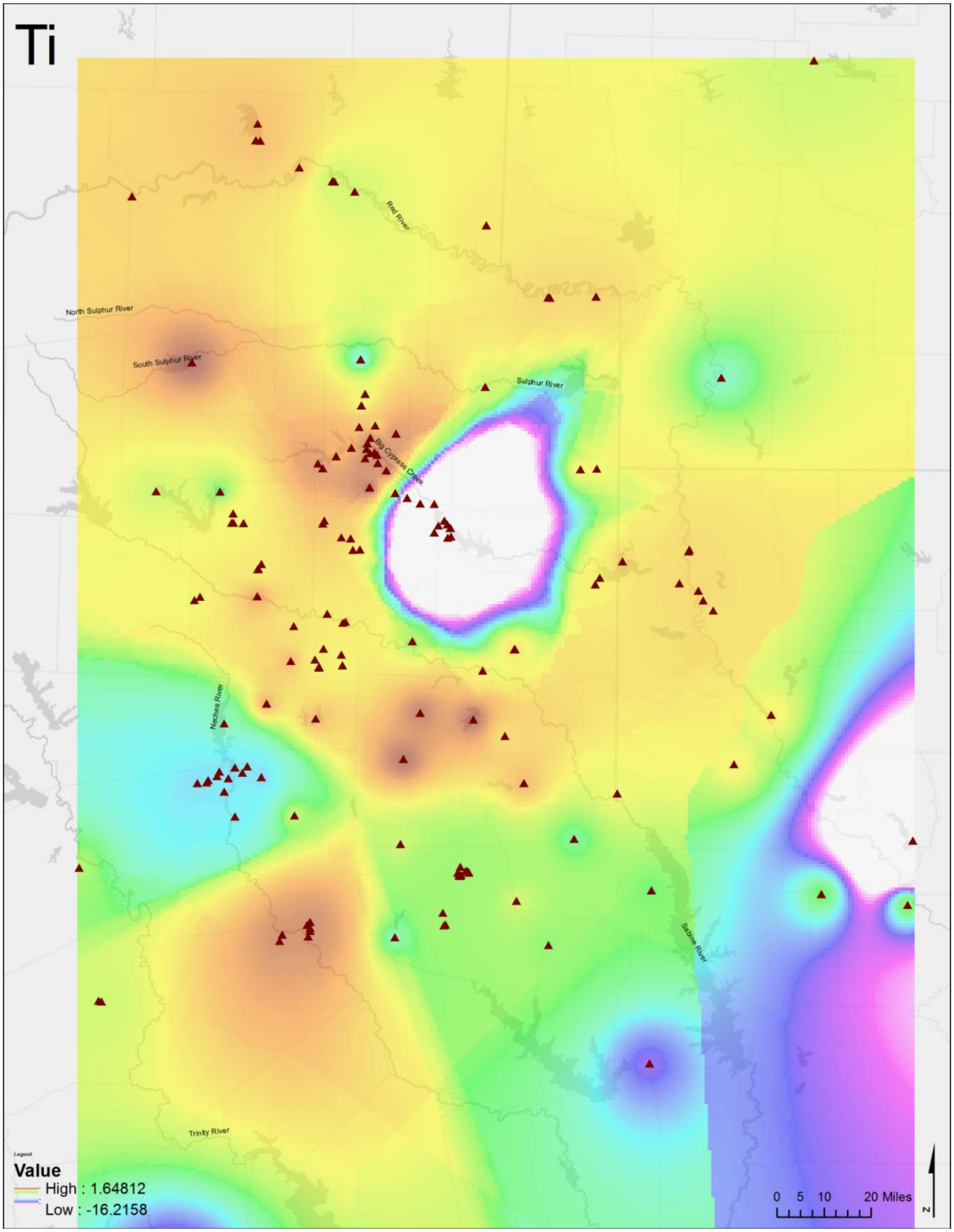

Figure A.29. Variation in titanium (Ti) concentrations for INAA of Caddo ceramics.

