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Living in the Low Country: Modeling Archaeological Site Location in the Francis Marion National Forest, South Carolina

Jason M. O'Donoughue
University of Tennessee, Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Jason M. O'Donoughue entitled "Living in the Low Country: Modeling Archaeological Site Location in the Francis Marion National Forest, South Carolina." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

David G. Anderson, Major Professor

We have read this thesis and recommend its acceptance:

Boyce N. Driskell, Kandace D. Hollenbach

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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LIVING IN THE LOW COUNTRY:
MODELING ARCHAEOLOGICAL SITE LOCATION IN THE FRANCIS MARION NATIONAL FOREST, SOUTH CAROLINA

A Thesis
Presented for the
Master of Arts Degree
The University of Tennessee, Knoxville

Jason M. O'Donoughue
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Dedication

For Erica

Acknowledgments

I would like to extend my deepest thanks to my advisor, Dr. David Anderson, for his patience, support, and guidance throughout my graduate education. Dr. Anderson's faith in my abilities never wavered, and he always provided a boost when my self-confidence faltered. I could not have asked for a better mentor and I consider myself fortunate to count him as friend. I would also like to extend sincere gratitude to my other committee members, Dr. Boyce Driskell and Dr. Kandace Hollenbach. They have been incredibly supportive and patient throughout this process and their insight has vastly improved the final product. I would also like to thank Dr. Gerald Schroedl for his advice and guidance, and for reinforcing for me the importance of hard work and perseverance. Dr. Kenneth Sassaman deserves thanks for starting me down this path, and for his continued support of my research endeavors.

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This thesis is the culmination of research initiated over a decade ago, and I would like to express my thanks to the numerous SCIAA personnel and University of Tennessee students who assisted in data collection. Funding for data entry was provided by the USDA Forest Service and the University of Tennessee work study program. I would also like to thank Dr. Jonathan M. Leader, South Carolina State Archaeologist, and the staff at the Office of the State Archaeologist for providing me with Site File data for Berkeley

and Charleston counties. The data and analyses used to develop this thesis have been placed on file with the USDA Forest Service offices in South Carolina.

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Our experiences are defined by the people we share them with, and I am certain that graduate school would be nearly intolerable without the support of good friends. My thanks to Clay Barry, Annie Blankenship, Bobby Braly, Erik Johanson, Shane Miller, Katherine McMillan, Jeremy Sweat, and many others for making my time in Knoxville so enjoyable.

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Finally, my most heartfelt thanks go to my wife, Amanda. She has seen the best and worst of me and endured it all with rare grace. Her steadfast support made this thesis possible. I am forever grateful for her remarkable patience, encouragement, and love.

Abstract

The Francis Marion National Forest, located in the Lower Coastal Plain of South Carolina, has a rich archaeological record generated from years of compliance-based research. Much of the cultural resource management activity in the Forest has been guided by a probabilistic model of archaeological site location. This model is an invaluable tool for Forest Service personnel conducting land-use planning and resource management, but it has seen only limited testing. This study examined the spatial location and environmental associations of the entire sample of archaeological sites in the Francis Marion National Forest to evaluate the extant probabilistic model and develop an improved model of archaeological site location. In addition, temporal and cultural variation in site location was examined to search for deviations from the larger patterns. This was accomplished by compiling a database of the artifacts recovered in the Forest, and using diagnostic materials to extract temporally and culturally specific site subsets. These analyses indicated that the extant model is only marginally effective, warranting the development of a new model. Based on the environmental associations, an improved model was developed using soil drainage class, proximity to wetlands, proximity to roads, and proximity to soil drainage ecotones. Further, several patterns were noted between the site subsets that have implications for both local and regional archaeological questions.

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Chapter 1. Introduction

The Francis Marion National Forest, located in the Lower Coastal Plain of South Carolina, has seen extensive compliance-based archaeological work over the past thirty years. The intensity of cultural resource management activities in the Forest has generated an impressive body of documentation and one of the densest concentrations of known archaeological sites in South Carolina. However, despite the abundance of information available, or perhaps because of it, relatively little directed research has been conducted using the entire corpus of archaeological data from the Forest. Over twenty-five years ago, Anderson and Logan (1981) produced a synthesis and overview of the archaeological research and cultural resources of the Forest. But since that time the pace and intensity of archaeological survey has increased exponentially, particularly following the devastation of hurricane Hugo in 1989 (e.g., Wise 1990).

Guiding these cultural resource management activities have been a series of implicitly and explicitly defined predictive – or, more accurately, probabilistic – models. Implicit probabilistic models are frequently employed by archaeologists when, for example, survey strategies are focused on areas thought to be preferred locales for past settlement and away from areas presumed to be poorly suited to archaeological site preservation or past settlement location (e.g., away from steeply sloped or saturated areas and concentrated adjacent to streams). Use of implicit models of site potential in the Francis Marion National Forest is apparent as early as the late 1970's. For instance, in a report of survey efforts in advance of road construction, Prokopetz (1978:1) states that "shovel tests were placed primarily in areas which topographically may have been

potential loci for habitation… it was hyposthezied [*sic*], that if sites were located in these 'swamps,' they would be located on the higher land forms." Indeed, it became common practice for U.S. Geological Survey (USGS) topographic maps to be examined "in order to locate potential site locations" (Logan 1979:2). Zierden (1982) was perhaps the first to explicitly lay out the criteria for high site potential:

> Prior to actual field entry, USGS topographical maps, aerial photographs, and soil maps were examined in an attempt to locate high probability areas for site location. It was expected that sites would most likely be located in areas of well drained soil, adjacent to permanent water sources… Areas of high ground, relatively close to a useable water supply represent high probability zones for both prehistoric and historic settlement [Zierden 1982:6].

Thus, implicit probabilistic models of archaeological site occurrence have been in place essentially since the Forest Service began conducting cultural resource management activities in the Francis Marion National Forest.

The archaeological probabilistic model currently in use on the Francis Marion National Forest has explicitly defined criteria, though the environmental variables employed are much the same as those in early, implicit models (Adams and Botwick 2005; Cable 2002; Ellerbee and Fletcher 2006). That is, soil drainage and proximity to water are retained as the critical factors in the extant Forest Service probabilistic model. Additional variables have been included, such as distance to ecotones at the interface of well- and poorly-drained soils. Further, the model now defines three probability zones: high, medium, and low.

The extant probabilistic model is an important tool for Forest Service personnel conducting land-use planning and cultural resource assessments. However, the effectiveness of this model has only rarely been tested. Cable (2002:447-450) evaluated the extant model using data from Forest survey tracts adjacent to the Santee River. He found a 65% success rate (i.e., percentage of sites intersecting the high and medium probability zones) with strict application of the model, and a 97% success rate with some adjustments. He cautions, however, that these results cannot be projected to the entire Forest, as the study area contains a higher proportion of well-drained landforms relative to the Forest as a whole.

While the extant probabilistic model may be quite effective as a planning tool, it is designed to capture sites from all time periods, and thus is not sensitive to cultural or temporal variability in site location. This has implications both for cultural resource management and for our understanding of past human behavior. Temporally specific assessments of archaeological site locations and environmental associations have the potential to be more accurate and informative representations of past land use patterns in the Francis Marion National Forest. The information generated by these analyses should allow productive inferences regarding the intersection of environmental variables and human settlement in the Forest, and provide additional data to evaluate and refine the extant probabilistic model.

Research Goals and Thesis Organization

The research presented in this thesis addresses three objectives. The first is to evaluate the effectiveness of the extant Forest Service probabilistic model using the entire

sample of archaeological sites in the Francis Marion National Forest. The second objective, if warranted, is to develop an improved model of archaeological site occurrence in the Francis Marion National Forest. The third objective is to investigate temporal and cultural variability in site distributions and environmental associations, with the goal of adding to current knowledge of past settlement organization and land use in the Lower Coastal Plain of South Carolina. This was accomplished by compiling a database of artifact assemblages from archaeological sites investigated in the Forest, so that temporally or culturally specific subsets of archaeological sites could be extracted. Geographic Information Systems (GIS) technology was used to measure a series of environmental variables for each site, and the environmental associations of various site subsets were evaluated to identify statistically significant differences. All three objectives are achieved in the current study.

Chapter 2 provides the background for this study. This chapter begins with a brief overview of the environmental and archaeological contexts of the Forest. This is followed by a discussion of previous efforts at probabilistic modeling in the Lower Coastal Plain of South Carolina.

In Chapter 3 the data and methodology of this thesis are outlined in detail. First, the archaeological datasets are discussed, including treatment of the steps in data collection, subsequent modification to the data, and a description of the artifact assemblage database. Following this, the digital environmental datasets are discussed. I outline how they were acquired and modified, and define the derived environmental variables that were used in the analyses of site-environment associations. The remainder of this chapter details the methods and tests used to evaluate the extant probabilistic

model, establish environmental associations for the archaeological site subsets, test for significant differences between subsets, and develop an improved probabilistic model.

Chapter 4 presents the results of data analysis. The extant probabilistic model is evaluated at the outset. This is followed by a comparison of the environmental parameters of archaeological site locales and the physical environment of the Francis Marion National Forest. Next, temporal and cultural variation in site distribution and environmental association is investigated. This is explored at three levels of increasing resolution. At the broadest scale, prehistoric and historic sites are compared. The prehistoric sample is then examined in more detail by comparing broad temporal periods (i.e., Archaic, Woodland, and Mississippian). Finally, individual diagnostic artifact categories are compared to investigate variability that is potentially masked in the larger site subsets.

Building on the results presented in Chapter 4, Chapter 5 outlines the development of a new probabilistic model of archaeological site occurrence in the Francis Marion National Forest. The steps taken in model development are described and the new model defined. The chapter closes with a comparison of the extant and new probabilistic models, to demonstrate the improved effectiveness of the new model.

Finally, Chapter 6 summarizes the research presented in the previous chapters, and discusses suggestions for future research.

Chapter 2. Background

This chapter outlines the background information for the research presented herein. First, the environmental and archaeological contexts of the Francis Marion National Forest are considered. This is followed by a summary of previous efforts at probabilistic modeling in the Lower Coastal Plain of South Carolina.

Environmental Setting

The Francis Marion National Forest covers an area of over 1,680 km^2 in Berkeley and Charleston counties, South Carolina (Figure 1). Within this area, the U.S. Department of Agriculture Forest Service owns some 263,000 acres (Oswalt 2005). This setting includes both coastal and inland locales, and falls within the Sea Islands section of the Coastal Plain physiographic province (Fenneman 1938).

Geology and Physiography

On the basis of geomorphology, the Sea Islands section of the Coastal Plain can be divided into three parts (Colquhoun 1974; Soller and Mills 1991:291-293). The Upper (or Inner) Coastal Plain is a narrow (ca. 30 km) area of erosional topography adjacent to the Fall Line. Elevation is generally below 150 m, with the seaward boundary marked by the Orangeburg Scarp. The sediments of the Upper Coastal Plain have been highly eroded and dissected, and thus surficial deposits tend to be older than those of the Middle and Lower Coastal Plain.

The Francis Marion National Forest lies entirely within the Lower (or Outer) Coastal Plain, which, in contrast to the dissected landscape of the Upper Coastal Plain, is

Figure 1. Location of the Francis Marion National Forest.

marked by constructional topography, with comparatively little erosion of primary landforms. This is a relatively flat, low-lying area, with elevation ranging from sea level to approximately 30 m.

The Middle Coastal Plain is transitional between these zones, and is differentiated from the Lower Coastal Plain by higher elevation (ca. 30 to 88 m) and greater fluvial erosion and landscape dissection. Primary landforms of the Middle Coastal Plain are somewhat obscured by erosion, but less so than those of the Upper Coastal Plain.

Though the modern surface of the Coastal Plain is generally flat, the underlying bedrock structures are characterized by undulating arches and basins/embayments. The axes of these structures run perpendicular to the modern coast. Most of the Coastal Plain in the vicinity of the Forest is underlain by the Charleston Embayment. This basin is bordered by the Cape Fear Arch to the north, and the Yamacraw Arch to the south. Overlying these bedrock structures are sedimentary deposits of Mesozoic and Cenozoic age. These sediments, derived from the eroding structures of the Blue Ridge and Piedmont, are much thicker on the Charleston Embayment than on either the Cape Fear or Yamacraw Arch (Horton and Zullo 1991). Quaternary deposits comprise the surficial and near surface sediments in the Lower Coastal Plain. These deposits are horizontally stratified, with younger deposits lying nearer the coast and at a lower elevation than older deposits. The majority of surface sediments in the vicinity of the Francis Marion National Forest were laid down during the Pleistocene; Holocene deposition has largely been restricted to the Santee River floodplain and the modern coastal strand.

