PREDICTIVE MODELING IN WESTERN LOUISIANA: PREHISTORIC AND HISTORIC SETTLEMENT PATTERNING IN THE KISATCHIE NATIONAL FOREST

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Abstract

This thesis is an effort to provide the US Forest Service with a tool to effectively and efficiently protect and manage the cultural resource heritage of the Kisatchie National Forest. The development and subsequent evaluation of modeling efforts are vital to the archaeology of the region. There are two goals of this modeling project: to evaluate the active US Forest Service Predictive Model and secondly, if warranted, which it was, to improve upon previous models in the region. To do so 23 environmental variables were analyzed, many of which are inter-related, to develop a new set of probability zones while considering temporal and geographic variability in the Forest.

The variables of distance to frequently flooded soils and distance to permanent streams proved the most significant and each play a prominent role in the creation of the proposed 2011 Kisatchie National Forest Model. The proposed model constructed within exhibits ideal gain values for each probability zone while accounting for the geographic and temporal variability present within the Kisatchie National Forest. The recommendation of this thesis is for the implementation of the proposed 2011 Kisatchie National Forest model in favor of both the 1995 Fort Polk Predictive Model and the 2010 Fort Polk Predictive Model for the Kisatchie National Forest and its surrounding region.

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Chapter 1. Introduction and Background

Introduction

This thesis is an effort to provide the US Forest Service with a tool to effectively and efficiently protect and manage the cultural resource heritage of the Kisatchie National Forest. The development and subsequent evaluation of modeling efforts are vital to the archaeology of the region. There are two goals of this modeling project: to evaluate the active US Forest Service Predictive Model and secondly, if warranted, which it was, to improve upon previous models in the region. To do so 23 environmental variables were analyzed, many of which are inter-related, to develop a new set of probability zones while considering temporal and geographic variability in the Forest.

The Kisatchie National Forest is located across seven central and northern Louisiana parishes: Vernon, Rapides, Grant, Natchitoches, Webster, Claiborne, and Winn. As a response to the region's declining timber industry during the Great Depression, the United States Department of Agriculture in 1930 designated over 604,000 acres or 244,000 hectares as public lands, creating Kisatchie National Forest. Combining the public land with privately owned property within the Forest boundaries there is a total coverage of 1,061,905 acres. The Forest today is segmented into five discontiguous ranger districts: Calcasieu, Caney, Catahoula, Kisatchie, and Winn (Figure 1.1 and 1.2). The Calcasieu District is further

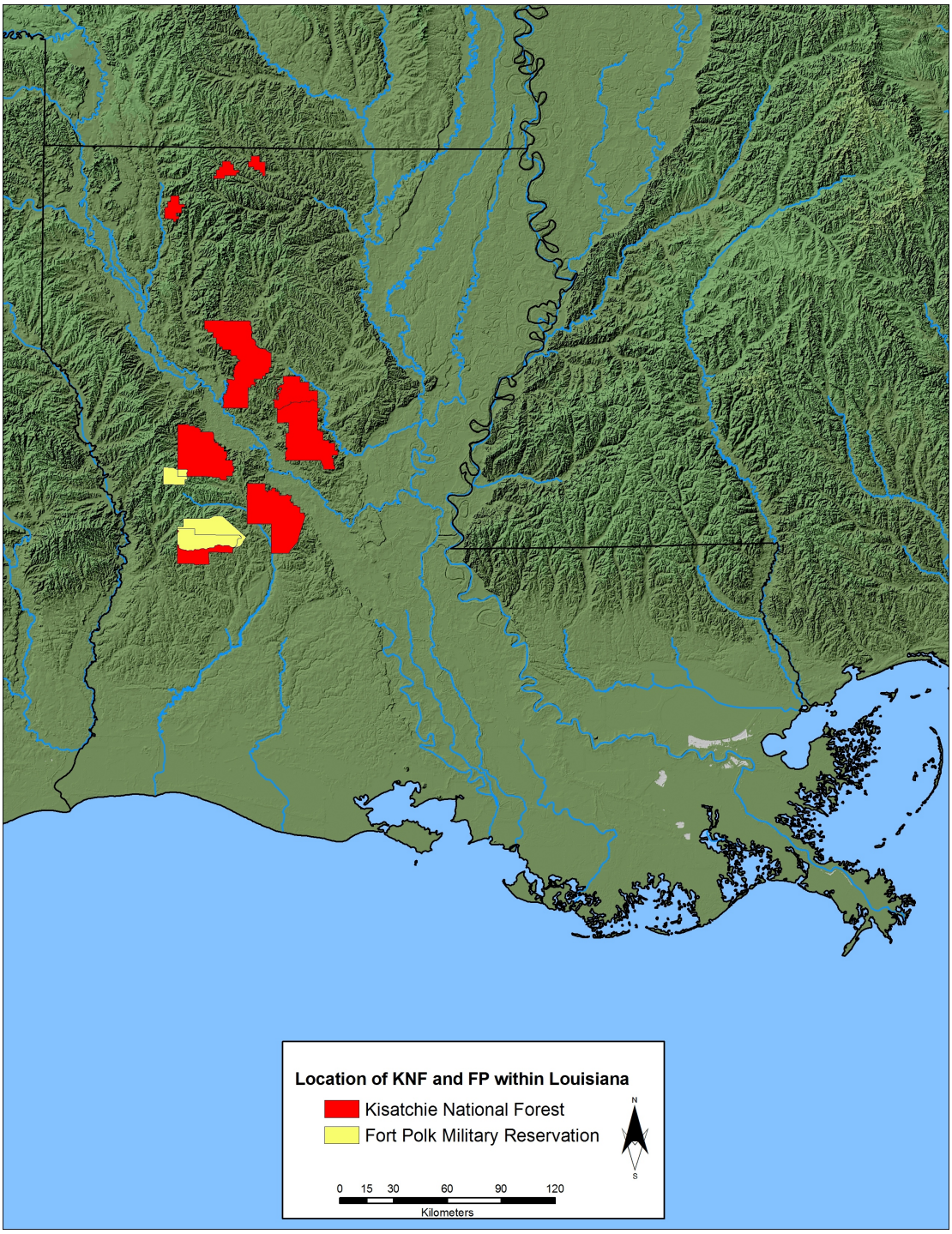


Figure 1.1. Location of the Kisatchie National Forest and the Fort Polk Military Reservation in Louisiana (See Figure 1.2 for KNF and Fort Polk by ranger district).

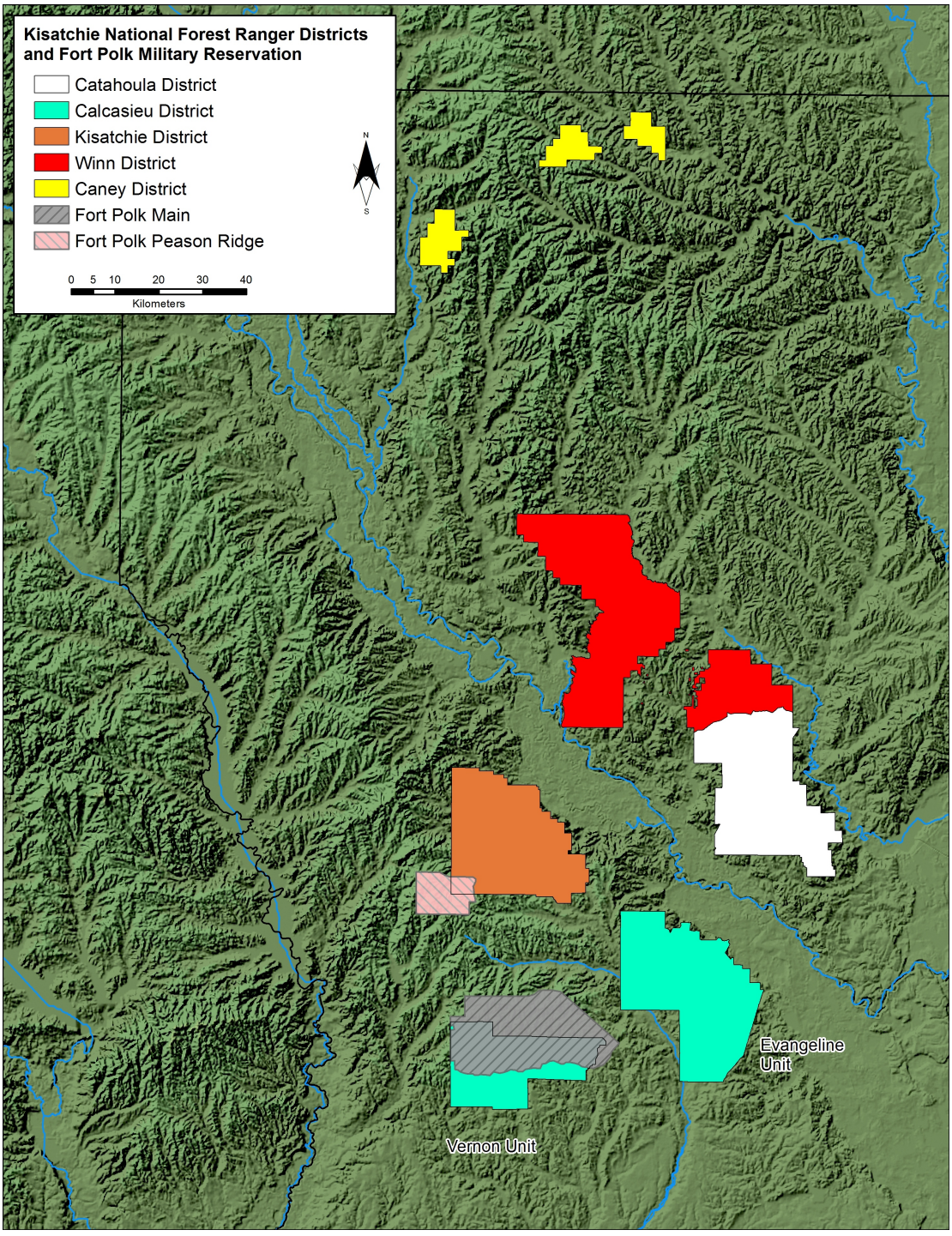


Figure 1.2. Location of the Kisatchie National Forest and the Fort Polk Military Reservation by ranger district.

subdivided into the Evangeline and Vernon Units—both of which are discontiguous from other districts as well as one another.

The Kisatchie National Forest (KNF) is headquartered in Pineville, Louisiana and managed by the U.S. Forest Service—an agency of the U.S. Department of Agriculture (USDA). The Kisatchie National Forest Heritage program is overseen by Velicia Bergstrom, the Forest heritage program manager. The program is responsible for the protection and curation of archaeological sites and structural features located on the Forest. As a federal agency, the Forest is required to conduct compliance-based archaeological work by the National Historic Preservation Act. Preservation efforts facilitated through the U.S. Forest Service have seen extensive archaeological survey across all ranger districts with 34.5 percent of USDA-owned lands surveyed as of 2011. An extremely large number of archaeological sites (n=4,175) [1], both prehistoric and historic, have been recorded within the total area of the Kisatchie National Forest including both USDA operated and privately held lands.

Guiding the cultural resource management efforts are settlement models and more recently predictive models, which serve to assign probabilities for containing archaeological sites to land areas based on an array of environmental variables. Such modeling efforts direct land-use planning and cultural resource assessments for Forest Service and Heritage personnel. The most common predictive models developed in and near the KNF are characterized by three probability zones (i.e. high, medium,

[1] The Louisiana Division of Archaeology defines the criteria for a site as a 20-meter x 20-meter area with the presence of five or more artifacts and a cultural feature with historic artifacts possessing an antiquity of at least 50 years.

low) containing corresponding densities of archaeological sites. Each probability zone reflects the selection and avoidance of areas for settlement by past populations. Prior to the development of formal empirical predictive models, archaeological fieldwork paralleled this process through clustering of surveys around logical features attractive to past human populations.

The predictive model currently employed by the Forest Service for the KNF was produced for the adjacent Fort Polk Military Reservation in 1995 (see Anderson et al. 1999; Anderson and Smith 2003). The Fort Polk Military Reservation overlays northern portions of the Vernon Unit of the Calcasieu ranger district as well as the southwestern corner of the Kisatchie ranger district (see Figure 1.2 above, also Appendix Figure A.1). The model recommends archaeological survey of tiered intensity based on probability zone. Variable survey intervals for shovel testing survey areas are not an uncommon recommendation as it serves to better allocate limited resources in the form of field technician hours. Implementing greater survey intensity in areas believed to contain more sites while limiting intensity in low probability zones does have the potential to become a self-fulfilling model, however, as by chance more sites should be encountered in zones receiving greater effort.

While the US Forest Service predictive model currently employed has been an important planning and management tool, it must be periodically evaluated for effectiveness, especially since the one currently in use was not produced for the Kisatchie National Forest. The current model, described in detail in Chapter 2 along with other models employed in the region, will be applied to evaluate geographic

variation between the ranger districts and to parse out any temporal and cultural variation in site distribution. A new Fort Polk predictive model developed concurrently with this study is also summarized within Chapter 2. The methodology employed in the evaluation of the existing model and the development of a new model is described in Chapter 3. The purpose of the analyses conducted here, described in Chapters 3 through 5, was to determine the effectiveness of the current predictive model and recommend its continued use or its replacement/revision. Selected environmental variables as described within Chapter 3 were evaluated to determine the correlation between each variable and the location of archaeological sites while considering the background environment. The evaluation of environmental associations of archaeological sites was completed by district with results presented within Chapter 5 as well as within Appendix B. The Appendices also contains additional figures of archaeological site locations across the Kisatchie National Forest as separated by temporal components (Appendix A) as well as the 2011 KNF Predictive Model probability zone results by district (Appendix C), both of which supplement the tables and figures embedded within the text of this study.

Although the existing model has appreciable utility, it does not work well in all districts, particularly in the Caney District. For this reason, an improved predictive model for the Kisatchie National Forest is presented in Chapter 6 with effectiveness by district illustrated statistically. The recommendation of this study is to adopt the predictive model developed here for use across all ranger districts in order to more accurately predict the location of both prehistoric and historic archaeological sites.

Environmental Setting

Predictive modeling within an archaeological context heavily incorporates the environment of the study area as well as the archaeological record. In this chapter, the environmental setting is given an in-depth overview while the archaeological record is also examined both regionally and locally.

Physiography

The Kisatchie National Forest lies in west-central Louisiana, which falls within the Coastal Plain physiographic province. Within Louisiana, the Coastal Plain physiographic province is subdivided into five major natural regions: the uplands of the northwest, coastal terraces, Mississippi and Red River alluvial plains, Mississippi delta, and Chenier Plain (Rees 2010; Yodis et al. 2003). This region encompassing the Forest is frequently referred to as the "Kisatchie Wold" (Welch 1942) and is marked by dissected Pleistocene-age deltaic plains and terraces.

Geology

A variety of lithic raw materials have been reported at archaeological sites within the Kisatchie National Forest and on the nearby Fort Polk Military Reservation. Previous archaeological work around the Forest has emphasized the importance of proximity to exploitable lithic sources (e.g. Franks and Yakubik 1990). Indeed, lithic raw materials prove a necessary resource in any setting due to the importance of stone tool usage for prehistoric populations. While the distribution of lithic sources should provide insight toward subsistence and settlement patterns as

well as trade relations in the region, the proximity to lithic material sources was not included within the analysis of environmental associations within Chapter 4 as the locations of the outcrops proved too approximate. This section instead serves as background insight as to why people settled the landscape around the Kisatchie National Forest.

Several in-depth reviews have been published of the geological formations as well as the lithic source locations within western Louisiana. Notably, Banks (1990) compiled a regional review of lithic sources for the Trans-Mississippi Coastal Plain with a detailed consideration of the Catahoula and overlying Fleming Formations that pass through the Kisatchie National Forest (Figure 1.3). The relative disparity in occurrence of lithic sources that naturally occur west of the Mississippi in western Louisiana highlights the importance of knappable raw material to the prehistoric human populations. Knowledge of and proximity to lithic outcrops, many researchers have argued, profoundly influenced settlement patterns in this lithic sparse region of the Trans-Mississippi Coastal Plain. It is therefore expected that higher densities of archaeological sites should be located near lithic sources; whether these sites express signatures of habitation or simply procurement requires detailed review of each site's archaeological assemblage. Future prehistoric modeling efforts would benefit from accurate lithic source locations of both high and low quality raw materials.

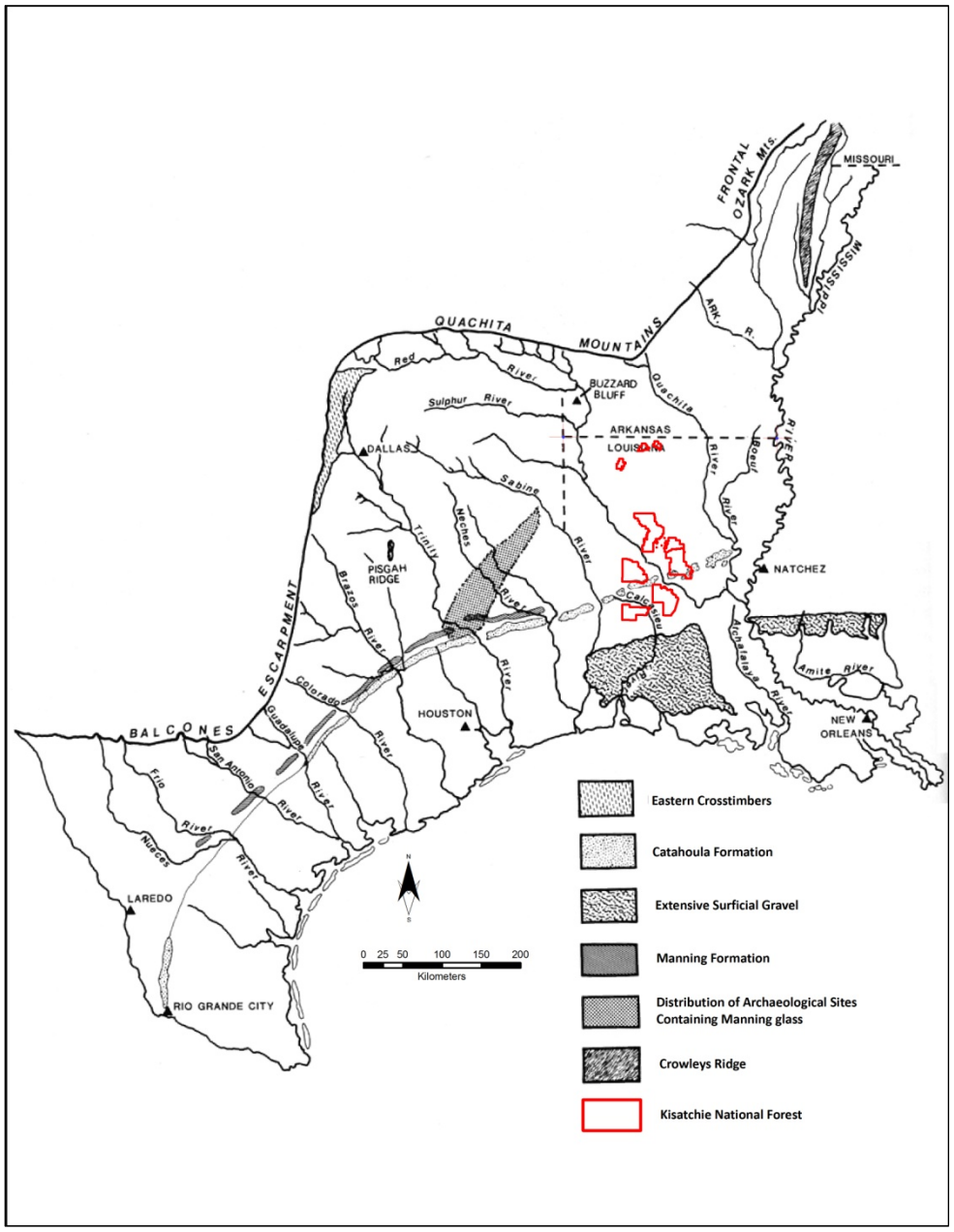


Figure 1.3. Chert sources in the Trans-Mississippi Gulf Coastal Plain in proximity to the Kisatchie National Forest (adapted from Banks 1990, Figure 2.1).

Within the outcropping strata of western Louisiana, six knappable lithic material types have been reported: silicified wood, Eagle Hill Chert, Gravel Chert, Fleming Gravel Chert, Fleming Opal, and Catahoula Sedimentary Quartzite (Banks 1990; Heinrich 1983, 1984; Jolly 1982; McGimsey 1996). Strata containing silicified wood tend to outcrop in broad bands across western Louisiana. Highly variable as a lithic resource, the process of opal and chert replacing the original organic wood produces stone of differing knapping quality based on the proportion of silica content. The variation can produce a black to dark grey material high in organic matter that fractures along the original wood grains in a flat or curved fashion or it can produce a highly permineralized hard material producing predictable conchoidal fractures when manipulated (Heinrich 1984:168).

Outcropping Miocene strata, namely the Catahoula and Fleming Formations, are identified as the primary source of silicified wood in the region and are concentrated within the upper Vernon Parish, lower Sabine Parish, and middle Rapides Parish (see figure 1.4 below) (Anderson 1960; Fisk 1940; Heinrich 1984; Matson 1916; Welch 1942). Additional, if less widespread sources, include the outcrops of the Sandel, Cockfield, and Summit Hall Formations of Central Sabine Parish (Anderson 1960:63, 92, 103), the Logansport Formation of the central De Soto Parish (Murray 1948:115), the Wilcox Group of southeastern Webster Parish (Martin et al. 1954:124), and the Pleistocene sands and gravels surrounding Vernon Parish. At the reported lithic sources, the lithic raw material—containing mostly palm

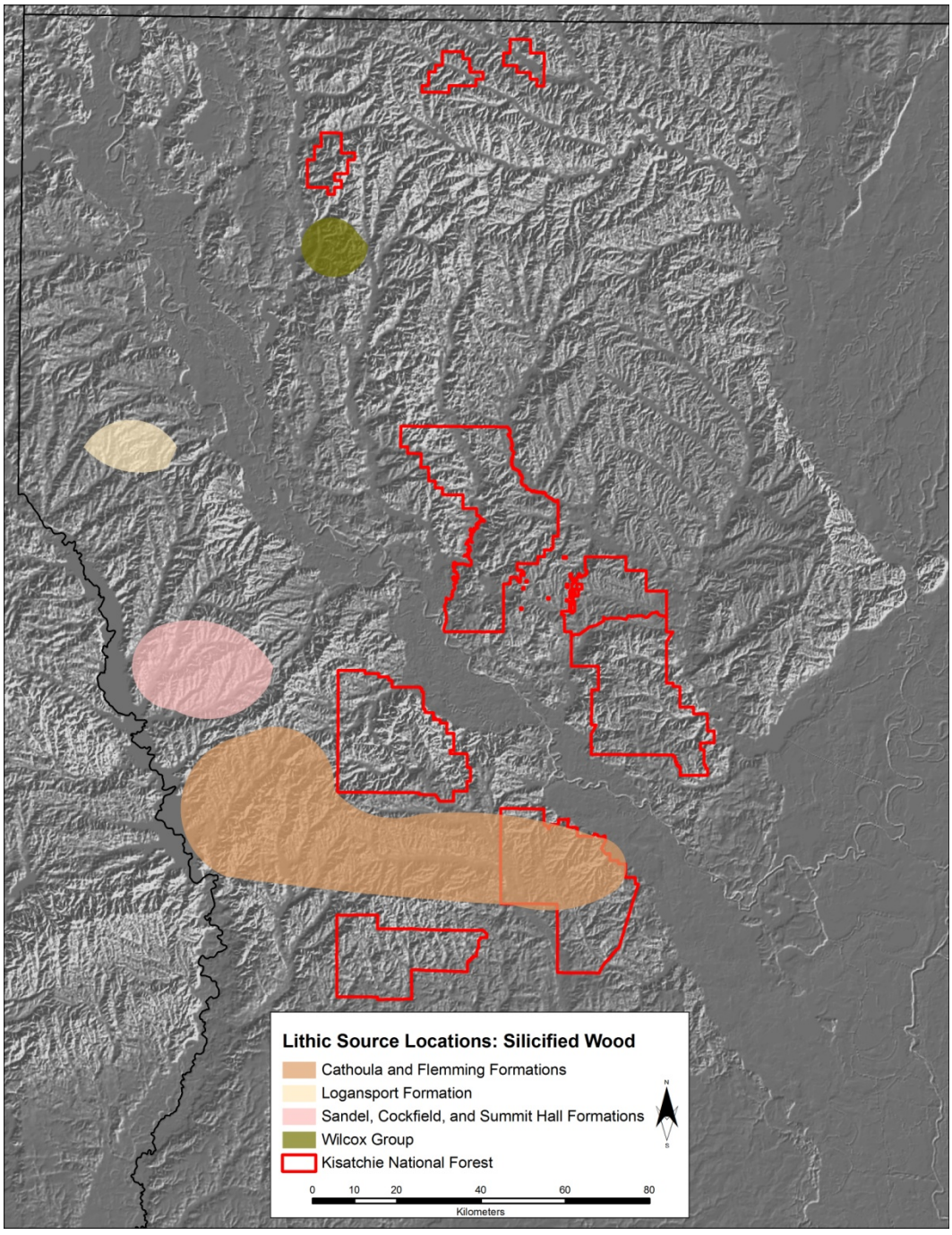


Figure 1.4. Lithic raw material source locations for silicified wood in western Louisiana (locations described by Heinrich 1984).

wood—erodes out in pebble-size fragments to large log-size packages over a meter in diameter (Heinrich 1984:170). Dissection of Miocene strata through slope and stream erosion provides the typical setting for the occurrence of large and small silicified wood packages (Brassieur 1983:251).

Eagle Hill Chert is a geographically restricted and highly silicified wood that lacks most semblances of its original wood structure. While Eagle Hill Chert is a silicified wood, it is discussed separately due to its relative absence of impurities, the uniform grain size of the microcrystalline quartz, and its restriction to the Eagle Hill area in Peason's Ridge at the southwest extent of the Kisatchie District (Figure 1.5) (Heinrich 1984:1973). Visually variable by color and opaqueness, Eagle Hill Chert turns a black to mottled black following thermal alteration (Heinrich 1984:172).

Archaeological and petrographic data suggests large quarries of silicified wood outcropping within the Eagle Hill area as a result of: (1) the mineralogy and relict texture of Eagle Hill Chert matching other local silicified woods, (2) archaeological sites in this proximity exhibiting large quantities of primary and secondary reduction debris of Eagle Hill Chert, (3) these same archaeological sites reporting above 90 percent of the lithic raw material to be Eagle Hill Chert, and (4) unmodified nodules of Eagle Hill Chert appearing southwest of Eagle Hill (Heinrich 1984:173-174). As visible within the archaeological record, Eagle Hill Chert appears limited to the Eagle Hill area in high concentrations though it is likely that smaller outcrops do occur throughout the Fleming Formation. There remains a possibility for

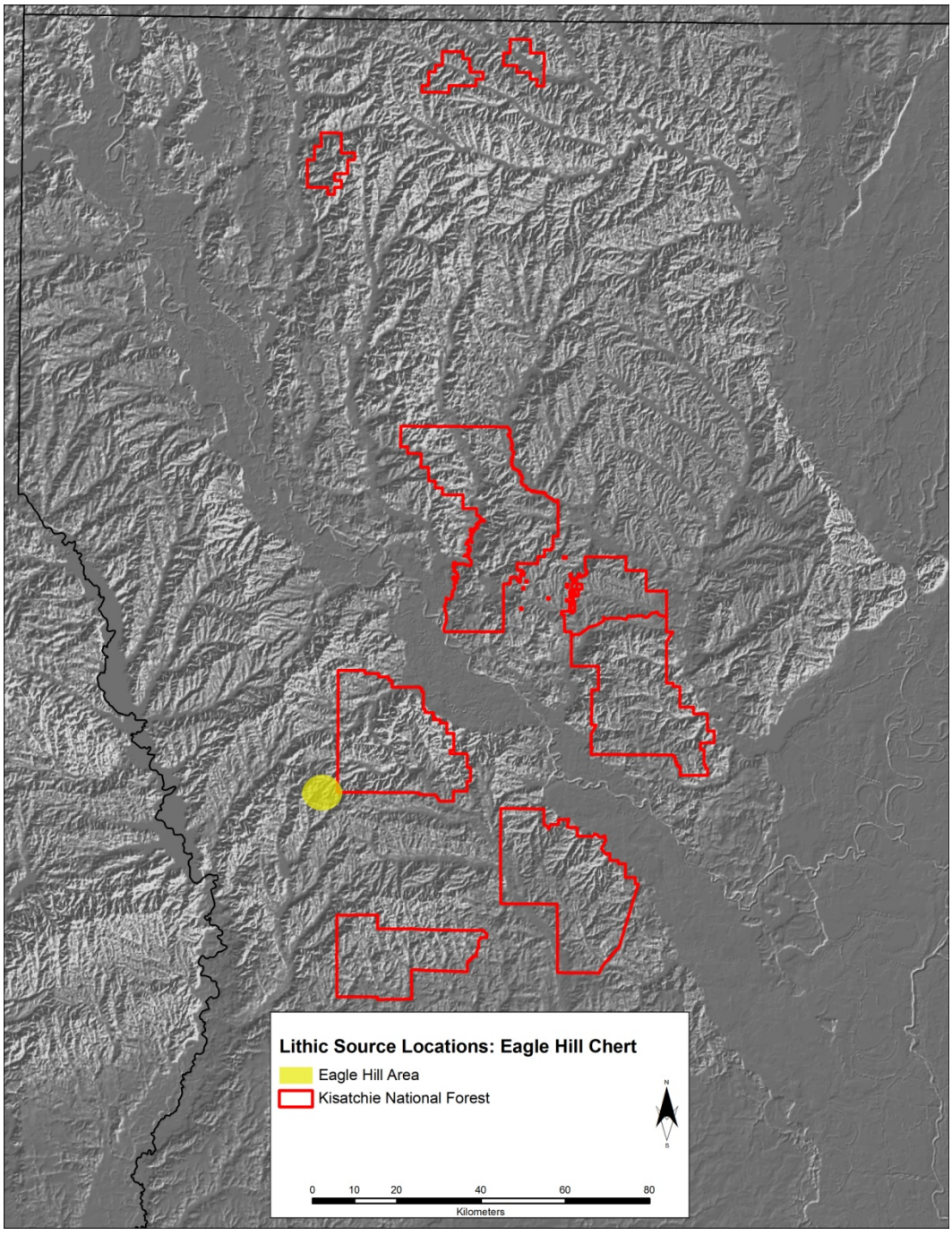


Figure 1.5. Lithic raw material source locations for Eagle Hill Chert in western Louisiana (locations described by Heinrich 1984).

other highly concentrated localized outcrops which would likely produce exotic appearing but local cherts (Heinrich 1984:175).

Gravel Chert comprises the most utilized lithic resource by the prehistoric populations of western Louisiana (Figure 1.6). Gravel Cherts are found within Pleistocene strata and Holocene fluvial sediments and are the weathered and river-worn remains of highly transported cherts from outcrops of Paleozoic strata (Heinrich 1984:175). Consisting of hard, microcrystalline silica, the inconsistent quality and often limited size of the gravel restricted the form of crafted artifacts (Brassieur 1983:253). Heinrich (1984:176) notes that Gravel Chert colors range from red to brown, typically within the 10YR Munsell hue. Inclusions of relict textures including dolomite, casts of evaporates, fossils, and sponge spicules, among others, are common additions to the granular microcrystalline quartz composition (Heinrich 1984:176). The majority of Gravel Cherts occur within Pleistocene aged deposits outcropping along a west-east belt across southern Vernon Parish, northern Beaureguard Parish, northern Allen Parish, and central Rapides Parish (Heinrich 1984:178; Woodward and Geno 1941).

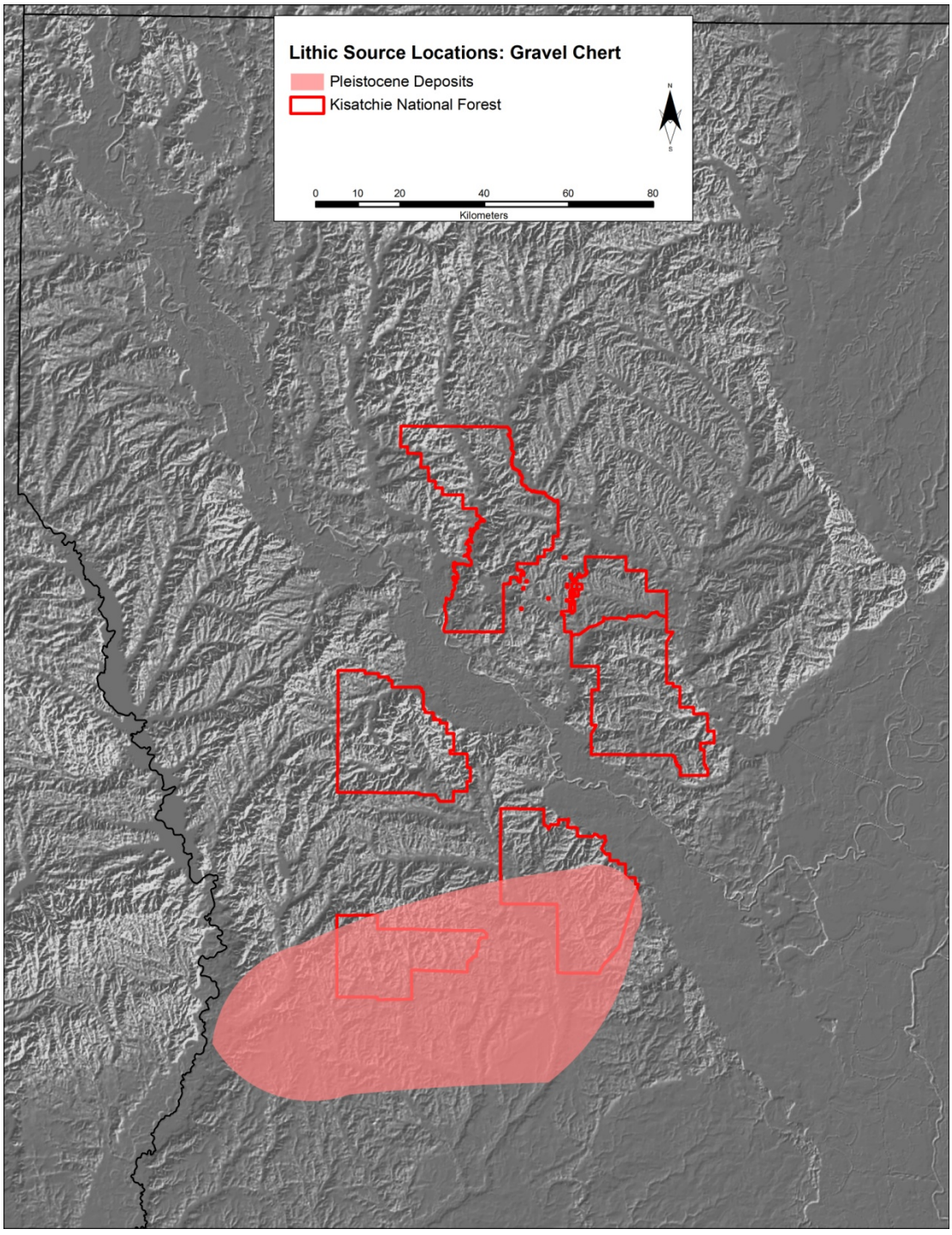


Figure 1.6. Lithic raw material source locations for Gravel Chert in western Louisiana. (locations described by Heinrich 1984).

Fleming Gravel Chert, named for the Fleming Formation where it occurs, shares most of its physical characteristics with the aforementioned Gravel Chert (Figure 1.7). Package sizes cluster around 2.5 cm in diameter, with the chert displaying a fine-grain black texture (Heinrich 1984:179). Isolated in its occurrence, Fleming Gravel Chert is reported by Heinrich (1984:179) to source to a ravine tributary of the Sabine River within Vernon Parish.

Occurring exclusively within the Fleming Formation (Figure 1.7), Fleming Opal represents a less dense material than chert that results in a blocky conchoidal fracture when manipulated (Heinrich 1984:180). A white to off-white cortex masks a highly variable opal color with specimens ranging from 10YR greys to 2.5YR browns (Heinrich 1984:180). The opal nodule package size ranges from 0.6 to 30 cm in diameter and has been identified by Heinrich (1984:181) and Welch (1942:42,49) to source to the Fleming Formation of Rapides and Vernon Parishes as well as within the Eagle Hill area.

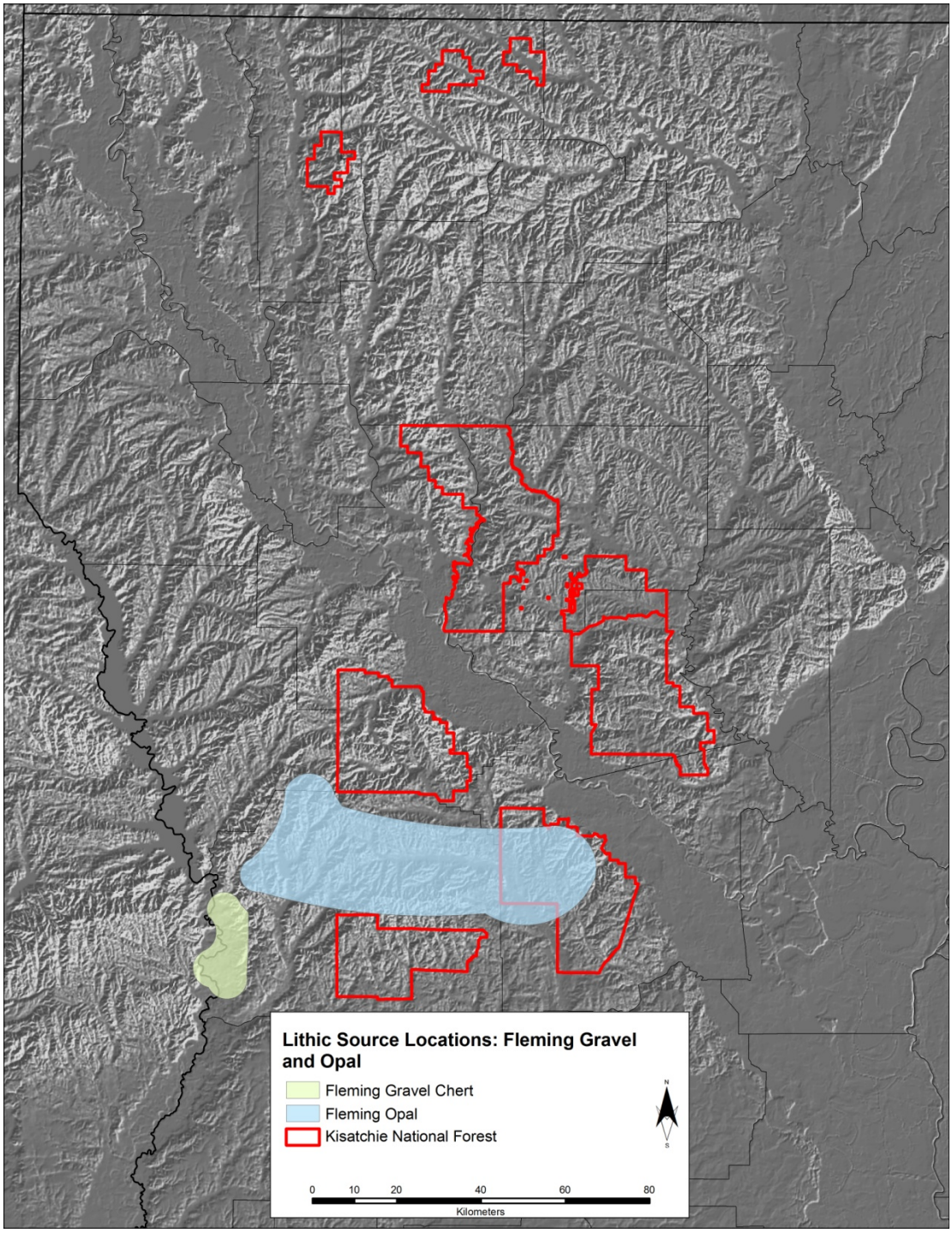


Figure 1.7. Lithic raw material source locations for Fleming Gravel and Fleming Opal in western Louisiana (locations described by Heinrich 1984).

Catahoula Sedimentary Quartzite is a relatively minor lithic material in western Louisiana likely due to the rough fracture characteristics of the material (Andrefsky 2005:24). Revealed through fracture, the quartzite typically is a rough vitreous material with floating grains of sands visible throughout the translucent dark grey material (Heinrich 1984:182). Scattered Pleistocene gravel exposures throughout the Catahoula Formation contain cobbles and pebbles of the quartzite along a west-east outcropping belt that is 8 to 16 km wide and 240 km long passing through southern Sabine Parish and central Nachitoches Parish (Heinrich 1984:184; Woodward and Geno 1941).

The typing of lithic artifacts from a sample of archaeological site assemblages across the Kisatchie National Forest by ranger district emphasizes the use intensity of gravel cherts in the region (Table 1.1). The remaining lithic sources together account for under 20 percent of the total analyzed artifacts. It can be inferred that prehistoric populations were utilizing more readily available lithic raw materials (e.g. Gravel Cherts). More data in the form of lithic outcrop locations will eventually provide an extremely relevant variable to incorporate into predictive modeling efforts in this region.

Table 1.1. Lithic Raw Materials, by Type, on a Sample of Sites from the Kisatchie National Forest (adapted from Anderson and Smith 2003:151, Table 3.3; Phillips and Haikey 1992).