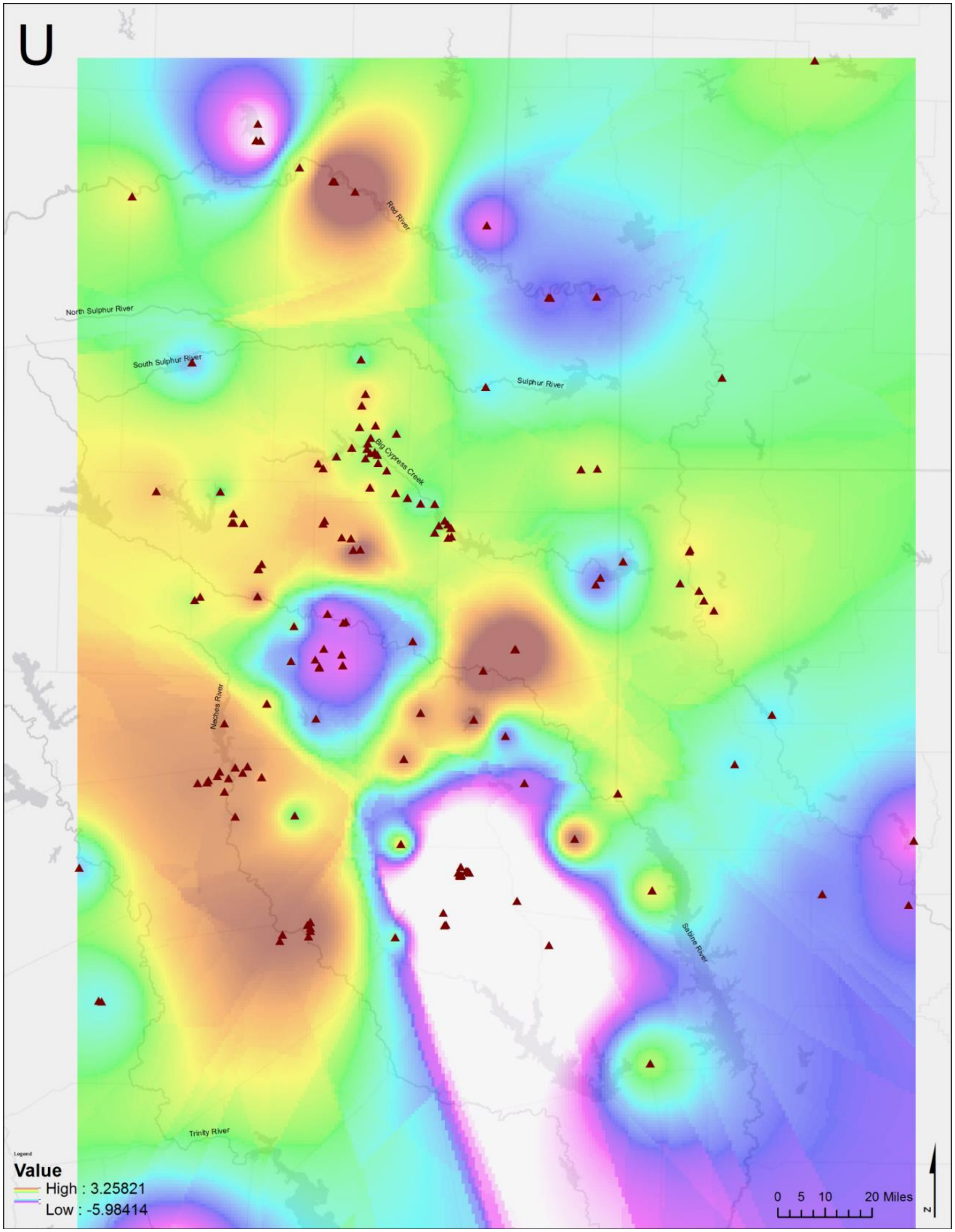

Figure A.30. Variation in uranium (U) concentrations for INAA of Caddo ceramics.