Deposition on the Coastal Plain during the Pliocene and Pleistocene was primarily controlled by two factors: inundation from repeated marine transgressive/regressive

cycles, and minor tectonic activity that adjusted the elevation of the continental shelf and shifted arch/basin configurations (Ward et al. 1991). This led to the deposition of “a sequence of shallow-marine, barrier, backbarrier, and fluvial sediments” (Soller and Mills 1991:290), and the development of a series of marine terraces running roughly parallel to the coast. These terraces are composed of relict barrier island and backwater facies, manifesting themselves as long, narrow ridges and erosional scarps. These ridge-scarp complexes are separated by areas of relatively featureless, flat terrain, and provide topographic relief to this otherwise low-lying area. Underscoring the importance of these features, Cable (1996:7) suggests that “because of their elevated topographical position, the linear ridges formed by the various barrier island facies on the Lower Coastal Plain played significant roles in [archaeological] site locational patterning throughout prehistory.”

The delineation, naming, and mapping of Pleistocene marine terraces has been the subject of intense research over the past century (e.g., Colquhoun 1974; Johnson 1907; Mathews et al. 1980). The most recent refinement of this sequence is provided by Doar and Willoughby (2006; Willoughby and Doar 2006), and I follow their scheme here. Each terrace is fronted on its seaward margin by an erosional scarp. On this basis six terraces can be defined in the vicinity of the Forest. These are, from inland to the coast, the Wicomico, Penholoway, Cordesville, Talbot, Pamlico, and Princess Anne terraces. The associated scarps are the Dorchester/Summerville, Macbeth, Bethera, Suffolk, and Awendaw. The locations of escarpments in the vicinity of the Francis Marion National Forest are presented in Figure 2.

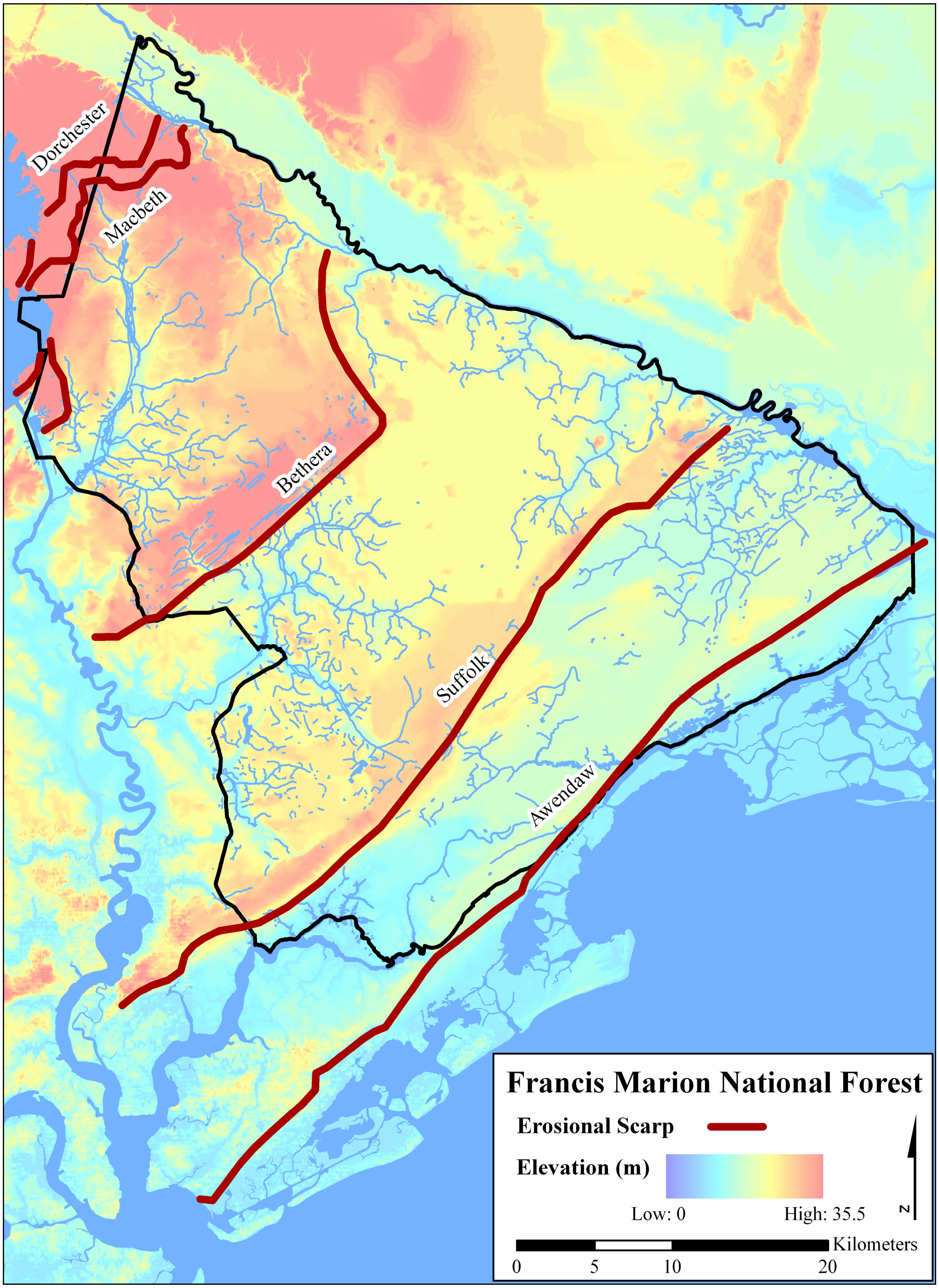

Figure 2. Erosional scarps fronting Pleistocene marine terraces in the vicinity of the Francis Marion National Forest.

Hydrology

The Francis Marion National Forest is generally low-lying, with extensive wetlands. This area is drained by three distinct watersheds. The Santee River is formed at the confluence of the Conagree and Wateree rivers, which originate in the Blue Ridge Mountains. This is the second largest river system in the eastern United States, draining an area of over 40,000 km^2 from the Blue Ridge Mountains to the Atlantic Coast (Hughes et al. 2000:3; Lacy 2005:35; Lunz 1943). Despite its size, the Santee River drains a relatively small portion of the Francis Marion National Forest, by way of Echaw, Wedboo, and Wambaw Creeks, and numerous smaller tributaries. The western and central portions of the Forest drain into the Cooper River. The West Branch Cooper River originates at Lake Moultrie and runs for approximately 30 km before it is joined by the East Branch to form the Cooper River proper. The Cooper River flows for another 50 km before emptying into Charleston Harbor. The southern portion of the Forest drains into the Wando River or directly to the Atlantic Ocean.

Ecoregions

Archaeologists in the Southeast often frame their discussions of the natural environment in terms of physiography. Physiographic regions are defined primarily on the basis of geology and landform history/geomorphology. While meaningful differences are apparent between the physiographic provinces of the region, these are rather broad categories which can mask intra-provincial variability.

The U.S. Environmental Protection Agency has implemented an alternative spatial framework for managing ecological resources. Ecoregions encompass both biotic

and abiotic resources in their definition, including flora, fauna, climate, soils, and hydrology in addition to geology and physiography (Griffith et al. 2002). Ecoregions are divided into four hierarchically organized levels, with progressively finer sub-division from Level I to Level IV. This schema was designed specifically to facilitate communication and integration across organizations responsible for resource management. As such, it is a useful framework for discussing the modern environmental context of the Francis Marion National Forest and for organizing research into past human settlement dynamics and landscape utilization. The following discussion of the Level III and Level IV ecoregions found in the Francis Marion National Forest draws from the descriptions provided by Griffith and colleagues (2002; see also South Carolina Department of Natural Resources 2005).

Five Level III ecoregions are delimited in South Carolina, two of which are represented within the Francis Marion National Forest: the Middle Atlantic Coastal Plain and the Southern Coastal Plain. The Middle Atlantic Coastal Plain ecoregion occurs primarily in the Carolinas. This region is generally at a lower elevation, with less relief, poorer drainage, and different vegetation than the Southeastern Plains ecoregion found further inland. Major terrestrial habitats of this region include grassland and early successional habitats, pine woodlands, bottomland hardwood forests, and geographically isolated wetlands (Richardson 2003; Sharitz 2003; Tiner 2003).

North of the Pee Dee River and into North Carolina, the Middle Atlantic Coastal Plain extends to the modern shoreline, including barrier islands and coastal wetlands. However, over the majority of South Carolina the coastal strand falls within the Southern Coastal Plain ecoregion. This region extends from South Carolina through Georgia and

most of Peninsular Florida, continuing along the Gulf Coast into Alabama and Mississippi. This region is lower, warmer, and wetter than the Middle Atlantic Coastal Plain, and includes different vegetation communities. Soils of the Southern Coastal Plain tend to be coarser and more homogenous with less pronounced horizonation than in areas further inland. This ecoregion contains the most diverse mix of habitats in South Carolina.

At a finer scale, three Level IV ecoregions can be found in and around the Francis Marion National Forest: the *Carolina Flatwoods* and *Mid-Atlantic Flood Plains and Low Terraces* of the Middle Atlantic Coastal Plain, and the *Sea Islands/Coastal Marsh* region of the Southern Coastal Plain (Figure 3).

The *Carolina Flatwoods* ecoregion is characterized by low topographic relief, with large expanses of poorly-drained soils. The surficial deposits of the Carolina Flatwoods tend to be Pleistocene to Pliocene in age, consisting primarily of marine sand, silt, and clay. Due to the low elevation and poor drainage characteristics of this region swamps, marshes, and Carolina Bays are abundant. Streams tend to be low gradient and meandering, with sandy or silty substrates. Uplands consist primarily of Pleistocene marine terraces (see above). Average precipitation ranges from 117 to 135 cm annually and there are typically 230 to 250 frost free days per year. Vegetation is dominated by loblolly pine (*Pinus taeda*) and shortleaf pine (*Pinus echinata*), though longleaf pine (*Pinus palustris*) was more common in the past. The majority of the Francis Marion National Forest falls within this ecoregion. The most abundant forest type in the Francis Marion National Forest is the Loblolly-Shortleaf Pine, followed by Oak-Gum-Cypress, Oak-Pine, Longleaf-Slash Pine, and Oak-Hickory (Oswalt 2005:Table A.1)

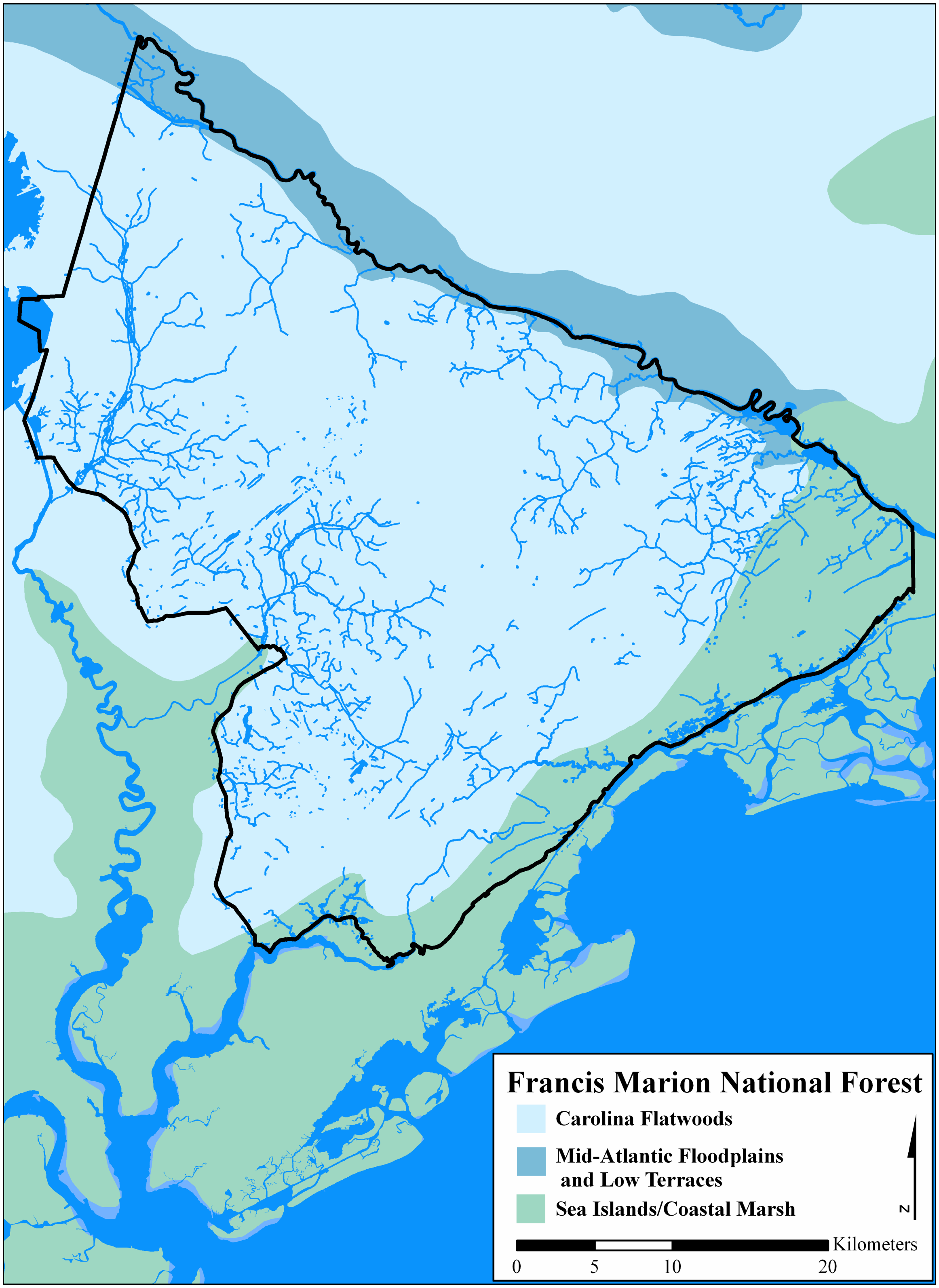

Figure 3. Level IV Ecoregions in the vicinity of the Francis Marion National Forest.