	Ranger District				
Material	Catahoula	Evangeline	Kisatchie	Vernon	Totals
Gravel Chert	1,309	1,749	901	2,569	6,528
(% of Total)	(72.8)	(82.54)	(82.54)	(82.54)	(82.54)
Silicified Wood	64	6	328	14	412
(% of Total)	(3.56)	(0.28)	(5.02)	(0.47)	(6.31)
Catahoula Sedimentary Quartzite	145	3	146	3	297
(% of Total)	(8.06)	(0.14)	(9.28)	(0.10)	(3.51)
Red Jasper	125	181	140	323	769
(% of Total)	(6.95)	(8.54)	(8.89)	(10.91)	(9.10)
Fleming Opal	0	0	2	4	6
(% of Total)	(0.00)	(0.00)	(0.13)	(0.14)	(0.07)
Fleming Chert	4	10	3	3	20
(% of Total)	(0.22)	(0.47)	(0.19)	(0.10)	(0.24)
Banded Chert	69	100	25	39	233
(% of Total)	(3.84)	(4.72)	(1.59)	(1.32)	(2.76)
Quartz	11	11	4	1	27
(% of Total)	(0.61)	(0.52)	(0.25)	(0.03)	(0.32)
Other	71	59	25	4	159
(% of Total)	(3.95)	(2.78)	(1.59)	(0.14)	(1.88)
Totals	1798	2119	1574	2960	8451
(% of Total)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

Soils

The soils in the region surrounding Kisatchie National Forest are classified by the USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) Database as highly weathered Ultisols with low organic preservation. Soil profiles in the uplands are shallow with cultural activity often detected within the upper thirty centimeters, often proving advantageous for archaeological survey as noted in cultural resource management (CRM) reports (e.g. Heide 1999:7). Due to floodplain dynamics, cultural material within the floodplain is frequently deposited significantly deeper than the cultural material in the uplands. Sixty-five distinct soil types are classified within the Forest's Geographic Information System (GIS) database—a result of a comprehensive USDA soil mapping project available through the Natural Resources Conservation Service (NRCS; http://soils.usda.gov/survey/geography/ssurgo/). These soils, along with the proportion of total forest acreage coverage by soil and drainage class are detailed in Table 1.2. The incorporated soil data for the modeling analysis are detailed in Chapter 3 as soil characteristics play a large role in both the active U.S. Forest Service Model and the newly developed predictive model outlined in Chapter 6.

Historically, the poor soil quality for growing crops directed early European settlement to areas along major river ways (Mann 2010). Unable to support substantial agriculture, the soils of western Louisiana, both those in the uplands and the flood-prone lowlands, appear to have been unfavorable for agriculture, and prevented large communities from forming in the historic era. This changed with the

establishment of the timber industry and the introduction of the railroad in the late 19th century, which resulted in access to imported agricultural products. The soil differences between the uplands and lowlands would have thus limited past settlement, both historically and prehistorically. This assertion is evaluated within the following chapters of this study.

Table 1.2. Soil Types in the Kisatchie National Forest and Their Percent Coverage of Total Area within the KNF Boundaries (NRCS; http://soils.usda.gov/survey/geography/ssurgo).

Soil Name	Phase	Coverage (%)	Drainage
ACADIA	SILT LOAM	0.18	Somewhat Poorly
ALAGA	LOAMY FINE SAND	0.01	Well
ANACOCCO	LOAM	1.37	Somewhat Poorly
ANGIE	VERY FINE SANDY LOAM	0.11	Somewhat Poorly
BEAUREGARD	VERY FINE SANDY LOAM	2.29	Somewhat Poorly
BEAUREGARD-MALBIS	COMPLEX	0.83	Somewhat Poorly
BELLWOOD	LOAM	5.19	Somewhat Poorly
BETIS	LOAMY FINE SAND	2.52	Well
BETIS-BOYKIN	COMPLEX	0.98	Well
BIENVILLE	LOAMY FINE SAND	0.36	Well
BOWIE	FINE SANDY LOAM	0.04	Somewhat Poorly
BOYKIN	LOAMY FINE SAND	0.93	Moderately Well
BRILEY	LOAMY FINE SAND	2.80	Moderately Well
BRIMSTONE	VERY FINE SANDY LOAM	0.04	Poorly
CADDO	VERY FINE SANDY LOAM	1.30	Poorly
CADEVILLE	VERY FINE SANDY LOAM	2.51	Somewhat Poorly
CAHABA	FINE SANDY LOAM	1.13	Moderately Well
DARDEN	LOAMY FINE SAND	0.07	Excessively
DARLEY	GRAVELLY	0.54	Moderately Well
DARLEY-SACUL	COMPLEX	0.13	Moderately Well
EASTWOOD	VERY FINE SANDY LOAM	1.23	Somewhat Poorly
FLO	LOAMY FINE SAND	0.10	Well
FORBING	SILT LOAM	0.03	Somewhat Poorly
FRIZZELL-GUYTON	COMPLEX	3.40	Somewhat Poorly
GALLION	SILT LOAM RARE FLOOD	0.05	Moderately Well
GLENMORA	VERY FINE SANDY LOAM	2.37	Somewhat Poorly
GORE	VERY FINE SANDY LOAM	2.98	Somewhat Poorly
GUYTON	COMPLEX	14.35	Poorly
GUYTON-LOTUS	ASSN. FREQ. FLOODED	1.09	Poorly
HARLESTON	FINE SANDY LOAM	0.04	Somewhat Poorly
HOLLYWOOD	SILTY CLAY LOAM	0.13	Somewhat Poorly
IUKA-DELTA	COMPLEX FREQ. FLOOD	0.42	Somewhat Poorly
KEITHVILLE	LOAM	0.45	Somewhat Poorly

Soil Name	Phase	Coverage (%)	Drainage
KIEFFER	LOAM	0.02	Somewhat Poorly
KISATCHIE	CLAY SEVERE ERODED	0.72	Moderately Well
KISATCHIE - ANACOCO	COMPLEX	0.42	Moderately Well
KISATCHIE-OULA	COMPLEX	3.29	Moderately Well
KISATCHIE-RAYBURN	COMPLEX	0.00	Moderately Well
KOLIN	SILT LOAM	0.97	Somewhat Poorly
LARUE	LOAMY FINE SAND	0.01	Moderately Well
MAHAN	FINE SANDY LOAM	0.21	Moderately Well
MALBIS	FINE SANDY LOAM	8.69	Somewhat Poorly
MAYHEW	SILTY CLAY LOAM	0.19	Poorly
MCLAURIN	LOAMY FINE SAND	0.05	Moderately Well
METCALF	VERY FINE SANDY LOAM	1.50	Somewhat Poorly
MORELAND	CLAY FREQ. FLOODED	0.71	Somewhat Poorly
MORSE	SILTY CLAY	0.04	Moderately Well
NATCHITOCHES	SANDY CLAY LOAM	0.33	Moderately Well
OCHLOCHONEE	SANDY LOAM	0.91	Moderately Well
OKTIBBEHA	SILT LOAM	0.25	Somewhat Poorly
OSIER	LOAMY FINE SAND	0.23	Poorly
PERRY	CLAY OCCAS. FLOODED	0.13	Poorly
RIGOLETTE-KISATCHIE	ASSOCIATION	0.11	Somewhat Poorly
ROXANNA	FREQUENTLY FLOODED	0.04	Moderately Well
RUSTON	FINE SANDY LOAM	7.77	Moderately Well
SACUL	FINE SANDY LOAM	7.08	Somewhat Poorly
SAVANAH	FINE SANDY LOAM	2.26	Somewhat Poorly
SAWYER	LOAM	0.04	Somewhat Poorly
SHATTA	VERY FINE SANDY LOAM	0.08	Moderately Well
SMITHDALE	FINE SANDY LOAM	11.62	Moderately Well
SMITHDALE-GORE	COMPLEX	0.11	Moderately Well
VAIDEN	SILTY CLAY	0.65	Somewhat Poorly
WOLFPEN	LOAMY SAND	0.59	Moderately Well
WRIGHTSVILLE	SILT LOAM	0.05	Poorly
YORKTOWN	CLAY FREQ. FLOODED	0.92	Very Poorly

Hydrology

Two primary drainages dissect Louisiana and influence the physiographic divisions of the state. The first, the Mississippi River, provides fertile floodplains for the eastern portion of the state, but it is not discussed at length due to its seventy kilometer distance from the nearest Forest District—the Catahoula district. The Red

River and its tributaries drain portions of the Kisatchie National Forest before emptying into the Mississippi River. Two other large drainages in the region, the Calcasieu and the Sabine rivers, also drain the southern districts southward into the Gulf of Mexico. The streams and the associated tributaries of these three river systems dissect the uplands and transport eroded soils. The activity of these systems results in the exposure of lithic sources, which prehistoric peoples frequently mined for materials to manufacture tools. The archaeological populations also favored these river systems for settlement and movement for a variety of reasons, primarily subsistence related.

Caney District in the north of Louisiana is within moderate proximity to the Red River as well as both the Bayou Dorcheat and Bayou D'Arbonne. Saucier (1994:50) notes that bayous and slow moving river systems are a relatively new feature to the landscape, only forming after sea levels and river channels stabilized between 5,000 and 2,000 years ago. While the glaciers of the Last Glacial Maximum indirectly impacted the landscape in Louisiana, the Lower Mississippi Valley underwent the most dramatic changes as a result of fluctuating water levels (Rees 2010b:34). Past settlement would have been affected by the differing environmental conditions; however, the general environment of the Forest area within the modeling context is assumed to be relatively similar to that of modern conditions with the exception being the hydrology of western Louisiana past 5,000 years ago.

Ecoregions

Ecoregions delineate geographical areas within which a homogeneous ecosystem exists while also denoting the category, quality, and magnitude of available environmental resources (Daigle 2006). For anthropological purposes, the inclusion of both biotic and abiotic environmental categories such as flora, fauna, climate, soils, and hydrology in addition to the historically utilized categories of physiography and geology aid in parsing out variability within the environment at a finer scale (Omernik 1987, 1995; Wiken 1986). The diversity of factors contributing to ecoregions is relevant when situating prehistoric and historic settlement patterns and landscape use within the modern ecosystem. Ecoregions spatially portray environmental changes and similarities based on ecosystem capacities and potentials (Bryce et al. 1999).

The U.S. Environmental Protection Agency developed and employs a hierarchical ecoregion schema for the research assessment of ecosystems between multiple monitoring agencies and organizations (McMahon et al. 2001; Omernik 1987). The schema involves a refining and subdividing structure ranging from Level I, which divides North America into 15 ecological regions, to Level IV, an extremely detailed partitioning of local ecosystems. As relevant to Kisatchie National Forest, only the Level III and Level IV ecoregions for Louisiana are detailed in the following dialogue as drawn from published descriptions presented by Diagle et al. (2006). The ecoregion figures and the discussion of ecoregions serve as background context for the analysis in subsequent chapters.

Louisiana contains six Level III ecoregions with the majority of the state classified as either the Mississippi Alluvial Plain region on the east or the South Central Plains region to the northwest (Figure 1.8). The boundary of the Kisatchie National Forest lies completely within the South Central Plains ecoregion, which extends eastward to the bottomlands of the Ouachita River and Red River and southward to the Gulf Coastal Plain. The South Central Plains region spans portions of Arkansas, Oklahoma, and east Texas in addition to Louisiana. Unlike the flatter and intact terrain of the adjacent Mississippi Alluvial Plain and Western Gulf Coastal Plain regions, the South Central Plains region exhibits undulating plains interrupted by flat fluvial terraces, bottomlands, sandy low hills, and low cuestas. This region displays more dissection with greater topographic relief as compared with its neighboring ecoregions within Louisiana. A lithologic mosaic, the South Central Plains' uplands are underlain with Tertiary Coastal Plain while its bottomlands and terraces are underlain with Quaternary alluvium, terrace deposits, or loess. The soil composition is mostly acidic sandy loams, silt loams, sands, and sandy clay loams.

At a more local level, four Level IV ecoregions are contained within the Forest's five ranger districts: the Red River Bottom Lands, the Pleistocene Fluvial Terraces, the Tertiary Uplands, and the Southern Tertiary Uplands (Figures 1.9 to 1.13). With the exception of the Caney District in the north of the state, the Southern Tertiary Uplands ecoregion accounts for the majority of the Kisatchie land area whereas the Caney District is entirely encompassed by the Tertiary Uplands ecoregion. The geographic extent of the Kisatchie National Forest, due to the discontiguous nature of the districts, makes it a diverse Forest system to model. The

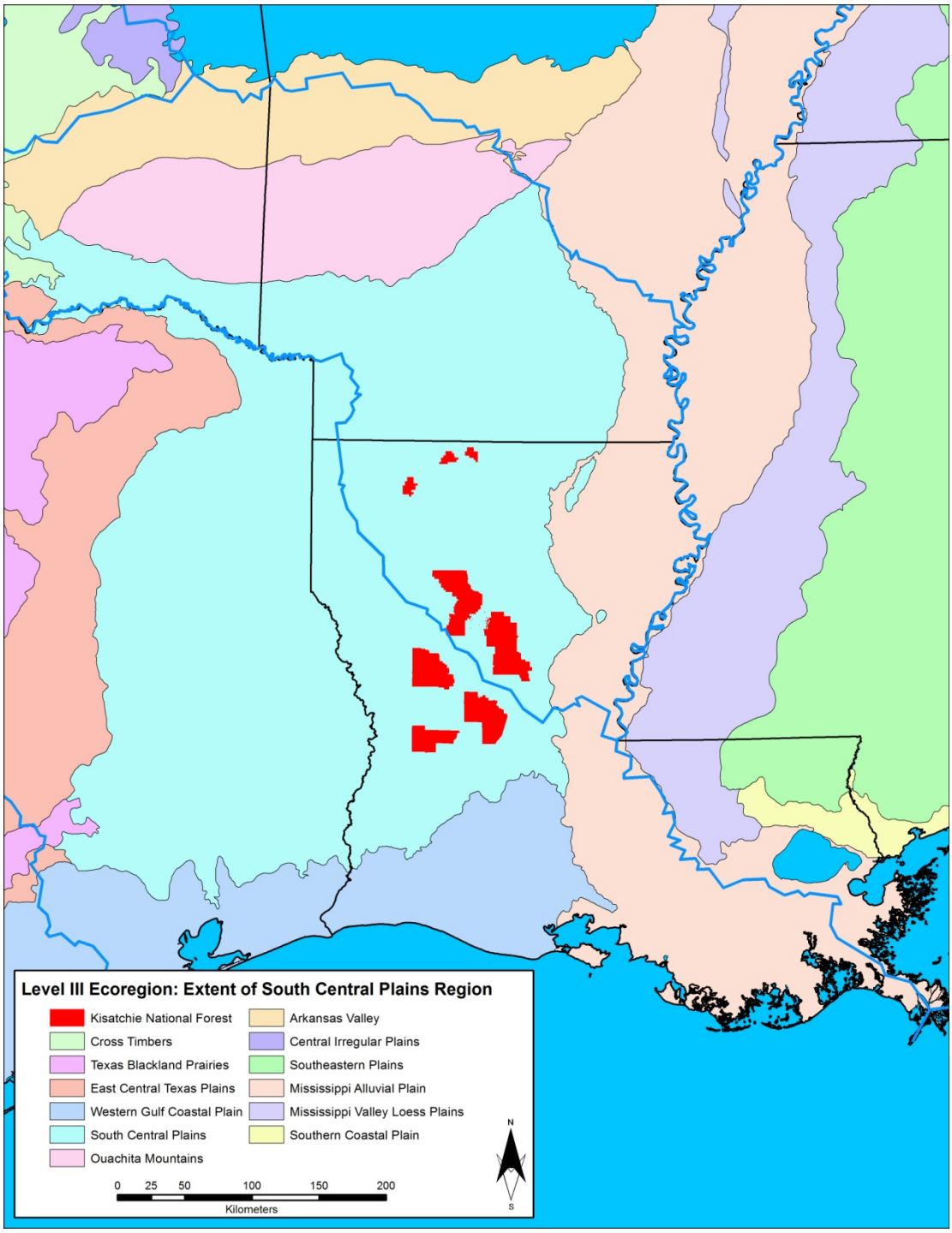


Figure 1.8. Extent of South Central Plains Level III Ecoregion (Daigle et al. 2006; US Environmental Protection Agency; GIS data available at http://www.epa.gov/wed/pages/ecoregions.htm).

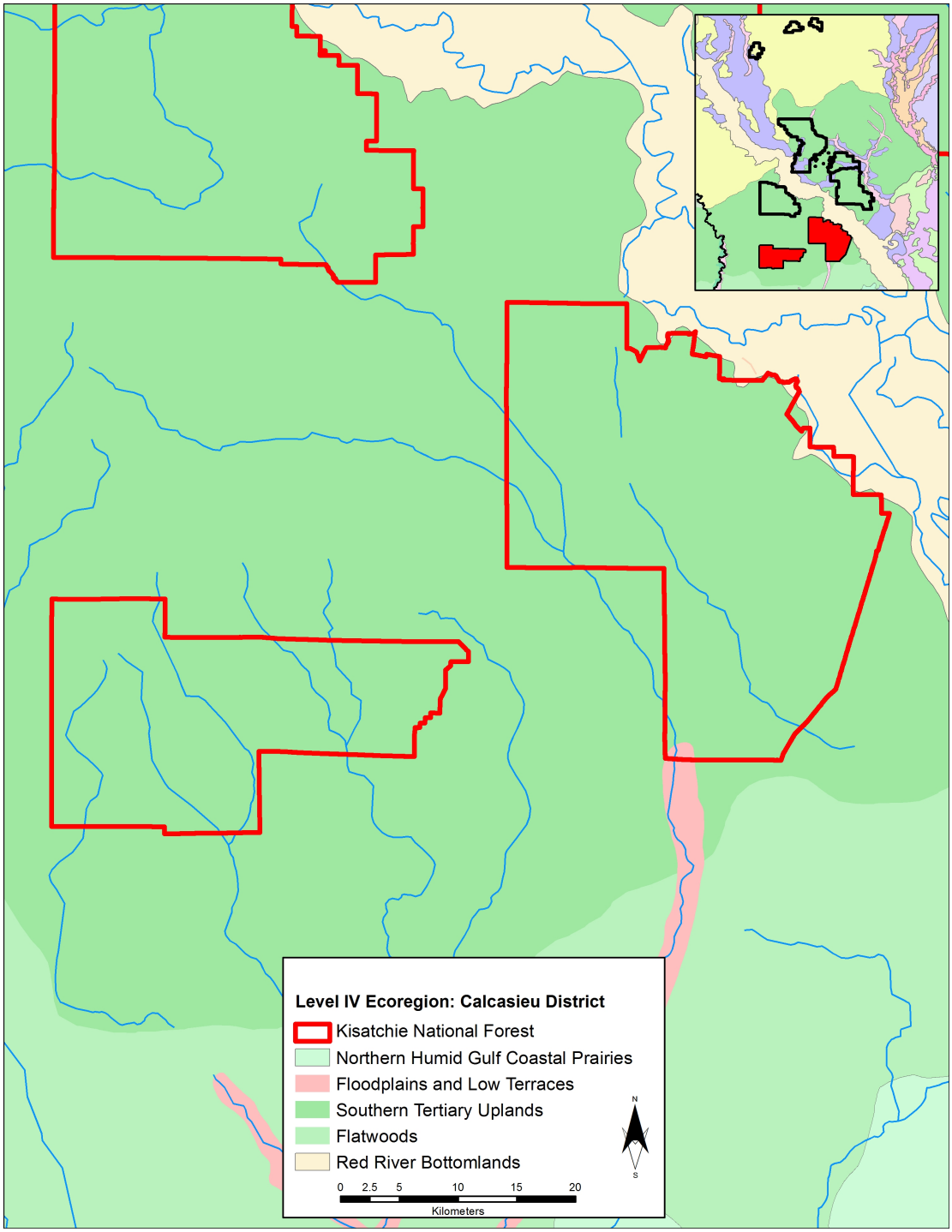


Figure 1.9. Level IV Ecoregion coverage for Calcasieu District—Vernon Unit (west) and Evangeline (east) (Daigle et al. 2006; US Environmental Protection Agency; GIS data available at http://www.epa.gov/wed/pages/ecoregions.htm).

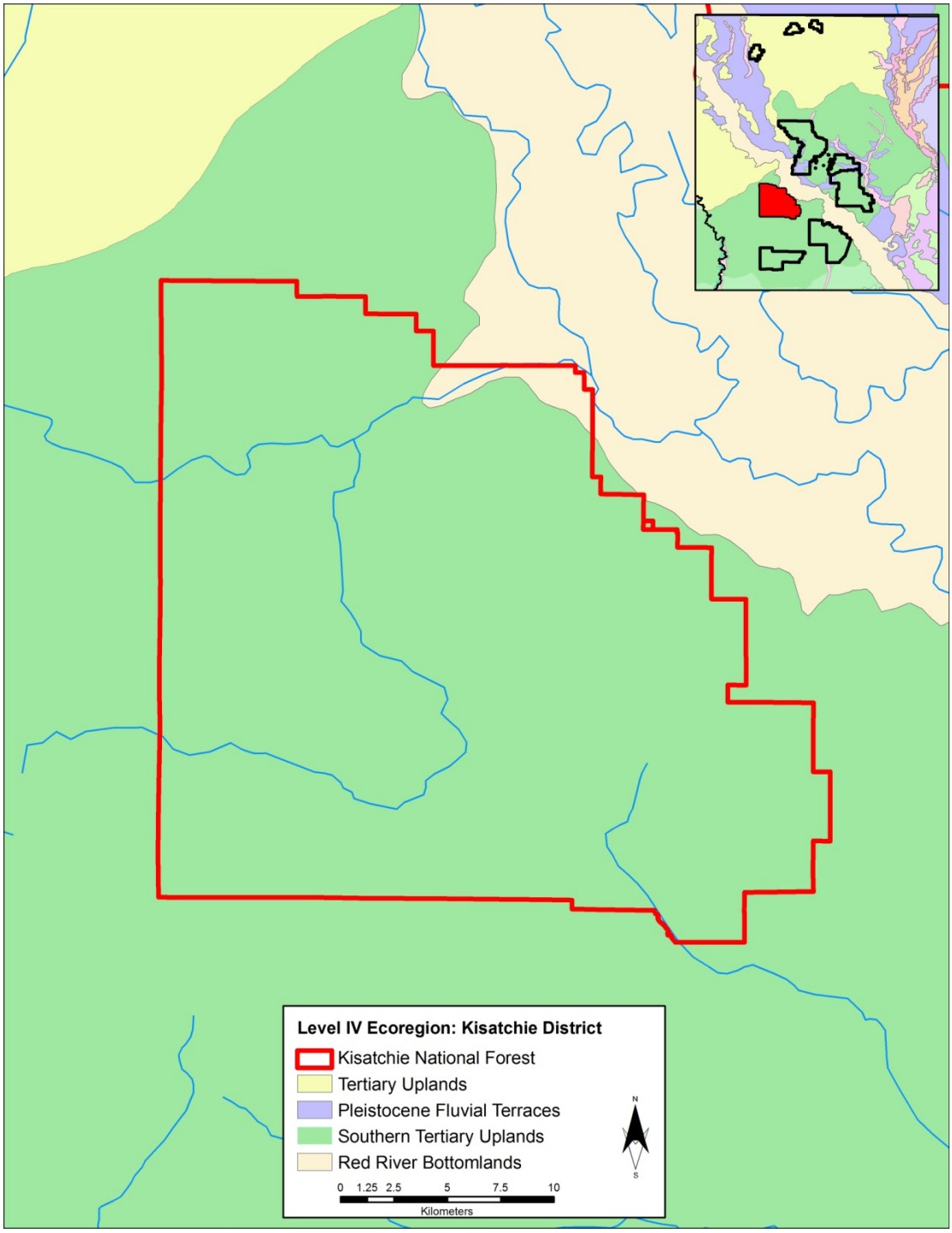


Figure 1.10. Level IV Ecoregion coverage for Kisatchie District (Daigle et al. 2006 US Environmental Protection Agency; GIS data available at http://www.epa.gov/wed/pages/ecoregions.htm).

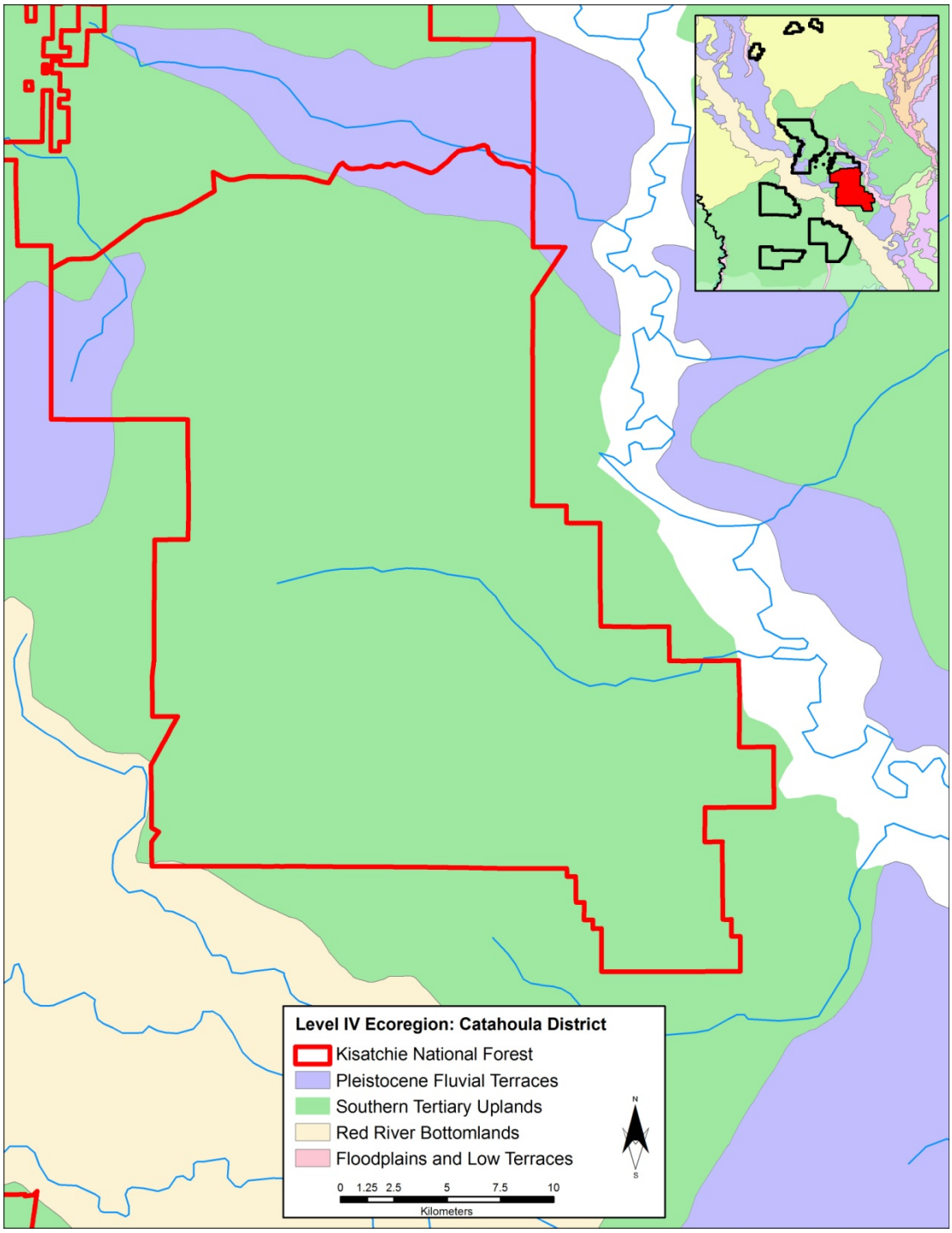


Figure 1.11. Level IV Ecoregion coverage for Catahoula District (Daigle et al. 2006; US Environmental Protection Agency; GIS data available at http://www.epa.gov/wed/pages/ecoregions.htm).

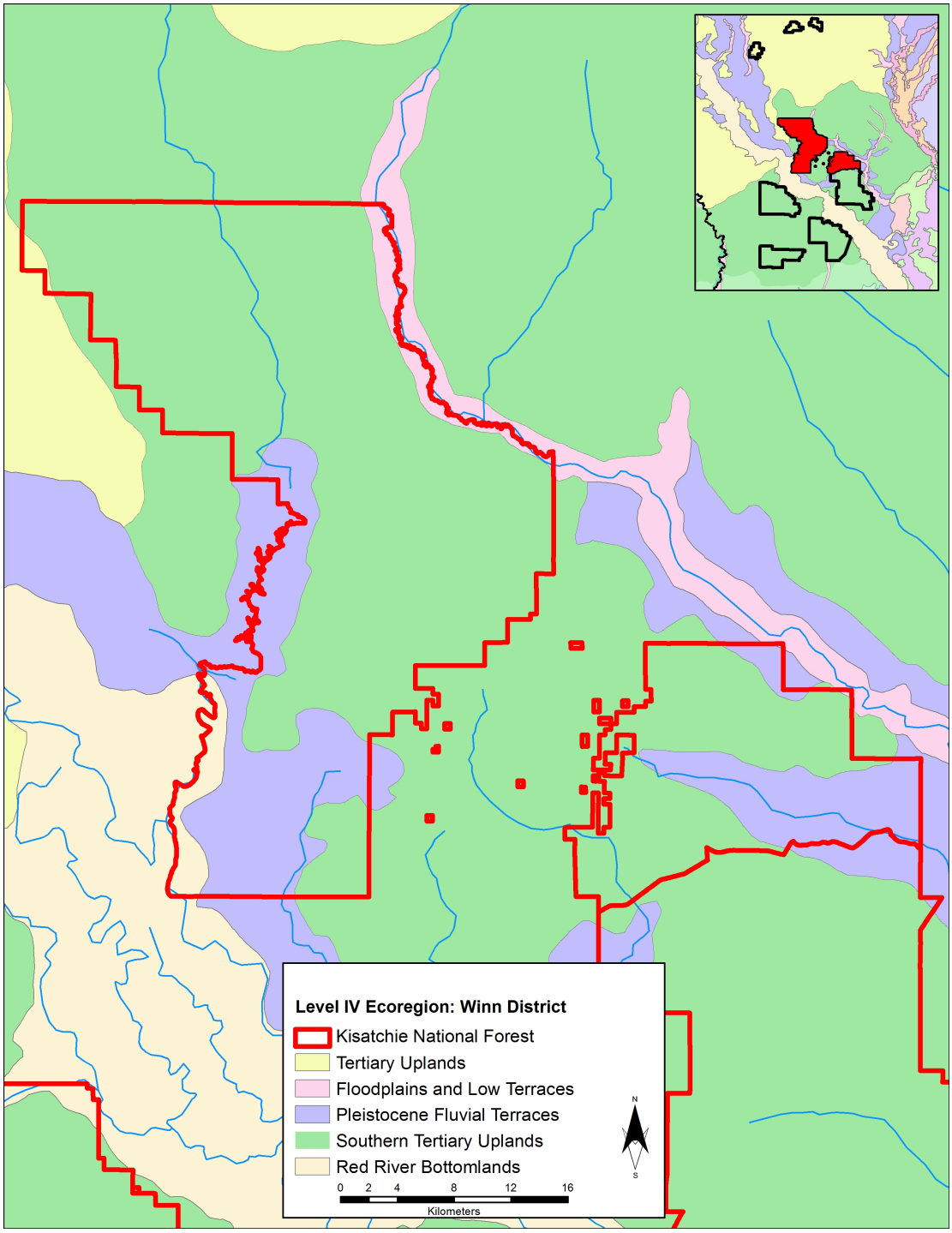


Figure 1.12. Level IV Ecoregion coverage for Winn District (Daigle et al. 2006; US Environmental Protection Agency; GIS data available at http://www.epa.gov/wed/pages/ecoregions.htm).

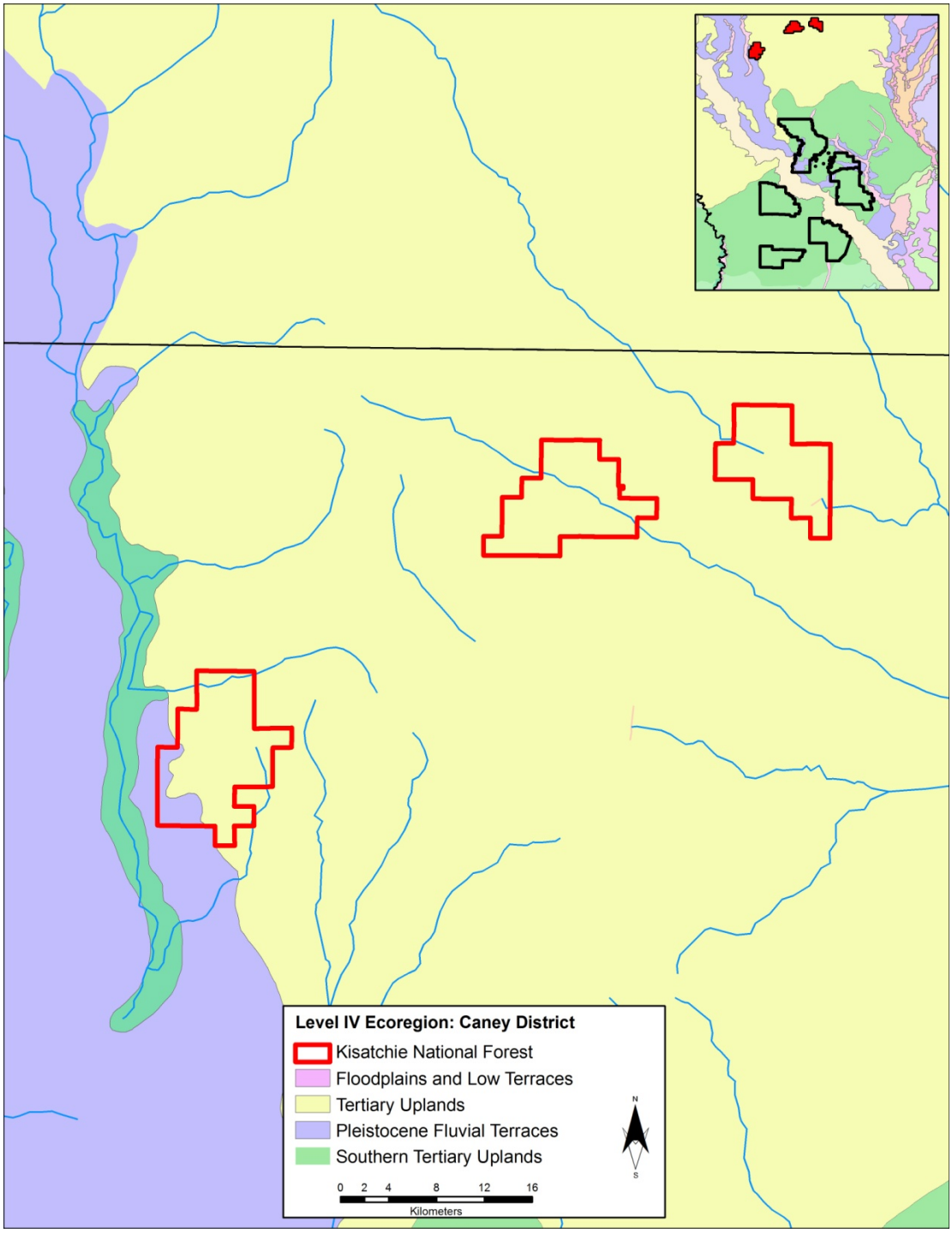


Figure 1.13. Level IV Ecoregion coverage for Caney District (Daigle et al. 2006; US Environmental Protection Agency; GIS data available at http://www.epa.gov/wed/pages/ecoregions.htm).

diversity between the different Level IV ecoregions is expressed in general diverging trends relating to geology, botany, and soils (Omernik 1987, 1995; Wiken 1986).

The Southern Tertiary Uplands (Omernik 1987) represents a hilly and well-drained region as a result of its Tertiary geology. The Ultisols and Alfisols soils that characterize the uplands are formed in humid climates and are mineral heavy with silt loam to loamy sand textures (Steila and Pond 1989: Chapter 10). The high basic saturation level of Alfisols suggests high soil fertility whereas the absence of a supply of bases results in the infertile nature of Ultisols suggesting varying soil quality across the ecoregion based on drainage (Steila and Pond 1989). Longleaf pine-bluestem woodlands comprise the majority of the historical vegetation of the Southern Tertiary Uplands region, and helped create the timber industry that has operated in the region since the late nineteenth century. Other contemporary vegetation includes shortleaf pine-hardwood forests, calcareous forests, mixed hardwood-loblolly pine forests, and hardwood-dominated forests near streams. Occurring in association with rare soil and geological outcrops, several rare vegetation communities exist. Isolated prairies with rare plants species occur in areas of calcareous clay soils while American beech or magnolia-beech-loblolly pine forests occur among the more common mesic localities within the Southern Tertiary Uplands. Acid bog species including southern sweetbay, gallberry, wax-myrtles, fetterbush, insectivorous plants, orchids, and wild azalea appear along seeps in sand hills.

Similar to the Southern Tertiary Uplands region in its geological and soil composition, the *Tertiary Uplands* (Omernik 1987) contain a variety of habitats and species including many of the state's rare plant and animal species. Native species of shortleaf pine-hardwood have largely been replaced by commercial pine plantations. Other native tree species include loblolly pine, southern red oak, post oak, black oak, white oak, hickories, and sweetgum with understory species consisting of American beautyberry, sumac, greenbriar, and hawthorn. Areas containing sandier soils possess more bluejack oak, post oak, and stunted pines. Numerous small waterways dissect the Tertiary Uplands with stream flow decreasing in summer and fall. Climatically, the region tends to produce less annual precipitation, marking it as one of the driest regions in Louisiana.

The Pleistocene Fluvial Terraces region (Omernik 1987) contrasts the gentle rolling landscape of the Southern Tertiary Uplands and Tertiary Uplands regions due to its flat topography and poorly-drained soils—Alfisols and Ultisols with loamy and sandy textures. Variation in the terracing occurs with the lowest terrace being extremely flat with greater clay concentration and extensive hardwood wetlands accustomed to the hydroxeric regime. Higher terraces, exhibiting greater geological antiquity as compared with the lower terraces, are more dissected with less wetlands. The higher terraces contain either pine flatwoods or mixed pine and oak forests. The midlevel terrace is a hybrid of the lower and upper with significant loess deposits.

The Red River Bottomlands region (Omernik 1987) follows the Red River and its broad bottomlands, including the floodplain and low terraces. Accompanying the

Red River channel are numerous backswamps, oxbow lakes, meander scars, and ridges. Clayey and loamy, reddish-brown, neutral to calcareous surfaces form the well to poorly drained Holocene alluvium. Major native trees of the bottomlands include water oak, sweetgum, willow oak, overcup oak, Nuttal oak, honey locust, water locust, river birch, red maple, green ash, and American elm. Cropland now dominates this region though poorly drained areas remain native woodland refuges. Prior to its damming, the waters of the Red River transported large loads of silt, producing an extremely turbid waterway.

The Floodplains and Low Terraces region (Omernik 1987) is remarkably similar to the Red River Bottomlands region both in terrain and inhabiting species. In addition, bald cypress and water tupelo are found in semi-permanently flooded areas, which provide an important habitat for a diverse variety of fish and wildlife. Soils are somewhat poorly drained to very poorly drained and comprised of Alfisols, Inceptisols, and Entisols.

Archaeological Context

The prehistoric record of the Kisatchie National Forest follows a temporal framework extending from the Paleoindian period to Protohistoric times. Recent summaries of the local cultural sequence (e.g., Anderson and Smith 2003:349-399; Avery 2010; Gibson 2010; Girard 2010; Hayes and Weinstein 2010; Lee 2010; Mann 2010;

McGimsey 2010; Morehead et al. 2002:18-19; Rees 2010b, 2010c; Roe and Schilling 2010; Saunders 2010; Thomas et al. 1997:13-14) have covered this ground in great detail; hence, the local cultural sequence is only briefly summarized here. The formation of a local archaeological sequence was first proposed by Campbell and Weed (1986) from evidence collected at Fort Polk Military Base. The local culture history sequence (Table 1.3) was later revised by Campbell et al. (1987), and again through the production of the Fort Polk Preservation Plan (HPP) (Anderson et al. 1988; Anderson and Smith 1999, 2003), which thoroughly synthesized the existing literature for the region of western Louisiana. Other more limited local sequencing efforts include Survello and colleagues (e.g., Servello 1983:161-168), Gunn and Kerr (1984), and Cantley (1984:256-262). These efforts, beginning in the mid-1980s and continuing through the present, alleviated a growing need for archaeologists to move beyond discussing a regional cultural framework and instead report at a local and detailed level.

Table 1.3. Western Louisiana Cultural Sequence in Calendrical and Radiocarbon Time (Anderson and Smith 2003:332 Table 6.1; calibrations from Struvier et al. 1998).