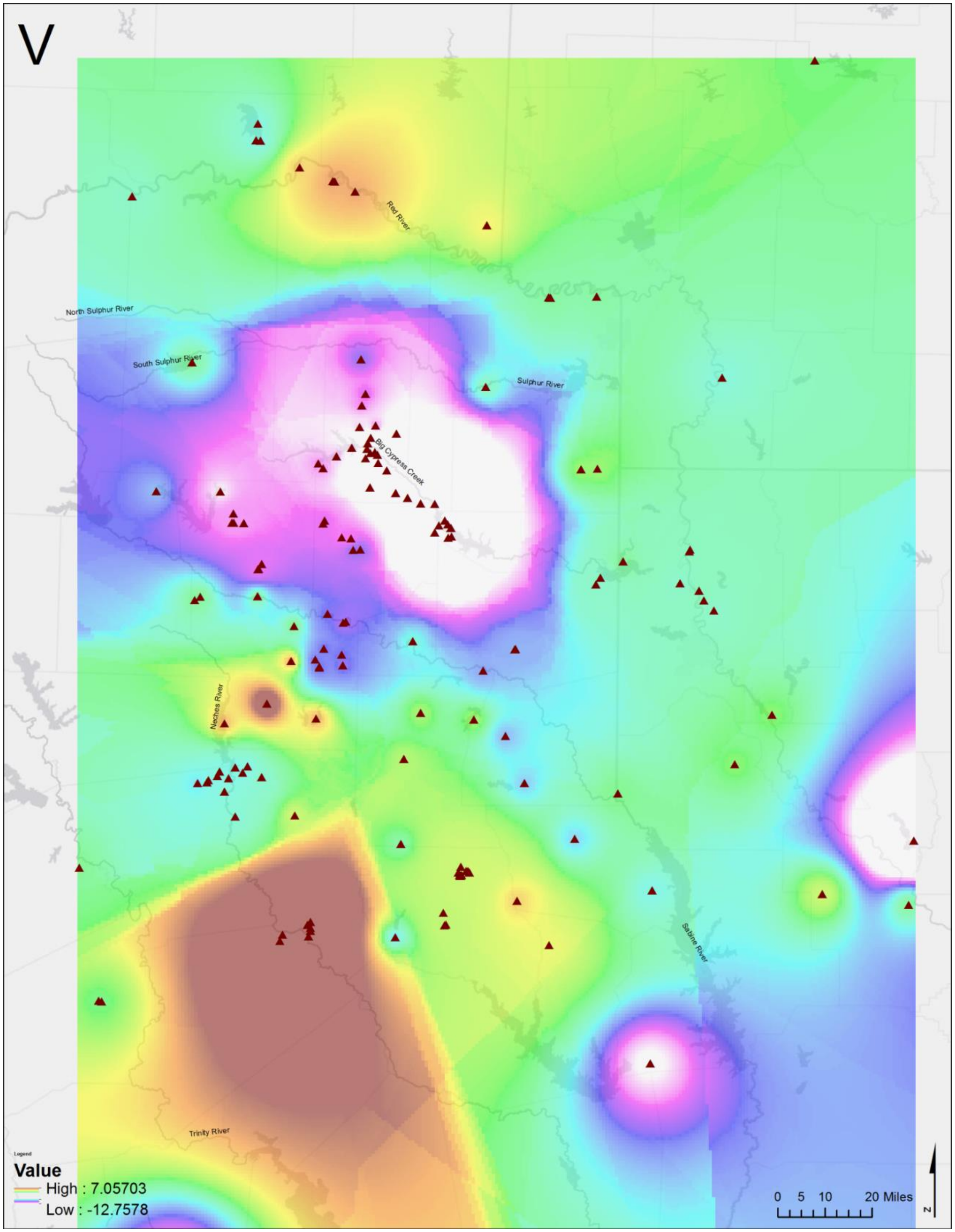

Figure A.31. Variation in vanadium (V) concentrations for INAA of Caddo ceramics.