The *Mid-Atlantic Floodplains and Low Terraces* ecoregion is largely similar to the Carolina Flatwoods, but differs slightly due to the influence of major rivers. This region is characterized by large, low gradient rivers and deep water swamps. Cypress-gum swamps and bottomland hardwood forests can be found amongst the alluvial sediments. Surficial deposits are younger than those of the adjacent Carolina Flatwoods, being formed primarily in the Holocene. Within the Francis Marion National Forest, this ecoregion is represented by the floodplain and terraces of the Santee River.

The *Sea Islands/Coastal Marsh* ecoregion is a sub-division of the Southern Coastal Plain, and as such is lower, flatter, and warmer than the ecoregions discussed above. This region comprises the terraces, islands, dunes, beaches, estuaries, and tidal creeks and marshes of the Atlantic coast. In South Carolina, this region is generally limited to a relatively narrow coastal strand south of the Pee Dee River. However, in the vicinity of the Francis Marion National Forest, this region extends up the Cooper and Wando rivers. Sediment deposition is more dynamic here – including aeolian, fluvial, and marine processes – resulting in relatively younger (i.e., Holocene) surface deposits. This region is the lowest in elevation in South Carolina, but despite this topographic homogeneity, it is ecologically quite diverse. Vegetation includes maritime forests of tupelo (*Nyssa* sp.), red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), bald cypress (*Taxodium distichum*), live oak (*Quercus virginiana*), sand laurel oak (*Quercus laurifolia*), slash pine (*Pinus elliottii*), and loblolly pine. Wetland vegetation includes cordgrass, saltgrass, and rushes. Precipitation ranges from 122 to 135 cm annually, with between 260 and 280 frost free days per year (Griffith et al. 2002).

Archaeological Context

The prehistory of the Francis Marion National Forest is organized by a temporal framework familiar to Southeastern archaeologists. Several recent overviews of the culture history of the Forest are available (e.g., Adams and Botwick 2005:5-16; Cable 2002:10-28; Ellerbee and Fletcher 2006:22-44; Elliott et al. 2002:13-35; Trinkley 1999:6-12), and these are summarized here. The prehistoric cultural sequence is based primarily on the work of Joffre Coe (1964) in the Piedmont of North Carolina, and the excavation of the Mattassee Lake sites in Berkeley County, South Carolina (Anderson et al. 1982; see also Anderson and Logan 1981). The sequences outlined in these works have been refined by John Cable, who has conducted extensive archaeological research in the Forest (e.g., Cable 1982, 1992, 1993, 1994, 2002). Figures 4 and 5 depict Cable's revised cultural sequence for the Forest.

Paleoindian Period

The Paleoindian period encompasses the earliest well-documented human settlement of the South Carolina Coastal Plain, spanning from approximately 10,000 to 8000 B.C. (ca. 12,000 – 9500 cal B.C.). The Paleoindian period is divided into three sub-periods in South Carolina, on the basis of diagnostic hafted biface forms. The earliest of these is the Clovis biface, followed by the fish-tailed Suwannee and Simpson bifaces, which are in turn supplanted by Dalton forms (Cable 2002:11). Though this period has traditionally been assumed to represent the earliest occupation of North America, evidence for a possible pre-Clovis horizon continues to mount (Goodyear 2005; McAvoy and McAvoy 1999; Meltzer et al. 1997). South Carolina figures rather prominently in this

Date	Period	Sub-Period	Phase	Diagnostic Artifacts
3000 BP	ARCHAIC	Late	Awendaw	Otaree Stemmed, Gary/Mack Stemmed, Thom's Creek Plain and Finger-pinched
3400 BP			Stallings I/Horse Island	Savannah River Stemmed, Fiber- and Sand-tempered plain and punctate
4000 BP			Savannah River	Savannah River Stemmed
5000 BP		Middle	Guilford/Brier Creek/Benton	Guilford Lanceolate, Brier Creek Lanceolate, Benton Stemmed, MALA
6000 BP			Morrow Mountain	Morrow Mountain Stemmed
7500 BP			Stanly	Stanly Stemmed
7800 BP			Kirk Stemmed	Kirk Stemmed, Kanawha
8000 BP		Early	Bifurcate	St. Albans, MacCorckle, LeCroy
8900 BP			Palmer/Kirk	Palmer/Kirk Corner-Notched
9500 BP			Taylor	Taylor Side-Notched
9900 BP	PALEOINDIAN	Late	Dalton	Dalton, Hardaway-Dalton
10500 BP		Middle	Simpson/Suwannee	Simpson, Suwannee, Quad
11000 BP		Early	Clovis	Clovis (Fluted)
11500 BP		Pre-Clovis	?	Prismatic Blades?, Bladelets?
???				

Figure 4. Paleoindian and Archaic Cultural Sequence for the Francis Marion National Forest (from Cable 2002:12).

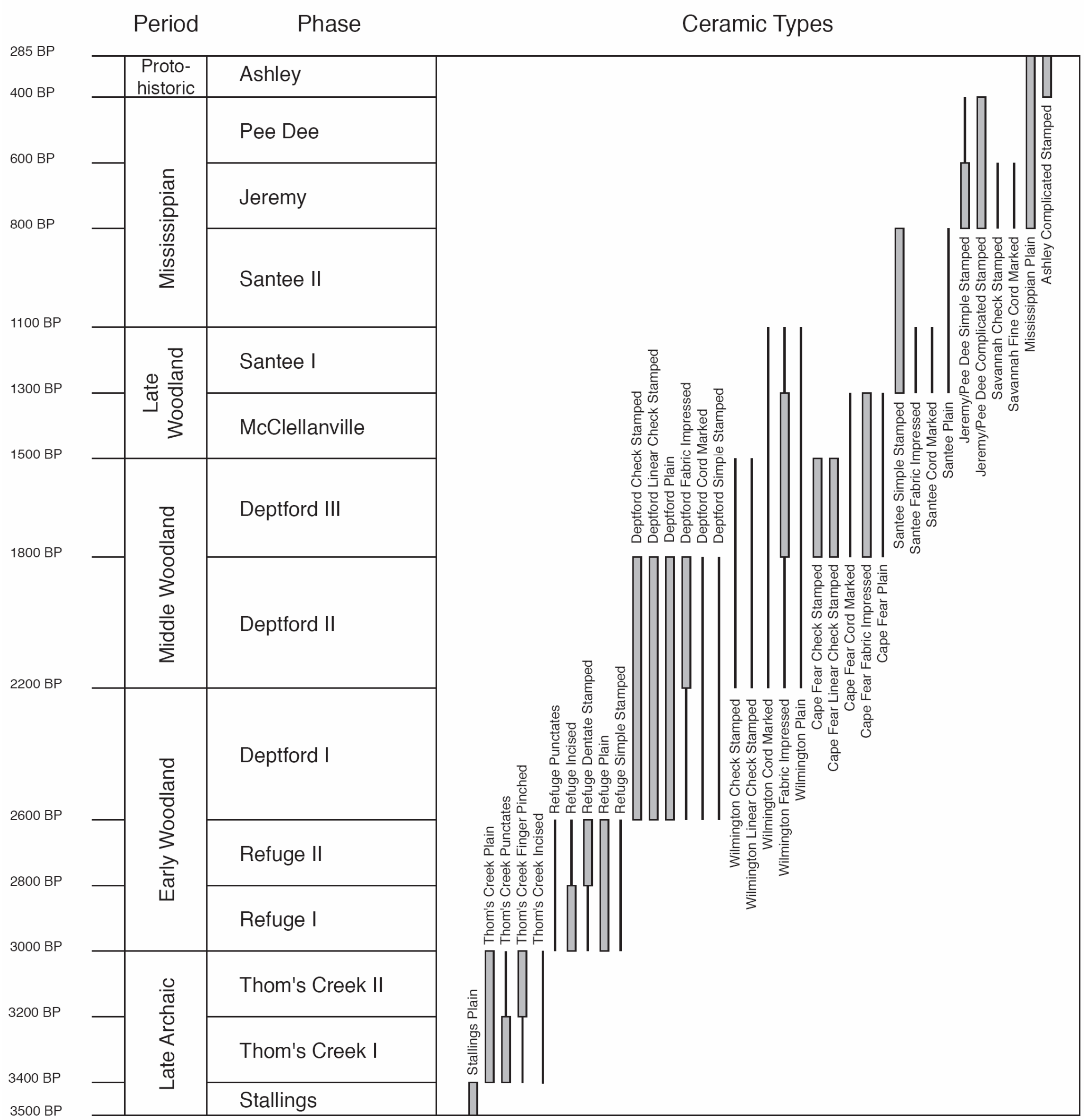

Figure 5. Revised Mattassee Lake Ceramic Sequence (from Cable 2002:13).

debate, as the Topper site in Allendale County is one of few purportedly pre-Clovis sites in the eastern U.S. (Goodyear 1999).

Goodyear and colleagues (1989) summarize the evidence for Paleoindian occupation in South Carolina. Generally, Paleoindian peoples are though to be highly-mobile groups focused on the exploitation of large game. Dense concentrations of fluted bifaces are present at Fall Line locales and in proximity to lithic outcrops in South Carolina. Thus, it appears that the spatial distribution of high quality cryptocrystalline lithic raw materials was a strong consideration in Paleoindian settlement strategies in South Carolina. Further, as the Fall Line is an ecotone between the Piedmont and Coastal Plain, this area may have served as a strategic launching point for exploiting the resources of both physiographic provinces. Alternatively, these dense concentrations may be indicative of seasonal settlement relocation between the coast and interior (Goodyear et al. 1989:44).

Archaic Period

The Archaic period (8000 – 1000 B.C.; ca. 9500 – 1200 cal B.C.) in the Southeast has long been characterized as a transitional period of mobile, egalitarian hunter-gatherer bands gradually adapting to warming Holocene environmental conditions and rising sea levels (Anderson and Sassaman 1996, 2004; Kidder and Sassaman 2008; Sassaman and Anderson 1995, 1996, 2004; Smith 1986; Steponaitis 1986). The Archaic is divided into three sub-periods: Early, Middle and Late. Investigations into the Early Archaic period (8000 – 6000 B.C.; ca. 9500 – 7000 cal B.C.) typically focus on environmental changes at the Pleistocene to Holocene transition, and concomitant human adaptation to new

climatic regimes. Similarly, Middle Archaic (6000 – 3000 B.C.; ca. 7000 – 3800 cal B.C.) cultural developments have largely been explained by reference to the warming and drying trend variously referred to as the Hypsithermal, Altithermal, or Mid-Holocene Climatic Optimum (e.g., Anderson 2001; Brown and Vierra 1983; Marquardt and Watson 2005). The Late Archaic (3000 – 1000 B.C.; ca. 3800 – 1200 cal B.C.), the most intensively studied of the three sub-periods, is characterized by the establishment of "modern" climatic conditions and an increase in the number of archaeological sites and, presumably, population. Caldwell (1958) considered this the apogee of Archaic adaptation in the Eastern Woodlands.

Early Archaic sites in South Carolina are recognized by diagnostic hafted biface forms, including Kirk and Palmer Corner-Notched and Taylor Side-Notched. Bifurcate and Hardaway Side-Notched forms are rare in South Carolina, and are largely restricted to the northern portion of the state (Anderson 1991; Sassaman 1996). Anderson and Hanson (1988) proposed a model of Early Archaic settlement on the South Atlantic slope that posits seasonal movement of individual bands within large river drainages. A mixed forager-collector strategy was proposed, with the Coastal Plain occupied during the winter and early spring and the Piedmont occupied during the late spring and summer. Information-exchange/mating networks were maintained through multi-band aggregation in the fall, most likely at locales along the Fall Line.