Calendrical (dates approximate)	Radiocarbon rcbp	Period	Culture (Phase)	Diagnostic Artifacts	Climatic Event
0 B.P./A.D. 1950	50	Modern	Industrial Revolution	Glass, Nails, Forged Metal Herty cups	Pronounced Warming
298 B.P./A.D. 1652	250	US National			Little Ice Age Ends
			European Colonization		Neo-Boreal
524 B.P./A.D. 1426	500		(Belcher Focus)	Belcher Ridged	
ca. 595 B.P./A.D. 1355	600	Caddoan/ Mississippian	Caddoan/Plaquemine		
672 B.P./A.D. 1278	750		(Bossier Focus)	Bossier Brushed	Little Ice Age Begins
694 B.P./A.D. 1256	800				
790 B.P./A.D. 1160	900		Coles Creek		Medieval Warm Period/ Neoatlantic
929 B.P./A.D. 1021	1000	Late Woodland	Early Caddo (Alto Focus)	Davis Incised, Kiam Incised, Dunkin Incised, Crockett Curvilinear Incised Alba points	
953 B.P./A.D. 997	1050				
ca. 1020 B.P./A.D. 930	1100		Coles Creek (Holly Springs)	Coles Creek Incised, French Fork Incised	
ca. 1130 B.P./820 A.D.	1200				
1261 B.P./A.D. 689	1300			arrow points (<1300 B.P.)	Scandic
1298 B.P./A.D. 652	1400				
ca. 1366 B.P./A.D. 583	1500		Troyville/Baytown	Churupa Punctate? Baytown Plain, *var. Satartia*	
1520 B.P./A.D. 430	1600				
ca. 1590 B.P./A.D. 360	1700	Middle Woodland		Marksville Incised, vars. *Leist, Yokena, Spansh Fort*	
ca. 1712 B.P./A.D. 238	1800		Marksville (Whisky Chitto)	Marksville Incised, Marksville Stamped	
ca. 1940 B.P./A.D. 10	2000				
ca. 2215 B.P. /265 B.C.	2200				
ca. 2584 B.P./ 635 B.C.	2500	Early Woodland	Tchefuncte	Tchefuncte Plain	Sub-Atlantic
ca. 3185 B.P./1235 B.C.	3000	Late Archaic	Poverty Point		
ca. 3770 B.P./1820 B.C.	3500		(Leander)	Motley, Epps points	
ca. 4477 B.P./2528 B.C.	4000		(Birds Creek)		Sub-Boreal
ca. 5122 B.P./3172 B.C.	4500			Birds Creek points	
5728 B.P./3779 B.C.	5000	Middle Archaic	Watson Brake		
6291 B.P./4342 B.C.	5500		(Sixmile)		
ca. 6809 B.P./4861 B.C.	6000		Big Creek Culture	Evans points	Atlantic/ Hypsithermal
ca. 7807 B.P./5857 B.C.	7000		(Kisatchie)	Sinner points Johnson/Bulverde points?	
ca. 8876 B.P./6926 B.C.	8000	Early Archaic	?		Cold Episode
10,189 B.P./8240 B.C.	9000		(Anacoco III)		
ca. 10,715 B.P./8765 B.C.	9500		Corner Notched Horizon	San Patrice, *var. Keithville*	Boreal
ca. 11,250 B.P./9300 B.C.	9900		(Anacoco II) Early Side Notched Horizon		
ca. 11,450 B.P./9500 B.C.	10,000	Late Paleoindian		San Patrice, *var. Dixon*	
ca. 11,850 B.P./9900 B.C.	10,200		(Anacoco I)	San Patrice, *var. St. Johns*	Younger Dryas ends
ca. 12,500 B.P./10,550 B.C.	10,500		San Patrice/Dalton	San Patrice, *var. Hope*	
12,900 B.P./10,950 B.C.	10,800				Younger Dryas begins
13,000 B.P./11, 050 B.C.	11,000	Middle Paleoindian	Clovis	Clovis points	Intra-Allerød cold period
13,450 B.P./11, 500 B.C.	11,500				Allerød
14,065 B.P./12,115 B.C.	12,000	Early Paleoindian	Pre-Clovis	?	Bølling-Allerød Warm Period
14,750 B.P./12,800 B.C.	12,500				Bølling

Paleoindian

The Paleoindian period (>11,450 cal B.P.) in Louisiana and the surrounding greater region follows a tripartite division of Early, Middle, and Late, a sequence that has been previously synthesized (e.g. Anderson 1990, 2001; Anderson and Sassaman 1996; Rees 2010b; Story 1990). Western Louisiana contains an abbreviated Paleoindian record relative to other temporal periods. There are no Early Paleoindian (pre-Clovis) assemblages located in this region and only limited assemblages for Middle and Late Paleoindian. Following the Last Glacial Maximum (LGM) at 22,000 year ago, lower sea levels at 125 meters below modern sea level exposed greater expanses of land with the Pleistocene shoreline approximately 200 km south of modern Louisiana shoreline (Saucier 1994). Early settlers may have exploited this now submerged landscape. Although the Paleoindian period receives less attention in Louisiana relative to later periods, several individuals have conducted considerable Paleoindian research within the state as a product of both state- and federally-funded research as well as academic synthesis (i.e. Campbell and Weed 1986; Hillman 1990; Moorehead et al. 2002; Rees 2010b; Saucier 1994).

The Middle Paleoindian period is recognized most notably by the occurrence of lanceolate Clovis fluted projectile points, which represent the earliest well-documented human settlement in Louisiana. The distribution of Clovis technology is consistently found across the continent during and just after the Inter-Allerød Cold Period at ca. 13,400-13,100 cal B.P. before being replaced by various subregional

traditions soon after the start of the Younger Dryas at ca. 12,900 cal B.P. (Anderson and Smith 2003:350; Waters and Stafford 2007).

Settlement patterns of Clovis peoples have been inferred from projectile point distribution on the continental level by scholars namely through the use of the Paleoindian Database of the Americas (PIDBA) (Anderson et al. 2010). The density of the data suggests that staging areas along the major rivers of the Midsouth and Midwest—rich in biotic resources—facilitated the expansion of Clovis peoples (Anderson 1990:187-189, 1996:34-39; Dincauze 1993:51-56). The Clovis population is characterized as highly mobile, egalitarian hunter-gatherers operating in bands that ranged over large distances and targeted a variety of biota, including megafauna. Louisiana lacks direct evidence of mastodon and *Bison antiquus* human kill sites found in surrounding states, yet megafauna remains are found across the state (Rees 2010b; Rice 1981). Gagliano's (1967) work at Salt Mine Valley on Avery Island in south central Louisiana has exposed deeply stratified Paleoindian sites along with fossilized remains of megafauna.

The Clovis tool kit contains some of the most sophisticated stone tools ever produced in prehistoric North America with fluted lanceolate projectile points as well as uniface tools (Goodyear 1979). While a systematic state-wide point database is absent for Louisiana, and therefore the Paleoindian record within the state as a whole is ambiguous, there is evidence of Clovis activity within Louisiana. Many of the earliest sites within Louisiana may remain in deeply buried or submerged contexts (Rees 2010b).

The Late Paleoindian period represents regional and subregional cultural traditions as opposed to the ubiquitous Clovis tradition. Coinciding with the start of the Younger Dryas cooling period from ca. 12,900 to 11,650 cal B.P., the diverse Late Paleoindian toolkit suggests a technological shift to focus on a wider breadth of available resources and a reliance on foraging in response to a rapid climatic reversal and a growing familiarity with local environments (Anderson and Smith 2003; Cable 1982, 1996; Jennings 2008; Meltzer 1984, 1988; Morse 1997). Examining the distribution of projectile points by lithic raw material within the PIDBA dataset, a range contraction appears to occur between Clovis and post-Clovis variants in the Southeast (Anderson et al. 2010; Johanson et al. 2010). This pattern indirectly suggests a greater isolation of existing populations, allowing for a cultural shift towards unique subregional traditions, such as that expressed by the Dalton and San Patrice cultural phases and their variations across the Southeast (Table 1.3; Anderson and Smith 2003:348; Coe 1964; Driskell 1996; Jennings 2008).

Archaic

The Archaic period, spanning from ca. 11,450 to 3,200 cal B.P. in the Southeast, has been generalized as a transitional stage of peoples adapting from a mobile, egalitarian lifeway to a more organizationally complex and possibly hierarchical society situated within a warming Holocene environment (Anderson and Sassaman 1996, 2004; Anderson et al. 2007; Kidder and Sassaman 2008; Sassaman and Anderson 1995, 1996, 2004; Saunders 2010; Smith 1986; Steponaitis 1986).

Similarly divided as the Paleoindian and following periods, the Archaic Period has Early (11,450 to 8,900 cal B.P.), Middle (8,900 to 5,700 cal B.P.), and Late (5,700 to 3,200 cal B.P.) sub-periods. The change from a mobile, generalized exploitation strategy utilized during the Early Archaic, to a more sedentary and selective exploitation strategy of the Middle Archaic is visible archaeologically within sites in Louisiana and across the region.

The Early Archaic period (11,450 to 8,900 cal B.P.) is recognized archaeologically by the Early Side-Notched points classified locally as Big Sandy and San Patrice *var. Dixon*—continuing from the Late Paleoindian period—as well as by the Corner-Notched points such as San Patrice *vars. Keithville and Leaf River*, Palmer, and Kirk, which replace the side-notched tradition after approximately 10,700 cal B.P. (Anderson and Smith 2003:366). The quality of the lithic raw material used in tool manufacture decreases during the Early Archaic as small bands exploited reduced ranges while utilizing more diverse resources on the landscape (Anderson 1996:160-16; Rees 2010b)

In eastern North America, the Middle Archaic period represents a major cultural shift in organizational structure and social interaction. It is during this period that ceremonial shell and earthen mound works were first constructed, long distance regional exchange networks formed, new tool forms were adopted, and evidence appears for increased violence (Anderson and Smith 2003:369; Russo 1994; Sassaman and Anderson 1996; Saunders 2010; Smith 1986). While there is a general trend for increased social organization during the Middle Archaic, smaller organized

foraging bands still persisted primarily within a geographically marginal context. Paleoenvironmnetal change (i.e. Hypsithermal, Altithermal) and its effects on the landscape dynamics of inhabiting populations is often given credence as a major factor in the origins of complexity, despite hunter-gatherers being less susceptible to that change than later agriculturalists (Gamble 2005:93).

The archaeological record of the area surrounding the Kisatchie National Forest suggests it was peripheral to the areas of primary settlement and regular use by prehistoric populations during this time (Anderson and Smith 2003:369). An alternative explanation for the local record favors undetected deeply stratified Middle Archaic deposits as a result of the circumscription of Middle Archaic peoples to a more favorable riverine setting. The emphasis on lowlands is a response to the environmental expression of the Hypsithermal during which the uplands are assumed to have become less favorable for human settlement due to heightened temperatures and changes in rainfall (Brown 1985; Sassaman 1995:182). Evidence for increased settlement permanence in the form of larger sites, midden deposits, storage pits, prepared surfaces, and formalized burials and cemeteries occurs at greater frequency in the eastern portion of the state, where Watson Brake, among other large Middle Archaic sites, has been recorded (Russo 1994, 1996; Sassaman and Anderson 2004; Saunders 2010; Saunders et al. 2005). Recent models have suggested that the layout of these mound sites may have made use of a common architectural grammar and measurement system, given the similarities that have been observed (e.g. Clark 2004; Sassaman and Heckenberger 2004). With the examination of the mound groups in eastern Louisiana, archaeologists began to recognize more sites in western Louisiana

of similar antiquity containing Middle Archaic Sinner and Evans points (Russo 1996; Saunders and Allen 1997).

Technologically, stemmed hafted bifaces in the form of Sinner and Evans points replace the corner notched points of the late Early Archaic. Sinner points, speculated to be an initial Middle Archaic type, date widely from ca. 9500 to 7800 cal B.P. (Thomas et al. 1997:25). Distinguished by a short broad stem with the presence of two or more pairs of notches above the shoulders that could also be considered deep serrations, Sinner points resemble Kirk Stemmed and Kirk Serrated points, which are not local to this area (Morehead et al. 2002). Temporally proceeding Sinner points, Evans points display a similar morphology with the presence of deep single notches on either side of the blade as a defining characteristic (Morehead et al. 2002). Restricted to Louisiana and southern Arkansas, Evans points provide an important link to the Middle Archaic mound sites in northeastern Louisiana and date from ca. 6000 and 5000 cal B.P. (Anderson and Smith 2003:372; Saunders and Allen 1997).

The Late Archaic period (5700 to 3200 cal B.P.) represents the stabilization of climatic and environmental parameters that carry over to present time. Modern values of temperature, precipitation rates, sea and lake levels, and vegetation communities are approached during the onset of the Late Archaic. The distinctive characteristics of the Middle Archaic proceed at a larger scale including greater mound building, long-distance exchange, and expanded warfare. Such traits are exemplified within the great mound sites of eastern Louisiana including Poverty

Point, Stallings Island, Indian Knoll, and Old Copper, while other sites are discovered in all parts of the landscape suggesting an intensification of human population (Anderson 1996; Gibson 2010; Griffin 1967; Smith 1986).

Two Late Archaic phases have been identified in west-central Louisiana including a range of dart point types, baked clay objects, and bannerstones (Anderson and Smith 2003:377; Morehead et al. 2002). The Birds Creek phase follows the Evans culture of the Middle Archaic with the Dooley Branch point cluster appearing at the end. Unifaces, ground stone tools, and baked clay objects complete the known assemblages in the area. The Leander phase exhibit several point types including Motley, Epps, Delhi, Gary, Kent, and Calcasieu, with bifaces commonly representing formal tools though ground stone is present (Morehead et al. 2002). Sandstone manos and metates have been discovered at sites in the region suggesting plant processing, but this activity appears to be occurring at a limited level due to the paucity of these artifacts and the lack of evidence for Eastern Agricultural Complex domesticates (Morehead et al. 1995). The proximity of the Kisatchie National Forest to the Poverty Point complex in northeast Louisiana and the possible relationship between these peoples has not fully been explored, though it has been proposed that the Kisatchie National Forest area served as a procurement ground for lithic materials and other resources (Anderson and Smith 2003:382).

Woodland

The Woodland period (3200 to 1000 cal B.P.) across the Eastern Woodlands sees the widespread adoption of domesticated plants, pottery, and burial mounds, along with a continuance of many Late Archaic practices (Anderson and Mainfort 2002; Russo 1994; Saunders et al. 2005; Smith 1986; Steponaitis 1986). The sub-periods of Early, Middle, and Late Woodland are defined largely by ceramic types, which locally in western Louisiana remain to be fully distinguished (Hays and Weinstein 2010).

The Early Woodland period (3200 to 2200 cal B.P.) in Louisiana follows the collapse of the Poverty Point complex, which may be related to the effects of the Sub-Boreal climatic episode in Eastern North America. This climatic episode represents two short-term cold events in relatively quick succession to one another, some two to three centuries apart (Anderson 2001; Fiedel 2001). While the Sub-Boreal episode likely stressed the environment, its effect alone was likely insufficient enough to cause the collapse of such a complex society.

Locally, the Tchefuncte culture corresponds to the Early Woodland period and is characterized by plain and incised ceramics with a temperless, laminated paste along with notched rims (Anderson and Smith 2003:383; Hays and Weinstein 2010). Birds Creek and Dooley Branch cluster points, along with Godley and Gary points, are often associated with Tchefuncte ceramics (Morehead et al. 2002). Tchefuncte culture surrounding the Kisatchie National Forest area needs to be compared and

related to the more visible Tchefuncte culture along the Gulf Coast. The connection between these two areas is still not clear and needs to be explored further.

The Middle Woodland period (2200 to 1600 cal B.P.) is a period of climatic stability, which, as suggested by Griffin (1960, 1961), may have facilitated the beginnings of Hopewellian iconography and exchange due to food surpluses as a direct result of the moderate conditions. Marksville Stamped and Incised ceramics denote the early Middle Woodland while the Baytown and Troyville cultures and their Baytown Plain and Mulberry Creek Cord Marked grog-tempered pottery denote the later Middle Woodland and into the Late Woodland (Kidder 2002; McGimsey 2010).

The small number of Marksville ceramics found in the vicinity of the Kisatchie National Forest and Fort Polk Military Reservation suggests some level of interaction for the area with respect to the Hopewellian Interaction Sphere (Anderson and Smith 2003:386; Caldwell 1964). The small number of Marksville and Mulberry Creek Cord Marked ceramics suggests that the area staged limited foraging or resource procurement activities as opposed to permanent or frequent settlements during the Middle Woodland.

The Late Woodland period (1600 to 1000 cal B.P.) represents a time where the global temperature decreased slightly preceding the agriculturally advantageous Medieval Warm Period (Anderson 2001). Intensive maize agriculture occurs elsewhere in the Eastern Woodlands, but limited evidence for this activity occurs in the Kisatchie National Forest, likely due to the poor soil characteristics of the region.

The archaeological expression of this period in western Louisiana is represented by the continuation of the Troyville culture from the later Middle Woodland period and eventually after 1300 cal B.P., by the emergence of the Coles Creek and early Caddo cultures (Anderson and Smith 2003:389; Kidder 2002; Lee 2010).

The Late Woodland is recognizable by grog-tempered or grog-and-sand tempered ceramics. The assemblages in western Louisiana contain Chevalier Stamped, Coles Creek Incised, Evansville Punctated, French Fork Incised, Mazique Incised, and Pontchartrain Check Stamped ceramics with Caddo equivalents reported as Dunkin Incised/Mazique Incised, Davis and Kiam Incised/Coles Creek Incised, or Wilkinson Punctated/Evansville Punctated (Anderson and Smith 2003:390; Roe and Schilling 2010). During this sub-period, the advent of the bow and arrow occurs with several arrow point types associated with both the Late Woodland and Caddo/Mississippian periods such as the Alba, Catahoula, Hayes, Friley, Scallorn, and Colbert types. The Iatt Lake Bluff Site, a Late Woodland site that has been nominated to the National Register of Historic Places, provides evidence of long term habitation, food gathering, processing, and storage in the Catahoula ranger district (Mayer 1996).

Mississippian/Caddo/Protohistoric

The Mississippian/Caddo period (1000 to 200 cal B.P.) in the Southeast corresponds with the advent of full-scale maize agriculture and sedentary village life. Mississippian/Caddo cultures are characterized as emerging in river valleys and

rapidly expanding and forming complex social networks. The Caddo culture, likely emerging from Coles Creek (Smith 1990), follows this trend from its origins in the Red River Valley of northwestern Louisiana and subsequent expansion throughout the state of Louisiana. The Mississippian culture emerged and expanded from the central Mississippi Valley and reached the Lower Valley as a local variant classified as Plaquemine, which is minimally expressed in western Louisiana (Rees 2010c; Rees and Livingood 2007). This period of complexity and expansion likely corresponded to a population increase prior to the onset of the Little Ice Age around ca. A.D. 1300, which would have caused unfavorable agricultural conditions leading to increased warfare and settlement nucleation (Griffin 1961; Milner 1999).

Caddo assemblages are distinguished on the basis of the presence of Harrison Bayou Incised, L'Eau Noire Incised, Mazique Incised *var. Manchac*, and Coles Creek Incised *var. Hardy* along with Alba, Bassett, and Bayougoula Fishtailed points (Morehead et al. 2002). Several local sequences have been established, beginning with the Caddo Alto focus, which principally includes Alba projectile points and Crockett Curvilinear Incised, Davis Incised, Dunkin Incised, Hickory Fine Engraved, Kiam Incised, and Pennington Punctated-Incised ceramics (Morehead et al. 2002:18, 56). Following the Alto focus and dating between ca. A.D. 1300 and 1500 (Story 1990), the Caddo Bossier focus assemblages are identified by Bossier Brushed, Pease Brushed-Incised, and Karnack Brushed-Incised ceramics along with Bassett, Alba, Bonham, Fresno, Hayes, and Perdiz points (Morehead et al 2002). From ca. A.D. 1500 to 1700 (Story 1990), the Caddo Belcher focus appears archaeologically and is

recognized by Belcher Ridged pottery and Bassett points, which become more dominant following the Bossier focus (Anderson and Smith 2003:394).

Whether Caddo people lived a sedentary village life year round is uncertain, though it has been suggested that populations may have seasonally relocated on the landscape for agricultural or winter hunting activities (Jackson 1984). Another interpretation of the archaeological record of the area around the Kisatchie National Forest was that the area was largely abandoned at this time, and served as a buffer between Caddo and Mississippian populations (Campbell et al. 1987).

European contact with the prehistoric peoples of Louisiana occurred in 1542 when members of the De Soto expedition encountered Caddo peoples in the northwestern portion of the state (Anderson and Smith 2003:394). Numerous Caddo groups resided in the western portion of the state in ca. 1700, including the Caddo Adai, Doustini, Natchitoches, Ouachita, and Yatasi (Kniffen et al. 1987). These populations were greatly reduced due to disease, warfare, and relocation, though later other Native American groups migrated to this area (Kniffen et al. 1987). Historical observations suggest that quarrying activities in the Kisatchie area were still of primary importance to historic native populations (Swanton 1946).

Historic context

During the nineteenth and early twentieth century, Kisatchie National Forest lands and surrounding areas were heavily logged at the expense of the archaeological

record. Indeed, the act of harvesting timber along with the transportation of the timber out of the Forest produced adverse conditions for archaeological deposits occupying the upper soil horizons (Anderson and Smith 2003:23). A small portion (n = 328) of the 4,175 sites in the Kisatchie National Forest's GIS database are typed as historic only with another 31 sites typed as containing both historic and prehistoric content (datasets detailed in Chapters 3 and 4). The majority of historic artifacts on Forest land relate to the timber industry and often to the transportation of harvested timber out of the region. The opening of the Southern Pacific Railroad in 1881 following a lull in transportation as a result of the Civil War boosted the development of the lumber industry (Humphreys 1964). The Weeks Act of 1911 allowed for greater land expansion for the forested land and incorporated long-term planning efforts, which enabled the utilization of the Civilian Conservations Corps (CCC) and a forest conservation program (Humphreys 1964:355).

The historical record of the Forest includes the preservation of the Stuart Seed Orchard and facilities, constructed to aid in the reforestation of harvested swaths of the National Forest. The Stuart Seed Orchard was constructed by the CCC following the designation of the National Forest in 1930. More CCC related structures and camps are curated on the Forest along with historic homesteads of early European settlers in the New World (Humphreys 1964).

In addition to the timber industry or National Forest-related construction projects, plantations and early European outposts appeared along the major waterways of the region. The Spanish arrived in the northwest of the state in the

early 1700s and quickly adopted the indigenous dietary staple of maize (Avery 2010). The spread of European goods and technology followed. The exchange of cultural attributes between contacting groups is expected along with a continual increase in mixed heritage (Avery 2010:225; Jaffrey 2004:29).

Natchitoches, west of the Winn Ranger District and north of the Kisatchie Ranger District, played an important role in colonial politics between the Spanish, French, and indigenous Native Americans (Avery 2010; Mann 2010). Earlier French and Spanish settlements and outposts in Louisiana clustered in the east and south of the state along the Mississippi river.

Louisiana's early history is one of indigenous Native Americans, French and Spanish colonizers, and enslaved and displace Africans. Plantations provided the means for large scale agricultural crop production yet the record of African American slavery in the state is mostly concentrated to the southeast of the state where extensive archaeological research exists (Wilkie et al. 2010). The excavation of slave quarters in addition to prominent plantation structures reveals a deeper dynamic of early history in Louisiana.

Discussion

Several analyses of the region around Fort Polk (e.g. Ezell and Ensor 1999) suggest that longer-term occupations likely occurred during Late Paleoindian San Patrice and Middle Woodland times. In contrast, Middle and Late Archaic and Caddo

components appear directed to shorter-term hunting and/or lithic-procurement activities (Ezell and Ensor 1999:391). It does appear that the Kisatchie National Forest area throughout much of prehistory was lightly settled or visited, and served primarily as a continued lithic procurement area for the greater region. There should be an expectation for more extralocal raw material if this is the case, as prehistoric peoples entering the area for materials would likely discard exhausted tools, some of which should be extralocal. While this study did not make use of lithic source location data or artifact assemblage data by lithic material, future models will benefit from the inclusion of this data. Historical data emphasizes the importance of the major waterways in the Kisatchie National Forest region as transportation arteries and areas of settlement, suggesting a shared importance of distance to water with the prehistoric populations.

Chapter 2. Past Modeling in West-Central Louisiana

In an attempt to better understand past settlement systems, as well as better manage the cultural resources of major federal land holding agencies in the area, over the past three decades several prehistoric and historic site location or predictive models have been developed and implemented in west-central Louisiana. These were developed on both the Kisatchie National Forest and adjacent Fort Polk Military Reservation, as summarized in detail in a recent synthesis (Anderson and Smith 2003:114-240), upon which the present text draws heavily. This chapter briefly reviews these modeling efforts, including the 1995 Fort Polk Predictive Model that is currently employed on Kisatchie National Forest, with the goal of ascertaining how to effectively evaluate the current models and, if necessary, develop replacements.

Kisatchie National Forest Models

In the first cultural resource overview prepared for the Kisatchie National Forest, Keller (1984) called for the development of a predictive model to guide cultural resource work on the Forest. Within Keller's (1984) report, general trends of site distribution were noted with several landscape areas targeted as high and low probability zones. At that time, sites in the uplands were infrequent and typically spanned an area under 10 meters in diameter (Keller 1984). Distance to stream was considered germane to site distribution with little differentiation accorded to stream

rank, since some sites were located adjacent to spatially limited (i.e. unmapped) water sources (Keller 1984). This early observation of the importance attributed to distance to water has continued to be viewed as one of the most critical variables constraining settlement in the vicinity of the Kisatchie National Forest.

1980 KNF Predictive Model

The earliest predictive modeling of the Kisatchie National Forest was conducted by Hillman (1980) using a sample of 112 archaeological sites situated on some 4,000 surveyed acres. While only a small site sample, the coverage spanned several ranger districts and the results were used by the Forest for nearly two decades with minor revision. Hillman developed three major zones: (1) bottomland areas, (2) heavily dissected ridge lands, and (3) low rolling hills. High site density was attributed to the terraces in Zone 1 and throughout Zone 2, while Zone 3 was reported as low density. The inclusion and consideration of the variable extent of landscape dissection in this early model was used in the two ensuing predictive modeling analyses conducted on the Kisatchie National Forest later in the 1980s (Anderson and Smith 2003:165).

1986 KNF Predictive Model

A second predictive model, developed by Johnson et al. (1986:90-120) for the Kisatchie National Forest, examined the environmental characteristics of 146 site

locations found within 5,016 tornado-damaged acres surveyed in the Winn Ranger District (see also Anderson and Smith 2003:165-166). Three zones were defined: (1) low relief, gently sloping bottomland and immediately adjacent terraces, (2) low relief and slightly dissected ridgeland, and (3) highly dissected landscape (Johnson et al. 1986:14–15). The analysis showed a greater propensity for both historic and prehistoric sites to be located on the boundaries of these zones with site and isolated find densities per hundred acres varying from 2.87 for Zone 1, 1.76 for Zone 2, and 4.98 for Zone 3 (Johnson et al. 1986:90). This modeling effort made use of soil type as a predictor of site location. Difficulty in replicability, a critical factor in any modeling effort, occurred in objectively measuring the degree of dissection, something explicitly noted by the authors (Johnson et al. 1986:116).

1987 KNF Predictive Model

Willingham and Phillips (1987) developed a model that attempted to address the inherent issues of replicability of Hillman (1980) and Johnson et al. (1986) (Anderson and Smith 2003:166-168). Based on a survey of 15,387 acres across all five ranger districts in which 162 sites were found, three major physiographic zones were identified that largely followed the previous efforts: (1) bottomlands and adjacent terrace areas, (2) minimally dissected uplands, and (3) heavily dissected uplands. Variable site density was observed between the zones, with the highest densities found in Zones 1 and 3. Willingham and Phillips (1987), like Johnson et al. (1986), noted high frequencies of sites along transitional boundaries. Prehistoric sites

clustered at the interface of the bottomland and minimally dissected upland zones while historic sites occurred along the minimally dissected and heavily dissected upland interface zones.

Attempting to alleviate the shortcomings in regards to the replicability of previous modeling efforts (e.g. Hillman 1980; Johnson et al. 1986), Willingham and Phillips (1987) developed a system to consistently extract environmental zones. They used USGS 7.5-minute quadrangle sheets to determine drainage characteristics:

> The boundary used to separate Zone I from Zone II and III was the first contour line at the base of the first slope component above the bottomland as indicated on USGS topographic maps. Zones II and III were differentiated by the quantity of dissection as determined by drain frequency. Using a modification of Strahler (1957), dissection was measured by the number of drains that occur within a given quarter section. A mean value of dissection was then computed for each zone. For the purposes of this study, Zone II is characterized by <15 drains per quarter section and Zone III is distinguished by >15 drains per quarter section [Willingham and Phillips 1987:210].

The three defined zones correspond to bottomlands and adjacent terrace areas (all areas within 10 feet or one contour line of a marked watercourse); minimally dissected uplands (less than 15 mapped drains per 7.5-minute USGS quarter section); and heavily dissected uplands (greater than 15 mapped drains per 7.5-minute USGS quarter section) (Anderson and Smith 2003:167). Other variables examined were soil

type, slope percentage, elevation, distance to nearest permanent water source, elevation above the water source, and stream rank.

The findings for Willingham and Phillips' (1987:218) model indicate the importance of distance to water. Out of 162 sites, the majority (n=89 sites, 55 percent) occurred within 500 feet of a permanent water source. Nearly all the sampled sites (n=145, 89.5 percent) are located no more than 60 feet in elevation above permanent water with the highest proportion (n=61 sites, 37.6 percent) being between 20 and 40 feet above permanent water. Willingham and Phillips (1987:218) noted that the occurrence of sites potentially eligible for the National Register of Historic Places was indirectly proportional to distance from Zone 1, or the bottomlands and adjacent terrace areas.

Willingham and Phillips (1987) developed three probability zones based on observed site densities within and between the three zones:

High Probability:

Zone I *areas elevated above the floodplain.*

Zone III *areas within 500 feet of the nearest permanent water source; areas within 500 feet of Zone I.*

Moderate Probability:

Zone I *floodplain.*

Zone II — *areas within 500 feet of the nearest permanent water source; areas within 500 feet of Zone I.*

Zone III — *areas between 500 and 1000 feet of the nearest permanent water source; areas between 500 and 1000 feet of Zone I.*

Low Probability:

Zone II — *areas greater than 500 feet of the nearest permanent water source.*

Zone III — *areas greater than 1000 feet of the nearest permanent water source* [Willingham and Phillips 1987:220].

The high, medium, and low probability zones were implemented by the Forest Service for cultural resource management efforts for over a decade, until they were replaced with those developed with data from Fort Polk and portions of jointly administered USFS districts in the 1990s (Anderson and Smith 1999, 2003). The USFS adopted specific survey procedures for each zone. Survey in high-probability areas was conducted using linear transects spaced 50 m apart, with subsurface testing every 30 m along these transects. Moderate-probability areas were to be surveyed using transects spaced100 m part, with shovel tests placed every 50 m along these transects. Shovel testing was judgmentally employed in low probability zones on level areas or on crests (Anderson and Smith 2003:168; Phillips and Haikey 1992:13). Operational issues with the model occurred as field operators experienced difficulty in locating each zone, though this is a typical constraint of any modeling effort, albeit

one obviated to some extent by modern GPS and GIS technology. Additional difficulties occurred in operationalizing the data as outlined by the model, due to the difficult and time consuming nature of determining drains per quarter section of grid. Some of these early difficulties to the model were later rectified with *elevation above water* eliminated as a criterion for determining site probability zones (Phillips and Willingham 1990:22-23).

Fort Polk Predictive Models

As a result of the National Historic Preservation Act of 1966 and Executive Order 11593 there have been near continuous cultural resource surveys of Fort Polk's 139,000 acres (56,250 hectares) since the early 1970s (Anderson and Smith 2003). Fort Polk lies in close proximity to the Kisatchie National Forest, with the southern extent of the military reservation bordering the northern bounds of the Vernon Unit of the Calcasieu District (Figure 1.2). The intensive archaeological work conducted on Fort Polk, coupled with its location with respect to the Kisatchie National Forest, encouraged the evaluation and adoption of the archaeological site models developed on each. The current predictive model utilized by the Kisatchie National Forest was developed on the Fort Polk Military Reservation in 1995 and is an extension of the 1988 Fort Polk Predictive Model (FFPM). Anderson and colleagues (Anderson 1987; Anderson and Macek 1987; Anderson and Scheele 1993; Anderson and Smith 1999; Anderson and Wilson 1988; Anderson et al. 1988, 1996) developed both the 1988 and 1995 models. While the initial 1988 predictive model relied on hand-coding

environmental variables, the 1995 predictive model incorporated variables examined using variables defined using Geographic Information Systems (GIS) technology.

1988 Fort Polk Predictive Model

In development of the 1988 Historic Preservation Plan (HPP), a predictive model was created using 1,657 sites and isolated finds located on the U.S. Army's Fort Polk Military Reservation. The 1988 FPPM, as a non-GIS analysis (the installation GIS was not put in place until the following decade), coded environmental variables for each site by hand. The variables examined included drainage basin, landform type, elevation, distance to nearest water, stream rank of nearest water, type of nearest water, elevation above and distance to nearest permanent water source, distance to nearest confluence of two or more water sources, major soil association, soil series, specific soil type, slope of specific soil type, geological formation underlying the site, and site aspect among others (Anderson et al. 1988; Anderson and Smith 2003:174-185). Anderson et al. (1988) used a random sample of 363 points on the landscape against which to compare the site data. Relying to a large extent on USGS 7.5-minute quadrangle sheets and soils maps, modeling variables needed to be replicable and as such be fairly easy to delineate on maps. Variables based on distance to water, elevation to water, and flood zones proved both easy to locate and extremely effective as a probability indicator of site location. Anderson and Macek (1987) produced three cultural probability zones to

direct future archaeological survey efforts based on the available settlement patterns on Fort Polk. Defined zones of the 1988 Fort Polk Predictive Model are as follows:

Zone 1: *Site Probability Indeterminate/Medium Probability*

Areas occupied by the floodplain. Significant sites are likely to exist with survey results ambiguous.

Zone 2: *High Probability*

Areas outside of the floodplain category, but within 300 meters horizontal distance or 60 feet vertical distance from a USGS 7.5-minute quadrangle sheet mapped water source.

Zone 3: *Low Probability*

All other areas. Upland areas more than 60 feet above and 300 meters distance from a USGS 7.5-minute quadrangle sheet mapped water source.

The 1988 Fort Polk Predictive Model shaped subsequent archaeological surveys on the military reservation, at least until it was replaced in 1995. Recommendations developed from the model included level of survey intensity. The high and indeterminate (medium) probability zones received approximately three

times the number of shovel tests than the low probability zone or uplands isolated from water (Anderson and Smith 2003:225). The sampling parameters for the high and indeterminate (medium) probability zones directed shovel tests and transects spaced at 30-meter intervals while the low probability zone directed shovel tests and transects spaced at 50-meter intervals. The implementation of this model was found to be challenging as locating each zone on the ground proved difficult. Areas within 300 meters distance or 60 feet elevation of a mapped water source could not be ascertained with great reliability. For this reason, planning for a new model, as part of a revision to the 1988 HPP, was initiated in the early 1990s (Anderson and Scheele 1993). A simpler model with equal or greater effectiveness, it was thought, would be more useful to installation land managers and easier for archaeologists to use in the field.

The in-field testing of the 1988 Fort Polk Predictive Model (Table 2.1) produced favorable results for the distribution of sites located in the high and indeterminate probability zones with a few exceptions (Anderson and Smith 2003:227-229). Survey results from an isolated area of Fort Polk to the north, Peason Ridge, suggested significantly different settlement patterning from that on the Main Fort. On Peason Ridge, which intersects with the southwest corner of the Kisatchie Ranger District, a disproportionate number of sites were found in the low probability (Figure 1.2). Anderson and Smith (2003:228) address this issue in prediction accuracy between the Main Fort area and Peason Ridge, noting that the model was "slightly less accurate" in the latter area, but observed that the vast majority of all

sites and isolated finds did fall within the high and indeterminate probability zones in both the 1988 and 1995 Fort Polk Predictive Models.

Table 2.1. 1988 Fort Polk Predictive Model Field Test (data from Anderson and Smith 2003:227-229).

Project	% Prehistoric Sites/Isolated Finds	Report
Earth Search, Inc.		McMakin et al. 1994
High Prob Zone	67%	
R. Christopher Goodwin and Associates, Inc. Survey 14		Williams et al. 1994a
High Prob Zone	78%	
Ind. Prob Zone	14%	
Low Prob Zone	8%	
R. Christopher Goodwin and Associates, Inc. Survey 15		Williams et al. 1994b
High Prob Zone	67%	
Ind. Prob Zone	33%	
R. Christopher Goodwin and Associates, Inc. Survey 16		Williams et al. 1995a
High & Ind. Prob Zone	91%	
Low Prob Zone	9%	
R. Christopher Goodwin and Associates, Inc. Survey 17		Williams et al. 1995b
High & Ind. Prob Zone	97%	
Low Prob Zone	3%	
R. Christopher Goodwin and Associates, Inc. Survey 18		Williams et al. 1994c
High & Ind. Prob Zone	80%	
Low Prob Zone	20%	
Gulf South Research Corporation, Inc. Survey 4		Shuman et al. 1996
Low Prob Zone	45%	
Gulf South Research Corporation, Inc. Survey 5		Jones et al. 1996a
High Prob Zone	71%	
Gulf South Research Corporation, Inc. Survey 6		Jones et al. 1996b
High Prob Zone	61%	
Gulf South Research Corporation, Inc. Survey 7		Jones et al. 1997
High Prob Zone	82%	

1995 Fort Polk Predictive Model

The 1995 Fort Polk Predictive Model (FPPM) became the first technologically intensive modeling effort in the region. Through the use of a GRASS (Geographic Resource Analysis Support System) GIS based analysis, the replicability of the analysis and the availability of digital data layers of important environmental variables improved markedly. Along with a different medium for the analysis, the 1995 Fort Polk Predictive Model examined an updated sample containing 2,785 sites and isolated finds and 2,136 randomly generated points as opposed to the 1,657 sites and isolated finds and 363 random points processed for the 1988 Fort Polk Predictive Model (Anderson and Smith 2003:185-188).

The primary data used to develop the 1995 Fort Polk Predictive Model is recorded in the HPP Cultural Resources Inventory Primary Data volume (Anderson et al. 1999). The digital datasets analyzed in the 1995 modeling effort range from soils to elevation to geological formations (Anderson and Smith 2003:185-229). *Soil Type*, *Soil Slope*, and *Distance to Floodplain and Upland Soils* GIS data layers were derived where available from USDA Natural Resources Conservation Service (NRCS) maps at a 20-meter resolution, using Euclidean distance values where relevant. *Potential Maximum Soil Depth of Archaeological Components* was developed by the US Army Construction Engineering Research Laboratories (USACERL) to estimate depth to locate archaeological artifacts. The *Elevation and Aspect* GIS data layer combines 100-meter resolution digital terrain elevation data (DTED) from the Defense Mapping Agency with 30-meter resolution digital

elevation map (DEM) data from USGS 7.5-minute quadrangle sheets. The combination of the DTED and DEM data was due to a limited availability at the time for 30-meter DEM data. A similar usage of the DTED and DEM data along with a 20-meter streams map produced the *distance to nearest water body* where Euclidean distance values represented distance. The *Geological Formation* GIS data layer was a digitized representation of a local geologic map produced by Welch (1942).

Upon analysis of the assembled digital datasets, a familiar tripartite division of probability zones was produced and examined through a GIS. The 1995 Fort Polk Predictive Model zones are defined as follows:

Zone 1: *Site Probability Indeterminate/Medium Probability*

Floodplain areas. Defined as locations with floodplain soils by the Natural Resources Conservation Service.

Zone 2: *High Probability*

Areas within a 200-meter buffer of Zone 1 or within a 200-meter buffer of a mapped water source.

Zone 3: *Low Probability*

All other areas (i.e. uplands).

The two variables of *distance to nearest water* and *distance to floodplain* most significantly shaped the formation of these zones. Despite the technological advancement inherent within the 1995 Fort Polk Predictive Model, an emphasis on functionality and efficiency (i.e., archaeological field implementation) superseded the inclusion of many variables within the final model. Following a detailed examination of the utility of individual environmental variables, distance to mapped watercourses and floodplain soils were identified as critical in shaping site occurrence (Anderson and Smith 2003:185-226). Using the installation GIS, these variables were buffered at increasing 50-meter intervals and the numbers of sites and isolated finds recorded within the high probability zone. When the buffer exceeded 200 meters, there was no justifiable benefit given the amount of additional acreage this would include in the high probability zone (Anderson and Smith 2003:229-236). The analyses also documented the numbers of sites considered eligible, potentially eligible, or not eligible for inclusion on the National Register of Historic Places, since management practices differed for each category.

The 1995 Fort Polk Predictive Model proved better than the 1988 FPPM by increasing the proportion of archaeological sites within the high and indeterminate zones and reducing the total number encompassed by the low probability zone (detailed comparisons of the effectiveness of the two models on the Main Fort and Peason Ridge subareas were conducted by Anderson and Smith 2003:229-236). This was achieved while maintaining approximately similar acreage figures for the zones and increasing the functionality of the model or ease by which it could be employed

in the field. Using buffers around floodplains and mapped watercourses (Figure 2.1) allowed for a more effective demarcating of environmental variable compared to those employed in the 1988 FPPM, which included both distance to and vertical elevation above mapped watercourses or floodplain soils.

In-field testing of the 1995 Fort Polk Predictive Model showed the model to be extremely effective for both the Main Fort and Peason Ridge (Table 2.2; Anderson and Smith 2003:235-239). The majority of National Register of Historic Places (NRHP) eligible sites also occurred in the high probability zone (Ezell and Ensor 1999:340; this was for the 1988 and 1995 models over the entire base sample as of 1995 in Anderson and Smith 2003). Compared to previous models in the region, the 1995 Fort Polk Predictive Model had a comparable or better success rate for the high and indeterminate zones to encompass a significant site while more efficiently occupying less acreage. Relative to more complex models employing multivariate logistical regression (e.g., Perez and Bundy 2011), the Fort Polk 1995 Predictive Model emphasizes a simpler development methodology while emphasizing the logical inclusion of environmental factors that shaped past settlement patterning. The 1995 Fort Polk Predictive Model has been used by both the US Forest Service on the Kisatchie National Forest and on Fort Polk in west-central Louisiana from 1995 to 2011.