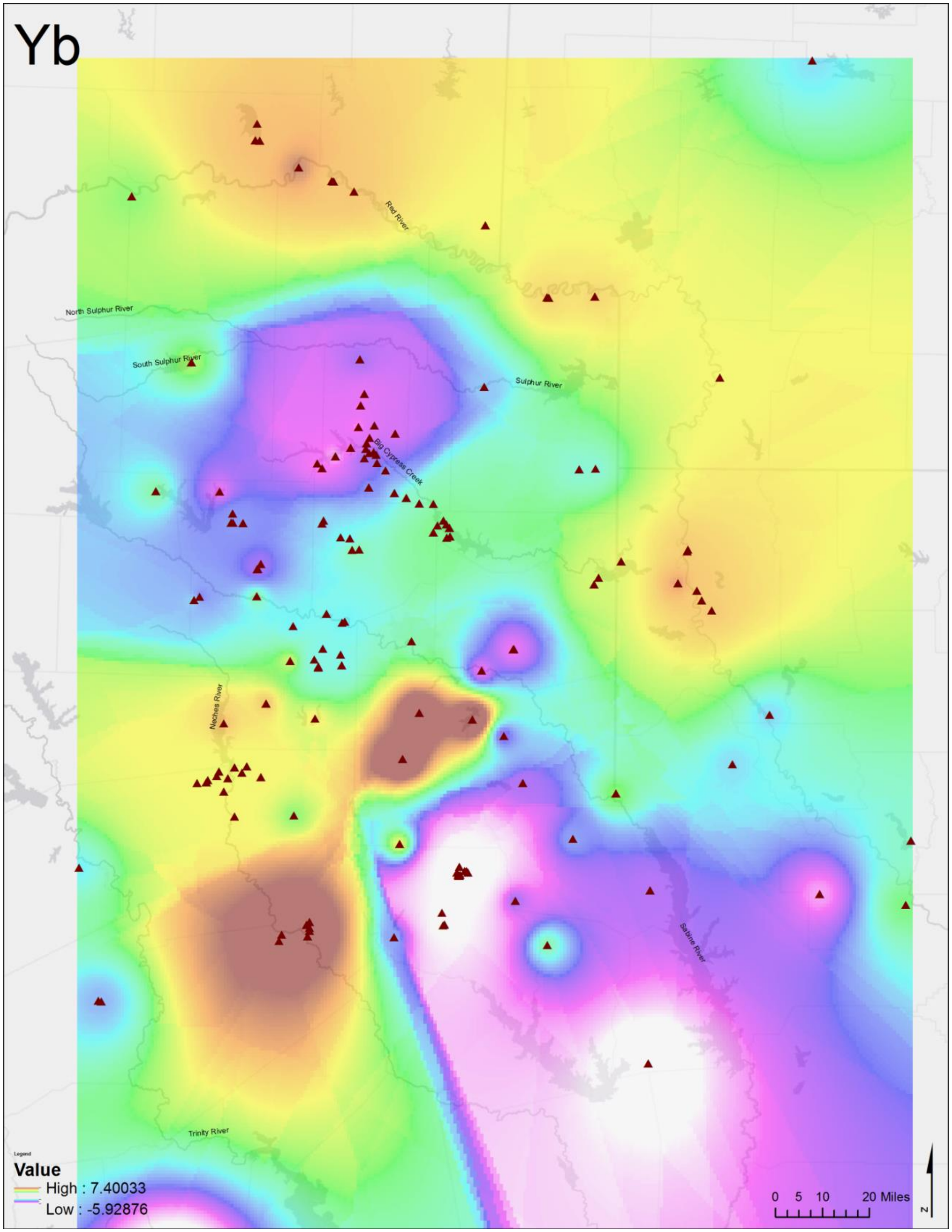

Figure A.32. Variation in ytterbium (Yb) concentrations for INAA of Caddo ceramics.