The Middle Archaic period is characterized by a significant shift in lithic technology, and evidence for reduced group range. Stemmed hafted bifaces appear during this interval; diagnostic forms are Kirk Stemmed/Serrated, Stanly Stemmed, Morrow Mountain, and Guilford and Brier Creek lanceolate. Concomitant with this change in

hafted biface forms is a greater reliance on locally available lithic raw materials and increased use of ground stone tools. Evidence for increased settlement permanence in the greater Southeast includes the establishment of larger sites, formation of extensive midden deposits, the presence of prepared surfaces ("living floors"), storage pits, formalized burials and cemeteries, and more permanent architecture (Anderson 2001:159-161; Brown 1985; Dye 1996; Sassaman and Anderson 2004; Smith 1986:22-24). This evidence is far more extensive in the interior Southeast than for the Atlantic Coastal Plain.

Middle Archaic sites are considerably less frequent in the Coastal Plain of South Carolina than in the Piedmont (Anderson 1996a:165; Blanton and Sassaman 1989; Sassaman 1983, 1991; Sassaman and Anderson 1995, 1996). It has been hypothesized that this may be due to a partial "abandonment" of the Coastal Plain as Oak-Hickory forests were gradually replaced by southern pine over the course of the Middle Holocene. However, there are significant differences in site structure between these physiographic provinces as well. Piedmont sites tend to be small, highly redundant, and evenly dispersed across landforms. In contrast, Coastal Plain sites tend to be exhibit greater structural diversity, with larger sites preferentially located along major rivers and swamp margins and smaller sites dispersed in inter-riverine zones. Sassaman (1991) thus suggests that the relatively stable and homogenous environment of the Piedmont allowed the persistence of high residential mobility, a strategy that could not be maintained in the more heterogeneous, unstable conditions of the Coastal Plain.

The Late Archaic period coincides with inferred environmental stability, as climatic conditions and sea level approached their modern states. These conditions are

thought to have allowed population expansion, increased sedentism, subsistence intensification, technological innovation, and increased socio-political complexity. Diagnostic Late Archaic hafted biface forms include Savannah River Stemmed and Gary/Mack Stemmed. Pottery also developed during the Late Archaic in South Carolina. The earliest of these is the fiber-tempered Stallings series (Griffin 1943). The dominant surface treatments on Stallings wares include drag-and-jab and reed punctations. The sand-tempered Thoms Creek series (Griffin 1945) appears slightly later than Stallings, though the two were contemporaneous for some time. Diagnostic Thoms Creek surface treatments include finger pinching and shell, reed, and drag-and-jab punctations (Cable 1994; Griffin 1945; Sassaman 1993; Trinkley 1980a, b).

One of the most distinctive aspects of Late Archaic settlement along the Atlantic coast is the presence of large shell rings. There is great variability in the size of these deposits, which range from approximately 20 to over 200 m in diameter, and .5 to 5 m in height (Russo and Heide 2001). Over 50 of these sites are known from Georgia and South Carolina alone, with another six or so known in Florida (Russo 2004:59).

The function of shell rings has been heavily debated. Trinkley (1985) has argued that these elevated deposits were the subsistence refuse of the inhabitants of a circular village. As such, these unique deposits represent gradually accumulating household trash heaps, which over time blended together to reflect a shape coincident to the shape of the associated village. Further, Trinkley posited that the circular, symmetrical shape of these rings reflects the egalitarian character of the inhabitants, with no individual or group occupying a favored position (Trinkley 1985:118).

An alternative perspective holds a more ceremonial role for shell rings, and suggests that shell rings may represent some of the earliest evidence for social inequality and large-scale public architecture (i.e. monumentality) in North America (e.g., Russo 2004; Saunders 2002). Russo (2004) found that some shell ring sites exhibit architectural features suggestive of intentional construction and hierarchical social organization. Specifically, he concluded that shell rings are likely the result of competitive feasting, and that these groups contained aggrandizing or prestige-seeking individuals. The debate over ring function is likely to continue, as is investigation of the relationship between shell rings and contemporaneous non-shell sites.

Woodland Period

The Woodland period (1000 B.C. – A.D. 1000; ca. 1200 cal B.C. – 1000 cal A.D.) in the Southeast is characterized by the widespread adoption of domesticated plants, pottery, and burial mounds across much of the region (Anderson and Mainfort 2002; Bense 1994; Smith 1986; Steponaitis 1986), though many of these practices were initiated during the Archaic (e.g., Russo 1994; Saunders et al. 2005; Saunders and Hays 2004; Yarnell 1993). Sub-periods and phases are defined by differing ceramic types, however many of the types defined for, or applied to, the South Carolina Coastal Plain intergrade and are difficult to distinguish. The Early Woodland (1000 B.C. – 200 B.C.; ca. 1200 cal B.C. – 200 cal B.C.) is identified by the Refuge and Deptford series. The Refuge series, defined by Waring (1968; see also DePratter 1979), consists of sand and grog-tempered ceramics. Surface treatments are similar to those found on both Thoms

Creek and Deptford wares, but dentate stamping and random punctations are apparently unique to Refuge (Anderson et al. 1982; Cable 1999; Waring 1968).

The Deptford series was defined by Caldwell and Waring (1939) at the Deptford site in Georgia. This series is characterized by a coarse, sand-tempered paste with a variety of check stamped motifs. Simple stamped, cord marked, and fabric impressed examples occur as well, though these are largely indistinguishable from other types with similar surface treatments and tempering agents reported from the South Carolina Coastal Plain (e.g., Cape Fear, Deep Creek, McClellanville, Mt. Pleasant, Santee) and appear to be restricted to the Middle Woodland (Espenshade and Brockington 1989).

Early Woodland settlement patterns are markedly different from the preceding Late Archaic. Large shell middens and rings are replaced by small, dispersed shell and non-shell sites. This shift may be indicative of population expansion and intensified use of previously under-exploited resources. In addition, Trinkley (1989:78) suggests that "settlement fragmentation, which began at the end of the Thom's Creek phase…probably relates to the increase in sea level…[that] drowned the tidal marshes (and sites) on which Thom's Creek people relied." This pattern of seasonal occupation of small, dispersed sites continues through the Middle and Late Woodland (Cable 2002:16; Ellerbee and Fletcher 2006:25-28; Espenshade and Brockington 1989; Trinkley 1989).

The Deptford series persists into the Middle Woodland (200 B.C. – A.D. 500; ca. 200 cal B.C. – 500 cal A.D.), which also sees the introduction of grog-tempered cord marked and fabric impressed pottery. These ceramics generally fall into one of three types: Wilmington, Hanover, and Berkeley. The Wilmington series was defined at the mouth of the Savannah River by Caldwell and Waring (1939), while the Hanover series

was defined by South (1960) from excavations on the southern coast of North Carolina. More recently, Cable (1993) has proposed the Berkeley type to distinguish grog-tempered wares with abundant sand inclusions in the paste. In addition to cord marking and fabric impressing, some check stamping is also found on grog-tempered vessels (Cable 1999).

The Cape Fear series, defined by South (1960), was initially used to describe all sand-tempered wares with cord marked or fabric impressed exteriors. However, several other types have been proposed on the basis of paste variability, including Deep Creek, Mt. Pleasant, McClellanville, Santee, and others (Anderson et al. 1982; Phelps 1983; Trinkley 1981). Additional Middle Woodland types include the Yadkin series (Anderson et al. 1982) – distinguished by crushed quartz temper with fabric impressed, cord marked, or check stamped surface treatments – and the limestone-tempered Wando series (Adams and Trinkley 1993).

Fabric impressed and cord marked types continue into the Late Woodland (A.D. 500 – 1000; ca. 500 – 1000 cal A.D.), while check stamping disappears (Cable 2002). Also added to the mix is the fine sand-tempered Santee type, which is dominated by simple stamped surface treatments (Anderson et al. 1982).

Woodland hafted biface typology is not as well resolved as that of other periods in South Carolina. The stemmed biface tradition established in the Middle and Late Archaic continues into the Early Woodland, with some modification. According to Sassaman and Anderson (1990:162):

> Compared to preceramic Late Archaic forms, the Early Woodland forms are generally smaller, exhibit a wider range of haft element design (corner-

removed, notched, tapered stem), are made on local, sometimes poor raw material, and are less frequently thermally altered.

In the Francis Marion National Forest these bifaces are often classified into a general Woodland Stemmed type. This subsumes a variety of established culture-historical types, including Otarre, Swannanoa, Gypsy, Thelma, Lamoka, and others. Appearing in the Middle Woodland are a variety of large triangular hafted biface forms. These include primarily Yadkin, Eared Yadkin, and Badin types. The Late Woodland is typified by small triangular hafted bifaces, a trend which continues into the Mississippian.

Mississippian Period

The Mississippian period (A.D. 1000 – 1550; ca. 1000 – 1550 cal A.D.) sees the advent of full-scale corn agriculture, sedentary village life, and "regionally integrated and hierarchically organized social, political, and ceremonial systems" across the Southeast (Cable 2002:17). Mississippian occupants of the Francis Marion National Forest may have been affiliated with mound centers in the upper Santee and middle Wateree River valleys. However, there is some indication that coastal populations were smaller, more mobile, and more reliant on wild food than their counterparts in the interior (Bense 1994:190; Cable 2002:17; Elliott et al. 2002:19-20). Diagnostic artifacts in the South Carolina Coastal Plain include small triangular hafted bifaces and a variety of complicated stamped ceramic wares, most of which are classified as the Jeremy or Pee Dee series within the Francis Marion National Forest.

Previous Efforts at Probabilistic Modeling in the Lower Coastal Plain of South Carolina

Numerous subsistence-settlement models have been proposed for the South Carolina Coastal Plain, but formal probabilistic models are relatively few. This section reviews four probabilistic models that are relevant to the Francis Marion National Forest: the Brooks and Scurry (1978; Scurry 1989, 2003) model for Woodland period site location in the Lower Coastal Plain; a model developed by the South Carolina Department of Natural Resources for the Edisto River basin (Beasley et al. 1996); the Charleston Harbor watershed model proposed by Cable (1996); and Whitley's (2006) model for the Charleston Naval Weapons Station. This discussion provides necessary context for the current Francis Marion National Forest archaeological probabilistic model, which is detailed in Chapter 3.

Brooks-Scurry Model

The earliest and most influential probabilistic model guiding research in the Francis Marion National Forest is that developed by Brooks and Scurry (1978; Scurry 1989, 2003). Building on the work of Widmer (1976), they developed a model of Woodland period site location in the Lower Coastal Plain that "emphasizes the relationship between the regional ecology, subsistence resource availability and cultural adaptation to the changing resource structure" (Scurry 2003:57). This model is based on the premise that resource structure is directly affected by soil drainage conditions, which in turn were influenced by past sea-level fluctuations (Brooks et al. 1989). A bipartite Woodland settlement-subsistence system was proposed, which saw the riverine zone

being most intensively used in the late winter through summer, and the inter-riverine zone exploited from the fall through early winter (Brooks and Scurry 1978:47-49). As a corollary to this, it was hypothesized that "the highest number and density of Woodland period archaeological sites would be located in moderately well- to well-drained soils that would have provided substantial oak-hickory forest stands for nut collection and deer browse" (Scurry 2003:59). Scurry (1989) refined the model using GIS technology, and found that moderate to well-drained areas that were at elevations of 11 to 30 m, had slopes of 2 to 15 percent, and were in proximity to an interface, or ecotone, between well- and poorly-drained soils had the highest potential for archaeological site occurrence.

Though developed for Woodland period sites, subsequent testing of the model found it to be effective for site of all prehistoric periods. Scurry (2003) defined the model high probability zone as moderately to well-drained areas that were within 100 m of an interface with poorly-drained soils and on slopes of 2 to 15 percent[1]. This zone, which accounted for only 9.67 percent of the study area, contained 55.6 percent of Woodland sites and 56.6 percent of non-Woodland archaeological sites. Importantly, the model was neither designed to locate nor tested against historic sites.

The Brooks-Scurry model has proved quite influential. It has been used in determinations of archaeological site potential by the South Carolina State Historic Preservation Office (Scurry 2003:60), and forms the basis for some of the models discussed below.

[1] Elevation was excluded as a variable because the resolution of the digital elevation model was found to be too coarse to adequately discriminate localized variations (Scurry 2003:95)

Edisto River Basin Model

The South Carolina Department of Natural Resources (SCDNR) developed a probabilistic model of archaeological site occurrence for the Edisto River Basin Project (Beasley et al. 1996:111-112). Separate models were developed for prehistoric and historic archaeological sites. The prehistoric model is an adaptation of the Brooks and Scurry (1978) model, and as such incorporates soil drainage class and distance to well-drained/poorly-drained ecotones. The high probability zone for prehistoric sites includes areas of moderate to well-drained soils that are within 100 m of an interface of poorly-drained soils, have slopes of 1 to 10 percent, and are within 300 m of a stream. Similar areas that have slopes of 1 to 10 percent and are within 300 m of a stream, but are more than 100 m from an interface with poorly-drained soils are classified as having a medium probability for prehistoric sites. All other areas are considered to have a low probability of prehistoric site occurrence.