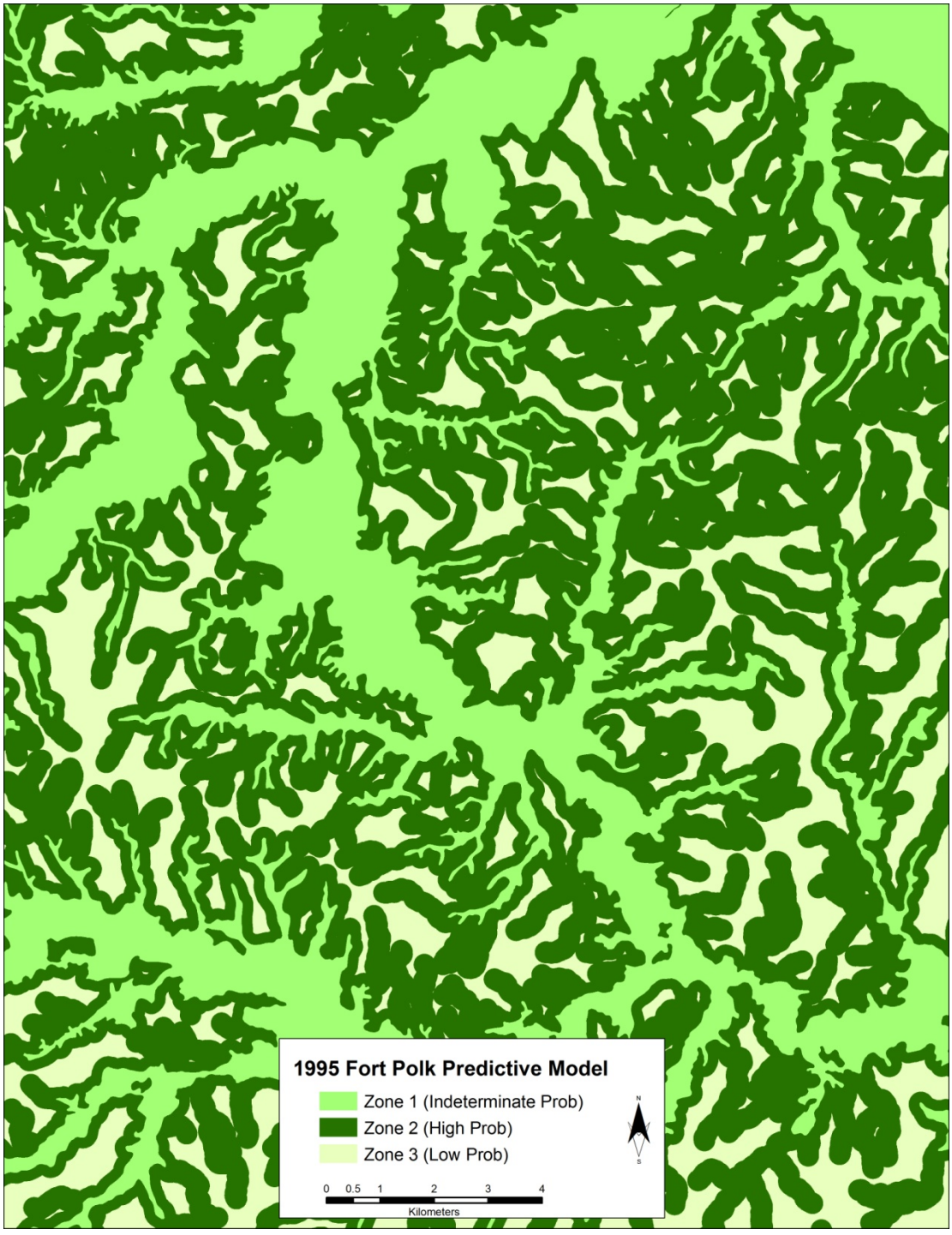


Figure 2.1. Example of the 1995 FPPM Division of Zones showing buffering of streams and floodplains.

Table 2.2. 1995 Fort Polk Predictive Model Field Test (data from Anderson and Smith 2003:235-238).

Project *(Area)*	% Sites	% Isolated Finds	Report
New South Associates, Inc. *(Main Fort)*			Cantley et al. 1997
High/Ind. Prob Zone	94%	86%	
SCIAA Survey *(Main Fort)*			Clement and Peterson 1998
High/Ind. Prob Zone	81%	81%	
TRC Garrow and Associates, Inc. *(Peason Ridge)*			Ensor et al. 1999
High Prob Zone	79%	86%	
TRC Garrow and Associates, Inc. *(Rustville Training Area)*			Ensor et al. 2001
High Prob Zone	97%	--	
Panamerican Consultants, Inc. Survey 1999-2000 *(Main Fort)*			Buchner and Saatkamp 2000
High Prob Zone	89%	58%	
Panamerican Consultants, Inc. Survey 2000 *(Main Fort/Limited)*			Buchner and Saatkamp 2001
High Prob Zone	100%	91%	

2006 Bogs and Seeps Model

A bogs and seep probability model (Ward and McCoy 2006) was developed for the Fort Polk Military Reservation. The model examines three factors to determine probability for seepage bog occurrence: (1) the underlying soil series, (2) the percent slope, and (3) the aspect of the location of known features. Perez and Bundy (2011) evaluated the model for prehistoric site occurrence on a limited study area of Fort Polk installation and concluded that it should not be included for models locating archaeological sites. The inclusion of wetlands as an evaluated environmental variable within Chapter 5 of this thesis showed extensive overlap

between the proximity of sites to wetland and the proximity of sites to frequently flooded soils. As the frequently flooded soils produced an easier to implement modeling variable, bogs and seeps were not evaluated within the development of the proposed model produced within this thesis.

2010 Fort Polk Predictive Model

In May 2011 a new predictive model was produced for the Fort Polk Military Reservation and nearby areas (Perez and Bundy 2011). The 2010 Prehistoric Model incorporated variables such as proximity to water, bogs and seeps, soil types, slope, and proximity to previously recorded prehistoric sites, and the scored vector layers unionized into a single category using ArcGIS 9.3 (Perez and Bundy 2011:63-67). A second model was produced for historic sites, using proximity to existing historic sites, and historic features digitized from maps (Perez and Bundy 2011:73-74). The two models are then overlaid to produce a single layer of high or low probability for the study area on Fort Polk.

The new model is challenging to compare as it produces two probability zones as opposed to the more traditional three. The authors argue that the new model performs more effectively than the 1995 FPPM, and is therefore recommended as a replacement. It should be noted, however, that the evaluation of the 1995 FPPM and the new model occurred using a limited study area, rather than the site and isolated find sample from the entire military reservation. The accuracy of the 2010 Model

will eventually need to be evaluated with respect to the entire military reservation. A criticism of the 2010 FPPM is the extremely large coverage area for the high probability zone, which accounts for up 80 percent of the land area within one study area (Perez and Bundy 2011:253, Table 14.3). A critical examination of model performance and in-field implementation between the 2010 FPPM and the proposed predictive model produced within this thesis is offered within the conclusion of Chapter 6.

Discussion

The models developed and used on the Kisatchie National Forest and Fort Polk over the past three decades have emphasized the critical importance of a number of environmental variables, notably distance to water, elevation above water, and soil characteristics. The probability zones outlined by the various models indicate how landscapes were used by past historic and prehistoric populations. Upland areas, away from major drainages, have lower frequencies of archaeological sites; where present, these sites are commonly considered to represent small, short-term, special-purpose occupations, probably as hunting or other short-term resource procurement or travelers' camps (Thomas et al. 1993d:179–180). These are inferred to be satellite camps to more permanent occupations located elsewhere, and as such have tended to occur in a wider variety of microenvironmental settings than larger, more permanent occupations. There also appears to be a decreased emphasis on proximity to water characterizes these smaller sites (Thomas et al. 1992:119). Larger settlements

concentrate within the bottomlands and, where found in the highly dissected uplands, distance to permanent water is a seemingly necessary prerequisite.

Like prehistoric sites, historic sites cluster around environmentally vital resources such as water. In addition, historic sites tend to cluster around roadways of appropriate age, though these are often difficult to ascertain. The environmental correlations for both prehistoric and historic sites are evaluated within Chapter 4, while the methodology used to do so is discussed within Chapter 3.

Chapter 3. Datasets and Methods

This chapter details the development and acquisition of the data used in the analyses described in subsequent chapters, as well as the methodology used to evaluate said data. The primary objective of the research undertaken here was to determine the success of the current archaeological predictive model for the Kisatchie National Forest study area (defined below as USDA-owned lands or culturally surveyed privately held lands within the Forest boundaries). The secondary objective, which proved merited, was to develop a new model for use on the Kisatchie National Forest. An additional tertiary objective was to evaluate the effectiveness of a single model for the entire forest as compared to multiple models encompassing different site types (i.e., historic, prehistoric) or Forest districts. A final objective was to evaluate the impact of varying dataset scales (e.g. 5-meter intervals vs. 30-meter intervals) for evaluating the environmental associations of known sites.

Analysis Study Area

As calculated within a GIS, the modern boundaries of the Kisatchie National Forest cover 416,057 hectares, yet 95.5 percent of all sites fall within a limited subset of the Kisatchie National Forest. In an attempt to avoid coverage bias within this analysis, the study area has been limited to USDA-owned lands or archaeologically

surveyed privately held lands. Tables 3.1 and 3.2 show that 54.2 percent (n = 2,263) of all sites occur on non-systematically surveyed lands (78.9 percent of the total area is non-surveyed with 65.5 percent of the USDA-owned lands non-surveyed). Therefore, the study area must include non-surveyed USDA-owned lands in addition to surveyed lands within the Forest. The derived study area covers 248,709 hectares or 59.8 percent of the area within the Forest boundaries (see Table 3.3).

Table 3.1. Kisatchie National Forest Ownership Areas and Surveyed Subsets.

Ownership	Area (m^2)	Area (hectares)	Area (acres)	% of Area
USDA	2459644657	245964	607792	59.1
surveyed	*759524920*	*75952*	*607792*	*18.2*
non-surveyed	*1700119737*	*170012*	*607792*	*40.9*
Private	1700926505	170093	607792	40.9
surveyed	*27444811*	*2744*	*607792*	*0.7*
non-surveyed	*1673481694*	*167348*	*607792*	*40.2*
KNF Total	4160571162	416057	1028100	100.0

Table 3.2. Sites by Surveyed or Non-Surveyed Area for the Entire Kisatchie National Forest Area.

	Area (m^2)	% Area	n sites	% sites
Surveyed	879025603	21.1	1912	45.8
Non-Surveyed	3284467747	78.9	2263	54.2
Total	4163493350	100.0	4175	100.0

Table 3.3. Study Area and Total Area on the Kisatchie National Forest with Number of Archaeological Sites.

	Area (m^2)	Area (hectares)	Area (acres)	% of Area	n of Sites
Study Area	2487089459	248709	614573	59.8	3986
KNF Total	4160571162	416057	1028100	100.0	4175

Archaeological Site Data

The location of archaeological sites within the state of Louisiana is managed by the State Site File Records. Some 4,175 sites from the vicinity of the Kisatchie National Forest are curated within Louisiana's database in the form of quad maps and site report forms as of February 2010. Sites within the modern boundaries of Kisatchie National Forest have been extracted from this database and represent either prehistoric, historic, unknown, or multiple component (both prehistoric and historic) occupations. Along with general temporal affiliation, eligibility to the National Register of Historic Places is an included field with 220 (5.3 percent) of the 4,175 sites judged eligible. The 4,175 sites located on the Kisatchie National Forest in total represent 2,367 prehistoric sites (56.7 percent), 327 historic sites (7.8 percent), 31 multiple component sites (0.7 percent), and 1,450 sites (34.7 percent) with unknown or unreported cultural affiliations.

Table 3.4. Site Types and National Register of Historic Places Eligibility by Temporal Category for the Kisatchie National Forest.

Site Type	n of sites	% of sites	NRHP eligible sites	NHRP % of sites
Prehistoric	2367	56.7	124	56.4
Historic	327	7.8	16	7.3
Multicomponent	31	0.7	8	3.6
Unknown	1450	34.7	72	32.7
Total	4175		220	

Greater temporal control of archaeological sites will aid future modeling efforts as patterns likely exist for the exploitation of the landscape within the prehistoric subset of sites. This is no small undertaking due to the enormous quantity of archaeological sites. The US Forest Service currently populates a relational database with assemblage data delineating temporal affiliation; however, this database exists for only a subset of the known archaeological sites. For this study, categories of prehistoric, historic, unknown, and multi-component were used for modeling purposes.

GIS Datasets

A majority of the digital environmental data pertinent to this study was provided by the US Forest Service in the form of polygon and line datasets (Table 3.5). This data was assembled and curated over numerous years and provides an extremely detailed digital representation of the Kisatchie National Forest with respect to environment, boundaries, and conducted archaeological work. Supplemental to the provided data, other digital datasets were incorporated into this study. Such independent variables include those related to the topography (e.g. DEM, LIDAR, DRG), the nature of the soil (e.g. slope, erosion, flooding, exposure), the hydrology (e.g. streams, rivers, lakes, wetlands), and the topology (e.g. distance to roads, property owners) along with additional digital datasets used for map display purposes only (Table 3.5). The elements of the digital dataset employed within this study are discussed explicitly within the following section.

Table 3.5. Digital Variables Used for Analysis Purposes with Source Information.

Variable Description	Type	Source
Soil Survey (texture, drainage, flooding freq.)	Polygon	NRCS - SSURGO database
Roadways (highway, all)	Line	Kisatchie NF GIS Data Server
Water Source	Line	Kisatchie NF GIS Data Server
Wetlands	Polygon	Kisatchie NF GIS Data Server
Ranger Districts	Polygon	Kisatchie NF GIS Data Server
Predicated Burns	Polygon	Kisatchie NF GIS Data Server
Ownership	Polygon	Kisatchie NF GIS Data Server
Elevation (DEM)	Raster (30m)	National Elevation Dataset
Elevation (LIDAR)	Raster (5m)	Atlas, Lousiana State University
Slope	Raster (5m, 30m)	
Aspect	Raster (5m, 30m)	
Distance to Soil Drainage Class	Raster (5m, 30m)	
Distance to Soil Flooding Frequency Class	Raster (5m, 30m)	
Distance to Stream Rank (1-9)	Raster (5m, 30m)	
Distance to Permanent Stream	Raster (5m, 30m)	
Distance to Seasonal Stream	Raster (5m, 30m)	
Distance to Wetland	Raster (5m, 30m)	
Distance to Road	Raster (5m, 30m)	
Distance to Highway	Raster (5m, 30m)	

All GIS datasets were projected to a NAD 1983 UTM Zone 15N coordinate system to ensure a standardized analysis. The data supplied by the US Forest Service includes polygons of ranger district boundaries of the Kisatchie National Forest, land ownership areas, cultural survey extent areas, prescribed forest burn areas, soil type areas, wetland margins, forest streams, and a road network dataset segmented by major and minor designations. These datasets provide the means to propose probability zones for past human settlement while also identifying inherent biases within the developed model. The GIS datasets supplied by the US Forest Service are

available online to the public through the Kisatchie National Forest webpage, which aids in the replicability of this study (http://www.fs.fed.us/r8/kisatchie/gis/).

Furnished as a single shapefile, the separate ranger districts of the Kisatchie National Forest were extracted to determine the model effectiveness for archaeological sites across the entire Forest as compared to subsets of ranger districts. The methodology employed and the evaluation techniques are discussed in the next section below. The GIS-calculated area of the entire Kisatchie National Forest is 416,057 hectares or 1,028,100 acres. Closely related to this data is the landownership dataset which classifies the land as private property (40.9 percent) or USDA owned property (59.1 percent). The spatial distribution of private and federal ownership is significant to the examination of the archaeological record of the Forest.

Culturally surveyed sections of the Forest are recorded as a series of polygons by US Forest Service personnel. These surveys are contracted to numerous cultural resource management (CRM) firms across the Southeast. The surveyed areas typically fall within the USDA ownership areas as only government owned lands require cultural resource management efforts. For the entire Forest, 18.9 percent has been surveyed with only a small percentage of that surveyed area overlaying private property (3.5 percent). The majority of known sites within the Kisatchie National Forest should be located within the culturally surveyed areas.

The study area for this analysis was assembled using the UNION function of the Analysis Tools toolset of ArcGIS to combine the USDA owned property with the culturally surveyed area overlaying private property. This USDA owned or culturally

surveyed subset of the entire Kisatchie National Forest accounts for 59.8 percent of the area while containing 95.5 percent of the reported archaeological sites. All analyses conducted utilize this subset or study area.

Predicated burns are a primary predicator of the discovery of archaeological sites. Through the removal of underbrush, the likelihood of locating archaeological sites is heightened both by increased visibility and increased erosion. Increased ground visibility enhances the ability to observe surface scatters of cultural remains. Erosional processes are accelerated in areas that have recently undergone a scheduled burning episode. Erosion is inextricably linked to site visibility as those sites on upland localities or along a sloping surface are affected by the loss of soil from runoff resulting in greater surface visibility. Conversely, sites located in bottomlands are preserved and rendered less visible through increased soil overburden. Additionally, bottomlands proximal to water courses experience alluvial deposition. The process of erosion and deposition is a primary consideration of site visibility and is more likely than past settlement patterning to limit the number of sites reported in the bottomland regions adjacent to major drainages and at relatively low elevations. Soil movements through erosion present a challenge to site preservation. Erosion also affects settlement decision making through soil characteristics such as drainage and texture.

County-level soil surveys are common and widely available in the United States through a multitude of federal and local agencies—namely the National Resource Conservation Service of the USDA. The Soil Survey Geographic Database (SSURGO; http://soils.usda.gov/survey/geography/ssurgo/) used within this analysis

was furnished by the US Service and serves to spatially delineate the soil types and characteristics as observed for the Kisatchie National Forest. Soil classifications including name, phase, coverage, and drainage class are discussed in Chapter 1 of this study and listed in Table 1.2. Table 3.6 below provides a summary of drainage class percent coverage for the study area of the Kisatchie National Forest in addition to the drainage class description used within this analysis. For similarity between classes and percent coverage purposes, several classes have been combined. Excessively drained soils include the original category of excessively drained as well as somewhat excessively drained.

Table 3.6. Drainage Class Description and Percent Coverage for the Study Area Examined In and Near the Kisatchie National Forest.

Drainage Class	Area (m^2)	% of Area
Excessively drained	121427904	4.9
Well drained	814258590	32.7
Moderately well drained	840758368	33.8
Somewhat poorly drained	294400469	11.8
Poorly drained	405846011	16.3
No Data	10398117	0.4
Total	2487089459	100.0

Soil surface texture is also an important characteristic that governs water movement, nutrient availability, and the erosion potential of that soil (Soil Survey Staff 2011). Many of the soil variables are interrelated and all come from the same SSURGO dataset. Caveats of utilizing county soil surveys for archaeological purposes have been offered by several authors (Holliday 2004:54-56; also Anderson and Smith 2003; Jones 1990:271; King 1983:102-104). The expressed inadequacies

of uncritical applications of county-level soil surveys relate to the disproportionately broad mapping scale as well as the classification of soil series. The complexity of the soils when sampled can be obscured through the assignment of a soil to a preset taxonomy. This action clusters soils as opposed to the partitioning of differentiated soils since minor soils (by percent presence) are discounted depending on soil series type. For instance, Holliday (2004:55) notes in discussing the soil taxonomy, that for a recorded location, a single inclusion is allowed if that soil's area is less than 10 percent of the total area sampled or less than 50 percent if similar to the primary soil. Such an allowance affects the confidence in soil boundaries as this marginalizes the consideration for soil gradation across space.

The geographic interval of a soil mapping unit spans 1 to 4 hectares—a distance that may prove insufficient to detect the complexity of soil relationships and transitions at a scale useful for locating an archaeological site. As with any small-scale survey, isolated but potentially extremely relevant soils may be overlooked. Archaeological survey along a predefined grid provides an appropriate analogy as valuable archaeological data may be undetected. The archaeological application of the soil survey dataset in the development of a predictive model for the Kisatchie National Forest is considered appropriate with the implicit understanding of the limitations of the available data. It should also be noted that with the availability of new technologies (e.g. LIDAR as discussed below), the scale of digital datasets relevant to local or regional models must expand as well.

The flooding frequency measure of soils was derived from the SSURGO database as available through the Natural Resources Conservation Service (NRCS). Soils susceptible to frequent or occasional flooding were selected for inclusion within this category. The flooding vulnerability of such areas would create unpredictable permanent settlement localities. Instead, these areas were likely used for specialized activities or in a limited or seasonal habitation role as they represent a unique exploitable resource.

USGS-recorded watercourses located on the Kisatchie National Forest were included within this study for several distance-based measures. The GIS data is available in pre-clipped form for the KNF through the federal Forest Service website (http://www.fs.fed.us/r8/kisatchie/gis/). The USGS stream dataset was processed into 12 categories including: all streams, only permanent streams, only seasonal streams, and streams separated by stream rank ordering (1 to 9). For the purpose of this study, permanent streams were defined as watercourses from the Forest stream dataset with rankings of ≥ 3 based on the Strahler (1957) method of stream rank-ordering. Seasonal streams were therefore defined as watercourses with stream ranks < 3.

Wetlands, areas with seasonally or permanently saturated soils, along with the streams and rivers intersecting the bounds of Kisatchie National Forest prove to be particularly important datasets for evaluating for past settlement patterning. Indeed, as discussed previously in Chapter 2 of this study, distance to water or from floodplain soils proves to be a primary consideration for locating archaeological sites within the presently implemented predictive model for the Kisatchie National Forest

(see Chapter 4 for an evaluation of the effectiveness). Water in the form of rivers and streams proves a vital resource for repeated exploitation with habitation sites and activity areas appearing to cluster in these areas.

Wetlands provide a similar draw along their perimeter with the added consideration of their distinct environmental conditions, attracting unique flora and fauna to these areas. In the KNF sample used here, 32 sites are recorded within the boundaries of the wetland polygons, which may represent foraging or hunting activities or possible habitation sites during the dry months of some seasonally effected wetlands. Areas of saturated soil are expected to produce fewer sites both as a result of reduced modern survey efforts, as well as avoidance of these areas for habitation by past peoples.

Roadways, both major and minor, provide this study with measurements of proximity of site to roadway. The distance to major roadway category is of special note for the distribution of historical sites. Distance to roadway also introduces sampling biases for two reasons: (1) the road may not be very old or follow an early route or trail, and (2) ease of access to portions of the Forest and frequency of use of that region may affect the number of recorded sites.

In addition to the environmental datasets discussed above, a digital elevation model (DEM) was assembled for the region within and immediately around the Kisatchie National Forest for this study. Data is available through the National Elevation Dataset's Seamless Data Distribution System (SDSS) in one-degree-by-one-degree blocks with elevations sampled at 30 meter intervals. The MOSAIC

function of the Data Management toolset of ArcGIS was executed to seamlessly join each one by one degree raster grid together. The topographic relief of the Kisatchie National Forest appears pronounced with drainages cutting the uplands that reach as high as 163 meters above sea level in the region surrounding the Forest. To determine the effect that the region's variable topography had on past settlement patterning, a slope measurement was calculated from the 30-meter DEM dataset. Using the SLOPE function of the Spatial Analyst toolset of ArcGIS, percent slope values were produced in a raster dataset using site centroids to extract the values. Aspect, the direction that the slope faces, was derived from the 30-meter DEM dataset using the ASPECT function of the Spatial Analysts Tools toolset of ArcGIS.

A new digital elevation dataform is readily becoming available in the United States with increased sampling intervals that produce extremely high resolution elevation datasets. Light Detection and Ranging data (LIDAR) utilizes airborne laser mapping to extract ground elevations at sub-5-meter intervals through the tree cover and other ground vegetation. LIDAR, as with Digital Elevation Models (DEM), is processed into a grid of cells containing elevation values that are georeferenced and available for a range of applications from state level geospatial data serving centers. Louisiana LIDAR data is distributed through "Atlas: The Louisiana Statewide GIS" (http://atlas.lsu.edu), which is maintained and operated by Louisiana State University CADGIS Research Laboratory.

Due to the resolution of the data, LIDAR is served at a quarter USGS quadrangle map level. Kisatchie National Forest intersects with 68 USGS quads. For

processing efficiency, the LIDAR data was processed using the MOSAIC function of the Data Management toolset of ArcGIS and then clipped to the extent of the Kisatchie National Forest. As with the 30-meter DEM data, to determine the effect that the region's variable topography had on past settlement patterning, a slope measurement was calculated from the LIDAR raster. Using the SLOPE function of the Spatial Analyst toolset of ArcGIS, percent slope values were produced in a raster dataset at 5-meter intervals using site centroids to extract the values. Aspect was derived from the 5-meter LIDAR dataset using the ASPECT function of the Spatial Analyst Tools toolset of ArcGIS.

Other datasets were constructed for use in the analysis by processing the primary environmental datasets in relation to archaeological site location to derive a Euclidean distance (a straight distance between two points) measure. Using the EUCDISTANCE function of the Spatial Analyst toolset of ArcGIS, a distance to nearest feature raster was created at both a 30-meter resolution comparable to the DEM and a 5-meter resolution comparable to the LIDAR. The EUCDISTANCE function calculates the Euclidean distance to the closest source for each cell from each recorded archaeological site. These EUCDISTANCE rasters include distance to major highway, distance to local road, distance to all roads, distance to drainage, distance to all streams, distance to permanent streams, distance to seasonal streams, distance to stream by rank (1 to 9), distance to wetlands, distance to frequently flooded soils, distance to frequently and occasionally flooded soils, distance to grouped well-drained soils (excessively, somewhat excessively, well, and moderately well drained), and distance to grouped poorly drained soils (very poorly, poorly, and

somewhat poorly drained). The methodology used to evaluate these variables is discussed below.

Methodology for Evaluating the 1995 FPPM

Predictive models serve to demarcate areas or zones of relative probability for encountering a select variable. As applied to the distribution of archaeological sites, the probability zones in most models developed in western Louisiana consist of a tripartite division of high probability, medium or moderate probability, and low probability based on the relationship between environmental variables like those outlined within this section and the location of archaeological sites. As an application for cultural resource management, predictive modeling zones shape the intensity of archaeological survey while reducing compliance field-time and increasing the discovery rates of sites. A primary goal in the development of predictive models for an applied purpose is the ease of implementation toward an application.

The limitation of locating the zones in the field often governs the type of variables used to define the probability zones. The on-ground testing of the 1988 Fort Polk model proved successful (see Chapter 2), although differentiating the boundaries or transitions from each zone proved challenging. The 1988 Fort Polk Predictive Model defines the zones as follows:

> Zone I, floodplain areas; Zone II, locations beyond this floodplain category yet within either 300 m horizontal distance or 60

> feet vertical distance of a water source mapped on the U.S. Geological Survey (USGS) 7.5-minute quadrangle sheets encompassing the fort; and Zone III, all other areas (upland areas more than 60 feet above and 300 m distant from a mapped water source). Site probabilities were found to differ among these three zones, as described below. Zone I, occupying floodplain areas, was listed as "Site Probability Indeterminate." Significant sites were thought to occur in this zone, but survey coverage had not been sufficient to settle the matter one way or the other. Zone II, encompassing the area intermediate between the floodplain zone and the uplands, was classified as a "High Probability" area, on the basis of the numbers of all components and particularly the diagnostic components identified. Zone III, occupying the upland areas of the base and more than either 60 feet in vertical elevation or 300 m distance (whichever came second) from a mapped water source, was classified as a "Low Probability" area [Anderson and Smith 2003:170].

The measure of vertical elevation defining Zones II (High Probability) and III (Low Probability) (60 feet vertical elevation above a mapped water source or floodplain) could only be determined on an approximate basis. A similar issue existed in locating the zones for the U.S. Forest Service model from Willingham and Phillips's (1987) analyses, which used a measure of 15 or more or fewer than 15 drains per quarter section as a variable. The 1995 Fort Polk predictive model emphasized functionality and efficiency with zones defined as follows:

> Zone 1, floodplain areas, defined as areas with floodplain soils; Zone 2, locations within a 200-m buffer of Zone 1 or within a 200-m buffer of a mapped water source; and Zone 3, all other areas. These three zones were assigned site probabilities of Indeterminate, High, and Low, respectively. These three zones are much easier than the earlier zones to locate on maps and in the field, since the variable of vertical elevation above nearest water source has been removed, and the easily measured high-probability zone accounts for a higher percentage of all sites and all significant sites than the comparable zone in the 1988 HPP model [Anderson and Smith 2003:171]

With the removal of the vertical elevation above water variable, the 1995 Fort Polk model becomes streamlined without a decrease in site incidence for the high and moderate probability zones. The resulting model produces zones that are located on the ground with greater reliability. The difficulty of locating zones on the ground translates to inefficient or inaccurate surveys as zones are sampled at differing intervals based on probability.

The 1995 Fort Polk model mandates a survey strategy of proportional intensity to the likelihood of locating sites. While surveys may be conducted at a greater resolution, the 1995 Fort Polk model's sampling parameters for the high and indeterminate (medium) probability zones recommends shovel tests and transects spaced at 30-meter intervals, while the low probability zone was to be examined using shovel tests and transects spaced at 50-meter intervals. Differential sampling

strategies provides efficiency for surveying large tracts of the Kisatchie National Forest or any land area.

For the current study, Velicia Bergstrom the Forest Heritage and Tribal Program Manager, provided a GIS dataset of the 1995 Fort Polk model as implemented on the Kisatchie National Forest (Table 3.7). Three discrete polygons representing the high, medium or indeterminate, and low probability zones were created in a GIS. The polygon of Zone I (medium) was extracted from the SSURGO Soil Flooding Frequency Dataset for areas deemed frequently or occasionally susceptible to flooding. The Zone II (high) polygon utilized the BUFFER function of the Analysis Tools toolset of ArcGIS to construct a 200-meter buffer of the Zone I polygon and a 200-meter buffer of the forest drainage dataset. The Zone III (low) polygon is the remaining area within the Kisatchie National Forest that does not overlap Zone I or Zone II. The low probability zone represents areas lacking dense archaeological materials while not precluding the encounter of such sites.

Table 3.7. Probability Zone Areas of the 1995 Fort Polk Predictive Model on the Kisatchie National Forest Study Area.

Probability Zone	Area (m^2)	Area (hectares)	Area (acres)	% of Area
Zone 1 (Medium)	338508668	33851	83647	13.6
Zone 2 (High)	1363591761	136359	336951	54.8
Zone 3 (Low)	784989030	78499	193975	31.6
Total	2487089459	248709	614573	100.0

A GIS was used to calculate the quantity of sites in each probability zone (i.e. high, medium, and low) to assess the effectiveness of the 1995 Fort Polk predictive

model as applied to the Kisatchie National Forest. Of the 4,175 site locations furnished by the Forest Service and curated in the State Archaeological Site Files, 3,986 sites from the study area were evaluated. The criteria for inclusion in this study required site centroids to be located fully within the study area boundaries for the Kisatchie National Forest. Only point locations of sites were used within this analysis, which can be derived by calculating the centroid of each site polygon in a GIS. The consideration of site points as opposed to site polygons allows for potential bias towards archaeological site density by not accounting for the extent of site area. Additionally, using site centroids introduces inaccuracies to the placement of a site overlapping multiple zones; however, a consistent evaluation of sites using the site centroid should place the site in the appropriate category as the center of the site typically falls within the majority zone with which the site polygon overlaps. Ultimately, the unavailability of the site polygon data governed the selection of site points for this analysis.

Significance of the number of sites per probability zone was determined using the chi-square statistic, a common method to evaluate for success of a model (e.g. Duncan and Beckman 2000; Jaroslaw and Hildebrandt-Radke 2009; O'Donoughue 2008; Warren and Asch 2000) and expressed as:

$$\chi^2 = \sum_{i=1}^{c} \frac{(fo - fe)^2}{fe}$$

The variable *c* is equal to the number of probability zones, *fo* is the observed frequency of sites in each zone, and *fe* is the expected frequency of sites. The

expected frequency of sites is derived for each probabilistic zone by multiplying the total number of observed sites by the ratio of each zone over the entire area. An expected frequency is a proportional measure and within this study *fe* represents the expected number of sites to occur within each zone based on coverage area if randomly distributed. The expected frequency is expressed as:

$$fe = (\text{zone area/total area}) \times \text{sites}$$

The chi-square (χ^2) values were evaluated at the $\alpha = .05$ probability level, with degrees of freedom (*df*) calculated where *r* equals the number of populations and *c* equals the number of levels for the categorical variable as:

$$df = r - 1 * c - 1$$

A statistical method to evaluate effectiveness of a predictive model is the gain statistic (Kvamme 1988), which affords a standardized measure of the proportion of sites relative to the proportional area. Kvamme's Gain Statistic is defined as:

Gain = 1 - [(% of total area covered by zone) / (% of total sites within zone)]

The gain statistic is evaluated as a vector with values near zero being interpreted as an equal proportion of archaeological sites to the proportional area of the zone. Positive values approaching 1 indicate a high proportion of archaeological sites to the zone area, whereas negative values indicate a lower than expected proportion of sites. As applied to the evaluation of archaeological sites, the gain statistic should indicate the effectiveness of the model with a gain above 0.5 representing a very effective zone. A model will ideally have a large positive gain for the high probability zone, a

smaller positive value in the medium probability zone, and a negative value in the low probability zone.

The statistical analyses outlined above are employed to evaluate the existing Forest Service predictive model for overall effectiveness. Further examination of the model's performance was conducted to determine temporal effectiveness when evaluating the historic subset and the prehistoric subset. The results of the gain statistic should show significantly more sites in the high and medium probability zones, and fewer in the low probability zone when compared to what is expected by chance. Any results indicating gains that conform to the trend of large positive value for the high probability zone, somewhat smaller but still positive value for the indeterminate/medium probability zone, and negative value for the low probability zone should suggest a highly effective model that may not need amending. If the gain results do not follow the above trend, they will serve to illustrate the need for a new and more effective model to be developed and implemented on the Kisatchie National Forest.

As a result of the discontiguous and widely spread ranger districts, two geographic subsets will be used to evaluate the model effectiveness. This effort attempts to determine the effectiveness of the active Forest Service predictive model for smaller ranges that may encompass less environmental variance. As the Caney Ranger District lies approximately 140 kilometers north of the centerpoint for the central cluster of ranger districts (i.e. Winn, Catahoula, Kisatchie, and Calcasieu Districts), the model effectiveness is evaluated independently for the central cluster

and the Caney District (see Figure 4.1 in the following chapter for representation of the geographic sub-areas). The level IV ecoregion overlays served as the criteria for selecting the Caney District as an outlier. Caney District is located primarily in the Tertiary Uplands ecoregion whereas the districts in the central cluster area are located in the Southern Tertiary Uplands ecoregion. As defined in detail within Chapter 1 of this study, the Tertiary Uplands ecoregion differs from the Southern Tertiary Uplands ecoregion in vegetation communities and climatic factors such as rainfall.

Additional analyses were completed for all the ranger districts separately. The results of the 1995 Fort Polk Predictive Model and the environmental associations are presented within the Chapter 4 by ranger district. The in text discussion will center around the Caney District area and the central cluster area.

The chi-square and gain statistical tests were employed to evaluate the model's effectiveness as applied to the two geographic sub-areas (i.e. Caney area and central cluster area). The same expectations of chi-square significance and gain values apply to these tests. The results of the geographic sub-areas will advocate for either the development of a singe model applied over the entire Forest or for multiple models by Forest districts or cluster areas.

Temporal affiliations for known sites have previously been assigned and overseen by Forest personnel. The Louisiana Division of Archaeology defines the criteria for a site as a 20-m x 20-m area with the presence of five or more artifacts and a cultural feature with historic artifacts possessing an antiquity of at least 50 years. Multi-component sites contain both historic and prehistoric assemblage data, while

unknown sites represent unexamined reported sites. Due to sample size limitations for multi-component sites (n = 26), only prehistoric (n = 2,284) and historic (n = 300) site model success is analyzed. Multi-component sites, while not examined on their own, are included within the analysis for both prehistoric (n = 2,310) and historic (n = 326) sites. The reduced sample size when considering temporal affiliation is due to the large number of excluded unknown sites (n = 1,376) where temporal affiliation is not known. Modeling without excellent temporal control of the known sites is not uncommon, and still has the ability to produce significant patterns (Jaroslaw and Hildebrandt-Radke 2009). Attempts to model settlement choice by temporal sub-period often prove of secondary importance to the larger modeling effort as data with too great a resolution proves too limited in size.

The model effectiveness was determined based on the chi-square and gain statistical tests as discussed above for all sites across the entire study area, for all sites located in the Caney and the central cluster sub-areas independently, and for temporal subsets of sites (e.g. all, prehistoric, and historic sites) located across the entire study area as well as the Caney and central cluster sub-areas. The recommendation for a new model or the continued use of the existing model depends on the results and whether those results produce statistically significant densities of sites while following an appropriate scale of high positive gain for the high probability zone, lower positive gain for the medium probability zone, and a negative gain for the low probability zone. The results, if deemed ineffective, will also suggest which environmental variables are most appropriate for forecasting site locations based on the geographic and temporal secondary tests.

Methodology for Evaluating Environmental Correlations

If the results indicate an ineffective model, the site locations must be examined for correlations with environmental variables. Some of the variables will overlap with the active US Forest Service Model such as hydrological features, but an array of additional variables will also be considered (see Table 4.13 in the following chapter). Initial tests will examine 25 variables with some overlap and covariance among the variables. Of the 25, there is one ordinal data variable, *soil drainage class*, and one nominal data variable, *soil surface texture*.

For nominal and ordinal data variables, the chi-square and gain statistics are employed. The methods for calculating these test statistics have been discussed in detail within the previous section of this chapter. Any variables exhibiting significance and large gains (either positive or negative) will be considered as an element of a new model. The values for each archaeological site were calculated within a GIS using a join function—a process combining the attributes of one dataset to that of another based on the overlay of each feature.

The remaining 23 variables represent ratio data and range from *distance to stream* to *aspect*. The appropriate statistical measure for evaluating ratio data is the Mann-Whitney rank-sum test, also known as the Mann-Whitney U-test or the Wilcoxon rank-sum test (Mink et al. 2006:228-229; Tamhane and Dunlop 2000:575-578; Warren and Asch 2000:14). The Mann-Whitney rank-sum test compares the

relationship of two independent grouping variables to a set of test variables. As this test is non-parametric, populations are not required to be normally distributed.

The null hypothesis of the test is that the independent grouping variables are of an equivalent distribution. In this study, the two independent grouping variables were archaeological sites and randomly sampled points of equal number across the study area. The Mann-Whitney rank-sum test combines data from both groups and assigns ranks to all cases, with an average rank used in the case of ties. The summed ranks for each of the grouping variables (S_1 and S_2) are calculated. The sum of ranks for tied observations is also calculated, where t is the number of observations tied for rank i *(group)*.

$$T_i = \frac{t3 - t}{12}$$

The average rank by group is represented with n_i as the sample size of group i:

$$S_i = S_i / n_i$$

The test statistic and statistical significance is calculated for group 1 as:

$$U = n_1 n_2 + \frac{n1(n1 + 1)}{2} - S_1$$

If $U > n_1 n_2 / 2$, then the statistic used is:

$$U' = n_1 n_2 - U$$

The test statistic corrected for ties is:

$$Z = \frac{(U - n1n2/2)}{\sqrt{\frac{n1\,n2}{N(N-1)}\left(\frac{N^3 - N}{12} - \sum_i Ti\right)}}$$

The statistical significance is evaluated at the α = .05 level with the null hypothesis of similar distributions between sample groups rejected with values of $p < .05$.

The Mann-Whitney rank-sum test was used to evaluate the appropriateness of the environmental variables within multiple subsets of grouping variables (i.e. sites vs. random background points, prehistoric sites vs. historic sites), for multiple geographic subsets of the study area (i.e. Caney area, central cluster area; individual KNF districts), and for multiple scales of processed variables (i.e. 5-m x 5-m raster cells and 30-m x 30-m raster cells). The evaluation of multiple subsets at multiple resolutions provides a detailed understanding of past landscape use that will contribute to a new site location predictive model.

Methods of Model Development

The detailed analysis allows for the correlation between any given environmental variable and known archaeological sites with the background environment accounted for with randomly sampled points. The results allow the demarcation of probability zones that indicate site location probability, in short, to develop a new predictive model, as was warranted in the present case (Chapters 5, 6). The analysis of an extensive array of environmental variables produced a more

efficient model, capable of accounting for cultural shifts (i.e. prehistoric vs. historic populations), and building upon past settlement models produced within the region, most notably the 1995 Fort Polk Predictive Model.

Predictive modeling within archaeology is a mature field with many scholarly contributors who have introduced new modeling techniques. One such notable scholar, Kenneth L. Kvamme, is credited with pioneering the use of logistic regression within the realm of archaeology (Warren 1990; i.e. Kvamme 1983). Logistic regression modeling is one of the more sophisticated and popular modeling techniques that produces some highly effective models (Hatzinikolaou 2006; e.g. Carmichael 1990; Kvamme 1985, 1992; Maschner and Stein 1995; Parker 1985; Warren and Asch 2000)

Logistic regression, while statistically sophisticated, requires the input of variables for both presence and absence. For archaeological purposes, areas where sites are known to be found must be complemented with areas where archaeological sites are known *not* to exist. Survey results for the Kisatchie National Forest cannot for certain be used to infer areas devoid of all sites. Some sites may have been missed due to sampling intervals or technician error during survey. A secondary challenge related to the development of logistic regression models is the difficulty of implementation, since the output often exists in fragmented form as opposed to smoother and more predictable buffers. As the purpose of this analysis was the evaluation and, if warranted, the development of a predictive model to aid resource management, a more easily implementable model was proffered.

The methodology selected for this analysis uses the buffering of highly significant variables previously evaluated statistically and selecting key buffers with high gains. Probability zones are then able to be assembled from the relevant buffers or parameters (Kvamme 1990; Mink et al. 2006). While undoubtedly a simpler and less sophisticated method than approaches such as logistic regression, the formation of the zones in this manner produces an elegant model that is easier to implement in the field.

Chapter 4. Modeling Analysis

The distribution of archaeological sites, both historic and prehistoric, is not random within morphoclimatic zones—areas of similar relief-forming processes shaped as a function of climate. Previous settlement patterning studies within archaeology have made use of relationships between environmental factors such as topographic relief, slope, distance to water, and soil conditions, among others, and the location of archaeological sites (Bauer et al. 2004; Duke 2003; Fletcher 2008; Jaros1aw and Hildebrandt-Radke 2009; Jochim 1976; Kvamme 1992; Stancic and Kvamme 1999; Vanacker et al. 2001; Warren 1990; Willey 1953; Williams 1956; Williams et al. 1973). And, as we have seen, a lot of such work has gone on in western Louisiana. Determining the significance of such relationships and the extent each environmental variable affects the relationship, ultimately shapes the formation of a predictive or forecasting model. The delineation of boundaries between zones—a reflection of a preference or avoidance of elements upon the landscape—proves challenging within localized areas exhibiting environmental similarities. Inherent within the evaluation of environmental relationships and the location of archaeological sites exists the effect of social or economical considerations for utilizing the landscape. Such considerations affected, to a degree, the location of known archaeological sites for both prehistoric and historic populations.