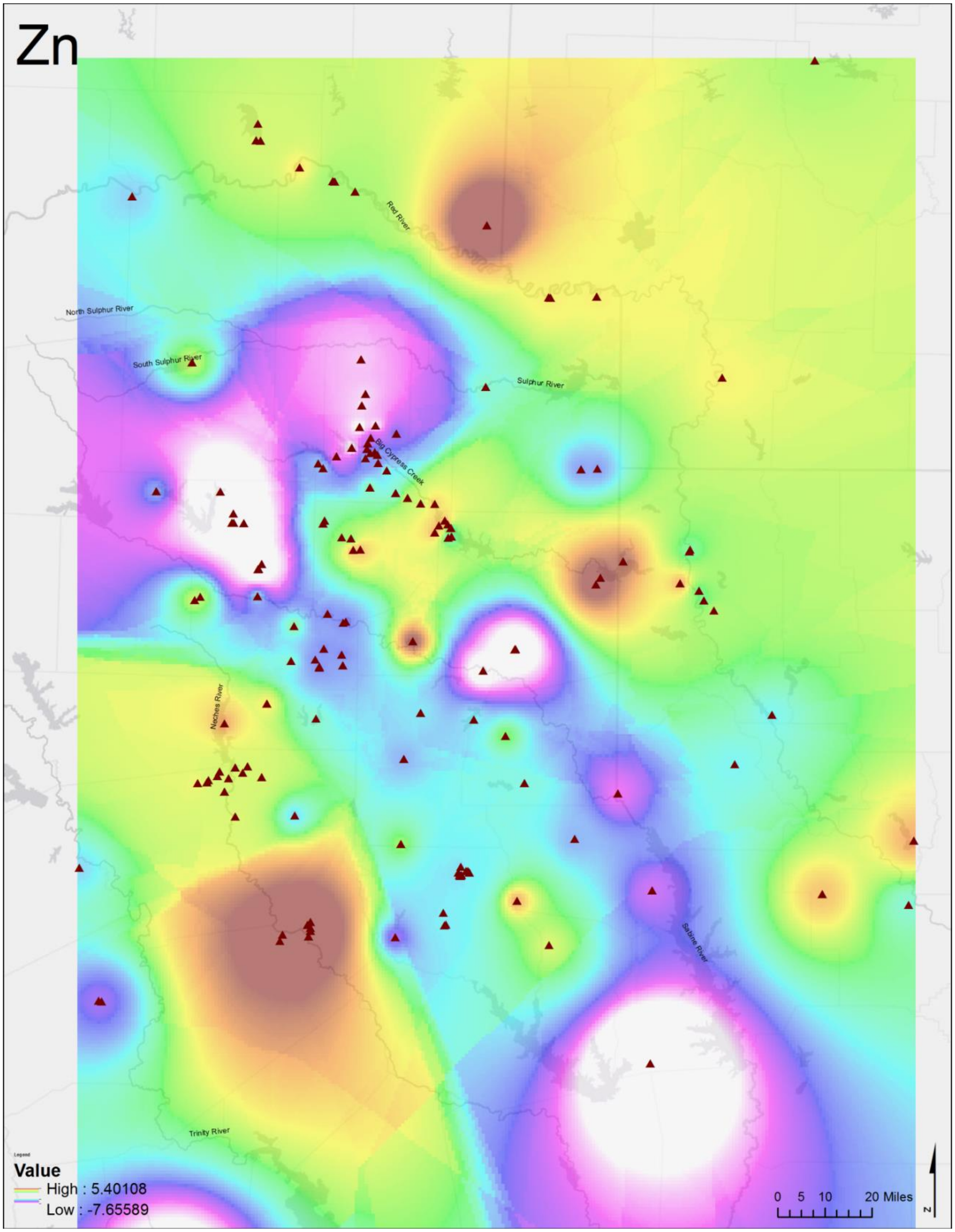

Figure A.33. Variation in zinc (Zn) concentrations for INAA of Caddo ceramics.