The probabilistic model for historic sites incorporates a distinct set of variables. The high probability zone for historic sites consists of areas within 300 m of a primary highway, railroad, or navigable water, and areas within 400 m of a town or municipality. The medium probability zone includes areas not classified as high probability that are within 200 m of a secondary highway or 100 m of a smaller road. All other areas are considered to have a low probability for historic sites (Beasley et al. 1996:112).

Charleston Harbor Watershed Model

Cable (1996) developed a probabilistic model of archaeological site location in the Charleston Harbor watershed using multiple linear regression. A total of 23

environmental variables were measured for 272 archaeological sites and 1,548 control points (Cable 1996:52-72). The project area was stratified into two zones, maritime and interior, and different regression equations were developed for each. Environmental variables included in the interior regression equation were distance to nearest stream, mean soil drainage diversity (.30 mile radius), distance to poorly-drained soils, distance to excessively-, well-, or moderately well-drained soils, and distance to soil interface. Variables included for the maritime zone regression equation were distance to nearest stream, soil drainage class, mean soil drainage diversity (.30 mile radius), soil diversity within .05 miles, distance to salt marsh, and distance to excessively- or well-drained soils (Cable 1996:157).

Limited testing of the models (Cable 1996:121-145) showed that the interior high and medium probability isotherms contained approximately 83 percent of archaeological sites while covering 58 percent of the survey parcels. Slightly greater success was achieved for the maritime model, where the high and moderate probability isotherms contained 83 percent of sites in 56 percent of the survey area. These results confirm the importance of soil drainage and proximity to ecotonal soil interfaces proposed in the Brooks-Scurry model. However, contrary to the Brooks-Scurry model, elevation and slope were not found to be significant indicators of archaeological site potential.

Charleston Naval Weapons Station Model

More recently, a probabilistic model was developed by Thomas G. Whitley, of Brockington and Associates, for the Charleston Naval Weapons Station in Berkeley and Charleston counties (Whitley 2001, 2006). Whitley (2006:367) criticizes Cable's (1996)

model for its lack of causal explanations and replicability, and its “limited applicability to unsurveyed areas”. Whitley (2006:361) further criticizes “data-dependent” models in general for their reliance on the archaeological record and the bias inherent to any site-environment correlations generated from this record. To circumvent these problems, Whitley adopts a “data-independent” approach to model development, beginning from theoretical models of settlement and subsistence patterning, and choosing environmental variables on the basis of “how we perceive they might have contributed to the prehistoric or historic processes of site placement, and… how easily we can measure them today” (Whitley 2006:371). The archaeological record was subjected to a tripartite temporal/cultural division: hunting and gathering adaptations, agricultural economies, and historic settlement. Thirty environmental variables were measured for the study area, and fifteen probability formulas were generated from extant theories of settlement and subsistence for each adaptational period. The probability formulas are additive combinations of environmental variables with (somewhat) arbitrary weights applied to each. The formulas were evaluated using the chi-square statistic for observed versus expected values of prehistoric and historic site samples. The probability formula selected for prehistoric site occurrence includes variables for cost-distance to and size of the nearest marsh ecotone, degree of slope, soil drainage class, and cost-distance to known historic resources. A separate formula was selected for historic sites, which includes measures of cost-distance to navigable waterways and interior travel corridors, soil capacity for seed crops, soil capacity for open-land, woodland, and wetland wildlife, degree of slope, soil drainage class, and size of and cost-distance to the nearest marsh ecotone. The models were tested by calculating the expected frequency of positive shovel tests in high, moderate, and low

probability zones. These expected frequencies were validated in subsequent survey of approximately 2,000 acres, which employed uniform shovel test intervals over the entire survey parcel (Whitley 2006:384-387).

Discussion

Each of the models discussed above has provides needed insight for evaluation of the Francis Marion National Forest probabilistic model and, as warranted, in the development of a new model (Chapters 4 and 5). The Brooks-Scurry model is undoubtedly robust and based on empirically derived theories of settlement-subsistence organization and the influence of changing environmental conditions on resource structure. However, as the model was developed specifically for Woodland period sites, its applicability as a probabilistic model utilized in land use planning and assessments of potential impact on archaeological resources in general is questionable. Further, the importance of elevation and slope are called into question by Cable's analysis. The Edisto River basin model is derived directly from the Brooks-Scurry model, and thus suffers from the same pitfalls, though it does include additional consideration of historic sites.

Both Cable's model for the Charleston Harbor watershed and Whitley's model for the Charleston Naval Weapons Station offer important insight as they employed different methodological approaches to model development. Cable's model confirms the importance of soil drainage and proximity to ecotones in past settlement location. However, as Whitley (2006:267) points out, the methods used to measure and code the variables make it difficult to apply this model elsewhere. Further, the variables used in

the multiple linear regression analyses do not satisfy the statistical assumptions of this technique.

Whitley's model has the advantage of being derived from extant theories of settlement-subsistence organization. However, his derivation of probability formulas is somewhat subjective and arbitrary, and unless all possible combinations of variables and weights are evaluated there is no guarantee that the formulas selected represent the "best" option. Further, his probability formulas incorporate a high number of variables, making them difficult to interpret and apply in the field.

This touches on a dichotomy in probabilistic modeling: whether the objective is to accurately model past human behavior and decision making or to provide a reliable tool for resource management and potential impact assessments. These goals are not necessarily mutually exclusive, though robust explanatory models will of necessity be more complex. As a planning tool, a parsimonious model is most desirable for its flexibility and ease of application.

In reviewing previous probabilistic models in the vicinity of the Francis Marion National Forest, the goal was not to find an existing model that was suitable for wholesale application, but rather to glean information that would be useful in model evaluation and development. All of the above models place importance on soil drainage and the proximity to water sources and soil drainage interfaces/ecotones. Distance from roads is also apparently an important factor in historic site location. The significance of elevation and slope are unclear, though they may be important factors even in the low lying environment of the Forest. Thus, the models reviewed provide some initial guidelines for selecting environmental parameters to investigate. The environmental

variables, archaeological datasets, and analytical techniques used in this thesis are the subject of the next chapter.

Chapter 3. Methods and Data Acquisition

This chapter outlines the datasets utilized in this thesis, the steps involved in their collection, and the analyses that were conducted with these data. There are three primary objectives of this thesis. The first is to evaluate the extant archaeological probabilistic model for the Francis Marion National Forest. The second, if warranted, is to develop a new model with increased effectiveness and utility as a management tool. The final objective of this research is to explore cultural or temporal variation in archaeological site distributions in the Francis Marion National Forest, with the goal of adding to current knowledge of past settlement organization and land use on the Lower Coastal Plain of South Carolina.

Archaeological Database

The archaeological database for this research consists of two components. The first was derived from the South Carolina State Archaeological Site Files. This database, containing records on over 20,000 archaeological sites in the state, is maintained by the Office of the State Archaeologist (OSA) at the South Carolina Institute of Archaeology and Anthropology (SCIAA) of the University of South Carolina in Columbia. These records consist of hardcopy maps of site locations and corresponding inventory forms that contain information on relevant environmental parameters, data recovery methods, artifact summaries, site type and size, ownership, and National Register of Historic Places status, among others (South Carolina Institute of Archaeology and Anthropology 1985). Importantly, the Information Management Division of the OSA has developed an

archaeological GIS dataset. This dataset is a critical component of the present analysis, as it provides the spatial location and extent of the archaeological sites examined.

Data pertaining to archaeological sites in Berkeley and Charleston counties were provided by the Office of the State Archaeologist. Contained in this dataset are records on 3,971 archaeological sites recorded in Berkeley (n = 2,035) and Charleston (n = 1,936) counties. Berkeley and Charleston counties exhibit some of the highest frequencies of archaeological sites of any county in South Carolina. This is due in large measure to compliance-based research in the Francis Marion National Forest, and as a result of the expansion of the city of Charleston. Data on 1,883 archaeological sites located within the district boundary of the Francis Marion National Forest were extracted from the larger dataset. This subset forms the spatial component of the archaeological database.

The second component of the archaeological database consists of artifact assemblage data for sites recorded in the Forest. While the GIS dataset provides the necessary spatial context for archaeological sites, this dataset was designed to provide temporal and cultural context. With assemblage data linked to the spatial data, the sample of archaeological sites can be subdivided based on the presence of temporally or culturally diagnostic artifacts.

The assemblage database was compiled by manual examination of all available reports of archaeological investigation in the vicinity of the Forest. As of fiscal year 2005, 330 Forest Service Heritage Resources Reports had been produced from work conducted in the Francis Marion National Forest. Of these, 312 were available for use in this analysis. An additional 16 documents were examined that reported on archaeological investigations conducted near or in the Forest but were not produced as official Heritage

Resource Reports. Finally, information on some sites was supplemented with data from State Archaeological Site Forms.

As each report was examined, the artifact inventory was entered into Microsoft Excel tables. In some cases artifacts were summarized by site, in others a complete inventory of artifacts by individual provenience was available. Information recorded in the Excel tables included state site number, Forest Service compartment and stand, provenience data (when available), artifact description, quantity, weight, reference information (i.e., report and page number), and miscellaneous notes.

Upon completion of data entry, the various Excel files were concatenated into a single file, which was then imported into Microsoft Access for data scrubbing and manipulation. Data entry was a drawn out process that saw the involvement of many individuals, including paid and unpaid assistants. In the process of concatenation several inconsistencies, duplicate entries, and omissions were noted that warranted detailed scrutiny of the data. The original data tables were re-examined and compared to the reports to ferret out discrepancies. This substantially improved the quality and reliability of the data and, though time consuming, minimized errors in the finished product. The final assemblage database contains 29,557 records, with information on nearly 200,000 artifacts recovered from 1,799 archaeological sites.

In addition to quality control, a further step was required to convert the data into a format suitable for analysis. Data entry had proceeded by entering information in the *Artifact Description* field exactly as it was presented in the report. That is, the values allowed for the field were not limited or defined at the outset. This resulted in thousands of redundant values (e.g., *plain sand-tempered pottery*; *sand-tempered plain sherds*;

pottery – plain, sand-tempered; etc.), iterations on a single type of artifact that could not be effectively queried. As the presence of diagnostic artifact types would be the primary criteria used to subdivide archaeological sites, it was necessary to develop a set of values to record this information. Therefore, a series of new fields were created to standardize the information provided in artifact descriptions.

The first step in this process was to subdivide the data into smaller categories. A new category, *Artifact Class*, was created and each record was assigned to one of six classes: *Botanical*, *Ceramic*, *Faunal*, *Historic*, *Lithic*, or *Modern*. The *Botanical* class consists primarily of wood charcoal and the heavy and light fractions from flotation samples. The *Ceramic* class subsumes all prehistoric pottery, regardless of culture-historical type. This includes small residual sherds/sherdlets and otherwise unidentifiable sherds. Faunal remains were primarily bone, antler, and shell. All post-contact artifacts were sorted into the *Historic* class, while all stone artifacts were grouped in the *Lithic* class. Finally, the *Modern* class consists of post-1950 materials recovered during the course of archaeological investigation.

Once the records were broken into more manageable subdivisions, the artifact types within each class could be more easily standardized. In order to make the data amenable to inquiries from a variety of research topics, the artifact description was divided over four fields: Artifact Class (discussed above), Artifact Type, Temper/Raw Material, and Surface Treatment/Style. The result is a hierarchical classification scheme, which has sufficient flexibility to allow artifacts (and sites) to be queried at multiple levels of detail, yet minimizes the complexity of the underlying database (Figure 6). With the data organized in this manner it is a relatively simple matter to query, for example, all

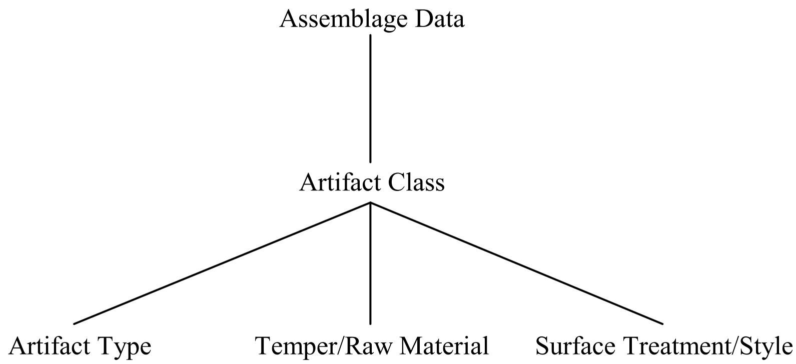

Figure 6. Schematic diagram of the classification system used to standardize artifact descriptions.

prehistoric pottery, or all prehistoric grog-tempered pottery, or, at a finer scale, all Wilmington, grog-tempered, fabric impressed pottery.