The US Forest Service predictive model as currently employed on the Kisatchie National Forest follows the zone definitions created for the 1995 Fort Polk

Predictive Model. As the Fort Polk model was created using a sample of archaeological sites (n = 2,785) located on the nearby Fort Polk military reservation, the evaluation of that model within the Kisatchie National Forest should confer its effectiveness in the west-central region of Louisiana. The Fort Polk Predictive Model will be assessed against a greater sample size of archaeological sites (n=3,986) on a larger expanse of land that is the Kisatchie National Forest, which also covers greater environmental variation. The evaluation of existing models and the consideration for the development of new models is of great value in the attempt to gain insight towards the settlement of past peoples and the attributes of the local environments which influence those movements.

Multiple analyses that tested the Fort Polk Predictive Model on the Kisatchie National Forest were conducted within this study, encompassing several subsets of the Kisatchie National Forest Ranger Districts. These areas included all lands within the ranger districts, lands solely owned by the United States Department of Agriculture (USDA), and lands owned by the USDA in addition to culturally surveyed areas of private property (study area defined explicitly in Chapter 3). The focus on areas owned and therefore managed by the US Forest Service in addition to private property that has experienced a cultural resource survey was considered the most appropriate study (see Figure 4.1 for ownership areas). The number of archaeological sites (n = 3,986) from this reduced area (USDA and surveyed private property) represents 95.5 percent of the total sites (n = 4,175) recorded within the

Kisatchie National Forest ranger district boundaries while covering only 59.8 percent of that total area.

While the active Forest Service predictive model and the model produced within this study are applied to the entire Kisatchie National Forest (Table 4.1), the effectiveness of those models is evaluated solely on the USDA owned and surveyed private property area (Table 4.2). Additionally, the effectiveness of these models is also evaluated with respect to ranger district subsets of the entire Forest study area including each district separately.

Table 4.1. Probability Zone Areas of the Active Predictive Model for the Entire Kisatchie National Forest.

Probability Zone	Area (m^2)	Area (hectares)	Area (acres)	% of Area
Zone 1 (Medium)	661298261	66130	163410	15.9
Zone 2 (High)	2229643383	222964	550957	53.6
Zone 3 (Low)	1272551705	127255	314454	30.6
Total	4163493350	416349	1028822	100.0

Table 4.2. Probability Zone Areas of the Active Predictive Model for the Kisatchie National Forest Study Area (USDA Owned or Culturally Surveyed Private Land).

Probability Zone	Area (m^2)	Area (hectares)	Area (acres)	% of Area
Zone 1 (Medium)	338508668	33851	83647	13.6
Zone 2 (High)	1363591761	136359	336951	54.8
Zone 3 (Low)	784989030	78499	193975	31.6
Total	2487089459	248709	614573	100.0



Figure 4.1. Analysis areas: USDA-owned property and culturally surveyed private property on the Kisatchie National Forest.

Evaluation of the Active KNF Predictive Model

The active Forest Service predictive model defines three zones of probability for containing archaeological sites: high, indeterminate or medium, and low. The limits of these zones are situated in respect to several environmental variables—namely frequently and occasionally flooded soils, distance from those flooded soils, and the proximity to recorded water. To determine the effectiveness of the model to capture archaeological sites within the high and medium zones, and in turn to evaluate the appropriateness of the inherent variables (i.e. flooded soils, proximity to water), several statistical tests were conducted, using methods described in Chapter 3. A chi-square test was used to determine the significance of the distribution of sites and the model zones, while the gain statistic was also used to show the proportion of archaeological sites to the proportion of model zone area (Table 4.3).

Table 4.3. Test Statistics of the Active Predictive Model of All Archaeological Sites across All Ranger Districts for the Study Area.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	338508668	13.6	542.5	670	16.8	30.0	0.19
Zone 2 (High)	1363591761	54.8	2185.4	2651	66.5	99.2	0.18
Zone 3 (Low)	784989030	31.6	1258.1	665	16.7	279.6	-0.89
Total	2487089459	100.0	3986.0	3986	100.0	408.7	-

df = 2, $\alpha = .05$, sig of $\chi 2 \geq 5.99$

The test statistics indicate very significant differences between the expected and observed number of archaeological sites in the *medium, high* and *low* probability

zones. The χ^2 value for the *medium* probability zone suggests the lowest significance between the expected and observed number of archaeological sites though its value is at a very high significance. The medium probability zone covers the smallest area (13.6 percent) while containing only 128 (or 3.2 percent) more sites than what is expected by chance. The high probability zone contains far more sites than expected with 66.5 percent of all archaeological sites occurring within 54.8 percent of the total area. The low probability zone contains only 16.7 percent of all sites for 31.6 percent of the total area—markedly less than expected by chance. The χ^2 value of 281 illustrates the high significance of observed as opposed to expected archaeological sites for the low probability zone. The high χ^2 value suggests a lack of utilization of the uplands by past peoples or at least the lack of detection of sites in the upland. The significant χ^2 values for the high, medium, and low probability zones suggest each zone contributes to the model when considering all archaeological sites on all ranger districts.

The gain statistic results do not follow an ideal progression of a positive higher probability gain to a smaller positive medium probability gain to a negative low probability gain. The magnitude of the gain values are not overwhelming and suggest poor performance, most notably for the high probability zone. Interpreting the gain statistics, there is a slightly higher concentration of sites to the relative land area for the medium and high probability zone, and a lower concentration of sites to land area for the low probability zone. The similar gains for the medium and high probability zones suggest improper variables used within the model to distinguish

between a high and medium likelihood of encountering the signature of a site in the archaeological record. An effective model should not produce a medium probability zone gain that is higher or equivalent to the high probability gain as is the case in this test. The poor positive gains for both the high and medium probability zones suggest poor overall performance of this model on the Kisatchie National Forest when considering all archaeological site types and all ranger districts.

While the overall model performance, that is the evaluation of all archaeological sites for all ranger districts, is considered poor as applied to the Kisatchie National Forest, the model should be further evaluated on ranger district subsections of the Kisatchie National Forest. This effort attempts to determine the effectiveness of the active Forest Service predictive model for smaller ranges that may encompass less environmental variance. As the Caney Ranger District lies approximately 140 kilometers north of the centerpoint for the central cluster of ranger districts (i.e. Winn, Catahoula, Kisatchie, and Calcasieu Districts), the model effectiveness is evaluated independently for the central cluster (Table 4.5) and the Caney District (Table 4.4) (see Figure 4.1 for Caney and central cluster areas). The Level IV ecoregion overlays served as the criteria for selecting the Caney District as an outlier. Caney District consisted primarily of the Tertiary Uplands ecoregion whereas the districts in the central cluster area consisted of Southern Tertiary Uplands ecoregion. As defined in detail within Chapter 1 of this study, the Tertiary Uplands ecoregion differs from the Southern Tertiary Uplands ecoregion in vegetation communities and climatic factors such as rainfall.

Table 4.4. Test Statistics of the Active Predictive Model of All Archaeological Sites on the Caney Ranger District of the Kisatchie National Forest.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	38395797	29.2	47.0	32	19.9	4.8	-0.5
Zone 2 (High)	63227747	48.0	77.4	99	61.5	6.1	0.2
Zone 3 (Low)	29977856	22.8	36.7	30	18.6	1.2	-0.2
Total	131601400	100.0	161.0	161	100.0	12.0	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

The results of the test statistics for all archaeological sites for the Caney Ranger District produce extremely poor results. The χ^2 value of the low and medium probability zones suggests no significance between the observed and expected number of archaeological sites. The low probability zone ($\chi^2 = 1.2$) covers less land area in the Caney District (22.8 percent) than overall on the Forest (31.6 percent). As the low probability zone of the active US Forest Service Model (FPPM 1995) can be simply defined as uplands isolated from water, the Caney District with a dramatically different gain value represents an area of distinct topographic relief within Kisatchie National Forest. The medium probability zone ($\chi^2 = 4.8$) covers a larger area in the Caney District (29.2 percent) than the overall Forest area (13.6 percent). The coverage increase of the medium probability zone provides further evidence for the differences in the topography as the medium probability zone is defined as soils of frequent and occasional flooding—a greater proportion of flooding areas suggests less topographic relief. The high probability zone ($\chi^2 = 6.1$) does contain significant differences between the observed and expected number of archaeological sites.

The gain statistics show a non-ideal progression from the high to low probability zones. While the high probability zone exhibits a positive gain, the magnitude of the value suggests minimal effectiveness for the model. The medium probability zone contains a negative gain, meaning a smaller proportion of sites occur in the zone than the proportion of the area. As the medium zone should contain a smaller but positive value, the zone is extremely ineffective. There is a lower concentration of sites to land area for the low probability zone, though not as low of a concentration as for the medium probability zone.

A possible explanation of these test statistics is the greater difficulty in detecting archaeological sites in frequently flooded areas due to greater soil deposition resulting in deeply buried sites. As the medium probability zone covers a greater area for the Caney District with respect to the entire Forest, the likelihood of detecting archaeological sites is greatly reduced. Alternatively, the environmental differences between the Caney District and the remaining districts may be significant enough that peoples were utilizing it much differently. The active US Forest Service model is highly ineffective for the Caney District and requires a new model. This is not surprising as the active US Forest Service predictive model was developed on the Fort Polk Military Reservation—an area some 180 kilometers away from the Caney District with less environmental variation than the Kisatchie National Forest.

Table 4.5. Test Statistics of the Active Predictive Model of All Archaeological Sites on the Central Cluster of Kisatchie Ranger Districts.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	300112869	12.7	507.5	638	16.0	33.6	0.2
Zone 2 (High)	1300364015	55.2	2198.9	2552	64.0	56.7	0.1
Zone 3 (Low)	756754669	32.1	1279.6	635	15.9	324.8	-1.0
Total	2357231553	100.0	3986.0	3986	96.0	415.0	-

df = 2, $\alpha = .05$, sig of $\chi 2 \geq 5.99$

The test statistics for the central cluster of ranger districts—Winn, Catahoula, Kisatchie, and Calcasieu Districts—produce similar chi-square values and gains as compared to the Forest as a whole. The similarity is expected as the central cluster of ranger districts accounts for 94.7 percent of the analyzed land area. The performance of the model improves with the removal of the outlying Caney District from analysis consideration, though the overall performance remains less than ideal. Additional test statistics for each separate ranger district in the central cluster is presented below in Tables 4.6 to 4.9. The results suggest large effectiveness differences between the Caney District and the central cluster of ranger districts.

The chi-square results indicate significant differences between the expected and observed number of archaeological sites in the medium, high, and low probability zones. The significance levels of the high, medium, and low probability zones suggest each zone contributes to the model when considering all archaeological sites for the central cluster of ranger districts.

The gain statistics echo the poor performance of the high probability zone as was the case with the initial overall test of the model. The high probability zone has a smaller, but still positive gain when compared to the medium probability zone. Both the high and medium probability zones represent a slightly higher concentration of sites to the relative land area for the medium and high probability zone while the low probability zone represents a lower concentration of sites to land. The absence of a higher gain for the high probability zone for all archaeological sites on the central cluster of ranger districts suggests the inefficiency within the model is just not a product of environmental variation over the extent of the Kisatchie National Forest, but rather a result of the variables employed within the model.

Table 4.6. Test Statistics of the Active Predictive Model of All Archaeological Sites on the Calcasieu Ranger District of the Kisatchie National Forest.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	79788137	10.6	243.0	413	18.0	118.9	0.4
Zone 2 (High)	356488246	47.4	1085.9	1491	65.1	151.1	0.3
Zone 3 (Low)	315511454	42.0	961.1	386	16.9	344.1	-1.5
Total	751787837	100.0	2290.0	2290	100.0	614.1	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table 4.7. Test Statistics of the Active Predictive Model of All Archaeological Sites on the Catahoula Ranger District of the Kisatchie National Forest.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	48722328	9.7	52.6	81	14.9	15.3	0.4
Zone 2 (High)	310166290	61.6	335.2	387	71.1	8.0	0.1
Zone 3 (Low)	144554293	28.7	156.2	76	14.0	41.2	-1.1
Total	503442911	100.0	544.0	544	100.0	64.5	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table 4.8. Test Statistics of the Active Predictive Model of All Archaeological Sites on the Kisatchie Ranger District of the Kisatchie National Forest.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	90485078	21.4	90.7	70	16.5	4.7	-0.3
Zone 2 (High)	246873190	58.5	247.5	275	65.0	3.1	0.1
Zone 3 (Low)	84616411	20.1	84.8	78	18.4	0.5	-0.1
Total	421974679	100.0	423.0	423	100.0	8.3	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table 4.9. Test Statistics of the Active Predictive Model of All Archaeological Sites on the Winn Ranger District of the Kisatchie National Forest.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	80971119	11.9	60.6	74	14.6	3.0	0.2
Zone 2 (High)	385944294	56.9	289.0	339	66.7	8.7	0.1
Zone 3 (Low)	211594284	31.2	158.4	95	18.7	25.4	-0.7
Total	678509697	100.0	508.0	508	100.0	37.0	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

The results of the active US Forest Service Model (1995 FPPM) evaluation for each Forest district (Tables 4.4, 4.6 to 4.9) further highlights the uniqueness of the Caney District and the similarities between the remaining districts in the central cluster. A separate model may prove necessary with consideration of the results and the extremely poor performance of the active US Forest Service Model on the Caney District. The Kisatchie District also produces poor model effectiveness.

Geographic variability appears to be an important factor suggesting the possible need for a separate Caney District model and a central cluster model. The model needs to also be evaluated temporally to determine the success for predicting

both prehistoric (Table 4.10) and historic (Table 4.11) site locations within the Kisatchie National Forest.

Table 4.10. Test Statistics of the Active Predictive Model of Prehistoric Archaeological Sites on All Ranger Districts of the Kisatchie National Forest.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	338508668	13.6	310.6	368	16.1	10.6	0.16
Zone 2 (High)	1363591761	54.8	1251.4	1556	68.1	74.2	0.2
Zone 3 (Low)	786732525	31.6	722.0	360	15.8	181.5	-1.0
Total	2488832954	100.0	2284.0	2284	100.0	266.2	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

The χ^2 values for prehistoric sites across all ranger districts of the Kisatchie National Forest study area convey significant differences between the observed and expected sites for each zone. Comparing the prehistoric gains of table 4.10 to the entire sample gains of table 4.3, the prehistoric distribution of sites by zone follows an ideal progression, suggesting the importance of factors such as distance to water for prehistoric peoples.

Table 4.11. Test Statistics of the Active Predictive Model of Historic Archaeological Sites on All Ranger Districts of the Kisatchie National Forest.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	338508668	13.6	40.8	31	10.3	2.4	-0.3
Zone 2 (High)	1363591761	54.8	164.4	174	58.0	0.5	0.1
Zone 3 (Low)	786732525	31.6	94.8	95	31.7	0.0	0.0
Total	2488832954	100.0	300.0	300	100.0	2.9	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

The χ^2 values for historic sites across all ranger districts of the Kisatchie National Forest do not convey significant differences between the observed and expected number of archaeological sites. The distribution of historic sites across Kisatchie infers less reliance on distance to water as evidenced by the number of observed sites in the low probability zone—upland areas isolated from water. The low positive gain for the high probability zone, the negative gain for the medium probability zone, and the zero gain for low probability zone do not follow an ideal progression for the model, which strongly suggests the need to consider different variables for the determination of historic site locations across the forest.

Similar patterns occurred for the test statistics of prehistoric, historic, and multi-component sites for the ranger cluster area subsets as they did for the entire Forest study area. These results are displayed in Tables 4.12 to 4.16. The test statistics (Table 4.9) for multi-component archaeological sites (both prehistoric and historic) for the entire Forest followed the trend for the prehistoric site locations though due to the small sample size (n = 26) for multi-component sites, the appropriateness of commenting on the modeling effectiveness is tenuous.

Table 4.12. Test Statistics of the Active Predictive Model of Multi-Component Archaeological Sites on All Ranger Districts of the Kisatchie National Forest.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	338508668	13.6	3.5	4	15.4	0.1	0.1
Zone 2 (High)	1363591761	54.8	14.2	18	69.2	1.0	0.2
Zone 3 (Low)	786732525	31.6	8.2	4	15.4	2.2	-1.1
Total	2488832954	100.0	26.0	26	100.0	3.2	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table 4.13. Test Statistics of the Active Predictive Model of Prehistoric Archaeological Sites on the Caney Ranger District of the Kisatchie National Forest.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	38395797	29.2	19.8	22	32.4	0.2	0.1
Zone 2 (High)	63227747	48.0	32.7	42	61.8	2.7	0.2
Zone 3 (Low)	29977856	22.8	15.5	4	5.9	8.5	-2.9
Total	131601400	100.0	68.0	68	100.0	11.4	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table 4.14. Test Statistics of the Active Predictive Model of Historic Archaeological Sites on the Caney Ranger District of the Kisatchie National Forest.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	38395797	29.2	8.2	1	3.6	6.3	-7.2
Zone 2 (High)	63227747	48.0	13.5	13	46.4	0.0	0.0
Zone 3 (Low)	29977856	22.8	6.4	14	50.0	9.1	0.5
Total	131601400	100.0	28.0	28	100.0	15.4	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table 4.15. Test Statistics of the Active Predictive Model of Prehistoric Archaeological Sites on the Central Cluster of Ranger Districts of the Kisatchie National Forest.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	300112869	12.7	282.1	346	15.6	14.5	0.18
Zone 2 (High)	1300364015	55.2	1222.5	1514	68.3	69.5	0.19
Zone 3 (Low)	756754669	32.1	711.4	356	16.1	177.6	-1.0
Total	2357231553	100.0	2216.0	2216	100.0	261.6	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table 4.16. Test Statistics of the Active Predictive Model of Historic Archaeological Sites on the Central Cluster of Ranger Districts of the Kisatchie National Forest.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	300112869	12.7	34.6	30	11.0	0.6	-0.2
Zone 2 (High)	1300364015	55.2	150.0	161	59.2	0.8	0.1
Zone 3 (Low)	756754669	32.1	87.3	81	29.8	0.5	-0.1
Total	2357231553	100.0	272.0	272	100.0	1.9	-

df = 2, $\alpha = .05$, sig of $\chi 2 \geq 5.99$

Overall, the active US Forest Service predictive model, an implementation of the 1995 Fort Polk Predictive Model, does not distinguish between the high and medium probability zones in an effective manner (see Table 4.3). The analysis of all archaeological sites across all ranger districts produces higher gains for the medium probability zone than the high probability zone, representing a fundamental flaw. The exception to this is over the prehistoric subsample of archaeological sites across the Forest, where the gain statistic produces an ideal progression of highest positive gain for the high probability zone, lower positive gain for the medium probability zone, and a negative gain for the low probability zone (see Tables 4.10, 4.13, and 4.15). This progression for the prehistoric analysis is ideal, but is not overwhelming in magnitude. The high probability zone gain conveys minimal effectiveness with values nearly equal to that of the medium probability zone. Whereas the distribution of only prehistoric archaeological sites improves the performance of the model, the inclusion of only historic sites in the analysis suggests incompatible variables considered to predict the location of historic sites.

The analysis results of the active US Forest Service Model articulate the necessity for a new model to be developed and implemented on the Kisatchie National Forest so as to improve the discovery rate for archaeological sites on the property. The new model should consider more variables, especially those relevant to the location of historic sites. Additionally, the new model should consider the uniqueness of the Caney Ranger District, though a separate model may be unnecessary.

Chapter 5. Environmental Correlations

The evaluation of the active US Forest Service Model revealed ineffective variables defining the *high* and *medium* probability zones as gain values were either equivocal or disproportionate between the zones. The active predictive model does effectively demarcate areas of low probability suggesting that upland terrain away from permanent water sources was an adverse environmental setting for both prehistoric and historic populations or for conditions allowing good preservation or recognition of sites. Through the analysis of a multitude of nominal, ordinal, and ratio environmental variables, statistically valuable environmental corollaries can be included within a new model (Table 5.1).

The statistical tests used to determine the value of each corollary include the chi-square test (ordinal) and the Mann-Whitney rank-sum test (ratio). As described in Chapter 3 of this study, the chi-square test is employed to evaluate nominal and ordinal data for significance, in this case on the variables of soil drainage and soil surface texture. The Mann-Whitney rank-sum test is used for ratio data such as distance to water and percent slope, etc.

Three sets of tests are conducted within this analysis to determine the extent of environmental associations for archaeological sites on the Kisatchie National Forest. The first test compares the entire site sample (n = 3,986) for the study area with a random sample of 3,986 points, which represent the background environmental parameters. Figures 5.1 to 5.5 display the distribution of known archaeological sites

and randomly sampled background points over the Kisatchie National Forest study area. Appendix A contains figures displaying the distribution of prehistoric and historic archaeological sites across each ranger district.

Table 5.1. Environmental Variables Examined to Pattern Site Locations in the Study Area on the Kisatchie National Forest.

Variable Description[a]	Variable	Data Type	Interval	Statistical Test
Distance from grouped poorly drained soil	dpoor	ratio	5-m, 30-m	M-W
Distance from grouped well drained soil	dwell	ratio	5-m, 30-m	M-W
Distance from frequently flooded soil	floodf	ratio	5-m, 30-m	M-W
Distance from freq/occasionally flooded soil	floodfo	ratio	5-m, 30-m	M-W
Distance from highway	hwy	ratio	5-m, 30-m	M-W
Distance from any road	roadall	ratio	5-m, 30-m	M-W
Distance from stream	stream	ratio	5-m, 30-m	M-W
Distance from stream rank 1	srank1	ratio	5-m, 30-m	M-W
Distance from stream rank 2	srank2	ratio	5-m, 30-m	M-W
Distance from stream rank 3	srank3	ratio	5-m, 30-m	M-W
Distance from stream rank 4	srank4	ratio	5-m, 30-m	M-W
Distance from stream rank 5	srank5	ratio	5-m, 30-m	M-W
Distance from stream rank 6	srank6	ratio	5-m, 30-m	M-W
Distance from stream rank 7	srank7	ratio	5-m, 30-m	M-W
Distance from stream rank 8	srank8	ratio	5-m, 30-m	M-W
Distance from stream rank 9	srank9	ratio	5-m, 30-m	M-W
Distance from seasonal stream	sseas	ratio	5-m, 30-m	M-W
Distance from permanent stream	sperm	ratio	5-m, 30-m	M-W
Distance from major drainage	drain	ratio	5-m, 30-m	M-W
Distance from wetland	wetl	ratio	5-m, 30-m	M-W
Surface aspect (deviation from north, degrees)	aspect	ratio	5-m, 30-m	M-W
Surface slope (% grade)	slope	ratio	5-m, 30-m	M-W
Elevation	elev	ratio	5-m, 30-m	M-W
Soil surface texture	stexture	nominal	--	Chi
Soil drainage class	sdrain	ordinal	--	Chi

[a] Statistical tests using these environmental variables examine the differences between sites and random points in the Kisatchie National Forest study area. M-W is the Mann-Whitney rank-sum test; Chi is the chi-square test.

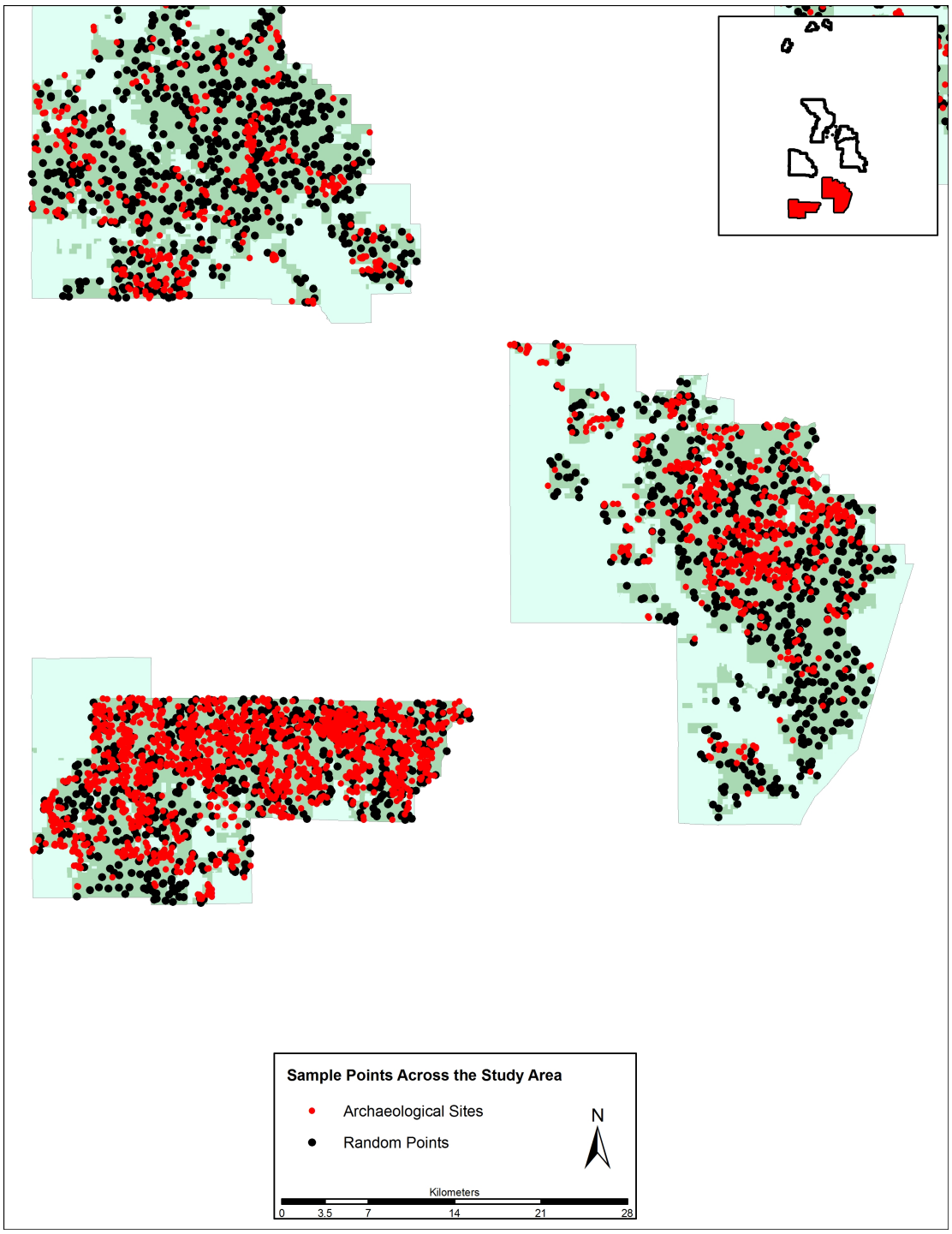


Figure 5.1. Distribution of all archaeological sites and randomly sampled points across the Calcasieu District of the Kisatchie National Forest study area.

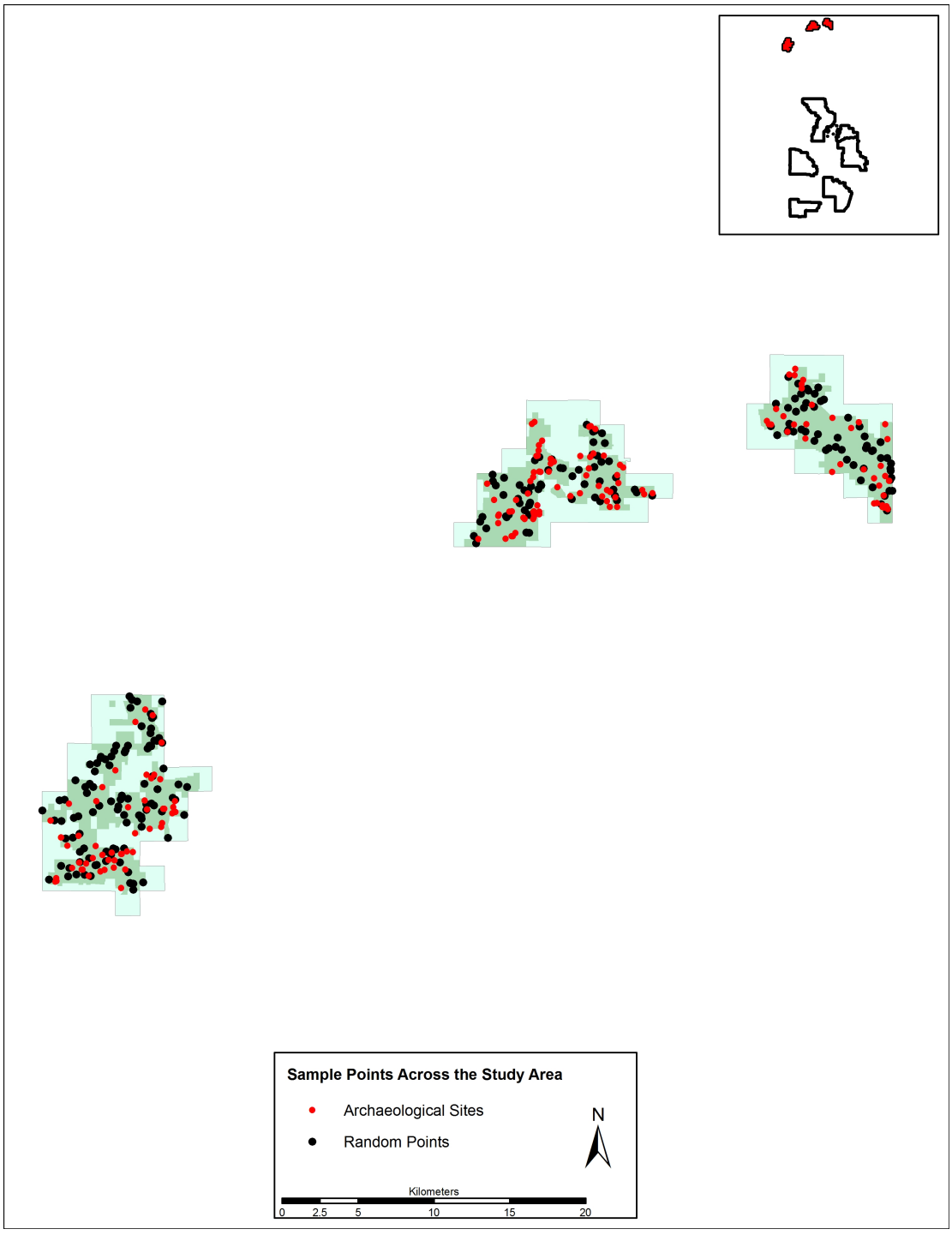


Figure 5.2. Distribution of all archaeological sites and randomly sampled points across the Caney District of the Kisatchie National Forest study area.

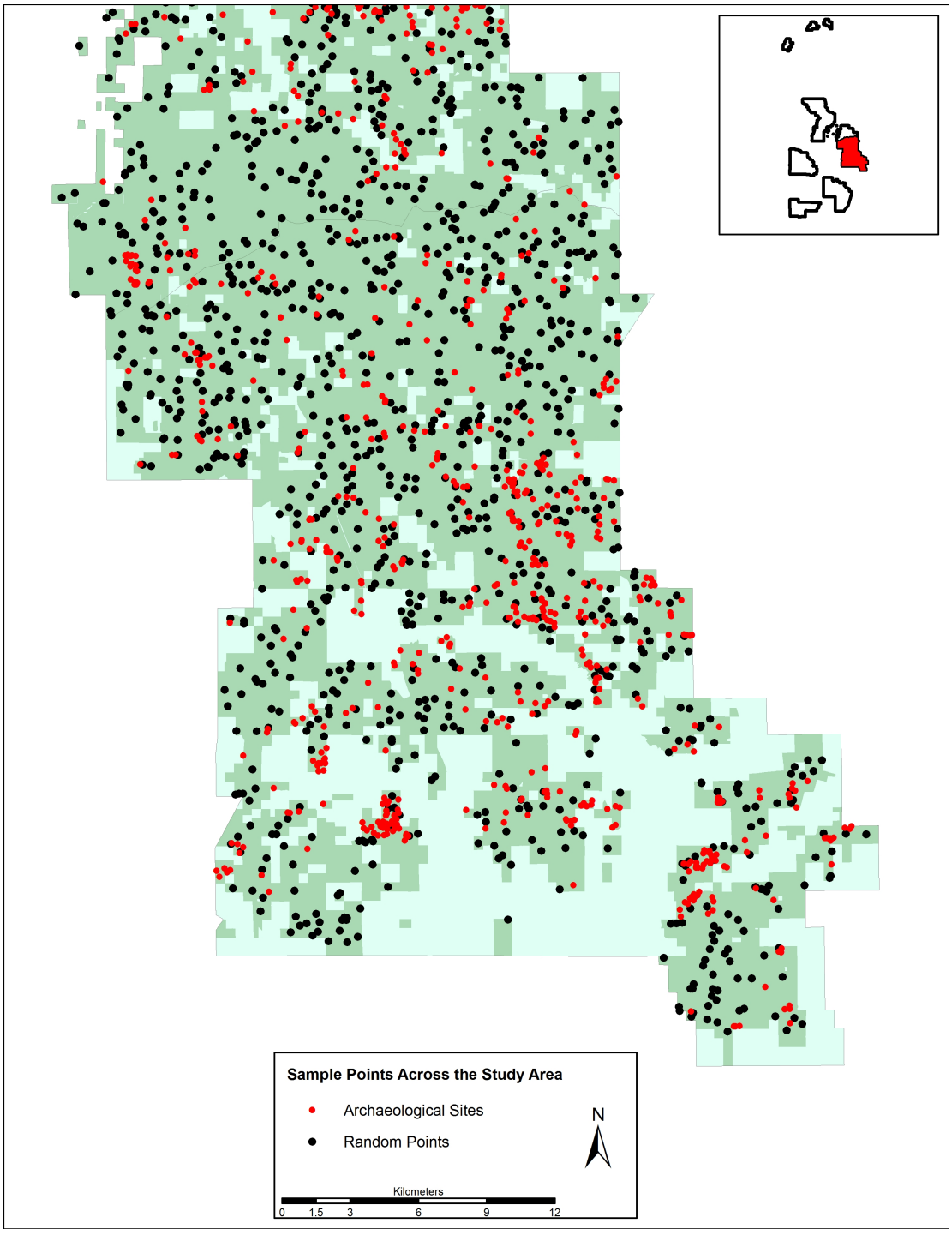


Figure 5.3. Distribution of all archaeological sites and randomly sampled points across the Catahoula District of the Kisatchie National Forest study area.

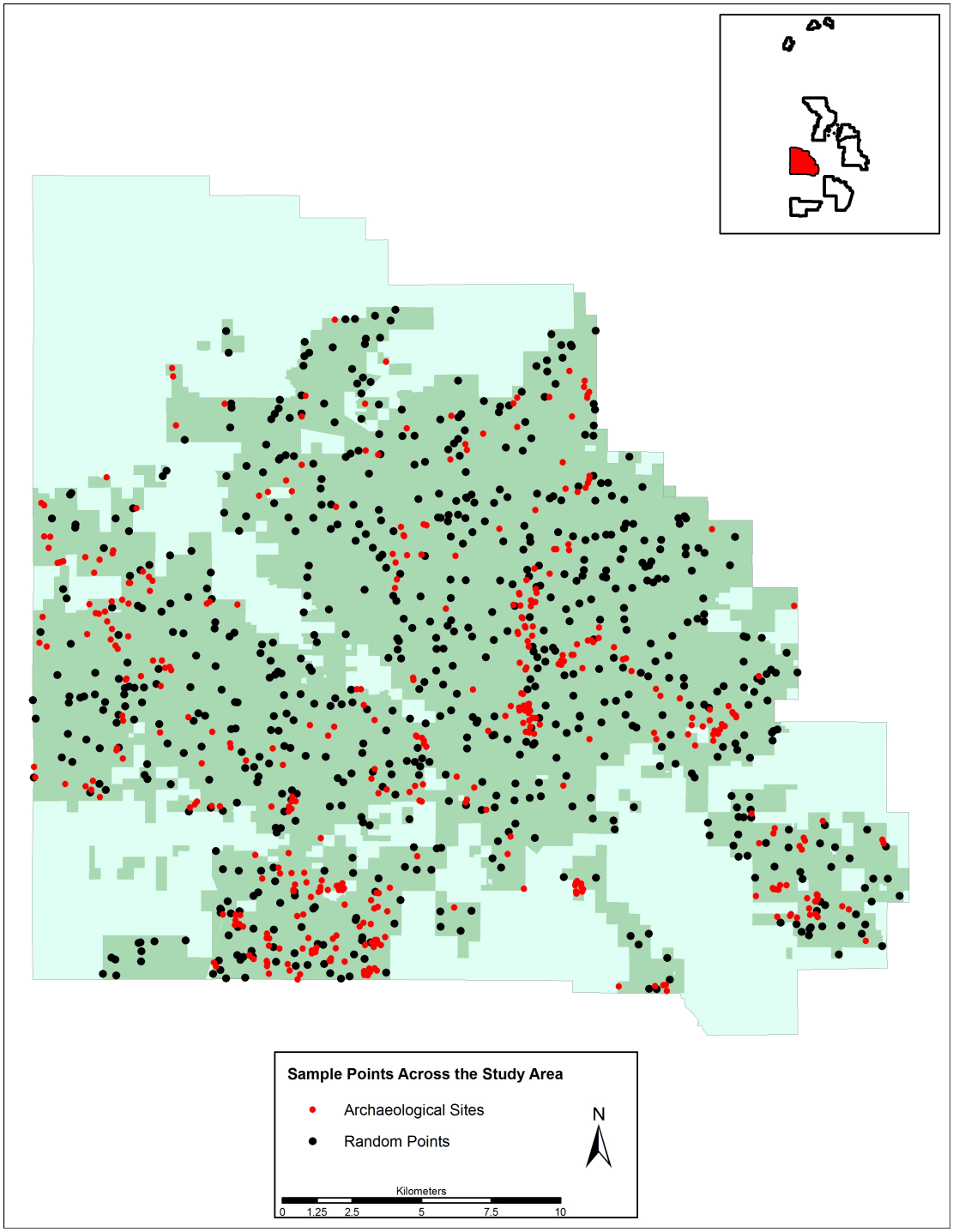


Figure 5.4. Distribution of all archaeological sites and randomly sampled points across the Kisatchie District of the Kisatchie National Forest study area.

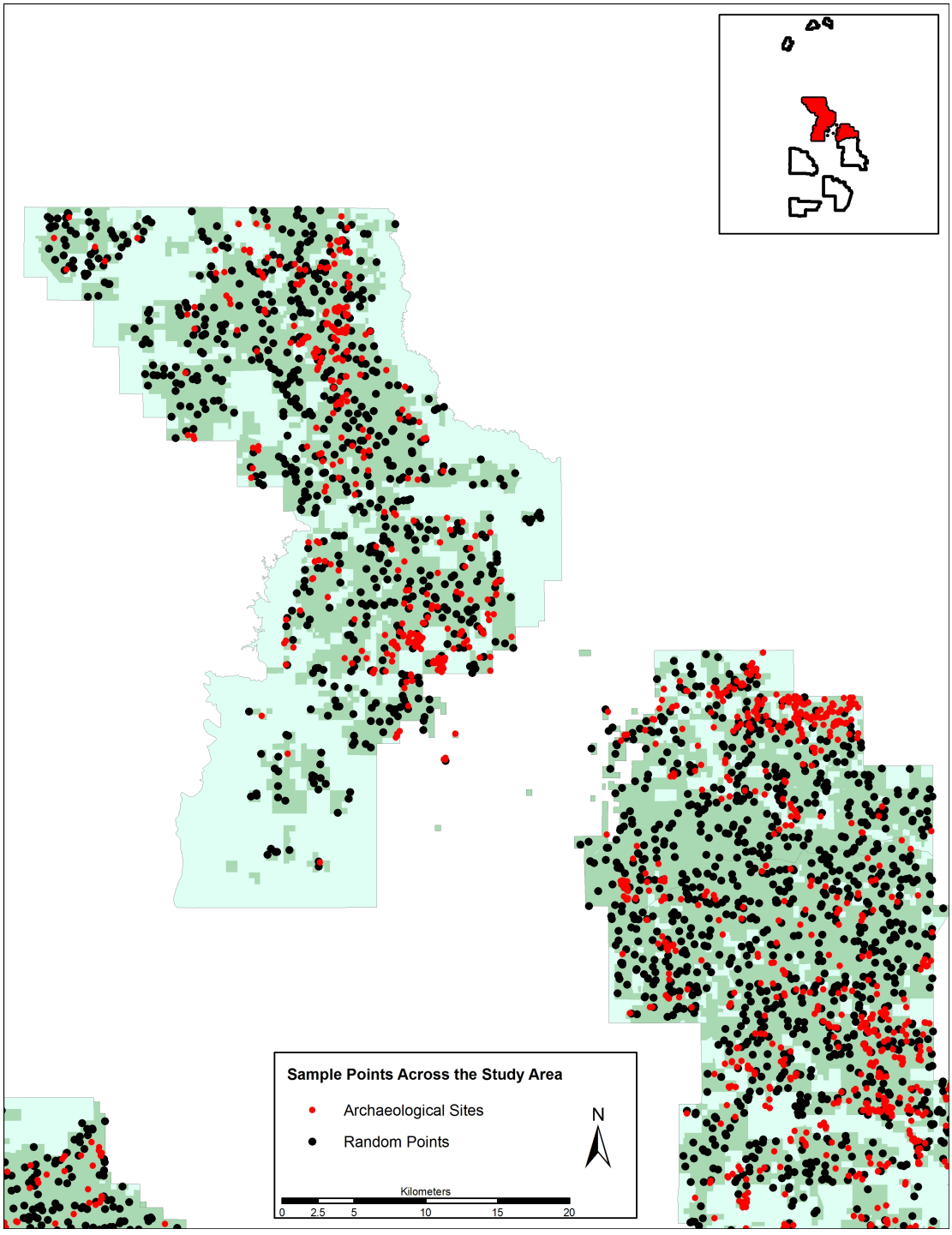


Figure 5.5. Distribution of all archaeological sites and randomly sampled points across the Winn District of the Kisatchie National Forest study area.