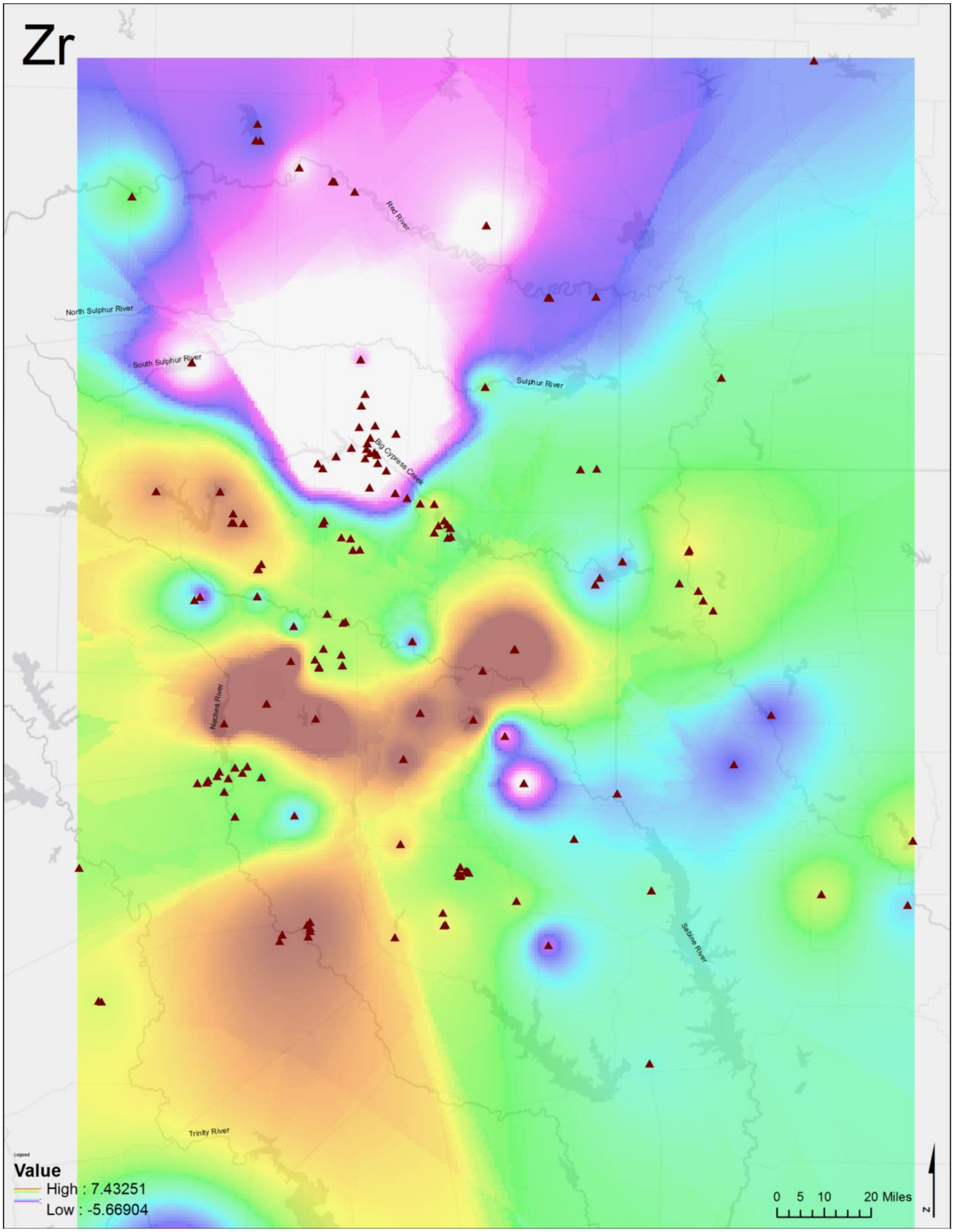

Figure A.34. Variation in zirconium (Zr) concentrations for INAA of Caddo ceramics.

Summary and Conclusion

INAA sample sizes must be increased within sites and from new sites to further current dialogues regarding possible ceramic provenance determinations within the ancestral Caddo territory. In order to achieve a confident level of statistical significance, a minimum of 30 sherds should be submitted for INAA from each site. This makes it possible to create a site-specific correspondence matrix from which an exploration of statistical similarities and differences can assist in the identification of clays found in the ceramics used at each site.

The chemical maps presented here represent an important new analysis of the Caddo INAA database. The results of this analysis illustrate that the chemical composition of ceramics associated with ancestral Caddo populations were diverse and highly variable across East Texas and surrounding states, hinting at the potential successes in ceramic provenance identifications for more robust (>30) samples of sherds from sites within this region.