Populating each of these fields required examination of the original artifact descriptions, maintained as a separated field in the database, and the use of update queries in Microsoft Access. The *Botanical*, *Faunal*, and *Modern* classes received the least treatment in this regard. These were deemed to be the least complete portion of the database, as they were inconsistently reported and recorded during data entry. The Modern class consists of only 88 records; no further subdivision of this class was undertaken. All of the artifacts in the *Faunal* class (n = 897 records) were assigned to one of four artifact types: antler, bone, shell, and miscellaneous. Similarly, botanical remains (n = 223 records) were classified as charcoal, nut, seed, wood, or miscellaneous. The original descriptions of these artifacts are maintained in the database, and thus still accessible for future research, but for purposes of the present analysis nothing further was done with these artifact classes.

Artifacts assigned to the *Lithic* class (n = 36,369 artifacts) were subdivided into six types: debitage, fire cracked rock, ground stone, hafted biface, other tool, and miscellaneous. Raw material was then input for each record where it was available in the description. Culture-historical type was recorded in the Surface Treatment/Style field. This was done only for hafted bifaces, as these are the lithic artifact type most often exhibiting temporally or culturally diagnostic traits.

Prehistoric ceramics comprise the majority of artifacts recorded in the database (n = 94,802 artifacts), and many temporally and culturally diagnostic types are present in this class. This resulted in the definition of 32 values for Artifact Type (Table 1). Nine different values were assigned for temper: fiber, grit, grog, limestone, quartz, sand, sand/grit, sand/grog, and temperless. Temper is perhaps the least reported attribute of prehistoric pottery, and as a result many records have null entries in this field. This is likely due to the predominance of sand as a tempering agent in the Lower Coastal Plain of South Carolina. It seems that, in some of the archaeological reports examined, sand is assumed to be the temper unless otherwise noted. However, there can be much variability in the size, shape, and abundance of sand particles within a paste, though whether this represents cultural or temporal difference, or geographic variation in source material is unclear. Surface Treatment/Style was highly variable within the *Ceramic* class. A total of 44 different values were recorded, including both surface treatment of ceramic vessels and functional categories of non-vessel ceramic artifacts (Table 2).

Historic artifacts are the second most abundant artifact class in the database (n = 51,810 artifacts). Forty-eight distinct artifact types were recorded (Table 3), while surface treatment/style values were fewer (n = 24, Table 4). Temper/Raw Material was rarely

Table 1. Artifact Type Values for Ceramic Artifacts.

Artifact Type	Number of Sites	Total Quantity
Ashley	6	51
Baked Clay Object	62	201
Berkeley	27	81
Cape Fear	200	4115
Cape Fear/Yadkin	2	4
Chicora	5	35
Daub	57	326
Deep Creek	5	158
Deptford	455	5009
Etowah	1	5
Fired clay	13	31
Hanover	68	350
Jeremy/Pee Dee	112	5461
McClellanville	35	694
Mississippian	96	1275
Mt. Pleasant	2	5
Non-vessel	13	35
Refuge	196	1478
Refuge/Deptford	3	14
Residual	213	28763
Santee	242	4047
Savannah	20	443
Savannah/Jeremy	4	60
Stallings	23	83
Thoms Creek	392	6059
Undetermined	889	24051
Unfired clay	9	9
Wando	7	16
Wilmington	160	1017
Woodland	282	5613
Yadkin	40	337

Table 2. Surface Treatment/Style Values for Ceramic Artifacts.

Surface Treatment/Style	Number of Sites	Total Quantity
Abrader	5	10
Applique	3	4
Brushed	48	182
Burnished	52	785
Check stamped	285	1720
Chunky stone	1	1
Clay bead	1	1
Clay pipe	4	4
Cockle shell impressed	3	10
Complicated stamped	102	3122
Cord marked	174	808
Corn cob impressed	9	18
Corrugated	3	5
Dentate stamped	73	311
Fabric impressed	439	6426
Figurine	1	17
Finger impressed	31	68
Finger pinched	28	52
Geometric stamped	2	5
Incised	142	557
Indeterminate textile impressed	7	14
Indeterminate/Eroded	832	44580
Linear check stamped	150	1557
Net impressed	6	17
Node	3	3
Notched rim	4	4
Perforated	3	3
Pinched rim	3	6
Plain	977	22491
Punctate	59	119
Punctate, Allendale	1	12
Punctate, brush	2	4
Punctate, drag-and-jab	31	117
Punctate, linear	7	11
Punctate, random	12	74
Punctate, reed	32	91
Punctate, reed separate	30	219
Punctate/Incised	2	2
Roughened	10	107
Scraped	52	177
Shell impressed	13	44
Shell scraped	45	251
Simple stamped	299	5226
Wiped	2	4

Table 3. Artifact Type Values for Historic Artifacts.

Artifact Type	Number of Sites	Total Quantity
Annularware	27	105
Brick	295	10886
Brick kiln	3	-
Buffware	8	39
Bullet	22	39
Button	37	54
CCC camp	1	-
Cemetery	1	-
Civil War gun emplacement	1	-
Colonoware	179	9431
Creamware	182	1325
Delft	46	169
Earthen dam	1	1
Earthenware	112	731
Edgeware	26	57
Glass	389	11053
Grist mill	1	-
House	6	-
Ironstone	52	221
Ironstone/Whiteware	5	9
Jackfield	8	23
Liquor still	13	3
Metal	201	1872
Mill	1	-
Miscellaneous	81	169
Miscellaneous architectural	51	1543
Miscellaneous ceramic	87	440
Nail	185	5022
North Devon gravel-tempered ware	4	7
Pearlware	175	1838
Pipe	139	999
Porcelain	129	566
Redware	36	170
Rice Mill	1	-
Saltware	1	3
Slave cabins	2	-
Slipware	49	361
Staffordshire	7	24
Stoneware	164	771
Tableware	1	5
Tar kiln	128	165
Undetermined	3	2
Well	1	-
White granite ware	3	4
Whiteware	190	1807
Yellowware	46	115

Table 4. Surface Treatment/Style Values for Historic Artifacts.

Surface Treatment/Style	Number of Sites	Total Quantity
19th century	3	-
20th century	3	-
Albany slipped	13	23
Alkaline glazed	24	55
Blue and white	1	2
Burnished	21	540
Clay pipe	3	4
Dipped refined	1	2
Eroded	1	1
Incised	2	2
Indeterminate/Eroded	151	7913
Painted	3	8
Plain	45	810
Red slipped	1	6
Salt glazed	49	142
Salt glazed, brown	25	43
Salt glazed, grey	31	63
Salt glazed, white	37	121
Scalloped rim impressed	1	2
Scraped	1	1
Shell edge	15	54
Shell edge, blue	26	77
Shell edge, green	19	45
Slipped	3	8
Transfer print	121	684
Whieldon	5	20

recorded for historic artifacts, being occasionally noted for clay pipes and Colonoware sherds.

The final assemblage database contains records for 1,799 archaeological sites. However, a number of these sites are located outside the boundary of the Francis Marion National Forest, with 1,668 being located in the Forest. Thus, of the 1,883 sites extracted from the State Site Files, 1,668 (88.6%) have associated assemblage data recorded, while 215 (11.4%) do not. This discrepancy is the result of three factors. First, 18 of the 330 Heritage Resource Reports produced as of 2005 could not be located for inclusion in the database. Second, many reports encompassing work conducted in 2006-2008 were not available for inclusion in the assemblage database. However, since site forms are typically filed before project completion to obtain formal state site numbers, many of these sites are recorded in the State Site Files, and thus present in the GIS dataset. Finally, some sites recorded in the Site File were never described in a formal report. Thus, though extensive, the assemblage database is not exhaustive. Inclusion of newer reports (when completed) and a thorough examination of the hard copy site forms could render the assemblage dataset more complete. However, it was felt that the information gained by rounding out the data did not justify the additional time required to do so, and at nearly 90% complete the sample size was deemed adequate for present purposes.

In the analyses that follow, the assemblage database was used to subdivide the archaeological sites in order to examine the spatial distribution and environmental associations of sites of differing temporal or cultural affiliation. The archaeological materials were broken down into successive levels of increasing specificity. At the broadest level, sites were divided into prehistoric and historic samples, based on the

presence of any artifact of prehistoric or historic provenance. For more detailed analyses, 38 artifact categories were defined and used to produce distributional maps (Table 5). The prehistoric sample was further divided into temporal period/phase subdivisions, on the basis of diagnostic artifacts. A conservative approach was adopted in delineating the artifact types indicative of certain periods or phases. Only those types that were deemed to be reliably sorted and unambiguously diagnostic were used to produce temporal site subsets. This was done in order to minimize potential error introduced by individual analysts and to circumvent typological ambiguity. This may seem overly restrictive, but without physical examination of artifact assemblages a conservative approach to assigning temporal or cultural affiliation is most valid.

The diagnostic artifact categories used to define temporal subsets are presented in Table 6. No Paleoindian diagnostics are recorded in the assemblage database. The Early and Middle Archaic periods are recognized by the presence of diagnostic hafted biface forms. Later periods are recognized by a combination of hafted bifaces and diagnostic pottery types. Plain ceramic wares were generally not considered diagnostic, unless they were combined with distinctive tempering agents, such as limestone (Wando), fiber (Stallings), or crushed quartz (Yadkin). The Woodland period proved most difficult to isolate, as many of the established culture-historical types were deemed too difficult to distinguish, or had only a single diagnostic surface treatment. Thus many of these had to be collapsed into more general categories of temper-surface treatment combinations. In some cases these were restricted to the Woodland period and could be included in the analysis. However, others (e.g., sand-tempered check stamped, simple stamped, and

Table 5. Artifact Categories Defined for the Analyses.

Artifact Category	Types Included
Corner-notched	Kirk, Palmer
Side-notched	Taylor, Hardaway
Kirk Stemmed	
Stanly Stemmed	
Morrow Mountain Stemmed	
Guilford	
Brier Creek Lanceolate	
Savannah River Stemmed	
Gary/Mack Stemmed	
Steatite	Vessel, perforated slab
Thoms Creek punctate	
Thoms Creek shell impressed	
Thoms Creek finger pinched	finger pinched, finger impressed
Stallings	Incised, plain, punctate, simple stamped
Refuge dentate stamped	
Refuge random punctate	
Deptford linear check stamped	
Santee simple stamped	
Wando	Check stamped, fabric impressed, plain, simple stamped
Yadkin	Check stamped, cord marked, fabric impressed, incised, plain, simple stamped
Woodland stemmed	Adena, Brewerton, Deptford Stemmed, Otarre, Santee Stemmed, Swannanoa, Thelma
Large triangular	Camp Creek, Copena, Levanna, Candy Creek, Yadkin
Wilmington cord marked	Wilmington, Hanover, Berkeley
Wilmington fabric impressed	Wilmington, Hanover, Berkeley
Wilmington check stamped	Wilmington, Hanover, Berkeley
Sand-tempered cord marked	Cape Fear, Deep Creek, Deptford, Jeremy/Pee Dee, McClellanville, Mt. Pleasant, Refuge, Santee, Undetermined, Yadkin
Sand-tempered fabric impressed	Cape Fear, Deep Creek, Deptford, McClellanville, Mt. Pleasant, Refuge, Santee, Undetermined, Yadkin
Sand-tempered check stamped	Cape Fear, Deptford, Jeremy/Pee Dee, Santee, Savannah, Undetermined, Yadkin
Sand-tempered incised	Deptford, Jeremy/Pee Dee, Refuge, Thoms Creek, Undetermined
Sand-tempered simple stamped	Cape Fear, Deptford, Jeremy/Pee Dee, McClellanville, Refuge, Santee, Thoms Creek, Undetermined, Yadkin
Mississippian complicated stamped	Ashley, Chicora, Etowah, Jeremy/Pee Dee, Santee, Savannah
Mississippian small triangular	Caraway, Madison
Colonoware	
Creamware	
Pearlware	
Whiteware	
Pipe	Kaolin, Ball Clay
Tar kiln	

Table 6. Temporal/Cultural Classes and Diagnostic Artifact Categories.