The second test explores geographic variation in the environmental associations of sites by evaluating the sites within each discontiguous ranger district. The third test is a refined extension of the first test, where temporal subsets (i.e. prehistoric and historic) are compared against an appropriate number of randomly sampled points. Both the second and third test results are discussed within subsequent sections of this chapter.

Two non-ratio variables, soil drainage class and soil surface texture, were statistically evaluated by comparing the expected and observed site frequencies for each class or texture. The observed site frequencies were tabulated within a GIS, while the expected site frequencies were calculated by coverage percent (detailed in Chapter 3). Both chi-square values and gains are used to evaluate the importance of these variables (Tables 5.2 and 5.3).

Table 5.2. Test Statistics of Soil Drainage Class for All Archaeological Sites across the Entire Study Area.

Drainage Class	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Excessively drained	121427904	4.9	194.6	200	5.0	0.1	0.03
Well drained	814258590	32.7	1305.0	1591	39.9	62.7	0.18
Moderately well drained	840758368	33.8	1347.5	1160	29.1	26.1	-0.16
Somewhat poorly drained	294400469	11.8	471.8	261	6.5	94.2	-0.81
Poorly drained	405846011	16.3	650.4	764	19.2	19.8	0.15
No data	10398117	0.4	16.7	10	0.3	2.7	-0.67
Total	2487089459	100.0	3986.0	3986	100.0	205.6	-

df = 5, $\alpha = .05$, sig of $\chi 2 \geq 11.1$

Table 5.3. Test Statistics of Soil Surface Texture for All Archaeological Sites across the Entire Study Area.

Drainage Class	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Loam	110391882	4.4	176.9	111	2.8	24.6	-0.59
Silt loam	686410098	27.6	1100.1	998	25.0	9.5	-0.10
Sandy loam	1423941804	57.3	2282.1	2293	57.5	0.1	0.00
Loamy sand	229709297	9.2	368.1	550	13.8	89.8	0.33
Clay	26237966	1.1	42.1	24	0.6	7.7	-0.75
No data	10398412	0.4	16.7	10	0.3	2.7	-0.67
Total	2487089459	100.0	3986.0	3986	100.0	134.3	-

df = 5, α = .05, sig of $\chi 2 \geq 11.1$

Each soil drainage class contains significant differences between the observed and expected values based on percent coverage except for the excessively drained class and no data categories with a χ^2 value of 0.1 and 2.7 respectively (see Table 5.2). The well drained soil drainage class represents a higher than expected density of archaeological sites with a high gain value of 0.18. The moderately well drained and somewhat poorly drained classes represent a reduced density of sites with regards to the well drained class. This suggests that for the known sites in the study area, there is a direct relationship between the extent of soil drainage and the likelihood for a site to occur or be discovered. This general trend is then falsified with the high gain value for the poorly drained soil drainage class. One possible explanation for this greater density of archaeological sites in poorly drained soils is for specific subsistence-based activities that benefit from decreased soil drainage (e.g. marsh resources).

Soil surface texture contains only two significant $\chi 2$ values and therefore does not lend itself toward predicting archaeological site locations. Soil surface texture is an important characteristic that governs the water movement, nutrient availability,

and the erosion potential of that soil (Soil Survey Staff 2011). While theoretically appearing to be a significant factor in controlling site locations, soil surface texture is perhaps too broad of an attribute. Sites located on soils with loamy sand textures are highly statistically significant with a χ^2 value of 89.8 and a gain of 0.33 (see Table 5.3). This single texture category does provide evidence of preferential selection towards the settlement or use of landscapes with loamy sand soils—likely due to drainage and soil fertility.

Table 5.4. Descriptive Statistics for All Archaeological Sites and Random Sample Points across the Entire Study Area **(30-meter cells).**

Variable[a]	N	Mean	Std. Deviation	Minimum	Maximum
dpoor	7972	270	444	0	4246
dwell	7972	47	149	0	2205
floodf	7972	327	354	0	2813
floodfo	7972	327	353	0	2783
hwy	7972	1604	1251	0	8111
roadall	7972	174	184	0	3036
stream	7972	75	72	0	1110
srank1	7972	126	120	0	1184
srank2	7972	212	172	0	1495
srank3	7972	399	314	0	2568
srank4	7972	851	691	0	5407
srank5	7972	1695	1186	0	8298
srank6	7972	3695	2360	0	12923
srank7	7972	12864	16930	0	96277
srank8	7972	40020	22248	0	107619
srank9	7972	64129	28062	3059	122082
sseas	7972	99	99	0	1110
sperm	7972	285	255	0	2597
drain	7972	166	147	0	1315
wetl	7972	3564	3200	0	23419
aspect	7972	174	103	0	360
slope	7972	5	3	0	27
elev	7972	62	18	20	139

[*] Emboldened variables represent those selected for further temporal and geographic analysis

Table 5.5. Mann-Whitney Rank-Sum Results for All Archaeological Sites and random sample points across the Entire Study Area **(30-meter cells).**

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	3986	3798.52	15140911.00
	Random Point	3986	4174.48	16639467.00
dwell	Site	3986	3914.71	15604024.50
	Random Point	3986	4058.29	16176353.50
floodf	Site	3986	3524.68	14049363.00
	Random Point	3986	4448.32	17731015.00
floodfo	Site	3986	3526.23	14055572.00
	Random Point	3986	4446.77	17724806.00
hwy	Site	3986	4103.45	16356352.50
	Random Point	3986	3869.55	15424025.50
roadall	Site	3986	4104.11	16358989.50
	Random Point	3986	3868.89	15421388.50
stream	Site	3986	3826.31	15251664.50
	Random Point	3986	4146.69	16528713.50
srank1	Site	3986	4010.42	15985519.00
	Random Point	3986	3962.58	15794859.00
srank2	Site	3986	3768.03	15019382.50
	Random Point	3986	4204.97	16760995.50
srank3	Site	3986	3599.98	14349535.50
	Random Point	3986	4373.02	17430842.50
srank4	Site	3986	3669.79	14627793.00
	Random Point	3986	4303.21	17152585.00
srank5	Site	3986	3773.36	15040595.50
	Random Point	3986	4198.70	16731810.50
srank6	Site	3986	3899.99	15545364.00
	Random Point	3986	4073.01	16235014.00
srank7	Site	3986	3937.79	15696049.00
	Random Point	3986	4035.21	16084329.00
srank8	Site	3986	4476.34	17842707.00
	Random Point	3986	3496.66	13937671.00
srank9	Site	3986	4532.97	18068417.00
	Random Point	3986	3440.03	13711961.00
sseas	Site	3986	3919.08	15621466.50
	Random Point	3986	4053.92	16158911.50
sperm	Site	3986	3448.86	13747165.00
	Random Point	3986	4524.14	18033213.00
drain	Site	3986	3638.71	14503916.00
	Random Point	3986	4334.29	17276462.00
wetl	Site	3986	3722.24	14836845.50
	Random Point	3986	4250.76	16943532.50
aspect	Site	3986	4001.89	15951539.50
	Random Point	3986	3971.11	15828838.50
slope	Site	3986	4143.25	16514975.00
	Random Point	3986	3829.75	15265403.00
elev	Site	3986	4186.23	16686326.50
	Random Point	3986	3786.77	15094051.50

* Emboldened variables represent those selected for further temporal and geographic analysis

Table 5.6. Significance of the Mann-Whitney Rank-Sum Results for All Archaeological Sites and Random Sample Points across the Entire Study Area Compared to All Random Sample Points **(30-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	7194820.0	15140911.0	-7.363	.000
dwell	7657933.5	15604024.5	-3.580	.000
floodf	6103272.0	14049363.0	-17.949	.000
floodfo	6109481.0	14055572.0	-17.889	.000
hwy	7477934.5	15424025.5	-4.537	.000
roadall	7475297.5	15421388.5	-4.568	.000
stream	7305573.5	15251664.5	-6.260	.000
srank1	7848768.0	15794859.0	-.930	.353
srank2	7073291.5	15019382.5	-8.479	.000
srank3	6403444.5	14349535.5	-14.996	.000
srank4	6681702.0	14627793.0	-12.287	.000
srank5	7094504.5	15040595.5	-8.251	.000
srank6	7599273.0	15545364.0	-3.356	.001
srank7	7749958.0	15696049.0	-1.890	.059
srank8	5991580.0	13937671.0	-19.004	.000
srank9	5765870.0	13711961.0	-21.200	.000
sseas	7675375.5	15621466.5	-2.626	.009
sperm	5801074.0	13747165.0	-20.864	.000
drain	6557825.0	14503916.0	-13.507	.000
wetl	6890754.5	14836845.5	-10.252	.000
aspect	7882747.5	15828838.5	-.597	.550
slope	7319312.0	15265403.0	-6.081	.000
elev	7147960.5	15094051.5	-7.749	.000

[a] Grouping variable: site vs random point. Emboldened variables represent those selected for further temporal and geographic analysis

Table 5.7. Descriptive Statistics for All Archaeological Sites and Random Sample Points across the Entire Study Area **(5-meter cells).**

Variable[a]	N	Mean	Std. Deviation	Minimum	Maximum
dpoor	7972	261	441	0	4226
dwell	7972	43	146	0	2201
floodf	7972	317	352	0	2795
floodfo	7972	317	351	0	2794
hwy	7972	1612	1251	0	8120
roadall	7972	179	184	0	3030
stream	7972	79	72	0	1110
srank1	7972	129	120	0	1199
srank2	7972	215	172	0	1485
srank3	7972	403	314	0	2585
srank4	7972	854	690	0	5425
srank5	7972	1699	1186	0	8285
srank6	7972	3699	2360	0	12903
srank7	7972	12867	16931	5	96291
srank8	7972	40024	22249	10	107638
srank9	7972	64107	28031	3050	120668
sseas	7972	103	99	0	1108
sperm	7972	290	255	0	2585
drain	7972	172	148	0	1315
wetl	7972	3552	3200	0	23406
aspect	7972	175	102	0	360
slope	7972	23	18	0	177
elev	7972	202	60	64	460

[*] Emboldened variables represent those selected for further temporal and geographic analysis

Table 5.8. Mann-Whitney Rank-Sum Results for All Archaeological Sites and Random Sample Points across the Entire Study Area **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	3986	3798.93	15142537.50
	Random Point	3986	4174.07	16637840.50
dwell	Site	3986	3911.10	15589645.00
	Random Point	3986	4061.90	16190733.00
floodf	Site	3986	3524.88	14050174.50
	Random Point	3986	4448.12	17730203.50
floodfo	Site	3986	3525.39	14052193.50
	Random Point	3986	4447.61	17728184.50
hwy	Site	3986	4103.25	16355566.00
	Random Point	3986	3869.75	15424812.00
roadall	Site	3986	4105.17	16363208.00
	Random Point	3986	3867.83	15417170.00
stream	Site	3986	3851.31	15351336.00
	Random Point	3986	4121.69	16429042.00
srank1	Site	3986	4011.98	15991756.50
	Random Point	3986	3961.02	15788621.50
srank2	Site	3986	3771.06	15031437.00
	Random Point	3986	4201.94	16748941.00
srank3	Site	3986	3599.95	14349390.50
	Random Point	3986	4373.05	17430987.50
srank4	Site	3986	3668.76	14623694.00
	Random Point	3986	4304.24	17156684.00
srank5	Site	3986	3773.15	15039756.00
	Random Point	3986	4198.91	16732650.00
srank6	Site	3986	3899.86	15544833.00
	Random Point	3986	4073.14	16235545.00
srank7	Site	3986	3937.68	15695590.50
	Random Point	3986	4035.32	16084787.50
srank8	Site	3986	4476.37	17842798.50
	Random Point	3986	3496.63	13937579.50
srank9	Site	3986	4532.83	18067868.50
	Random Point	3986	3440.17	13712509.50
sseas	Site	3986	3923.84	15640445.00
	Random Point	3986	4049.16	16139933.00
sperm	Site	3986	3449.75	13750707.50
	Random Point	3986	4523.25	18029670.50
drain	Site	3986	3644.75	14527954.00
	Random Point	3986	4328.25	17252424.00
wetl	Site	3986	3722.50	14837872.00
	Random Point	3986	4250.50	16942506.00
aspect	Site	3986	4026.04	16047813.50
	Random Point	3986	3946.96	15732564.50
slope	Site	3986	4143.29	16515164.50
	Random Point	3986	3829.71	15265213.50
elev	Site	3986	4191.05	16705512.50
	Random Point	3986	3781.95	15074865.50

* Emboldened variables represent those selected for further temporal and geographic analysis

Table 5.9. Significance of the Mann-Whitney Rank-Sum Results for All Archaeological Sites and Random Sample Points across the Entire Study Area Compared to All Random Sample Points **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	7196446.5	15142537.5	-7.345	.000
dwell	7643554.0	15589645.0	-3.760	.000
floodf	6104083.5	14050174.5	-17.938	.000
floodfo	6106102.5	14052193.5	-17.918	.000
hwy	7478721.0	15424812.0	-4.529	.000
roadall	7471079.0	15417170.0	-4.604	.000
stream	7405245.0	15351336.0	-5.245	.000
srank1	7842530.5	15788621.5	-.989	.323
srank2	7085346.0	15031437.0	-8.358	.000
srank3	6403299.5	14349390.5	-14.996	.000
srank4	6677603.0	14623694.0	-12.327	.000
srank5	7093665.0	15039756.0	-8.259	.000
srank6	7598742.0	15544833.0	-3.361	.001
srank7	7749499.5	15695590.5	-1.894	.058
srank8	5991488.5	13937579.5	-19.005	.000
srank9	5766418.5	13712509.5	-21.195	.000
sseas	7694354.0	15640445.0	-2.431	.015
sperm	5804616.5	13750707.5	-20.823	.000
drain	6581863.0	14527954.0	-13.259	.000
wetl	6891781.0	14837872.0	-10.242	.000
aspect	7786473.5	15732564.5	-1.534	.125
slope	7319122.5	15265213.5	-6.083	.000
elev	7128774.5	15074865.5	-7.935	.000

[a] Grouping variable: site vs random point. Emboldened variables represent those selected for further temporal and geographic analysis

Differing analysis scales or resolutions were employed for the initial evaluation of the 23 environmental correlates of past human settlement. Table 5.4 characterizes the descriptive statistics while Tables 5.5 and 5.6 represent the test statistic results for the variables as processed into 30-m-by-30-m cell rasters, while Tables 5.7-5.9 reflect the variables as processed into 5-m-by-5-m cell rasters. The

comparison of 30-m to 5-m variable resolution attempts to evaluate the effect such scales have on the modeling process. For the initial 22 ratio variables considered, which include some redundant variables, each variable was statistically assigned significance with respect to its influence on the location of archaeological sites and random sample points using the Mann-Whitney Rank-Sum test. Any variable that contained incomplete data for a given site or sampled point was removed from the test statistics analysis through a test-by-test procedure. The test results show statistical significance for all variables except aspect and several stream rank categories.

Additional Mann-Whitney rank-sum tests (Tables 5.10 to 5.13) are conducted for key variables with the removal of zero values from consideration. Environmental variables such as distance from frequently flooded areas (*floodf*), distance from varying drained soils (*dpoor/dwell*), and distance from wetlands (*wetl*) are statistically skewed when considering the distance values of zero, which indicates the location of sites or random points within the same raster cell as the environmental variable, thus possessing a zero value.

Table 5.10. Mann-Whitney Rank-Sum Results for All Archaeological Sites and Random Sample Points across the Entire Study Area Excluding Values of Zero **(30-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	2965	2638.95	7824473.00
	Random Point	2902	3235.46	9389305.00
dwell	Site	1032	905.94	934933.50
	Random Point	1094	1212.13	1326067.50
floodf	Site	3327	2922.57	9723394.00
	Random Point	3462	3849.01	13325261.00
wetl	Site	3954	3678.06	14543049.50
	Random Point	3944	4221.63	16650101.50

Table 5.11. Significance of the Mann-Whitney Rank-Sum Results for All Archaeological Sites and Random Sample Points across the Entire Study Area Compared to All Random Sample Points Excluding Values of Zero **(30-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	3427378.00	7824473.00	-13.50	.000
dwell	401905.50	934933.50	-11.59	.000
floodf	4187266.00	9723394.00	-19.48	.000
wetl	6724014.50	14543049.50	-10.59	.000

a Grouping variable: site vs random point

Table 5.12. Mann-Whitney Rank-Sum Results for All Archaeological Sites and Random Sample Points across the Entire Study Area Excluding Values of Zero **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Sites	2968	2636.93	7826420.50
	Random Point	2900	3239.04	9393225.50
dwell	Sites	1028	901.97	927230.00
	Random Point	1096	1213.07	1329520.00
floodf	Sites	3319	2927.98	9717976.00
	Random Point	3467	3839.14	13310315.00
wetl	Sites	3955	3678.38	14548010.00
	Random Point	3944	4222.37	16653040.00

Table 5.13. Significance of the Mann-Whitney Rank-Sum Results for All Archaeological Sites and Random Sample Points across the Entire Study Area Compared to All Random Sample Points Excluding Values of Zero **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	3420424.50	7826420.50	-13.61	.000
dwell	398324.00	927230.00	-11.68	.000
floodf	4208436.00	9717976.00	-19.15	.000
wetl	6725020.00	14548010.00	-10.60	.000

a Grouping variable: site vs random point

The results of the analysis excluding values of zero (Tables 5.22 - 5.24) maintain statistical significance for the variables. For each variable, the location of known archaeological sites is within closer proximity to said variable than compared to the randomly sampled points. The results when excluding zero values suggest that sites are located further from areas expressing the variable than when the analysis includes sites located within the area exhibiting a zero value. For example, the results of distance from grouped poorly-drained soils (*dpoor*) suggest that sites located in grouped well-drained soils are located closer to poorly-drained soils than expected by chance (i.e. distribution of randomly sampled points). However, the reanalysis excluding zero values suggests these sites are located at greater distance than previously calculated while still remaining significant. The same logic can be applied to the remaining reanalyzed variables, though distance to wetland (*wetl*) is relatively unchanged. The other 18 variables were not considered for reanalysis as there was not an expectation for sites or random points to bias the measure by falling within the variable area (i.e. within a roadway, within a stream, etc.).

In consideration of the appropriateness and significance of the initial 22 ratio variables, stream rank (*srank1*-9) proved too detailed a category, though information was gained through this detail that would not be noticed within the grouped variable category of seasonal stream (stream rank < 3) and permanent stream (stream rank ≥ 3). The dense distribution of recorded streams of rank 1 for both the 30-meter and 5-meter resolutions does not assign statistical significance to the role of *srank1* and the location of known archaeological sites as compared with a random sample of points. Furthermore, stream ranks of greater than six tend to be of a rarity within the west-central region of Louisiana. The significance of these grouped variables is secondary to that of grouped stream ranks (i.e. permanent stream and seasonal stream) which prove more important within this modeling effort. Stream rank is therefore removed from further analyses in favor of seasonal stream (*sseas*) and permanent stream (*sperm*). Additionally, the major drainage variable (*drain*) is similar to, but less effective than the permanent stream variable and therefore is also not considered further.

Soil flooding class variables such as frequently flooding soils (*floodf*) and frequently and occasionally flooding soils (*floodfo*) produce similarly significant results, though there is no marked advantage to include the occasional flooding soil class as no sites have been discovered in these zones, which cover a limited portion of the study area. The frequently and occasionally flooded soil class (*floodfo*) is a major aspect of the definition for medium or indeterminate probability zone within the active US Forest Service model (Fort Polk 1995 Predictive Model). For this analysis,

the frequently flooded soil class (*floodf*) is preferred as it contains the same quantity of sites (n = 670) while covering less land area.

The variable for major highways (*hwy)* lacks relevance for the distribution of known sites as compared to all roadways (*roadall*). Roadways provide a greater likelihood for site discovery by chance due to modern traffic. While major highways offer increased traffic capacity, the limited overlap between the study area and the network of major highways does not translate into a greater likelihood for site discovery or for the patterning of historic settlement. Major highways did not convey statistical significance for any temporal or geographic subset of the data. As such, all roadways (*roadall)* is preferred.

Several prominent trends appear within the study area that relate to the environmental characteristics of sites and random points. While further temporal and geographical evaluations of the environmental variables are needed before revising or developing a predictive model for the Kisatchie National Forest, some general observations can be remarked upon:

1) Archaeological sites are located significantly closer to frequently flooded soils (*floodf*) relative to the distribution of randomly sampled points. Similarly, distance to grouped poorly drained soils (*dpoor*) and distance to grouped well drained soils (*dwell*) produce patterns suggesting a greater propensity for sites to be located at shorter distances to the variables relative to random points. The intersections of drainage ecotones as well as flooding ecotones contain a higher than expected proportion of sites.

The ability to exploit multiple ecotones confers a benefit to both prehistoric and historic populations.

2) Known archaeological sites tend to cluster around streams with greater frequency than randomly sampled points. Even more significant is the location of archaeological sites and random points with respect to permanent streams only *(sperm*). Hydrological factors serve a prominent role within the active US Forest Service model (FPPM 1995), and upon initial testing the assigned prominence is appropriate.
3) Wetlands (*wetl*) appear to attract human activity as known archaeological sites are located significantly closer to areas of recorded wetlands than the random sample of points. Wetlands offer a unique array of biota, which appears to have attracted past populations.
4) Sampled surface areas with greater slope tend to contain archaeological sites, while the randomly sampled points are mostly distributed within areas of reduced slope—a seemingly counterintuitive trend. Site locations within the study area exhibit higher than anticipated percent slopes suggesting the selection of areas above the flat bottomlands that are prone to flooding while remaining within close proximity to streams. Erosion's role in exposing artifacts offers an alternative interpretation of the significance of greater slope, as greater artifact visibility translates to greater likelihood for discovery.
5) Supporting the hypothesis that sites tend to cluster on steeper slopes above lowlands, the known archaeological sites lie at greater elevations relative

to the random background points. Sites average an elevation of 207 m while the randomly sampled points average an elevation of 198 m.

6) In theory, roadways provide a greater likelihood for site discovery by chance due to modern traffic. The results of the Mann-Whitney rank-sum test suggests the contrary, that archaeological sites are typically located a greater distance from roads (*roadall*) than the randomly sampled points. It should be noted that this pattern only holds when considering all site types, as historic sites exhibit a different distribution.
7) The analyzed environmental variable of aspect possesses no significance with respect to the background sample of random points and known archaeological sites. Aspect seems evenly distributed for both datasets. The same negative correlation does not apply to the variable of major highway (*hwy*), yet it fails in appropriateness due to its limited occurrence within the study area. Stream rank conveys too detailed of a set of variables while failing to offer more value than distance to permanent stream (*sperm*) or distance to seasonal stream (*sseas*).

While these observations hold for the entire dataset, greater value may be extracted by examining the environmental variables across geographic and temporal subsets. As with the examination of the active US Forest Service Model in Chapter 4, the Caney District and the central cluster of Calcasieu, Catahoula, Kisatchie, and Winn Districts will be analyzed separately to determine the influence of

environmental variation within the Kisatchie National Forest. Variation is also expected between the prehistoric and historic subsets of archaeological sites. Cultural and subsistence differences would likely influence the distribution of sites across the Forest within the prehistoric component, and especially between the prehistoric and historic components.

The lack of any effect upon variable significance between the 30-m and 5-m raster cell scales implies the equality between these two resolutions for this study area (see Table 5.6 and 5.9) As several variables, most notably Aspect, fluctuated towards significance from the 30-m scale (Z = -.597, p = .550) to the 5-m scale (Z = -1.534, p = -.125), the 5-m scale resolution is accepted as the standard for the remaining analysis (see Table 5.6 and 5.9).

Geographic Correlation of Environmental Variable and Archaeological Site Location

The correlation of environmental variable and archaeological site location for the entire study area proved significant for 10 of the 11 emboldened variables selected for further analysis with the exception of Aspect (see Table 5.9). Separating the study area into the Caney District to the north and the central cluster of Calcasieu, Catahoula, Kisatchie, and Winn Districts, this secondary test attempts to determine the effect of environmental variation within the Forest study area while considering

smaller ranges that may encompass less environmental variance and in turn produce greater or reduced significance for the analyzed variables. As the Caney Ranger District lies approximately 140 kilometers north of the centerpoint for the central cluster of ranger districts (i.e. Winn, Catahoula, Kisatchie, and Calcasieu Districts), the random background points and known archaeological sites and their environmental characteristics are evaluated independently for the central cluster and the Caney District (see Figure 5.1 for Caney and central cluster areas). As discussed in Chapter 4, the level IV ecoregion overlays served as the criteria for selecting the Caney District as an outlier. As the results analyses of environmental variables by district conform to the results of the Caney District and the central cluster of ranger districts, only the geographic area subsets are discussed here.

The random sample points were generated for the entire study area and then extracted by study area subset along with recorded archaeological sites. This sampling technique produces slightly disproportionate quantities of random points to recorded sites when extracted. The central cluster study area contains 3,825 archaeological sites and 3,770 random background points while the Caney study area contains 161 archaeological sites and 216 random background points.

Table 5.14. Descriptive Statistics for All Archaeological Sites and Random Sample Points across the Central Cluster Subset of the Study Area **(5-meter cells).**

Variable	N	Mean	Std. Deviation	Minimum	Maximum
dpoor	7595	223	306	0	2260
dwell	7595	44	148	0	2201
floodf	7595	321	354	0	2795
roadall	7595	181	186	0	3030
stream	7595	78	72	0	1110
sseas	7595	102	98	0	1108
sperm	7595	289	256	0	2585
wetl	7595	3335	2641	0	17039
aspect	7595	175	102	0	360
slope	7595	23	18	0	177
elev	7595	201	59	64	399

Table 5.15. Mann-Whitney Rank-Sum Results for All Archaeological Sites and Random Sample Points across the Central Cluster Subset of the Study Area **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	3825	3607.78	13799766.00
	Random Point	3770	3990.99	15046044.00
dwell	Site	3825	3729.56	14265572.50
	Random Point	3770	3867.44	14580237.50
floodf	Site	3825	3338.84	12771052.50
	Random Point	3770	4263.86	16074757.50
roadall	Site	3825	3918.54	14988397.00
	Random Point	3770	3675.71	13857413.00
stream	Site	3825	3665.16	14019251.00
	Random Point	3770	3932.77	14826559.00
sseas	Site	3825	3739.01	14301729.00
	Random Point	3770	3857.85	14544081.00
sperm	Site	3825	3279.61	12544513.50
	Random Point	3770	4323.95	16301296.50
wetl	Site	3825	3529.54	13500493.00
	Random Point	3770	4070.38	15345317.00
aspect	Site	3825	3831.25	14654530.50
	Random Point	3770	3764.27	14191279.50
slope	Site	3825	3942.92	15081664.50
	Random Point	3770	3650.97	13764145.50
elev	Site	3825	4007.28	15327848.50
	Random Point	3770	3585.67	13517961.50

Table 5.16. Significance of the Mann-Whitney Rank-Sum Results for All Archaeological Sites across the Central Cluster Subset of the Study Area Compared to All Random Sample Points **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	6482541.0	13799766.0	-7.690	.000
dwell	6948347.5	14265572.5	-3.507	.000
floodf	5453827.5	12771052.5	-18.411	.000
roadall	6749078.0	13857413.0	-4.826	.000
stream	6702026.0	14019251.0	-5.318	.000
sseas	6984504.0	14301729.0	-2.362	.018
sperm	5227288.5	12544513.5	-20.754	.000
wetl	6183268.0	13500493.0	-10.748	.000
aspect	7082944.5	14191279.5	-1.331	.183
slope	6655810.5	13764145.5	-5.802	.000
elev	6409626.5	13517961.5	-8.379	.000

[a] Grouping variable: site vs random point

Table 5.17. Mann-Whitney Rank-Sum Results for All Archaeological Sites and Random Sample Points across the Central Cluster Subset of the Study Area Excluding Values of Zero **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	2830	2485.68	7034461.00
	Random Point	2732	3087.94	8436242.00
dwell	Site	1002	874.73	876476.50
	Random Point	1046	1167.97	1221699.50
floodf	Site	3189	2794.93	8913034.50
	Random Point	3306	3685.03	12182725.50
wetl	Site	3795	3493.19	13256638.00
	Random Point	3736	4043.12	15105108.00

Table 5.18. Significance of the Mann-Whitney Rank-Sum Results for All Archaeological Sites the Central Cluster Subset of the Study Area Compared to All Random Sample Points Excluding Values of Zero **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	3028596.00	7034461.00	-13.98	.000
dwell	373973.50	876476.50	-11.22	.000
floodf	3826579.50	8913034.50	-19.13	.000
wetl	6053728.00	13256638.00	-10.98	.000

a Grouping variable: site vs random point

The results of the analysis for the all archaeological sites across the central cluster subset of the study area are relatively undifferentiated from the results for the entire study area. Again, only the aspect variable fails to produce a statistically significant difference between sites and random points (see Table 5.16). Several variables underwent further analysis with values of zero being excluded from the Mann-Whitney rank-sum test (variables not emboldened in initial test). The results share the interpretations of the test as run on the entire study area.

Table 5.19. Descriptive Statistics for All Archaeological Sites and Random Sample Points across the Caney Subset of the Study Area **(5-meter cells).**

Variable	N	Mean	Std. Deviation	Minimum	Maximum
dpoor	377	1031	1266	0	4226
dwell	377	37	110	0	760
floodf	377	232	274	0	1340
roadall	377	145	132	0	764
stream	377	94	70	0	437
sseas	377	125	106	0	593
sperm	377	313	233	0	1015
wetl	377	7933	7485	0	23406
aspect	377	180	105	0	359
slope	377	20	16	0	89
elev	377	231	75	105	460

Table 5.20. Mann-Whitney Rank-Sum Results for All Archaeological Sites and Random Sample Points across the Caney Subset of the Study Area **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	161	201.74	32480.00
	Random Point	216	179.50	38773.00
dwell	Site	161	179.62	28918.50
	Random Point	216	195.99	42334.50
floodf	Site	161	185.60	29881.50
	Random Point	216	191.53	41371.50
roadall	Site	161	181.37	29201.00
	Random Point	216	194.69	42052.00
stream	Site	161	193.12	31092.50
	Random Point	216	185.93	40160.50
sseas	Site	161	190.07	30600.50
	Random Point	216	188.21	40652.50
sperm	Site	161	175.51	28256.50
	Random Point	216	199.06	42996.50
wetl	Site	161	200.66	32306.50
	Random Point	216	180.31	38946.50
aspect	Site	161	196.82	31688.50
	Random Point	216	183.17	39564.50
slope	Site	161	197.42	31785.00
	Random Point	216	182.72	39468.00
elev	Site	161	189.57	30520.00
	Random Point	216	188.58	40733.00

Table 5.21. Significance of the Mann-Whitney Rank-Sum Results for All Archaeological Sites across the Caney Subset of the Study Area Compared to All Random Sample Points **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	15337.0	38773.0	-1.966	.049
dwell	15877.5	28918.5	-2.060	.039
floodf	16840.5	29881.5	-.526	.599
roadall	16160.0	29201.0	-1.173	.241
stream	16724.5	40160.5	-.634	.526
sseas	17216.5	40652.5	-.164	.870
sperm	15215.5	28256.5	-2.076	.038
wetl	15510.5	38946.5	-1.794	.073
aspect	16128.5	39564.5	-1.203	.229
slope	16032.0	39468.0	-1.296	.195
elev	17297.0	40733.0	-.087	.931

[a] Grouping Variable: Site vs Random Point

Table 5.22. Significance of the Mann-Whitney Rank-Sum Results for All Archaeological Sites across the Caney Subset of the Study Area Compared to All Random Sample Points Excluding Values of Zero **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Sites	138	158.36	21854.00
	Random Point	168	149.51	25117.00
dwell	Sites	26	27.21	707.50
	Random Point	50	44.37	2218.50
floodf	Sites	130	133.48	17353.00
	Random Point	161	156.11	25133.00
wetl	Sites	160	192.88	30861.50
	Random Point	208	178.05	37034.50

Table 5.23. Mann-Whitney Rank-Sum Results for All Archaeological Sites and Random Sample Points across the Caney Subset of the Study Area Excluding Values of Zero **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	10921.00	25117.00	-0.87	.384
dwell	356.50	707.50	-3.21	.001
floodf	8838.00	17353.00	-2.28	.023
wetl	15298.50	37034.50	-1.33	.185

a Grouping variable: site vs random point.

The test statistics of the Mann-Whitney rank-sum test produced only three significant values representing differences between archaeological sites and random background points in the Caney District for distance to grouped poorly drained soils, distance to grouped well drained soils, and distance to permanent stream (see Table 5.21). The significant environmental variables change with further analysis excluding values of zero from the Mann-Whitney rank-sum test. Distance to poorly drained soils is no longer significant while distance to frequently flooded soils becomes significant with the test-by-test removal of zero values (Tables 5.22 to 5.23).

Distance to well drained soils increases in significance while remaining significant with sites on average located closer relative to random background points. Sites are also located closer to frequently flooded soils and permanent streams than the randomly sampled points. Neither slope nor elevation has any significant effect on the location of known sites, suggesting a differently utilized topography.

While there is a marked difference in sample size between the Caney and central cluster subsets, the results of the Mann-Whitney rank-sum suggest either the development of two models or the consideration of variables appropriate across both study area subsets. The effectiveness of each environmental variable must also be examined temporally between historic and prehistoric sites.

Temporal Correlation of Environmental Variables and Archaeological Site Location

Extending over 12,000 years, prehistory in North America encompasses both great temporal breadth and in turn, cultural variation. In contrast, the historical record covers an abbreviated span with sites located in proximity to modern features upon the landscape such as roadways. Creating a successful model to forecast the locations of both prehistoric and historic sites relies on understanding the relationship between each temporal category and the environment. The following set of tests compares the distribution of prehistoric and historic sites with respect to the selected environmental variables.

Two non-ratio variables, soil drainage class and soil surface texture, were statistically evaluated by comparing the expected and observed site frequencies for each class or texture for both prehistoric and historic sites (see Tables 5.24 and 5.25). The observed site frequencies were tabulated within a GIS, while the expected site frequencies were calculated by coverage percent (detailed in Chapter 3). Both chi-square values and gains are used to evaluate the importance of these variables.

Table 5.24. Test Statistics of Soil Drainage Class for Prehistoric Archaeological Sites across the Entire Study Area.

Drainage Class	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Excessively drained	121427904	4.9	111.5	110	4.8	0.0	-0.01
Well drained	814258590	32.7	747.8	922	40.4	40.6	0.19
Moderately well drained	840758368	33.8	772.1	677	29.6	11.7	-0.14
Somewhat poorly drained	294400469	11.8	270.4	149	6.5	54.5	-0.81
Poorly drained	405846011	16.3	372.7	420	18.4	6.0	0.11
No data	10398117	0.4	9.5	6	0.3	1.3	-0.59
Total	2487089459	100.0	2284.0	2284	100.0	114.1	-

df = 5, α = .05, sig of $\chi 2 \geq 11.1$

Table 5.25. Test Statistics of Soil Drainage Class for Historic Archaeological Sites across the Entire Study Area.

Drainage Class	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Excessively drained	121427904	4.9	14.6	12	4.0	0.5	-0.22
Well drained	814258590	32.7	98.2	115	38.3	2.9	0.15
Moderately well drained	840758368	33.8	101.4	102	34.0	0.0	0.01
Somewhat poorly drained	294400469	11.8	35.5	37	12.3	0.1	0.04
Poorly drained	405846011	16.3	49.0	34	11.3	4.6	-0.44
No data	10398117	0.4	1.3	0	0.0	1.3	-
Total	2487089459	100.0	300.0	300	100.0	9.2	-

df = 5, α = .05, sig of $\chi 2 \geq 11.1$

Only three of the soil drainage class variables contain significant differences between the observed and expected values based on percent coverage respectively for the prehistoric test (Table 5.24), while the historic test produced no variables of significance (Table 5.25). The well drained and somewhat poorly drained soil drainage classes are highly significant while the moderately well drained class also represents a significant value. The well drained soil drainage class contains a marginally higher than expected density of prehistoric archaeological sites with a high gain value of 0.19 (Table 5.24), which is a slight increase from the gain value (0.18 to 0.19) when considering all archaeological sites (Table 5.2). The converse is true when considering the site density for both the moderately well drained and somewhat poorly drained classes. This suggests that for the known sites in the study area, there is a direct relationship between the extent of soil drainage and the likelihood for a site to occur or be discovered. The presence of well drained soils is a good indicator of increased probability for prehistoric site discovery. While drainage class is appropriate for prehistoric sites, it does not lend itself toward predicting historic site locations.

Soil surface texture contains three significant $\chi 2$ values—all within the prehistoric (Table 5.26) and none within the historic (Table 5.27). While statistically significant with a positive gain, the number of sites (n = 274) located within areas of *loamy sand* surface texture as opposed to the number of expected sites (n = 211) does not provide overwhelming evidence for preference of this surface texture. The converse holds for *loam* and *silt loam* soil surface textures. Considering the poor

results of the variable class when considering all sites as well as the poor results for the prehistoric and historic tests, soil surface texture does not translate effectively to site location prediction.

Table 5.26. Test Statistics of Soil Surface Texture for Prehistoric Archaeological Sites across the Entire Study Area.

Drainage Class	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Loam	110391882	4.4	101.4	63	2.8	14.5	-0.61
Silt loam	686410098	27.6	630.4	533	23.3	15.0	-0.18
Sandy loam	1423941804	57.3	1307.7	1389	60.8	5.1	0.06
Loamy sand	229709297	9.2	211.0	274	12.0	18.8	0.23
Clay	26237966	1.1	24.1	19	0.8	1.1	-0.27
No data	10398412	0.4	9.5	6	0.3	1.3	-0.59
Total	2487089459	100.0	2284.0	2284	100.0	55.9	-

df = 5, α = .05, sig of $\chi 2 \geq 11.1$

Table 5.27. Test Statistics of Soil Surface Texture for Historic Archaeological Sites across the Entire Study Area.

Drainage Class	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Loam	110391882	4.4	13.3	17	5.7	1.0	0.22
Silt loam	686410098	27.6	82.8	71	23.7	1.7	-0.17
Sandy loam	1423941804	57.3	171.8	173	57.7	0.0	0.01
Loamy sand	229709297	9.2	27.7	39	13.0	4.6	0.29
Clay	26237966	1.1	3.2	0	0.0	3.2	-
No data	10398412	0.4	1.3	0	0.0	1.3	-
Total	2487089459	100.0	300.0	300	100.0	11.7	-

df = 5, α = .05, sig of $\chi 2 \geq 11.1$

Significant differences are apparent when comparing the distribution of prehistoric and historic sites with respect to the selected environmental variables. Distance to well drained soils (*dwell*) and distance to seasonal streams (*sseas*) are the only two variables that express no significant differences between prehistoric and historic site locations. Historic sites in general tend to be located at greater distance from hydrologic features such as streams, wetlands, and frequently flooded soils. Historic sites also tend to be located at greater elevations on surfaces of reduced percent slope relative to prehistoric sites. Importantly, historic sites tend to cluster around roads, which is a notably absent variable within the active US Forest Service Model (FPPM 1995).

Table 5.28. Descriptive Statistics for Prehistoric and Historic Archaeological Sites across the Entire Study Area **(5-meter cells).**

Variable	Prehistoric (n = 2284)				Historic (n = 300)			
	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
dpoor	206	335	0	3340	322	552	0	3987
dwell	26	90	0	1440	39	167	0	1573
floodf	249	313	0	1966	335	331	0	1687
roadall	184	136	0	997	136	134	0	680
stream	70	54	0	490	88	64	0	440
sseas	98	84	0	700	102	83	0	484
sperm	214	192	0	1191	329	234	5	1773
wetl	2980	2624	0	21433	3845	3349	5	18605
aspect	175	103	0	360	190	99	0	358
slope	24	18	0	177	20	14	0	83
elev	198	59	68	379	210	58	83	448

Table 5.29. Mann-Whitney Rank-Sum Results for Prehistoric and Historic Archaeological Sites across the Entire Study Area **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Prehistoric Site	2284	1275.97	2914310.50
	Historic Site	300	1418.37	425509.50
dwell	Prehistoric Site	2284	1294.43	2956482.50
	Historic Site	300	1277.79	383337.50
floodf	Prehistoric Site	2284	1263.32	2885414.50
	Historic Site	300	1514.69	454405.50
roadall	Prehistoric Site	2284	1330.04	3037819.00
	Historic Site	300	1006.67	302001.00
stream	Prehistoric Site	2284	1266.81	2893393.00
	Historic Site	300	1488.09	446427.00
sseas	Prehistoric Site	2284	1284.79	2934462.00
	Historic Site	300	1351.19	405358.00
sperm	Prehistoric Site	2284	1242.72	2838369.00
	Historic Site	300	1671.50	501451.00
wetl	Prehistoric Site	2284	1267.95	2896006.50
	Historic Site	300	1479.38	443813.50
aspect	Prehistoric Site	2284	1279.60	2922609.00
	Historic Site	300	1390.70	417211.00
slope	Prehistoric Site	2284	1314.35	3001969.00
	Historic Site	300	1126.17	337851.00
elev	Prehistoric Site	2284	1277.37	2917505.50
	Historic Site	300	1407.72	422314.50

Table 5.30. Significance of the Mann-Whitney Rank-Sum Results for Prehistoric and Historic Archaeological Sites across the Entire Study **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	304840.5	2914310.5	-3.131	.002
dwell	338187.5	383337.5	-.479	.632
floodf	275944.5	2885414.5	-5.496	.000
roadall	256851.0	302001.0	-7.058	.000
stream	283923.0	2893393.0	-4.830	.000
sseas	324992.0	2934462.0	-1.449	.147
sperm	228899.0	2838369.0	-9.359	.000
wetl	286536.5	2896006.5	-4.615	.000
aspect	313139.0	2922609.0	-2.425	.015
slope	292701.0	337851.0	-4.107	.000
elev	308035.5	2917505.5	-2.845	.004

[a] Grouping Variable: Prehistoric Site vs Historic Site

Discussion

The temporal differences are not enough to advocate for multiple temporal models, while the geographic differences appear more significant. The Caney District produces significantly different associations between the environmental variables and site location with respect to the central cluster area. A model should first be developed for the entire sample, and if the gain values of the high and medium probability zone do not carry the appropriate values for the Caney District, a second model should be produced for the Caney District. Appendix B contains the results of a combined temporal and geographic correlation of environmental variables and archaeological site location. Results of the variables evaluated for this chapter will be implemented within the next chapter.