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APPENDIX B

BIBLIOGRAPHY ON WOODLAND AND CADDO INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS STUDIES IN EAST TEXAS, NORTHWEST LOUISIANA, EASTERN OKLAHOMA, AND SOUTHWEST ARKANSAS [5]

The work presented in this chapter has been published by committee member Timothy K. Perttula and the author in the *Caddo Archeology Journal.* The characterization of the chemical and mineralogical composition of ceramic vessels and sherds from Woodland and Caddo sites by instrumental neutron activation analysis (INAA) and petrographic analysis provides a unique opportunity to gather and study evidence on the nature of trade and exchange of ceramic vessels (and perhaps their contents?) conducted by ancestral Caddo people with their neighbors, both near and far (i.e., other ancestral Caddo groups as well as non-Caddo communities) (see Perttula 2002). This evidence in turn can be used to explore changes in the nature of social and economic relationships between particular Caddo groups and with other prehistoric peoples. Compositional and paste differences that have been identified between the different wares made by Caddo groups (i.e., plain wares, utility wares, and fine wares) have also been used to explore functional and technological differences in vessel function and form (see Perttula 2000i:138).

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According to Ferguson et al. (2012:224), the database of INAA samples of ceramic sherds from Woodland and Caddo sites done at the University of Missouri Research Reactor Center at the University of Missouri-Columbia, "consisting of more than 1000 ceramic samples…is one of the largest samples from any region in the world. It is also one of the most complicated. Over the past decade the compositional group structure has undergone numerous modifications, as well as a complete reanalysis (Ferguson et. al 2010). The most recent iteration of the East Texas Caddo database divides the region into 11 sub-regions." Each of these sub-regions (Figure 1) has then been treated as an individual dataset, and for most sub-regions, a core group has been defined and identified. The INAA sample has been gathered from more than 200 Woodland and Caddo sites/ceramic assemblages, and the petrographic sample is almost equally as large.

A considerable amount of work has been accomplished in Caddo area ceramic studies over the last 15 years—although the first work was done more than 40 years ago (see Bareis and Porter 1965; Porter 1971)—that have focused on technological and provenance issues and whether particular vessels and sherds from vessels from Woodland and Caddo sites were made locally or were the product of trade and exchange from non-local production sources. However, most of this work has been done in contexts—especially cultural resource management projects—where the results of these studies are found only in very limited distribution reports and publications. Thus, many archeologists that currently work in the Caddo area may not aware of the scope of the research that has been accomplished to date, nor are they aware of the primary published and unpublished literature on the subject. Consequently, we have assembled a bibliography of all known (current through October 2012) reports and publications that concern themselves with

INAA and petrographic analysis of ceramic vessels and ceramic vessel sherds in the Caddo area.