Period	Artifact	Number of Sites	Total Quantity
Early Archaic	All Early Archaic	22	25
	Corner-notched	20	23
	Side-notched	2	2
Middle Archaic	All Middle Archaic	41	66
	Kirk Stemmed	1	1
	Stanly Stemmed	3	3
	Morrow Mountain	22	32
	Guilford Lanceolate	19	24
	Brier Creek Lanceolate	4	6
Late Archaic	All Late Archaic	161	701
	Savannah River Stemmed	15	19
	Gary/Mack Stemmed	9	15
	Steatite	9	10
	Stallings	23	83
	Thoms Creek finger pinched	57	120
	Thoms Creek punctate	76	400
	Thoms Creek shell impressed	16	54
	All Thoms Creek	130	574
Woodland	All Woodland	604	12438
	Refuge dentate stamped	76	311
	Deptford linear check stamped	147	1535
	Santee simple stamped	101	2881
	Wando	7	16
	Yadkin	40	337
	Wilmington cord marked	29	91
	Wilmington fabric impressed	170	1009
	All Wilmington	183	1100
	Sand-tempered cord marked	159	704
	Sand-tempered fabric impressed	360	5404
	Woodland stemmed	36	95
	Large triangular	21	55
Mississippian	All Mississippian	119	3226
	Mississippian complicated stamped	102	3122
	Mississippian small triangular	28	104

incised) spanned beyond the Woodland period, and thus could not be considered diagnostic of any single temporal division.

Digital Environmental Datasets

Investigation of the environmental associations of archeological sites was enabled by the availability of high-quality digital environmental datasets. These datasets were acquired from a variety of sources, including both state and federal agencies. As replicability is an important consideration, the environmental data used in the following analyses are widely and freely available. The primary digital environmental datasets used in this analysis, and secondary datasets derived from these, are presented in Table 7. The environmental variables are discussed in detail below, along with the geoprocessing techniques used in their derivation.

Soils data were obtained from the USDA county soil surveys of Berkeley (Long 1980) and Charleston (Miller 1971) counties. Digital spatial data generated from these surveys is available from the USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database (Soil Survey Staff 2006a, b). Holliday (2004:54-60) notes several limitations of USDA county soil surveys, and cautions against their uncritical application to archaeological research. Most notable of these limitations are the generalizations inherent in mapping soil series. Many differences in soil may be too complex to map at the scale of county soil surveys, and thus these maps have the capacity to mask variability. Indeed, in discussing the extant probabilistic model in the Francis Marion National Forest, Cable (2002:30, 447) notes that isolated, well-drained patches and small Carolina Bays are often not detected in soil survey maps, necessitating

Table 7. Primary and Derived Digital Environmental Datasets.

Dataset	Type	Source
Soils - Berkeley County (SSURGO)	Polygon	NRCS - Soil Data Mart
Soils - Charleston County (SSURGO)	Polygon	NRCS - Soil Data Mart
Digital Elevation Model	30 m raster	National Elevation Dataset
National Wetlands Inventory	Polygon	South Carolina Department of Natural Resources
FMNF roads	Line	USDA Forest Service
FMNF major roads	Line	USDA Forest Service
FMNF district boundary	Polygon	USDA Forest Service
Major rivers	Line	University of South Carolina, GIS Data Server
Major rivers	Polygon	University of South Carolina, GIS Data Server
Ocean	Polygon	University of South Carolina, GIS Data Server
Scarps	Line	Doar and Willoughby 2006
Percent slope	30 m raster	
Distance from scarp (m)	30 m raster	
Distance from wetland (m)	30 m raster	
Distance from stream (m)	30 m raster	
Distance from perennial Stream (m)	30 m raster	
Distance from poorly- or very poorly-drained soil (m)	30 m raster	
Distance from very poorly-drained soil (m)	30 m raster	
Distance from well-drained soil (m)		
Distance from road (m)	30 m raster	
Distance from major road (m)	30 m raster	
Distance from coast (m)	30 m raster	

testing in areas outside those dictated by the model. These objections notwithstanding, soils surveys are a highly useful resource for archaeologists, provided their accuracy and level of detail is not overestimated.

The primary soil attribute used in this analysis is soil drainage, which "refers to the frequency and duration of wet periods under conditions similar to those under which the soil developed"(Soil Survey Division Staff 1993:31). Many models of prehistoric and historic settlement in the Lower Coastal Plain use soil drainage as one of the primary constraining features of the landscape (e.g., Brooks and Scurry 1978). It is generally thought that because this region is relatively low-lying with expansive wetlands, areas of well-drained soils would be preferred for past settlement. Soil drainage was determined for each soil mapping unit by reference to the county soil survey reports and to official soil series descriptions (Soil Survey Staff 2008). Where discrepancies were encountered between these sources, the drainage class assigned in the more recent official descriptions was preferred. Ten unique soil drainage classes were encountered in Berkeley and Charleston counties. These were collapsed into seven drainage classes for purposes of this analysis (Table 8). Areas classified as mines, borrow pits, or made land in the soil surveys were not assigned drainage classes. This information was appended to the attribute table of the SSURGO data, and the resulting datasets were joined together using the MERGE function of the Spatial Analyst extension of ESRI ArcGIS 9.2. This dataset was then clipped to match the extent of the Francis Marion National Forest.

A digital elevation model (DEM) was extracted for the Forest and surrounding area from the National Elevation Dataset. The DEM is derived from USGS 7.5 minute topographic quadrangles. Elevation is sampled every 30 m, and the resulting dataset is a

Table 8. Soil Drainage Categories.

SSURGO Drainage Class	Analysis Drainage Class
Excessively	Excessively
Somewhat excessively	Excessively
Well	Well
Moderately well	Moderately well
Moderately well to somewhat poorly	Moderately well
Somewhat poorly	Somewhat poorly
Poorly	Poorly
Poorly to very poorly	Very poorly
Very poorly	Very poorly
No data	No data

grid (raster) of cells with elevation values. Elevation may seem to be relatively homogenous across the Forest, but there is some topographic relief that was potentially important in past settlement location. Much of this relief is related to Pleistocene marine terraces, as discussed in Chapter 2. A raster dataset of percent slope was calculated from the DEM, using the SLOPE function of the Spatial Analyst extension of ArcGIS.

Wetlands data were taken from the National Wetland Inventory (NWI) of the United States Fish and Wildlife Service. This inventory provides a hierarchical classification of wetlands into estuarine, lacustrine, marine, palustrine, and riverine, according to the Cowardin classification system (Cowardin et al. 1979). The NWI datasets were obtained from the SCDNR, which had previously modified them to include land use data for the adjacent uplands (Scurry 2003). The NWI data are divided by USGS topographic quadrangle, 22 of which completely or partially overlap the Francis Marion

National Forest. These 22 datasets were downloaded from the SCDNR GIS Data Clearinghouse. To facilitate analysis, the individual datasets were joined into a single dataset using the ArcGIS MERGE function. The DISSOLVE function was then used to remove boundary lines remaining from the original datasets. Finally, the upland areas were removed, and the remaining wetlands clipped to the extent of the Forest.

Streams and water body datasets were used to supplement the wetlands data described above. These data were obtained from the USDA Forest Service website. The datasets are Digital Line Graphics derived from USGS 7.5 minute quadrangle maps, and represent stream and water body features depicted on the maps. Additional stream and water body datasets were obtained from the University of South Carolina GIS Data Server, but these were used only as base map data for display purposes.

Additional data supplied by the USDA Forest Service includes a polygon of the district boundary of the Francis Marion National Forest, and a transportation dataset of all roads traversing the Forest. A secondary layer of major roads was derived from this data. Federal, state primary, state secondary, and county roads were considered major roads for purposes of this analysis, and were extracted from the transportation data.

The final environmental dataset used in this analysis was the location of Pleistocene marine scarps (Doar and Willoughby 2006). These scarps form the boundary between the beach/barrier island facies of one marine terrace and the backwater facies of the adjacent terrace. As these terraces have been postulated to be determinative of past human settlement in the Forest, their location is an important factor for consideration.

A series of secondary datasets were derived from the primary environmental datasets for use in the analysis. Each of these was calculated as a raster dataset with the

same resolution and extent as the DEM. This was accomplished with the EUCDISTANCE function of the Spatial Analyst extension of ArcGIS. The EUCDISTANCE function calculates the straight line distance from the center of the nearest feature in the source dataset to the center of each cell in the output raster. These derived datasets include distance from wetlands, distance from streams or water bodies, distance from perennial streams, distance from poorly- or very poorly-drained soils, distance from very poorly-drained soils, distance from well-drained soils[2], distance from roads, distance from major roads, distance from scarps, and distance from the Atlantic coast. The archaeological site and assemblage data and all GIS datasets used in these analyses are available in electronic format, and have been filed with the USDA Forest Service.

Evaluating the Extant Probabilistic Model

The existing archaeological probabilistic model for the Francis Marion National Forest is used by Forest Service personnel to identify areas of high, medium, and low probability of archaeological site occurrence. These probability zones in turn indicate the level of survey intensity to be implemented when conducting compliance work in the Forest, with the goal of reducing person hours in the field while maximizing site discovery rates. The probability zones are under frequent revision as new surveys are completed and more data are incorporated into the model. A review of descriptions of the Forest Service probability zones in recent cultural resource management reports illustrates this dynamic. For example, Cable (2002) describes the probability zones as follows:

[2] For this measure distance was taken from excessively-, well-, or moderately well-drained soils

> High Site Potential polygons are defined as well drained locations in floodplains and well to moderately drained settings in flatwoods within 60 meters of a water source. Moderately drained locations in floodplains and flatwoods within 90 meters of water sources are assigned a Moderate Site Potential rating, and poorly drained locations within floodplains and flatwoods are classified as containing Low Site Potential. In addition to these basic environmental variables, three other factors are considered in creating High Site Potential polygons, proximity to historic roads and building sites and locations of previously recorded sites [Cable 2002:29].

More recently, Adams and Botwick (2005:22-27) describe the probabilistic model as containing only two zones: high and low probability. The high probability zone is defined as:

> Areas at a distance of 0 to 160m (525ft) from the interface of poorly drained soils and moderate- to well-drained soils... 70m (230ft) around the perimeter of small ponds or bays… areas surrounding small bays, ponds, or other water bodies that are not mapped by the SCS soil survey and interfaces between poorly drained soils and soils with better drainage [Adams and Botwick 2005:22].

Areas of moderate to well-drained soils within 70 m of abandoned or historic roads were also considered to be within the high probability zone. All areas not satisfying the criteria

of the high probability zone were considered to have a low probability of containing archaeological materials. Ellerbee and Fletcher (2006:5) provide a nearly identical description of the probability zones, but they expand the criteria for high probability to include areas of somewhat poorly- to well-drained soils within 120 m of historic or abandoned roads.

Not only have the criteria for establishing site probability zones changed over time, but so too have the survey strategies within the zones. High probability zones have generally been surveyed with shovel tests spaced 30 m apart, along transects spaced 30 m apart. Medium probability zones have been surveyed with shovel tests spaced 30 to 60 m apart, along transects spaced at 30 m. Low probability zones have, in some cases, been surveyed with transects and shovel tests spaced at 60 m, but have more often been subject only to pedestrian survey and judgmental shovel tests. Flexibility in field methodology is apparent, however, as localized drainage conditions (e.g. standing water or isolated areas of well-drained soils) often dictate modification of these survey strategies.

An ArcGIS dataset of the Francis Marion National Forest site probability zones was provided by Robert T. Morgan, Forest Archaeologist. These polygons differ slightly from the descriptions provided in extant cultural resource management reports, again illustrating the fluid nature of the model. This dataset contains high and medium probability zones, and is based on the criteria established by Brooks and Scurry (1978). The high probability zone includes areas of excessively- to moderately well-drained soils within 120 m of either a water source or an interface with poorly- to very poorly-drained soils. The medium probability zone consists of areas of somewhat poorly-drained soils that are within 60 m of a water source or an interface with poorly- to very poorly-drained

soils. Areas outside of these zones are considered to have a low probability for archaeological materials (Table 9).

To test the effectiveness of the extant probabilistic model, the GIS was used to determine the frequency of sites in each probability zone (i.e., high, medium, and low). A total of 1,883 archaeological sites in the State Archaeological Site Files are located within the bounds of the Forest in Berkeley and Charleston counties. These sites are recorded as polygons in the site files, representing the site boundaries delineated during archaeological survey and testing. This poses a problem as, in some cases, a site may cross multiple probability zones. In the analyses that follow, model performance was examined with sites represented as both points and polygons. Point locations were extracted using GIS to calculate the centroid of each site polygon. To obviate the problem of sites intersecting multiple probability zones when represented as polygons, the following criteria were applied:.(1) if any portion of a site intersects the high probability zone it was counted in the site frequency of this zone; (2) sites which intersect the medium probability and do not intersect the high probability zone were counted in the site frequency of the medium probability zone; (3) only sites that are completely contained in the low probability zone were counted in the site frequency of this zone. This is perhaps not the most accurate way to measure the observed frequency of sites in each zone, but it makes better use of the spatial extent of sites, and lends some benefit of doubt to the model by boosting the number of sites in the high and medium probability zones. Presumably, if any portion of a site falls within the high or medium probability zone, it stands a reasonable chance of being detected by archaeological survey strategies guided by the model.

Table 9. Probability Zones of the Extant Francis Marion National Forest Probabilistic Model.