Chapter 6. Proposed 2011 Kisatchie National Forest Model and Conclusions

The analysis results presented within Chapter 4 and 5 warrant the development of a new predictive model for the Kisatchie National Forest. The active US Forest Service Model lacks definition between the high and medium probability zones with respect to Kvamme's (1988) gain statistic, since the medium probability zone exhibits a slightly higher gain than the high probability zone. The high probability zone accounts for too large of an area to produce a sufficiently high site density, while the medium or indeterminate probability zone covers a smaller and more specific land area—frequently flooded soils. While both the high and medium probability zones produce more sites than expected by chance, there should be a greater proportion of sites in the high probability zone than is currently exhibited. The active Forest model is extremely effective in indicating low probability areas (i.e. upland locales located away from water sources) as it contains an appropriate negative gain statistic. A new model should better demarcate the medium and high probability zones to aid Forest personnel in resource management efforts.

The development process for the new predictive model relied on the analyses conducted within Chapter 5, which explored the environmental correlations between an array of variables and archaeological site location. Several variables were removed from the initial testing due to insignificance or redundancy. For example, stream rank one through nine produced a similar, but less effective relationship to site location than stream permanence, defined as a mapped watercourse with a stream

rank value equal to or greater than three. A portion of the remaining significant variables co-varied as they represented similar data. Due to the topography of the region, elevation is directly proportional to the distance from permanent stream or frequently flooded soils. Elevation and slope, both significant factors in settlement patterning, did not convey effectiveness for delimiting probability zones. The significance was better represented by horizontal distance from permanent streams and flooded soils, both of which occurred at lower elevations of less percent slope. With an increase in horizontal distance from a permanent stream or frequently flooded soil, there is generally an increase in slope and elevation as well.

Selecting appropriate variables that displayed significance, while also pertaining to settlement patterning, limited the inclusion of several variables. Distance to road produced the most significant correlation between historic site location and a variable; however, due to the extremely limited sample of historic sites (n = 300) and the large percentage of area a road buffer encompasses, the distance to road variable was not included. This was also partially due to the high median value, which requires an extremely large buffer to maximize effectiveness. A 100-m full buffer around roadways throughout the entire study area only encompassed half of the historic sites (n = 152), while a 50-m full buffer overlapped with roughly under a third (n = 99). If the large sample of unknown archaeological sites was known to contain significantly more historic sites, the inclusion of this buffer may be appropriate. The inclusion of a road buffer to increase the density of prehistoric sites within a high or medium probability zone further compounds the biasing effect that roads represent for site discovery. As neither the historic or prehistoric sites are

correctly influenced by road buffer inclusion, distance from roads was not included in model development.

The formative variables within the new predictive model center upon the intersection between soil types and their ability to drain water. Categories of degree of drainage and flooding frequency of soils are closely related and are both produced from the SSURGO soils dataset. Within the analysis of select variables, distance to frequently flooded soils superseded distance to grouped poorly drained soils, suggesting the appropriateness of that category for developing a high probability zone. Theoretically, the ecotones between differently drained soils provide a key environment for both prehistoric and historic peoples to exploit. Proximity to two distinct patches of landscapes increases subsistence diversity for biotic communities and therefore subsistence opportunities. The intersection of frequently flooded soils with non flooded soils is also within proximity to permanent water sources, conferring greater attractiveness for exploitation. As the characteristics of individual locations on the landscape influence settlement, areas conferring greater benefits (e.g. proximity to ecotones, proximity to water, elevation, slope, etc.) will be selected for habitation (Jochim 1976).

Using central place foraging theory, Hollenbach (2010) models the relationship between campsite location and the exploitation of the landscape's resources. The resource procurement model suggests that foragers select camp site locations in areas where short-term foraging will produce the greatest returns. Areas of ecotones straddling multiple landscape patches provide greater resource diversity

and density, which follows with central place foraging theory. Incorporating this theoretical consideration in the formation of zone definitions, the new Kisatchie National Forest Predictive Model assigns high probability to areas that allow for foraging efficiency.

A tripartite probability division that is similar to the 1995 model was selected for the new predictive model so as to facilitate comparison with the active US Forest Service model. Gain statistics serve as the assigning criteria for high, medium, and low probabilities for containing archaeological sites. The gain statistics should follow a pattern of high positive gain for high probability areas, lower positive gain for medium probability areas, and negative gains representing low probability areas.

The modeling technique used to develop the proposed predictive model involved buffering significant variables. An example of the buffering technique for distance to road is displayed within the text for all sites (Table 6.1) and historic sites (Table 6.2). The gain values calculated for the historic sites sample is negative; suggesting that distance to road is not an appropriate variable to formulate a zone for historic sites. This is due to the low number of historic sites recorded on the Kisatchie National Forest relative to the large percentage of area that the buffering of the roadways encompasses. This technique was used for each variable with the increasing of buffering increments ceasing only after a drop in gain was noted. Typically the buffer with the highest gain was selected unless a buffer of similar gain represented considerably less area while containing a high number of sites.

Table 6.1. An Example of the Buffering Strategy and Statistical Evaluation for the Road Variable using All Archaeological Sites.

Variable	Area (m^2)	% of Area	Expected Sites	Observed Sites	% Sites	$\chi 2$	Gain
Road Buffer 20	209527498	8.4	59.0	341	8.6	43.2	0.02
Road Buffer 30	311049157	12.5	108.0	520	13.0	83.5	0.04
Road Buffer 40	410318406	16.5	143.3	690	17.3	110.8	0.05
Road Buffer 50	507419340	20.4	200.9	828	20.8	161.5	0.02
Road Buffer 60	602340962	24.2	200.9	967	24.3	155.3	0.00
Road Buffer 75	740418475	29.8	314.7	1120	28.1	261.0	-0.06
Road Buffer 100	958857109	38.6	478.5	1381	34.6	411.7	-0.11

df = 6, α = .05, sig of $\chi 2 \geq 12.59$

Table 6.2. An Example of the Buffering Strategy and Statistical Evaluation for the Road Variable using only Historic Archaeological Sites.

Variable	Area (m^2)	% of Area	Expected Sites	Observed Sites	% Sites	$\chi 2$	Gain
Road Buffer 20	209527498	8.4	2.5	99	2.5	0.0	-2.39
Road Buffer 30	311049157	12.5	2.5	99	2.5	0.0	-4.04
Road Buffer 40	410318406	16.5	2.5	99	2.5	0.0	-5.64
Road Buffer 50	507419340	20.4	2.5	99	2.5	0.0	-7.21
Road Buffer 60	602340962	24.2	2.5	99	2.5	0.0	-8.75
Road Buffer 75	740418475	29.8	4.2	129	3.2	0.2	-8.20
Road Buffer 100	958857109	38.6	5.8	152	3.8	0.7	-9.11

df = 6, α = .05, sig of $\chi 2 \geq 12.59$

The two primary environmental variables considered for the model development include distance to frequently flooded soils and distance to permanent streams as these proved to be extremely significant factors for the location of archaeological sites, especially when compared to randomly sampled background points. The soil intersection between frequently and non-frequently flooded soils was explored with the buffering of the intersection in increasing 10-m increments both internally (towards the flooded soils) and externally (towards non-flooded soils), each

conducted independently of the other. A similar buffering technique was utilized for the permanent streams in the study area while being conscious of the need to use datasets extending beyond the study area so as to receive the full buffering of any variable and not a truncated buffer due to a modern abstract boundary. The areas with the highest gain statistic were selected for use within the model. After selection of the high probability zone, additional buffers were conducted radiating from the zone to delimit medium probability zones.

The high probability zone, areas of non-frequently flooded soils located within 100-m of frequently flooded soils, represents a small land area with an abnormally high density of recorded archaeological sites contrasts the large high zone size of the active US Forest Service Model (1995 FPPM). A 100-m buffer extending from the intersection of frequently and non-frequently flooded soils in the direction of well drained soils produced a gain value of 0.51, suggesting its assignment as the high probability zone. The high probability zone covers 14.2 percent of the total study area while encompassing 29.0 percent of all archaeological sites. This buffered area represents a landscape in non-frequently flooded soils within 100-m of frequently flooded soils, allowing for efficient foraging activities within a close proximity to available water. A simple buffer promotes ease of field-use as opposed to a more segmented high probability zone offered by alternative modeling techniques (e.g., the 2010 Fort Polk model, Perez and Bundy 2010)

Table 6.3. Test Statistics for the Probability Zones of the Proposed 2011 Kisatchie National Forest Model for the Entire Study Area and All Archaeological Sites.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% Sites	$\chi 2$	Gain
Zone 1 (High)	353127618	14.2	565.9	1156	29.0	615.2	0.51
Zone 2 (Medium)	1000159583	40.2	1602.9	1889	47.4	51.1	0.15
Zone 2 (Low)	1133802258	45.6	1817.1	941	23.6	422.4	-0.93
Total	2487089459	100.0	3986.0	3986	100.0	1088.6	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table 6.4. Test Statistics for the Probability Zones of the Active U.S. Forest Service Predictive Model for the Entire Study Area and All Archaeological Sites.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	338508668	13.6	542.1	670	16.8	30.2	0.19
Zone 2 (High)	1363591761	54.8	2183.9	2651	66.5	99.9	0.18
Zone 3 (Low)	786732525	31.6	1260.0	665	16.7	281.0	-0.89
Total	2488832954	100.0	3986.0	3986	100.0	411.0	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

The medium probability zone area is comprised of a multitude of factors relating to proximity to both the high probability zone and permanent streams. A 100-m buffer into non-frequently flooded soils from the high probability zone, a 200-m buffer from the intersection of frequently and non-frequently flooded soils towards frequently flooded soils, and a 300-m buffer of permanent streams clipping frequently flooded soils, were UNIONED and then DISSOLVED within ArcGIS to form the medium probability zone. This zone covers 40.2 percent of the total study area while encompassing 47.4 percent of all archaeological sites, resulting in a gain statistic of 0.15. The medium probability zone represents an exploitable landscape slightly less

attractive to intense human settlement or activities, but still more utilized than low probability zones. The area contains a significantly higher density of sites per the landscape than expected by chance alone.

The low probability zone is the remainder of the area and is expected to contain a modest number of archaeological sites with respect to the high and medium probability zones. The Low Probability Zone covers the largest swath of land, 45.4 percent of the total study area, while encompassing the lowest percentage of all archaeological sites (23.6 %). The low probability zone exhibits significantly less archaeological sites than expected by chance alone with a gain of – 0.93.

The proposed 2011 Kisatchie National Forest Predictive Model is recommended for use as a singular model for all of the forest districts. Detailed evaluations show the probability zones prove effective within the Caney District as well as within the central cluster area (Tables 6.5 to 6.8). The results of the model performance for each ranger district within the central cluster area indicate effective modeling zones with all maintain an ideal gain progression (Appendix C). In comparison with the model it is replacing, the proposed 2011 Kisatche National Forest Predictive Model greatly exceeds the gains of the active U.S. Forest Service predictive model when considering the ideal distribution and appropriateness of gains.

Table 6.5. Test Statistics for the Probability Zones of the Proposed 2011 Kisatchie National Forest Model for the Central Cluster Study Area and All Archaeological Sites.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% Sites	$\chi 2$	Gain
Zone 1 (High)	331002554	14.1	537.5	1114	29.1	618.4	0.52
Zone 2 (Medium)	951287513	40.4	1544.7	1815	47.5	47.3	0.15
Zone 2 (Low)	1073313185	45.6	1742.8	896	23.4	411.5	-0.95
Total	2355603252	100.0	3825.0	3825	100.0	1077.2	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table 6.6. Test Statistics for the Probability Zones of the Active U.S. Forest Service Predictive Model for the Central Cluster Study Area and All Archaeological Sites.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	300112869	12.7	487.0	638	16.7	46.8	0.24
Zone 2 (High)	1300364015	55.2	2110.1	2552	66.7	92.6	0.17
Zone 3 (Low)	756754669	32.1	1228.0	635	16.6	286.3	-0.9
Total	2357231553	100.0	3825.0	3825	100.0	425.7	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table 6.7. Test Statistics for the Probability Zones of the Proposed 2011 Kisatchie National Forest Model for the Caney District Study Area and All Archaeological Sites.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% Sites	$\chi 2$	Gain
Zone 1 (High)	22125064	16.8	27.1	42	26.1	8.2	0.35
Zone 2 (Medium)	48872069	37.2	59.8	74	46.0	3.3	0.19
Zone 2 (Low)	60489074	46.0	74.1	45	28.0	11.4	-0.65
Total	131486208	100.0	161.0	161	100.0	23.0	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table 6.8. Test Statistics for the Probability Zones of the Active U.S. Forest Service Predictive Model for the Caney District Study Area and All Archaeological Sites.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
Zone 1 (Medium)	38395797	29.2	47.0	32	19.9	4.8	-0.5
Zone 2 (High)	63227747	48.0	77.4	99	61.5	6.1	0.2
Zone 3 (Low)	29977856	22.8	36.7	30	18.6	1.2	-0.2
Total	131601400	100.0	161.0	161	100.0	12.0	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

The new predictive model for the Kisatchie National Forest consists of three highly statistically significant zones with appropriate gains associated with each (Figures 6.1 to 6.5). The model is defined by the formative variables of distance to frequently flooded soils and distance to permanent stream. The high probability zone is defined as:

1) Areas of non-frequently flooded soils located within 100-ms of frequently flooded soils, as defined by the NRCS.

The medium probability zone is defined as:

1) Areas of non-frequently flooded soils located within 100-ms of the high probability zone.
2) Areas of frequently flooded soils located within 200-ms of non-frequently flooded soils.
3) Areas on non-frequently flooded soils located within 300-ms of permanent watercourses.

The low probability zone consists of all other areas defined as:

1) Areas of non-frequently flooded soils located more than 200-ms from frequently flooded areas.
2) Areas of non-frequently flooded soils located more than 300-ms from permanent watercourses.
3) Areas of frequently flooded soils located more than 200-ms from non-frequently flooded soils.

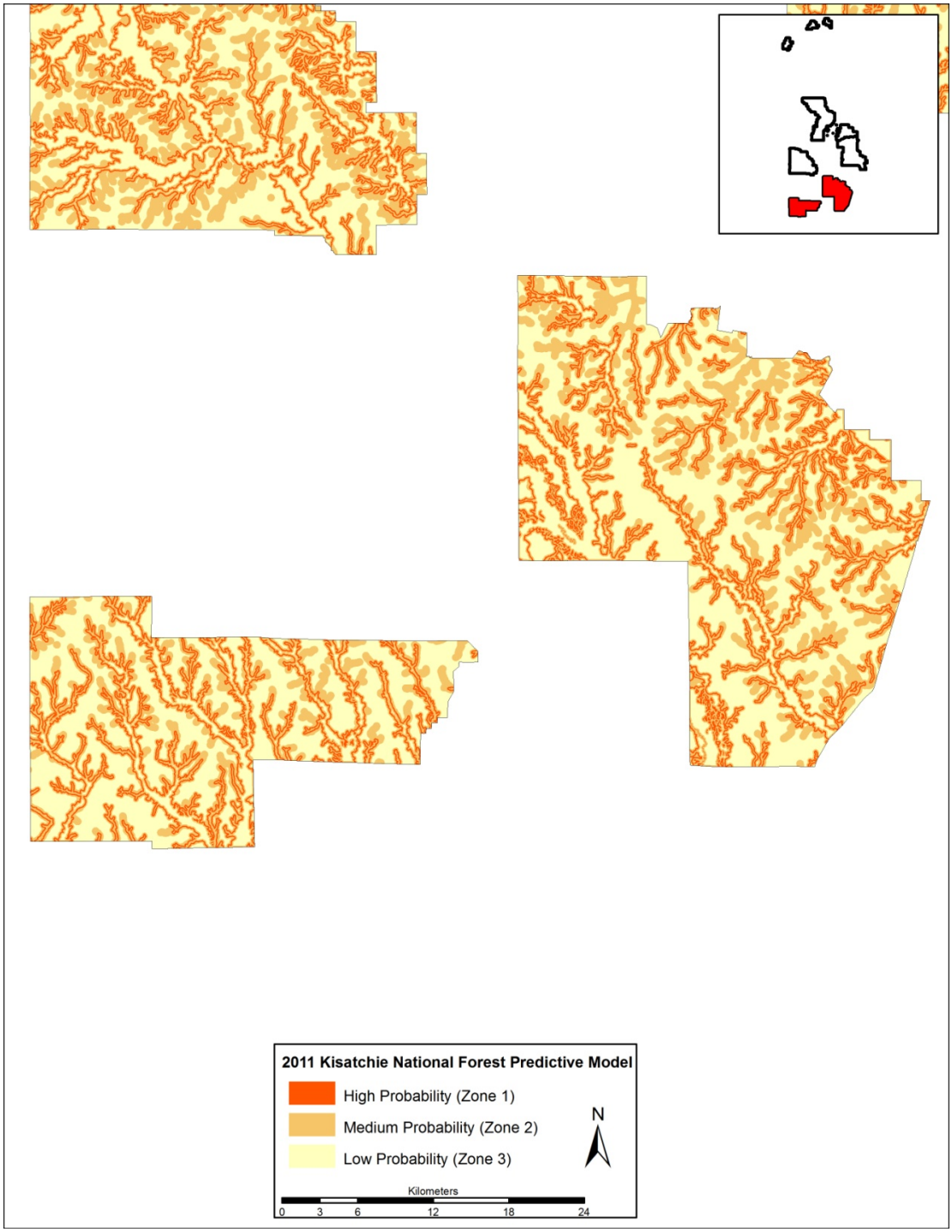


Figure 6.1. The proposed 2011 Kisatchie National Forest predictive model probability Zones for the Calcasieu District.



Figure 6.2. The proposed 2011 Kisatchie National Forest predictive model probability zones for the Caney District.

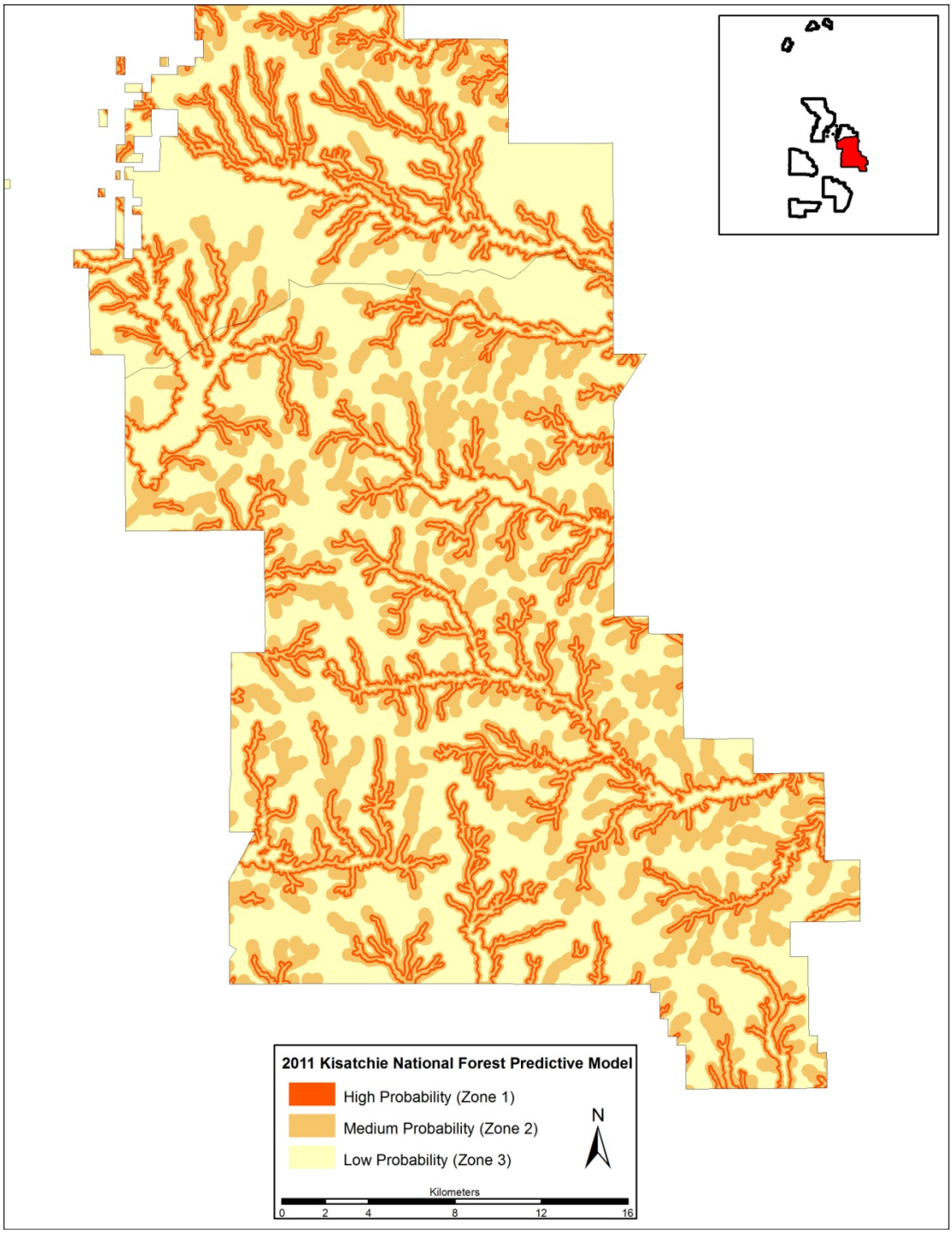


Figure 6.3. The proposed 2011 Kisatchie National Forest predictive model probability zones for the Catahoula District.

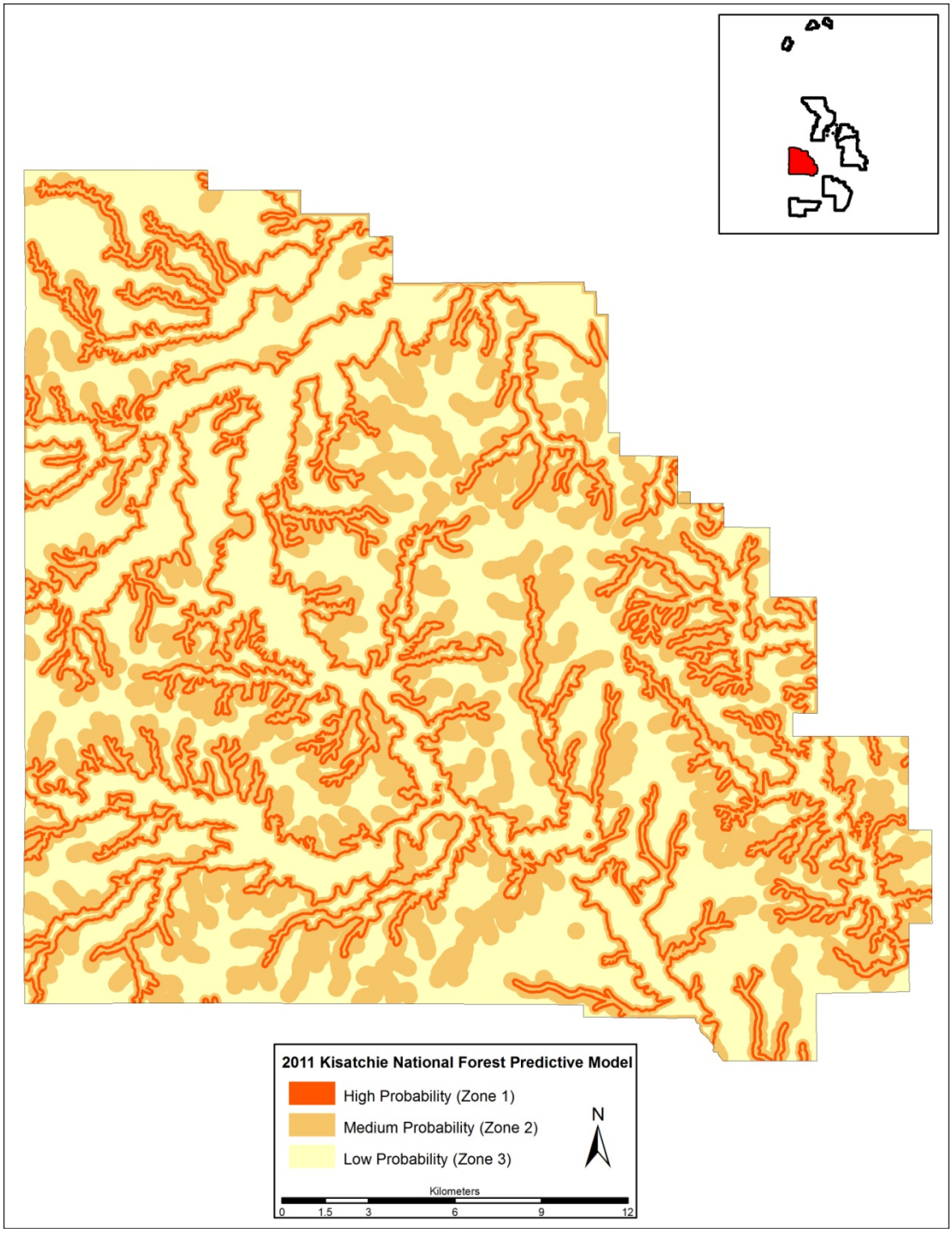


Figure 6.4. The proposed 2011 Kisatchie National Forest predictive model probability zones for the Kisatchie District.

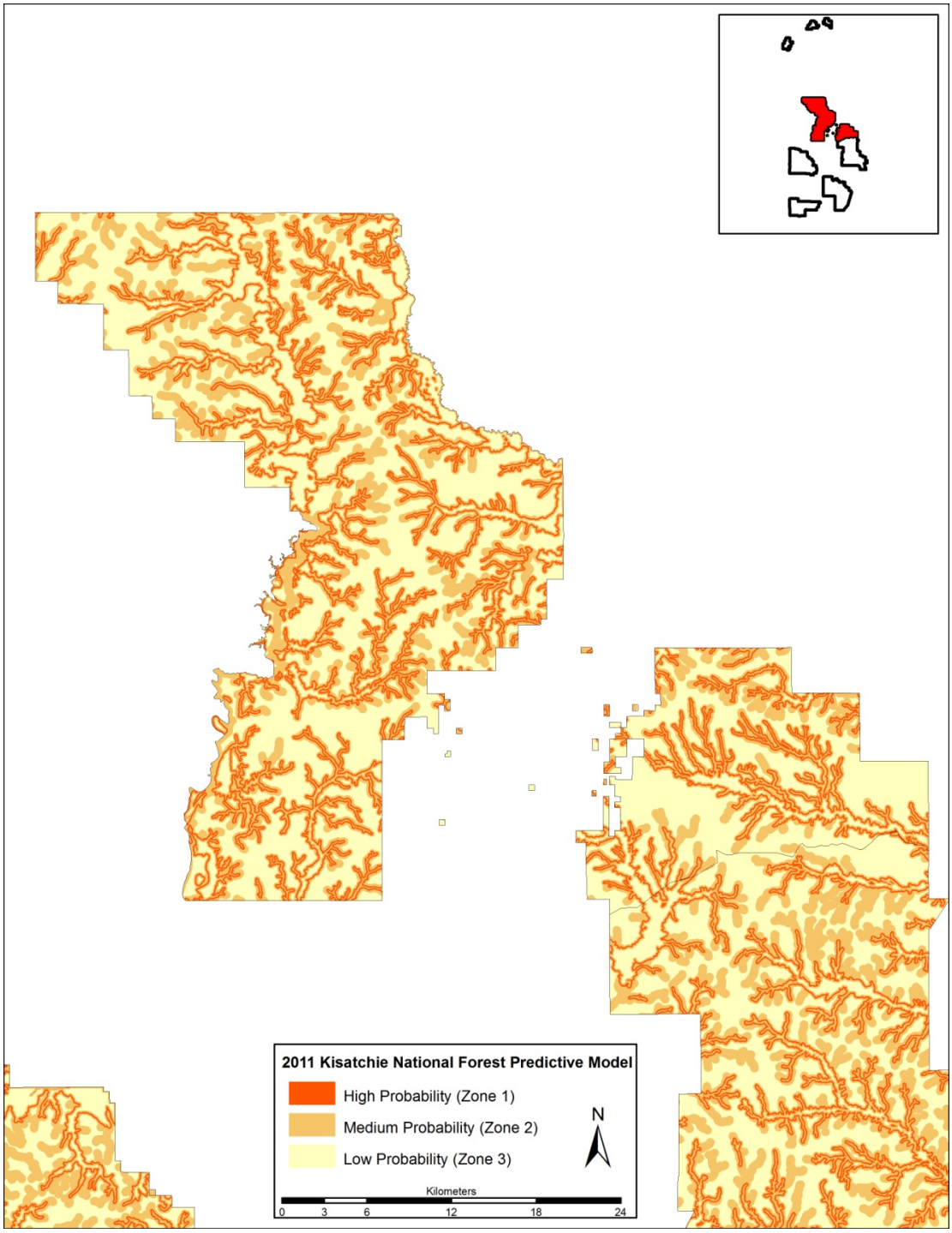


Figure 6.5. The proposed 2011 Kisatchie National Forest predictive model probability zones for the Winn District.

Conclusions and Recommendations

The newly developed and proposed 2011 Kisatchie National Forest predictive model shares many of the same environmental variables as the active US Forest Service Model (1995 FPPM) it is recommended to replace. These variables are shared as they are the most appropriate within the region and represent areas of varying resource offerings, as well as being easily operationalized in the field. The different strategies employed in the formation of each zone separate the models and produce varying levels of effectiveness. The proposed predictive model developed within this thesis has the advantage of being designed with consideration allotted for the larger region while also testing the model with the same dataset used in its construction. Several distinct differences were noted between the 1995 and the newly proposed 2011 Kisatchie National Forest predictive model with the coverage area differences between the high and medium zones most apparent. The differing gain statistics suggest that the new model more efficiently and effectively captures a greater number of archaeological sites relative to the total study area.

Geographically, the proposed 2011 Kisatchie National Forest predictive model appears to control for environmental and topographic variation more effectively as it markedly outperforms the active U.S. Forest Service Model (1995 FPPM) in both the Caney District and central cluster of ranger districts. The increased model performance within the Caney District negates the need for separate

models for the Caney District and the clumped ranger districts encompassed within the central cluster area.

While the proposed 2011 Kisatchie National Forest predictive model zones may not be completely obvious in the field—for instance, determining the boundary between frequently and non-frequently flooded soils may prove challenging—it will be simpler to implement than a model that produces very segmented probability zones in a completely unpredictable fashion (e.g. 2010 FPPM, Perez and Bundy 2011). While the adoption of modern technology (i.e. precise in-field GPS devices with GIS capabilities) is becoming more ubiquitous within the field of archaeology, planning transects with tiered sampling intervals proves more complex and prone for in-field error for instances when a predictable buffer-type of zone is not followed.

The 2011 Kisatchie National Forest predictive model significantly outperforms both the active U.S. Forest Service Model (1995 FPPM) as well the recently developed 2010 FPPM (Tables 6.9 to 6.12). Gain statistics illustrate the effectiveness of each model. Since the 2010 FPPM probability zones were only generated over a small area and are difficult to replicate over larger areas, data from this study area were used to evaluate both the 1995 and 2010 Fort Polk predictive models (see Perez and Bundy 2011:253, Table 14.3 for values as used)(Tables 6.9 to 6.11). The utility of the Kisatchie National Forest predictive model was demonstrated over the entire Calcasieu ranger district study area, which includes portions of Fort Polk (Table 6.12). As the 2010 FPPM contains only two zones, the high and medium zones were combined for the 1995 FPPM and the proposed 2011 Kisatchie National

Forest predictive model to render the results comparable. Examining the gain statistics as well as the areas and numbers of sites in each zone, the best performance is clearly by the proposed 2011 Kisatchie National Forest predictive model. Interestingly, the gain statistics also indicate that the 1995 FPPM also outperforms the 2010 FPPM, although not as much as the 2011 Kisatchie National Forest predictive model (Tables 6.9 to 6.12).

Table 6.9. Test Statistics for the High (includes Medium) and Low Probability Zones of the 1995 Fort Polk Predictive Model for the 2010 FPPM Study Area Including All Sites.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
High (Zone 1+2)	84352	52.3	1428.5	1789	65.5	91.0	0.20
Low	77032	47.7	1304.5	944	34.5	99.6	-0.38
Total	161384	100.0	2733.0	2733	100.0	190.6	-

df = 2, α = .05, sig of $\chi 2 \geq 3.84$

Table 6.10. Test Statistics for the High and Low Probability Zones of the 2010 Prehistoric Fort Polk Predictive Model for the 2010 FPPM Study Area.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
High	107880	85.7	1909.1	1945.0	87.3	0.7	0.02
Low	18018	14.3	318.9	283.0	12.7	4.0	-0.13
Total	125898	100.0	2228.0	2228.0	100.0	4.7	-

df = 2, α = .05, sig of $\chi 2 \geq 3.84$

Table 6.11. Test Statistics for the High and Low Probability Zones of the 2010 Historic Fort Polk Predictive Model for the 2010 FPPM Study Area.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
High	106639	85.5	216.4	239.0	94.5	2.4	0.09
Low	18018	14.5	36.6	14.0	5.5	13.9	-1.61
Total	124657	100.0	253.0	253.0	100.0	16.3	-

df = 2, α = .05, sig of $\chi 2 \geq 3.84$

Table 6.12. Test Statistics for the High (includes Medium) and Low Probability Zones of the Proposed 2011 Kisatchie National Forest Predictive Model for the Calcasieu District Study Area Including All Sites.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
High (and Medium)	394885272	52.5	1202.8	1768	77.2	265.5	0.32
Low	356902565	47.5	1087.2	522	22.8	293.8	-1.08
Total	751787837	100.0	2290.0	2290	100.0	559.3	-

df = 2, $\alpha = .05$, sig of $\chi 2 \geq 3.84$

The proposed 2011 predictive model is also recommended to be adopted for the Kisatchie National Forest rather than the 2010 FPPM because it is simpler to implement in the field without excessive patchiness as previously discussed. Even with the common usage of GPS devices capable of displaying GIS layers, the patchy and unfluid nature of the high and low probability zones of alternative models, such as the 2010 Fort Polk predictive model make it challenging to operationalize for archaeological surveys. For these reasons, it is recommended that the US Forest Service adopt the model developed herein for use on its lands.

In addition to recommending that the U.S. Forest Service adopt the proposed 2011 Kisatchie National Forest predictive model, this study also recommends that authorities on the Fort Polk military reservation consider evaluating the proposed 2011 Kisatchie National Forest predictive model against the 1995 and 2010 FPPM over the entire Fort Polk area and, if the results are like those produced in the tests conducted here in Tables 6.9 to 6.12, consider adopting the proposed 2011 Kisatchie National Forest predictive model for the Fort Polk area as well. The data layers for

the probability zones in the 2011 Kisatchie National Forest predictive model are easy to generate and use in the field and, the results of this study suggest, have applicability over much of western Louisiana.

Following the tiered sampling intensity strategy recommended by Anderson et al. (1996) for the 1995 Fort Polk Predictive Model, the high (zone 1) and medium (zone 2) probability zones as located on Kisatchie National Forest should receive shovel test pits (STPs) spaced at 30-m intervals along transects spaced 30-m apart, while the low (zone 3) probability zone should receive 50-m interval STPs along 50-m spaced transects. This recommended sampling strategy will intensify survey in areas of higher than expected likelihood for site discovery, while reducing field technician hours spent in low probability areas.

The use of a predictive model creates an incidence of survey bias and therefore, the model tends to become a self-fulfilling prediction. The circular nature of modeling archaeological site location is overcome by its benefits towards managing resources over large tracts of land. The implementation of the proposed 2011 Kisatchie National Forest predictive model, as outlined in this thesis, provides heritage personnel with a guide that will increase both accuracy and efficiency of site discovery, thus aiding Forest Service management efforts in the assessment, protection, and conservation of cultural resources. The proposed 2011 Kisatchie National Forest predictive model utilizes variables in its zone construction that influenced prehistoric and historic settlement patterning beyond just the Kisatchie

National Forest. The proposed model may prove a useful tool for the entire state and even the larger region due to its high gain values and ease of implementation.

The proposed 2011 Kisatchie National Forest Predictive Model Zones and study area has been made available to the Kisatchie National Forest in digital form.

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Appendix

Appendix A

Appendix A contains a figure of the location of Fort Polk Military Reservation with respect to the Kisatchie National Forest. Also contained within Appendix A are figures showing the distribution of the sample of known prehistoric and historic sites across the ranger districts of the Kisatchie National Forest. Dark green areas represent the study area within the Kisatchie National Forest. Relevant district extent emboldened in red by figure.

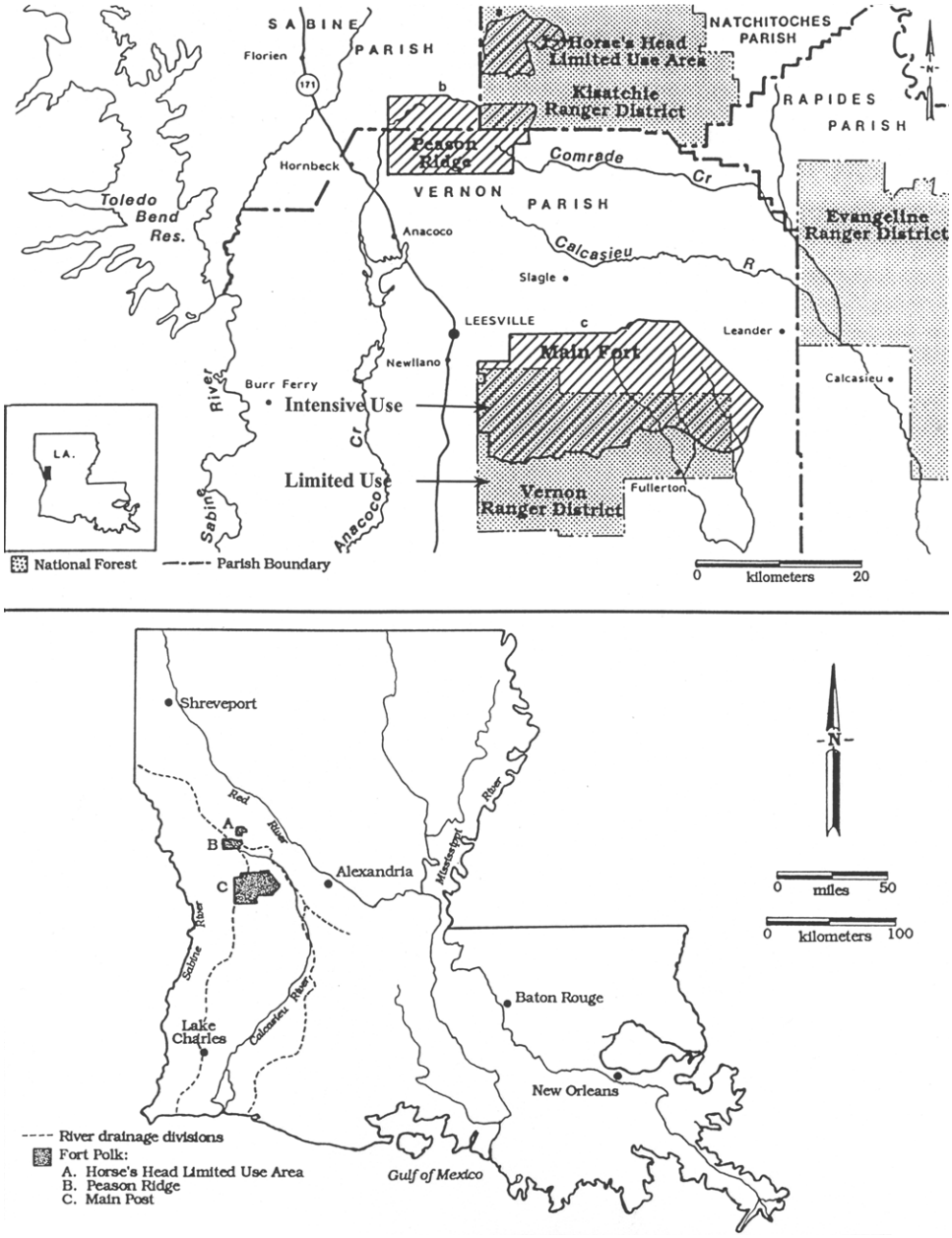


Figure A.1. Location of Fort Polk Military Reservation with respect to the Kisatchie National Forest. Overlap Occurs with the Vernon Unit of the Calcasieu ranger district and the Kisatchie ranger district (from Anderson and Smith 2003:3; Thomas et al. 1982;2, 47).