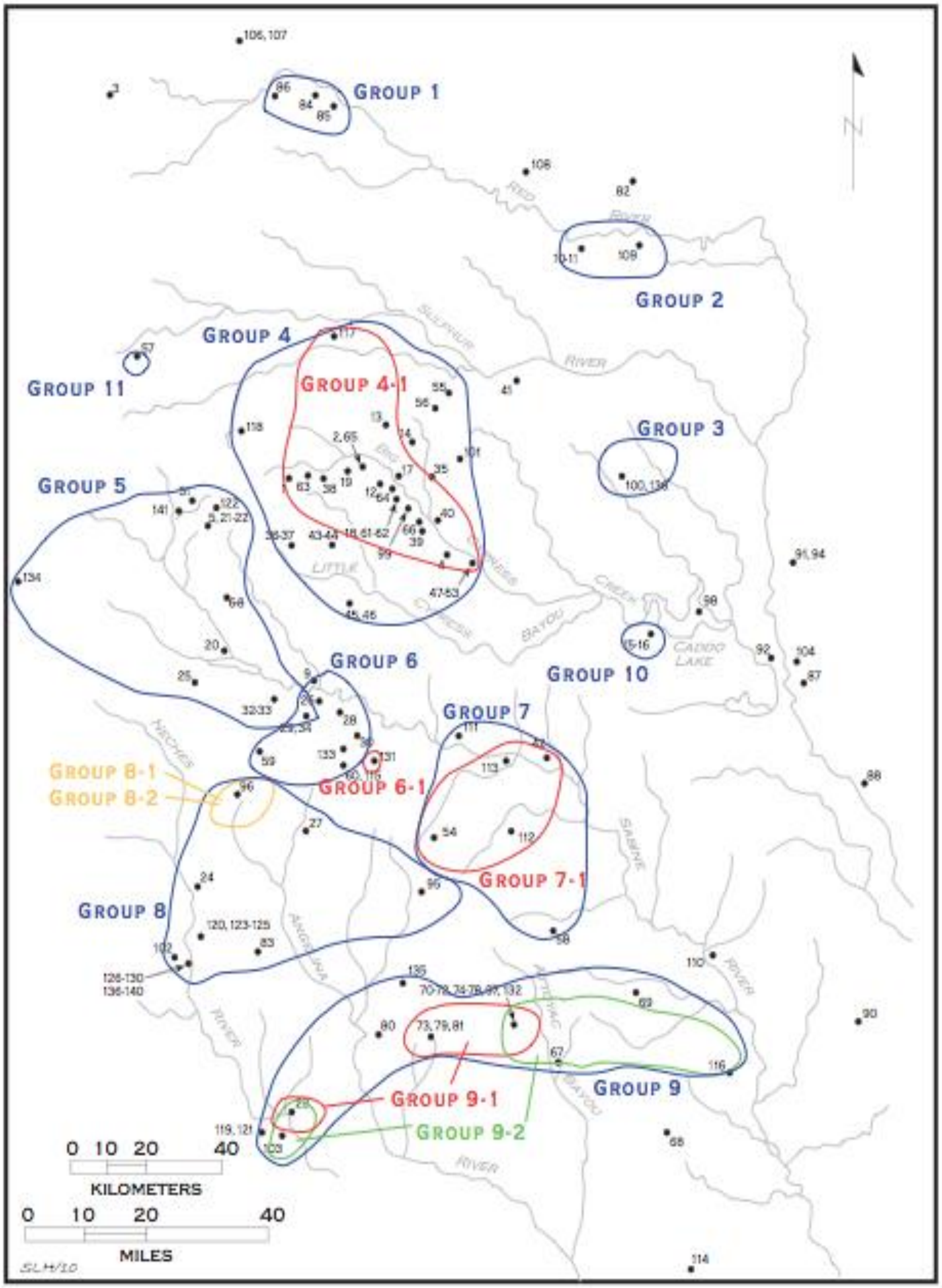

Figure B.1. Current Chemical Groups defined in INAA analyses of sherds, mainly in sites in East Texas (Perttula and Ferguson 2010: Figure 3).

As the bibliography shows, the vast majority of the INAA and petrographic analysis studies completed to date on Woodland and Caddo sites in the Caddo area have been done on sites in East Texas. We think it is important that comparable studies be completed on Woodland and Caddo vessels and vessel sherds from assemblages in adjoining states, so consequently this article is a plea that Caddo archeologists working in all parts of the Caddo area strongly consider undertaking their own INAA and petrographic research. Such research can (1) help to better clarify the compositional nature of these ceramic wares across the entire Caddo temporal and geographic landscape, not just one part of the Caddo world; (2) help pinpoint other ceramic manufacturing locales and chemical/mineralogical compositional groups, but also to assess their apparent technological complexity; and (3) lead to better evaluations of the regional character of prehistoric and historic Woodland and Caddo trade and interaction networks (across our modern state lines) that existed, and more definitively establish whether there were changes through time in the direction and intensity of trade and interaction on local and long distance scales. The disparate pieces of information contained in the sherds and vessel fragments of Woodland and Caddo ceramics scattered on many prehistoric and early historic sites over a broad region have the potential to address these questions and research issues, and can contribute unique information on relationships that existed in the distant past between Woodland groups and Caddo farmers and other aboriginal groups in the Southeast, Midwest, and Southern Plains.

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