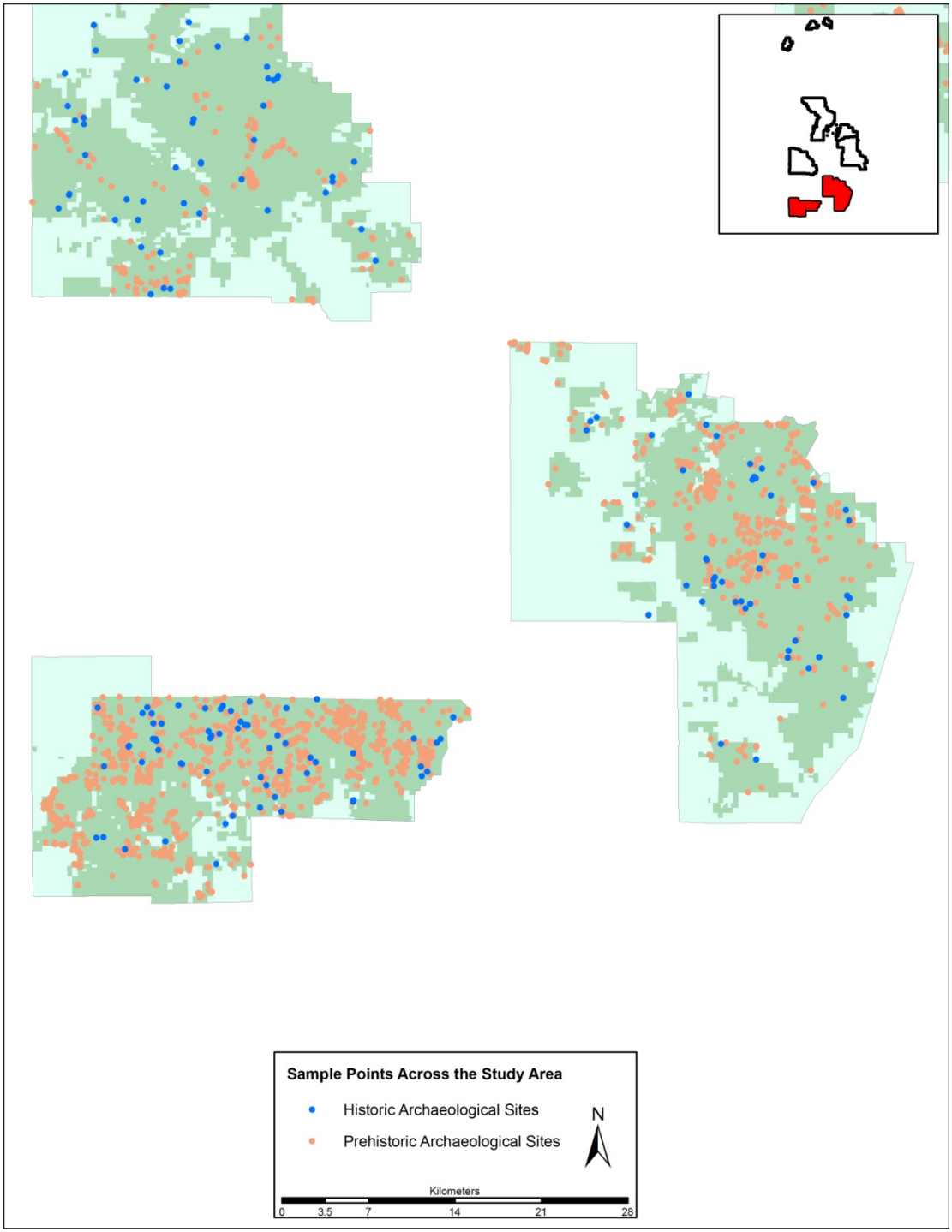


Figure A.2. Distribution of prehistoric and historic archaeological sites across the Kisatchie National Forest study area for the Calcasieu District.

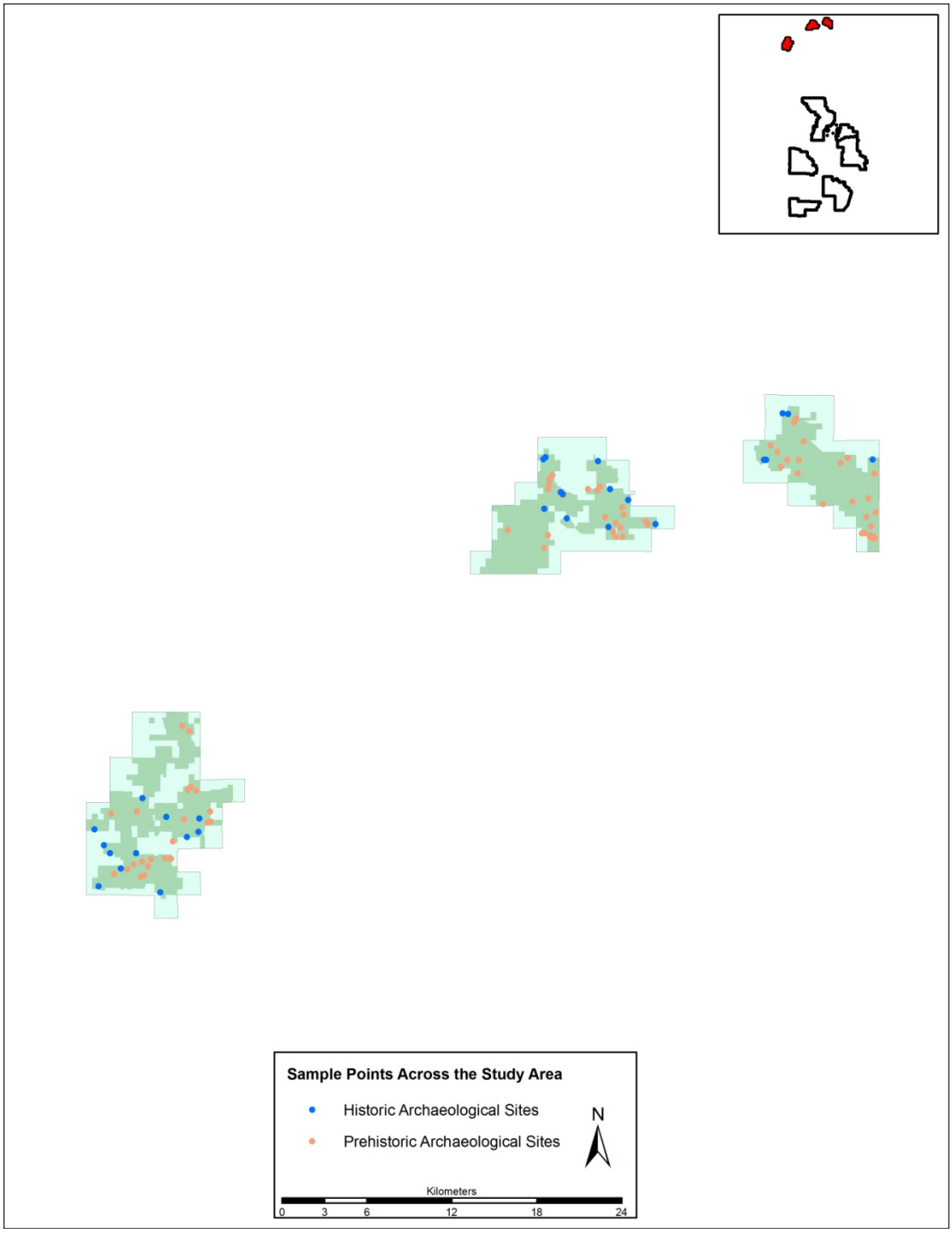


Figure A.3. Distribution of prehistoric and historic archaeological sites across the Kisatchie National Forest study area for the Caney District.

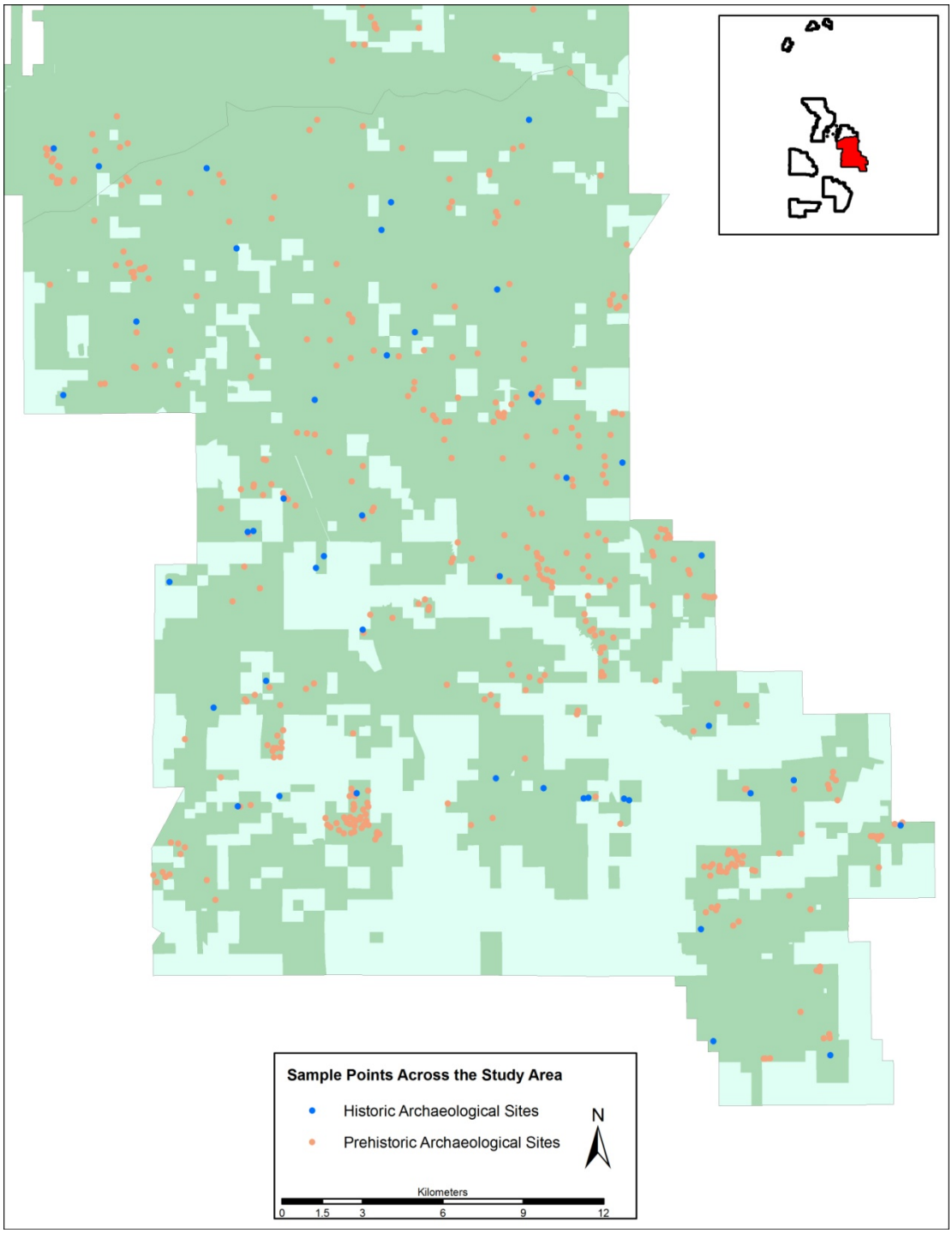


Figure A.4. Distribution of prehistoric and historic archaeological sites across the Kisatchie National Forest study area for the Catahoula District.

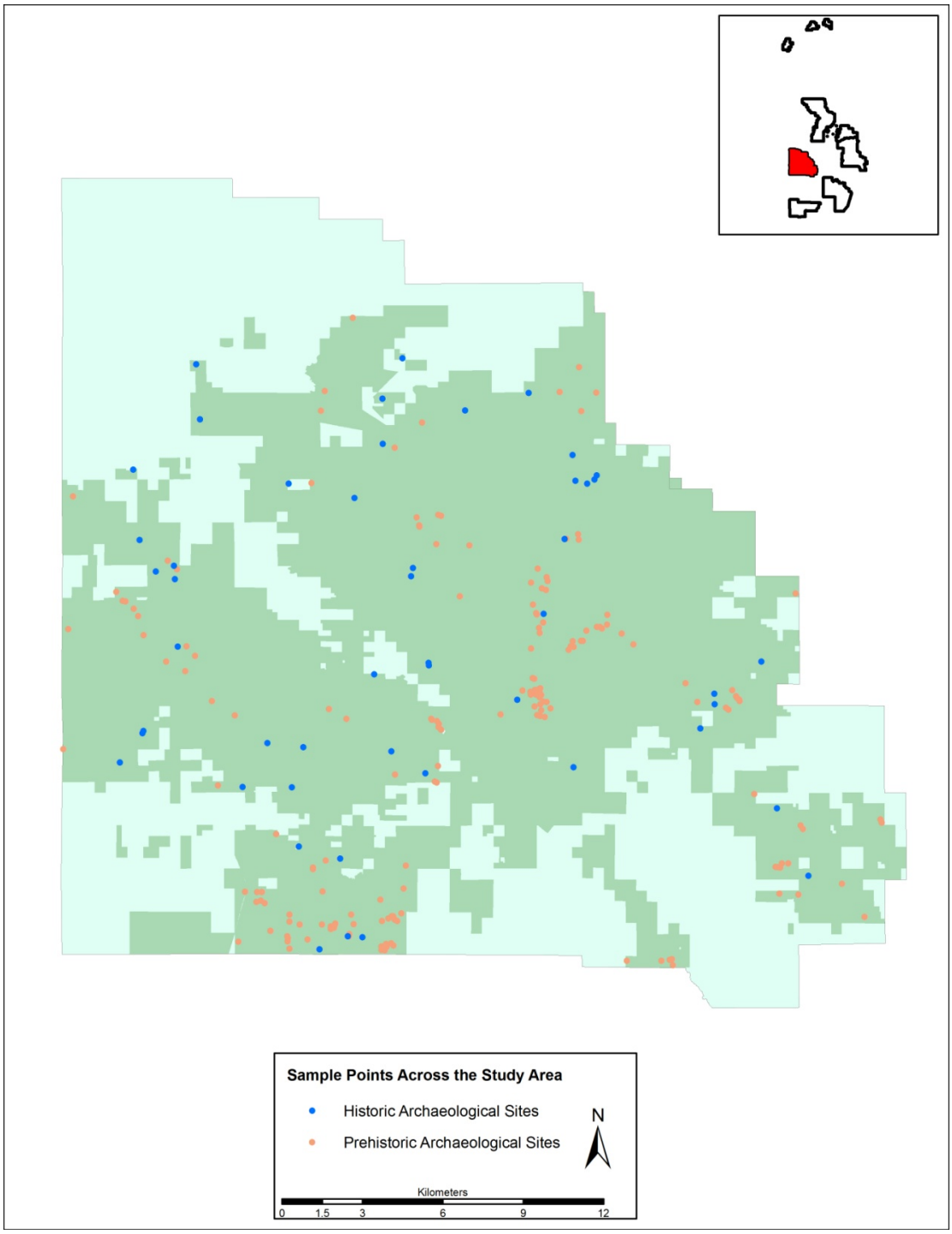


Figure A.5. Distribution of prehistoric and historic archaeological sites across the Kisatchie National Forest study area for the Kisatchie District.

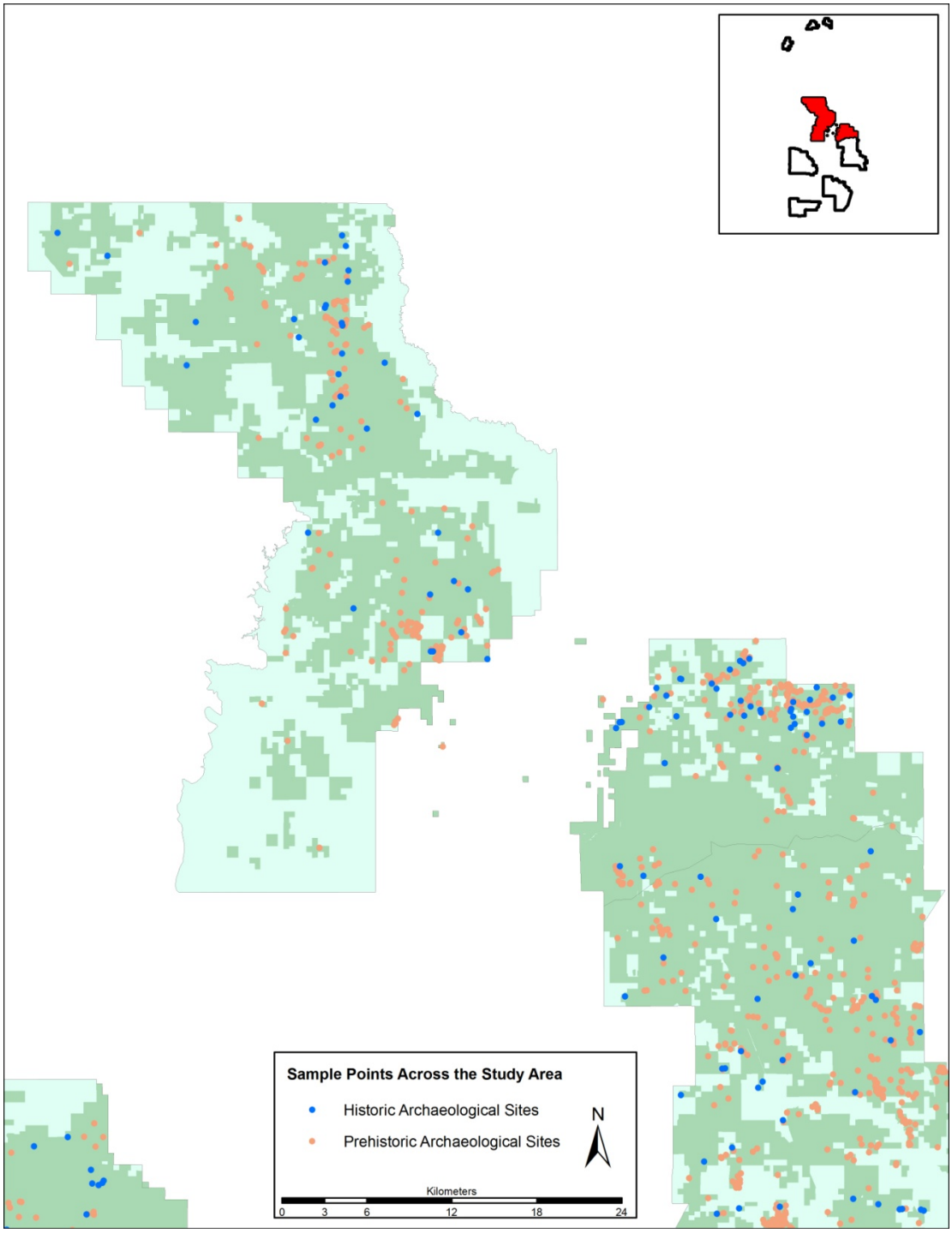


Figure A.6. Distribution of prehistoric and historic archaeological sites across the Kisatchie National Forest study area for the Winn District.

Appendix B

Statistical results for environmental association between known archaeological sites (prehistoric and historic) and sampled random points with additional tests for excluding values of zero.

Table B.1. Descriptive Statistics for Prehistoric Archaeological Sites and Random Sample Points across the entire Study Area **(5-meter cells).**

Variable	N	Mean	Std. Deviation	Minimum	Maximum
dpoor	4568	250	402	0	4085
dwell	4568	43	141	0	1970
floodf	4568	317	352	0	2795
roadall	4568	181	176	0	2458
stream	4568	78	69	0	912
sseas	4568	103	97	0	1057
sperm	4568	283	251	0	2585
wetl	4568	3421	2977	0	22705
aspect	4568	174	103	0	360
slope	4568	23	18	0	177
elev	4568	198	60	66	445

Table B.2. Mann-Whitney Rank-Sum Results for Prehistoric Archaeological Sites and Random Sample Points across the entire Study Area **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	2284	2179.75	4978543.50
	Random Point	2284	2389.25	5457052.50
dwell	Site	2284	2225.94	5084057.50
	Random Point	2284	2343.06	5351538.50
floodf	Site	2284	2006.03	4581783.50
	Random Point	2284	2562.97	5853812.50
roadall	Site	2284	2398.00	5477037.00
	Random Point	2284	2171.00	4958559.00
stream	Site	2284	2208.78	5044853.50
	Random Point	2284	2360.22	5390742.50
sseas	Site	2284	2266.09	5175738.50
	Random Point	2284	2302.91	5259857.50
sperm	Site	2284	1922.97	4392073.50
	Random Point	2284	2646.03	6043522.50
wetl	Site	2284	2092.11	4778371.00
	Random Point	2284	2476.89	5657225.00
aspect	Site	2284	2290.91	5232437.50
	Random Point	2284	2278.09	5203158.50
slope	Site	2284	2379.53	5434847.00
	Random Point	2284	2189.47	5000749.00
elev	Site	2284	2298.58	5249955.00
	Random Point	2284	2270.42	5185641.00

Table B.3. Significance of the Mann-Whitney Rank-Sum Results for Prehistoric Archaeological Sites across the entire Study Area Compared to Prehistoric Random Sample Points **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	2369073.5	4978543.5	-5.418	.000
dwell	2474587.5	5084057.5	-3.856	.000
floodf	1972313.5	4581783.5	-14.292	.000
roadall	2349089.0	4958559.0	-5.817	.000
stream	2435383.5	5044853.5	-3.881	.000
sseas	2566268.5	5175738.5	-.944	.345
sperm	1782603.5	4392073.5	-18.528	.000
wetl	2168901.0	4778371.0	-9.860	.000
aspect	2593688.5	5203158.5	-.328	.743
slope	2391279.0	5000749.0	-4.870	.000
elev	2576171.0	5185641.0	-.722	.471

[a] Grouping Variable: Site vs Random Point

Table B.4. Mann-Whitney Rank-Sum Results for Prehistoric Archaeological Sites and Random Sample Points across the entire Study Area Excluding Values of Zero **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Sites	1719	1491.83	2564452.00
	Random Point	1643	1879.95	3088751.00
dwell	Sites	571	527.28	301076.00
	Random Point	647	682.06	441295.00
floodf	Sites	1918	1665.77	3194940.50
	Random Point	1990	2232.79	4443245.50
wetl	Sites	2262	2064.22	4669256.00
	Random Point	2258	2457.13	5548204.00

Table B.5. Significance of the Mann-Whitney Rank-Sum Results for Prehistoric Archaeological Sites across the entire Study Area Compared to Prehistoric Random Sample Points Excluding Values of Zero **(5-meter cells)**.

Variable	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	1086112.00	2564452.00	-11.59	.000
dwell	137770.00	301076.00	-7.66	.000
floodf	1354619.50	3194940.50	-15.71	.000
wetl	2109803.00	4669256.00	-10.12	.000

a Grouping Variable: Site vs Random Point

Table B.6. Descriptive Statistics for Historic Archaeological Sites and Random Sample Points across the entire Study Area **(5-meter cells).**

Variable	N	Mean	Std. Deviation	Minimum	Maximum
dpoor	600	318	519	0	3987
dwell	600	47	170	0	1709
floodf	600	343	340	0	2153
roadall	600	161	190	0	2647
stream	600	90	90	0	1110
sseas	600	111	113	0	1108
sperm	600	330	265	0	1976
wetl	600	3747	3278	0	18605
aspect	600	183	99	0	359
slope	600	21	17	0	164
elev	600	203	58	68	448

Table B.7. Mann-Whitney Rank-Sum Results for Historic Archaeological Sites and Random Sample Points across the entire Study Area **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	300	297.35	89204.50
	Random Point	300	303.65	91095.50
dwell	Site	300	297.99	89397.00
	Random Point	300	303.01	90903.00
floodf	Site	300	297.99	89397.50
	Random Point	300	303.01	90902.50
roadall	Site	300	273.29	81986.00
	Random Point	300	327.71	98314.00
stream	Site	300	311.86	93556.50
	Random Point	300	289.15	86743.50
sseas	Site	300	299.33	89800.00
	Random Point	300	301.67	90500.00
sperm	Site	300	308.19	92456.00
	Random Point	300	292.81	87844.00
wetl	Site	300	308.02	92406.50
	Random Point	300	292.98	87893.50
aspect	Site	300	311.89	93568.00
	Random Point	300	289.11	86732.00
slope	Site	300	296.64	88991.50
	Random Point	300	304.36	91308.50
elev	Site	300	321.34	96402.00
	Random Point	300	279.66	83898.00

Table B.8. Significance of the Mann-Whitney Rank-Sum Results for Historic Archaeological Sites across the entire Study Area Compared to Historic Random Sample Points **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	44054.5	89204.5	-.448	.654
dwell	44247.0	89397.0	-.476	.634
floodf	44247.5	89397.5	-.355	.723
roadall	36836.0	81986.0	-3.845	.000
stream	41593.5	86743.5	-1.605	.109
sseas	44650.0	89800.0	-.165	.869
sperm	42694.0	87844.0	-1.086	.277
wetl	42743.5	87893.5	-1.063	.288
aspect	41582.0	86732.0	-1.610	.107
slope	43841.5	88991.5	-.546	.585
elev	38748.0	83898.0	-2.945	.003

[a] Grouping Variable: Site vs Random Point

Table B.9. Mann-Whitney Rank-Sum Results for Historic Archaeological Sites and Random Sample Points across the entire Study Area Excluding Values of Zero **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	229	225.37	51610.00
	Random Point	229	233.63	53501.00
dwell	Site	71	60.89	4323.50
	Random Point	71	82.11	5829.50
floodf	Site	269	255.07	68613.50
	Random Point	258	273.31	70514.50
wetl	Site	300	304.02	91206.50
	Random Point	296	292.90	86699.50

Table B.10. Significance of the Mann-Whitney Rank-Sum Results for Historic Archaeological Sites across the entire Study Area Compared to Historic Random Sample Points Excluding Values of Zero **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Dpoor	25275.00	51610.00	-0.67	.504
dwell	1767.50	4323.50	-3.07	.002
floodf	32298.50	68613.50	-1.37	.169
wetl	42743.50	86699.50	-0.79	.431

a Grouping variable: site vs random point

Table B.11. Descriptive Statistics for Historic Archaeological Sites and Random Sample Points across the Caney District Study Area **(5-meter cells).**

Variable	N	Mean	Std. Deviation	Minimum	Maximum
dpoor	44	1019	1257	0	3987
dwell	44	51	150	0	760
floodf	44	283	289	0	1126
roadall	44	138	152	0	623
stream	44	113	68	5	270
sseas	44	147	124	0	588
sperm	44	353	229	5	850
wetl	44	7209	6621	0	18605
aspect	44	189	100	0	340
slope	44	19	15	0	83
elev	44	235	71	114	448

Table B.12. Mann-Whitney Rank-Sum Results for Historic Archaeological Sites and Random Sample Points across the Caney District Study Area **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	28	25.54	715.00
	Random Point	16	17.19	275.00
dwell	Site	28	19.71	552.00
	Random Point	16	27.38	438.00
floodf	Site	28	27.71	776.00
	Random Point	16	13.38	214.00
roadall	Site	28	19.46	545.00
	Random Point	16	27.81	445.00
stream	Site	28	20.54	575.00
	Random Point	16	25.94	415.00
sseas	Site	28	18.54	519.00
	Random Point	16	29.44	471.00
sperm	Site	28	25.34	709.50
	Random Point	16	17.53	280.50
wetl	Site	28	24.21	678.00
	Random Point	16	19.50	312.00
aspect	Site	28	21.64	606.00
	Random Point	16	24.00	384.00
slope	Site	28	24.93	698.00
	Random Point	16	18.25	292.00
elev	Site	28	26.21	734.00
	Random Point	16	16.00	256.00

Table B.13. Significance of the Mann-Whitney Rank-Sum Results for Historic Archaeological Sites across the Caney District Study Area Compared to Historic Random Sample Points **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	139.0	275.0	-2.078	.038
dwell	146.0	552.0	-2.988	.003
floodf	78.0	214.0	-3.577	.000
roadall	139.0	545.0	-2.074	.038
stream	169.0	575.0	-1.342	.180
sseas	113.0	519.0	-2.708	.007
sperm	144.5	280.5	-1.940	.052
wetl	176.0	312.0	-1.171	.242
aspect	200.0	606.0	-.586	.558
slope	156.0	292.0	-1.659	.097
elev	120.0	256.0	-2.537	.011

[a] Grouping Variable: Site vs Random Point

Table B.14. Mann-Whitney Rank-Sum Results for Historic Archaeological Sites and Random Sample Points across the Caney Study Area Excluding Values of Zero **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	27	19.33	522.00
	Random Point	10	18.10	181.00
dwell	Site	1	2.00	2.00
	Random Point	6	4.33	26.00
floodf	Site	27	19.56	528.00
	Random Point	8	12.75	102.00
wetl	Site	28	22.21	622.00
	Random Point	14	20.07	281.00

Table B.15. Significance of the Mann-Whitney Rank-Sum Results for Historic Archaeological Sites across the Caney District Study Area Compared to Historic Random Sample Points Excluding Values of Zero **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	126.000	181.000	-.308	.758
dwell	1.000	2.000	-1.000	.317
floodf	66.000	102.000	-1.650	.099
wetl	176.000	281.000	-.534	.594

a Grouping variable: site vs random point

Table B.16. Descriptive Statistics for Historic Archaeological Sites across the Central Cluster District Study Area **(5-meter cells).**

Variable	N	Mean	Std. Deviation	Minimum	Maximum
dpoor	556	263	355	0	2196
dwell	556	47	172	0	1709
floodf	556	347	344	0	2153
roadall	556	163	193	0	2647
stream	556	88	91	0	1110
sseas	556	109	112	0	1108
sperm	556	328	268	0	1976
wetl	556	3473	2679	0	16627
aspect	556	183	99	0	359
slope	556	21	17	0	164
elev	556	200	57	68	374

Table B.17. Mann-Whitney Rank-Sum Results for Historic Archaeological Sites and Random Sample Points across the Central Cluster District Study Area **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	272	267.55	72773.50
	Random Point	284	288.99	82072.50
dwell	Site	272	280.30	76242.00
	Random Point	284	276.77	78604.00
floodf	Site	272	269.87	73403.50
	Random Point	284	286.77	81442.50
roadall	Site	272	255.78	69571.00
	Random Point	284	300.26	85275.00
stream	Site	272	291.10	79180.50
	Random Point	284	266.43	75665.50
sseas	Site	272	280.45	76282.50
	Random Point	284	276.63	78563.50
sperm	Site	272	282.68	76889.50
	Random Point	284	274.49	77956.50
wetl	Site	272	282.81	76924.00
	Random Point	284	274.37	77922.00
aspect	Site	272	290.76	79088.00
	Random Point	284	266.75	75758.00
slope	Site	272	271.49	73844.50
	Random Point	284	285.22	81001.50
elev	Site	272	292.67	79605.00
	Random Point	284	264.93	75241.00

Table B.18. Significance of the Mann-Whitney Rank-Sum Results for Historic Archaeological Sites across the Central Cluster District Study Area Compared to Historic Random Sample Points **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	35645.5	72773.5	-1.584	.113
dwell	38134.0	78604.0	-.344	.731
floodf	36275.5	73403.5	-1.241	.215
roadall	32443.0	69571.0	-3.264	.001
stream	35195.5	75665.5	-1.811	.070
sseas	38093.5	78563.5	-.280	.779
sperm	37486.5	77956.5	-.601	.548
wetl	37452.0	77922.0	-.619	.536
aspect	35288.0	75758.0	-1.762	.078
slope	36716.5	73844.5	-1.007	.314
elev	34771.0	75241.0	-2.035	.042

[a] Grouping Variable: Site vs Random Point

Table B.19. Mann-Whitney Rank-Sum Results for Historic Archaeological Sites and Random Sample Points across the Central Cluster Study Area Excluding Values of Zero **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Sites	202	201.70	40743.50
	Random Point	219	219.58	48087.50
dwell	Sites	70	59.29	4150.00
	Random Point	65	77.38	5030.00
floodf	Sites	242	235.29	56940.50
	Random Point	250	257.35	64337.50
wetl	Sites	272	280.81	76380.00
	Random Point	282	274.31	77355.00

Table B.20. Significance of the Mann-Whitney Rank-Sum Results for Historic Archaeological Sites across the Central Cluster Study Area Compared to Historic Random Sample Points Excluding Values of Zero **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	20240.50	40743.50	-1.51	.132
dwell	1665.00	4150.00	-2.69	.007
floodf	27537.50	56940.50	-1.72	.085
wetl	37452.00	77355.00	-0.48	.633

a Grouping variable: site vs random point

Table B.21. Descriptive Statistics for Prehistoric Archaeological Sites and Random Sample Points across the Caney District Study Area **(5-meter cells).**

Variable	N	Mean	Std. Deviation	Minimum	Maximum
dpoor	186	881	1167	0	4085
dwell	186	41	118	0	735
floodf	186	225	292	0	1340
roadall	186	143	129	0	716
stream	186	93	72	0	437
sseas	186	128	108	0	589
sperm	186	288	226	0	1015
wetl	186	6798	6926	0	22705
aspect	186	175	105	0	359
slope	186	18	15	0	79
elev	186	224	80	105	445

Table B.22. Mann-Whitney Rank-Sum Results for Prehistoric Archaeological Sites and Random Sample Points across the Caney District Study Area **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	68	84.08	5717.50
	Random Point	118	98.93	11673.50
dwell	Site	68	94.57	6430.50
	Random Point	118	92.89	10960.50
floodf	Site	68	70.82	4815.50
	Random Point	118	106.57	12575.50
roadall	Site	68	101.18	6880.50
	Random Point	118	89.07	10510.50
stream	Site	68	100.65	6844.00
	Random Point	118	89.38	10547.00
sseas	Site	68	102.63	6979.00
	Random Point	118	88.24	10412.00
sperm	Site	68	70.78	4813.00
	Random Point	118	106.59	12578.00
wetl	Site	68	87.02	5917.50
	Random Point	118	97.23	11473.50
aspect	Site	68	99.47	6764.00
	Random Point	118	90.06	10627.00
slope	Site	68	84.03	5714.00
	Random Point	118	98.96	11677.00
elev	Site	68	76.85	5226.00
	Random Point	118	103.09	12165.00

Table B.23. Significance of the Mann-Whitney Rank-Sum Results for Prehistoric Archaeological Sites across the Caney District Study Area Compared to Prehistoric Random Sample Points **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	3371.5	5717.5	-1.821	.069
dwell	3939.5	10960.5	-.280	.779
floodf	2469.5	4815.5	-4.400	.000
roadall	3489.5	10510.5	-1.478	.139
stream	3526.0	10547.0	-1.374	.169
sseas	3391.0	10412.0	-1.756	.079
sperm	2467.0	4813.0	-4.369	.000
wetl	3571.5	5917.5	-1.246	.213
aspect	3606.0	10627.0	-1.148	.251
slope	3368.0	5714.0	-1.821	.069
elev	2880.0	5226.0	-3.201	.001

[a] Grouping Variable: Site vs Random Point

Table B.24. Mann-Whitney Rank-Sum Results for Prehistoric Archaeological Sites and Random Sample Points across the Caney Study Area Excluding Values of Zero **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	51	64.11	3269.50
	Random Point	94	77.82	7315.50
dwell	Site	17	16.76	285.00
	Random Point	25	24.72	618.00
floodf	Site	47	43.51	2045.00
	Random Point	91	82.92	7546.00
wetl	Site	68	82.02	5577.50
	Random Point	113	96.40	10893.50

Table B.25. Significance of the Mann-Whitney Rank-Sum Results for Prehistoric Archaeological Sites across the Caney District Study Area Compared to Prehistoric Random Sample Points Excluding Values of Zero **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	1943.50	3269.50	-1.88	.060
dwell	132.00	285.00	-2.06	.039
floodf	917.00	2045.00	-5.49	.000
wetl	3231.50	5577.50	-1.79	.074

a Grouping variable: site vs random point

Table B.26. Descriptive Statistics for Prehistoric Archaeological Sites and Random Sample Points across the Central Cluster Study Area **(5-meter cells).**

Variable	N	Mean	Std. Deviation	Minimum	Maximum
dpoor	4382	223	305	0	1908
dwell	4382	43	142	0	1970
floodf	4382	321	354	0	2795
roadall	4382	183	178	0	2458
stream	4382	77	69	0	912
sseas	4382	102	96	0	1057
sperm	4382	282	252	0	2585
wetl	4382	3277	2589	0	16946
aspect	4382	174	103	0	360
slope	4382	24	18	0	177
elev	4382	197	59	66	393

Table B.27. Mann-Whitney Rank-Sum Results for Prehistoric Archaeological Sites and Random Sample Points across the Central Cluster Study Area **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Site	2216	2102.37	4658850.00
	Random Point	2166	2282.69	4944303.00
dwell	Site	2216	2131.79	4724044.50
	Random Point	2166	2252.59	4879108.50
floodf	Site	2216	1927.78	4271955.00
	Random Point	2166	2461.31	5331198.00
roadall	Site	2216	2294.38	5084353.50
	Random Point	2166	2086.24	4518799.50
stream	Site	2216	2115.04	4686927.00
	Random Point	2166	2269.73	4916226.00
sseas	Site	2216	2170.73	4810346.50
	Random Point	2166	2212.75	4792806.50
sperm	Site	2216	1851.39	4102671.00
	Random Point	2166	2539.47	5500482.00
wetl	Site	2216	2009.10	4452175.00
	Random Point	2166	2378.11	5150978.00
aspect	Site	2216	2193.63	4861079.00
	Random Point	2166	2189.32	4742074.00
slope	Site	2216	2287.83	5069836.50
	Random Point	2166	2092.94	4533316.50
elev	Site	2216	2223.36	4926972.00
	Random Point	2166	2158.90	4676181.00

Table B.28. Significance of the Mann-Whitney Rank-Sum Results for Prehistoric Archaeological Sites across the Central Cluster Study Area Compared to Prehistoric Random Sample Points **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	2202414.000	4658850.000	-4.762	.000
dwell	2267608.500	4724044.500	-4.052	.000
floodf	1815519.000	4271955.000	-13.977	.000
roadall	2171938.500	4518799.500	-5.445	.000
stream	2230491.000	4686927.000	-4.047	.000
sseas	2353910.500	4810346.500	-1.099	.272
sperm	1646235.000	4102671.000	-18.001	.000
wetl	1995739.000	4452175.000	-9.653	.000
aspect	2395213.000	4742074.000	-.113	.910
slope	2186455.500	4533316.500	-5.099	.000
elev	2329320.000	4676181.000	-1.686	.092

[a] Grouping Variable: Site vs Random Point

Table B.29. Mann-Whitney Rank-Sum Results for Prehistoric Archaeological Sites and Random Sample Points across the Caney Study Area Excluding Values of Zero **(5-meter cells)**.

Variable	Site Class	N	Mean Rank	Sum of Ranks
dpoor	Sites	1668	1436.54	2396146.00
	Random Point	1549	1794.71	2780007.00
dwell	Sites	554	510.66	282903.50
	Random Point	622	657.83	409172.50
floodf	Sites	1871	1614.73	3021160.50
	Random Point	1899	2152.28	4087174.50
wetl	Sites	2194	1986.03	4357349.00
	Random Point	2145	2358.17	5058281.00

Table B.30. Significance of the Mann-Whitney Rank-Sum Results for Prehistoric Archaeological Sites across the Central Cluster Study Area Compared to Prehistoric Random Sample Points Excluding Values of Zero **(5-meter cells)**.

Variable[a]	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
dpoor	1004200.00	2396146.00	-10.93	.000
dwell	129168.50	282903.50	-7.42	.000
floodf	1269904.50	3021160.50	-15.16	.000
wetl	1949434.00	4357349.00	-9.78	.000

a Grouping variable: site vs random point

Appendix C

The predictive modeling zone catchment results of the 2011 Kisatchie National Forest Predictive Model for each ranger district of the Kisatchie National Forest.

Table C.1 Test Statistics for the Probability Zones of the 2011 Kisatchie National Forest Model for the Calcasieu District Study Area and All Archaeological Sites.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% Sites	$\chi 2$	Gain
Zone 1 (High)	108725291	14.5	331.2	705	30.8	421.9	0.53
Zone 2 (Medium)	286159981	38.1	871.7	1063	46.4	42.0	0.18
Zone 2 (Low)	356902565	47.5	1087.2	522	22.8	293.8	-1.08
Total	751787837	100.0	2290.0	2290	100.0	757.7	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table C.2. Test Statistics for the Probability Zones of the 2011 Kisatchie National Forest Model for the Caney District Study Area and All Archaeological Sites.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% Sites	$\chi 2$	Gain
Zone 1 (High)	22125064	16.8	27.1	42	26.1	8.2	0.35
Zone 2 (Medium)	48872069	37.2	59.8	74	46.0	3.3	0.19
Zone 2 (Low)	60489074	46.0	74.1	45	28.0	11.4	-0.65
Total	131486208	100.0	161.0	161	100.0	23.0	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table C.3. Test Statistics for the Probability Zones of the 2011 Kisatchie National Forest Model for the Catahoula District Study Area and All Archaeological Sites.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% Sites	$\chi 2$	Gain
Zone 1 (High)	54617136	10.8	59.0	143	26.3	119.5	0.59
Zone 2 (Medium)	216492058	43.0	233.9	297	54.6	17.0	0.21
Zone 2 (Low)	232333717	46.1	251.1	104	19.1	86.1	-1.41
Total	503442911	100.0	544.0	544	100.0	222.6	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table C.4 Test Statistics for the Probability Zones of the 2011 Kisatchie National Forest Model for the Kisatchie District Study Area and All Archaeological Sites.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% Sites	$\chi 2$	Gain
Zone 1 (High)	65670404	15.6	65.9	93	22.0	11.2	0.29
Zone 2 (Medium)	202001137	47.9	202.6	214	50.6	0.6	0.05
Zone 2 (Low)	154012571	36.5	154.5	116	27.4	9.6	-0.33
Total	421684112	100.0	423.0	423	100.0	21.4	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Table C.5 Test Statistics for the Probability Zones of the 2011 Kisatchie National Forest Model for the Winn District Study Area and All Archaeological Sites.

Probability Zone	Area (m^2)	% of Area	Expected Sites	Observed Sites	% Sites	$\chi 2$	Gain
Zone 1 (High)	101989724	15.0	85.4	173	30.5	89.9	0.51
Zone 2 (Medium)	246464698	36.3	206.3	241	42.4	5.8	0.14
Zone 2 (Low)	330055277	48.6	276.3	154	27.1	54.1	-0.79
Total	678509699	100.0	568.0	568	100.0	149.9	-

df = 2, α = .05, sig of $\chi 2 \geq 5.99$

Vita

Erik N. Johanson was born in St. Paul, MN on March 28, 1985. In 2008, he received a B.A. in Anthropology from the University of Tennessee, Knoxville. He entered the graduate program at the University of Tennessee, Knoxville in the fall of 2008 where he received his M.A. in Anthropology. Erik is currently pursuing his doctorate in anthropology at the University of California, Santa Barbara.