Probability Zone	Area (m2)	% of Total
High	388136860	23.07
Medium	242247940	14.40
Low	1052017513	62.53
Total	1682402313	100.00

The GIS was used to query the number of sites in each probability zone, using the criteria outlined above. Following Scurry (2003) and Gillam (2004), significance was evaluated using the chi-square statistic (Baxter 2003:129-130; Tamhane and Dunlop 2000:315-318; Thomas 1986:264-290), given as:

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

where c is equal to the number of probability zones, fo is the observed frequency of sites, and fe is the expected frequency of sites. The expected frequency of sites in each probability zone is calculated by multiplying the proportional area of each zone by the total number of observed sites. That is, if the high probability zone occupies 40% of the total area of the Forest, we should expect that, if the sites are randomly distributed, 40% of the sites will be found in that zone by chance alone. Thus:

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

The χ^2 values were evaluated at the $\alpha = .05$ probability level, with degrees of freedom (v) calculated as:

$$v = c - 1$$

An alternative method of assessing model effectiveness is the gain statistic (Kvamme 1988), defined as:

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

The gain statistic provides a standardized measure of the proportion of sites relative to the proportional area. In evaluating the gain statistic, values close to zero indicate that the proportion of archaeological sites is approximately equal to the proportional area of the zone. Values approaching one indicate a high proportion of archaeological sites relative to zone area, while negative values indicate a lower than expected proportion of sites[3]. Ideally, a probabilistic model will yield the greatest gain in the high probability zone, a slightly lower (but still positive) value in the medium zone, and a negative value in the low probability zone.

Though the tests outlined above should be effective for evaluating the extant probabilistic model, there are some problems with the analysis. The polygon test is, admittedly, biased towards model success, and there is no account taken of site area. Thus, a third, similar test was devised to address these issues. In this analysis, rather than use the frequency of sites in each zone as a measure of success, the total site area in each zone was measured. The sample size is somewhat reduced (n = 1847), as a small number of recently recorded sites in the site file database are not represented as polygons.

In addition to evaluating the model using the entire sample of sites, a more detailed analysis was undertaken. The extant model was tested against the temporal/cultural site subsets outlined above, to determine if model performance varied for differing classes of sites. These analyses rely on the assemblage database to assign cultural/temporal information to the sites, and thus the total site sample is reduced (n =

[3] A value equal to 1 is theoretically (i.e., mathematically) possible, but practically impossible as the model/zone in question would have to encompass 0% of the total area yet still contain >0% of the total sites.

1668). The first of these tests examined model performance against historic and prehistoric sites. The second evaluated the model for four subdivisions of the prehistoric sample: Early/Middle Archaic, Late Archaic, Woodland, and Mississippian.

The initial tests of model performance against all archaeological sites utilized both point locations and polygons representing site boundaries. However, in the more specific analyses sites were represented only as points. The rationale for this rests on the presence of multiple occupations of archaeological sites (i.e., multi-component sites), and the difficulty in resolving the spatial extent of each occupation/component from the overall boundary of the site. For example, if a hypothetical site has an artifactually dense, but spatially restricted, Early Archaic component, several sparse Woodland components, and an expansive and dense Mississippian component, it would be incorrect to refer to the "site" boundary – which encompasses the spatial extent of *all* occupations at that locale – when discussing any given component or subdivision of the archaeological record. Ideally, the spatial extent of each distinct occupation/component would be provided in reports or the state site files, but this is rarely the case (but see Cable 2002 for an exception). Given the inability to resolve the extent of specific components, using a point to define site location is the most appropriate way to proceed.

The effectiveness of the extant probabilistic model was evaluated on the basis of the above tests. The extant model can be deemed adequate if the high and medium probability zones have significantly more sites, and the low probability zone significantly fewer sites, than expected by chance alone. Further, the high probability zone should have the highest gain statistic, with the medium probability zone exhibiting a slightly lower positive gain, and the low probability zone showing negative gain. If this is

demonstrated for all sites, and for the temporally specific site subsets, then modification of the probability zones and construction of a new probabilistic model or models may not be justified. However, even if these expectations are met, a new model may still be developed which exhibits more efficient probability zones (i.e., higher gain).

Examining Environmental Associations

To anticipate the results, the tests outlined above warrant modification of the extant Forest Service probabilistic model. Minimally, different parameters are needed to model the location of historic and prehistoric sites. Further, there are significant differences between the prehistoric temporal subsets that may warrant separate treatment for certain classes in model development.

A series of tests were conducted to determine which environmental variables are effective indicators of site location, and if there are significant differences in environmental parameters between site classes. Thirteen environmental attributes were calculated for each archaeological site: soil drainage class, elevation, percent slope, and ten distance measures (see above, Table 7).

Soil drainage class was determined through a spatial join function, which appends the attributes of one dataset to the attribute table of another based on their relative location. Following this, the point dataset of archaeological sites was converted to a 30 m grid raster for comparison with the environmental raster datasets. The SAMPLE function was then used to create a table of the remaining environmental attributes of each archaeological site.

The first tests examined the environmental variables to determine which, if any, are effective indicators of probable site occurrence. Following a well established procedure (e.g., Anderson and Smith 2003; Cable 1996; Duncan and Beckman 2000; Kellogg 1987; Warren and Asch 2000), a random sample of 1,883 points was taken and their environmental attributes calculated. This will serve as a measure of the background environmental variables for comparison with the attributes of archaeological sites.
The significance of soil drainage class (nominal scale) was evaluated using the chi-square statistic. In this case, the expected frequency of sites in each soil drainage class is calculated by multiplying the proportional area of each by the total number of observed sites. Thus:

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

The χ^2 values were evaluated at the $\alpha = .05$ probability level, with degrees of freedom (v) calculated as:

$$v = c - 1$$

where c is the number of soil drainage classes.

Ratio scale environmental variables (e.g., elevation, slope, distance from wetlands) were evaluated using the Wilcoxon Rank Sum Test (Mink et al. 2006:228-229; Tamhane and Dunlop 2000:575-578; Thomas 1986:307-322; Warren and Asch 2000:14-15). Wilcoxon Rank Sum, equivalent to the Mann-Whitney *U*-test, is a non-parametric test for comparing two independent samples. Being non-parametric, this test has the advantage of not requiring that populations be normally distributed. The null hypothesis for the test is that the samples come from populations with equivalent distributions. To conduct the test, the two samples are combined and rank-ordered, and then the rank

values are summed over each sample, given as w_i. If the two populations have the same distribution, then their respective rank sums should be approximately equal (i.e., w_1 should be approximately equal to w_2). The statistical significance of any difference between w_1 and w_2 is tested by comparison to the large sample normal approximation. Significance was evaluated at $\alpha = .05$, and thus the null hypothesis was rejected where $p<.05$, indicating significant difference between the site and non-site samples.

The chi-square and Wilcoxon tests outlined above indicate which environmental variables are significantly different for site and non-site locales, and thus which variables are appropriate for inclusion in the probabilistic model. The next series of tests were designed to determine if there are significant differences in the environmental associations of prehistoric and historic sites. The chi-square statistic was again used to determine if soil drainage associations differ between the two samples and the Wilcoxon Rank Sum test was used to evaluate differences of ratio scale environmental variables.

Further tests were devised to examine differences in the environmental associations of the temporal site subsets. The samples compared were Early/Middle Archaic, Late Archaic, Woodland, and Mississippian. Nominal scale environmental variables (i.e., soil drainage class) were evaluated using the chi-square statistic. Ratio scale variables were evaluated using the Kruskal-Wallis test. The Kruskal-Wallis test is a generalization of the Wilcoxon Rank Sum test for cases where more than two samples are compared (Tamhane and Dunlop 2000:581). Kruskal-Wallis is a non-parametric test, analogous to one way analysis of variance (ANOVA). The test involves pooling and rank ordering all observations, then calculating the rank sum and mean rank for each sample.

The null hypothesis is that the samples compared come from populations with equivalent distributions . The Kruskal-Wallis test statistic is calculated as:

$$kw = \frac{12}{N(N+1)} \sum_{i=1}^{a} \frac{r_i^2}{n_i} - 3(N+1)$$

where N is the total number of observations, a is the number of sample groups, n_i is the number of observations in sample i, and r_i is the rank sum of sample i. A significance test can be conducted through comparison to the chi-square distribution, where the null hypothesis is rejected if:

$$kw > \chi^2_{a-1,\alpha}$$

The significance test indicates if there are differences across all samples. In order to determine which samples differ from each other, pairwise comparisons must be made (Tamhane and Dunlop 2000:583). This can be done by using the differences in their mean ranks as a test statistic. Samples i and j are deemed to be different if:

$$\left|\bar{r}_i - \bar{r}_j\right| > \frac{q_{a,\infty,\alpha}}{\sqrt{2}} \sqrt{\frac{N(N+1)}{12}\left(\frac{1}{n_i} + \frac{1}{n_j}\right)}$$

Where $\bar{r}_i$ is the mean rank of the observations in sample i, n_i is the number of observations in sample i, q is the critical value of the Studentized range distribution (Tamhane and Dunlop 2000:469), a is the number of sample groups, and N is the total number of observations. The results of pairwise comparisons for each ratio scale environmental variable will be presented as a matrix, with significant differences noted in bold (Table 10). These tests determined if there are any significant differences in the environmental parameters between temporally distinct site samples that need to be considered in probabilistic model development.

Table 10. Example Statistics for Kruskal-Wallis Pairwise Comparisons.

	Mean Rank	Early/Middle Archaic $\bar{r}_i$	Late Archaic $\bar{r}_j$	Woodland $\bar{r}_k$	Mississippian $\bar{r}_l$	Historic $\bar{r}_m$
Early/Middle Archaic	$\bar{r}_i$	0.00	$\lvert\bar{r}_i - \bar{r}_j\rvert$	$\lvert\bar{r}_i - \bar{r}_k\rvert$	$\lvert\bar{r}_i - \bar{r}_l\rvert$	$\lvert\bar{r}_i - \bar{r}_m\rvert$
Late Archaic	$\bar{r}_j$	$\lvert\bar{r}_j - \bar{r}_i\rvert$	0.00	$\lvert\bar{r}_j - \bar{r}_k\rvert$	$\lvert\bar{r}_j - \bar{r}_l\rvert$	$\lvert\bar{r}_j - \bar{r}_m\rvert$
Woodland	$\bar{r}_k$	$\lvert\bar{r}_k - \bar{r}_i\rvert$	$\lvert\bar{r}_k - \bar{r}_j\rvert$	0.00	$\lvert\bar{r}_k - \bar{r}_l\rvert$	$\lvert\bar{r}_k - \bar{r}_m\rvert$
Mississippian	$\bar{r}_l$	$\lvert\bar{r}_l - \bar{r}_i\rvert$	$\lvert\bar{r}_l - \bar{r}_j\rvert$	$\lvert\bar{r}_l - \bar{r}_k\rvert$	0.00	$\lvert\bar{r}_l - \bar{r}_m\rvert$
Historic	$\bar{r}_m$	$\lvert\bar{r}_m - \bar{r}_i\rvert$	$\lvert\bar{r}_m - \bar{r}_j\rvert$	$\lvert\bar{r}_m - \bar{r}_k\rvert$	$\lvert\bar{r}_m - \bar{r}_l\rvert$	0.00

The final set of analyses in this sequence examined differences in settlement patterning and site location at a finer scale of analysis. Each of the prehistoric site subsets utilized in the above analyses were tested to determine if the temporally/culturally diagnostic artifacts used in their definition exhibit differences in distribution or environmental associations (see above, Table 6).

Environmental associations were compared using the chi-square and Kruskal-Wallis tests outlined above. These analyses were designed to explore temporally or culturally based variation in site location in more detail, with the hope of contributing to archaeological understanding of past settlement organization and landscape use.

Probabilistic Model Development

The results of the above analyses indicate which environmental variables are effective at discriminating site from non-site locales, and thus useful for producing probability zones of site occurrence. They also indicate whether any variables need to be treated differently to effectively locate sites with different temporal or cultural

affiliations. Several techniques have been used by archaeologists for probabilistic modeling, one of the most popular of which is logistic regression. According to Hatzinikolaou (2006:440), “logistic regression is undoubtedly the most well-known and commonly applied method for the prediction of archaeological site locations”. This technique was developed for cases where the dependent variable is categorical rather than continuous (as in multiple linear regression; Kvamme 2006; Warren 1990). It is thus ideally suited to archaeological applications, where site presence/absence is treated as the dependent variable and the environmental parameters as independent variables. The regression coefficients are used to calculate the probability of site presence at any given locale. Kenneth L. Kvamme is largely credited with pioneering the use of this technique in archaeology (Warren 1990), and he and others have used it to produce highly effective probabilistic models (e.g., Kvamme 1983; Warren and Asch 2000).

Though logistic regression is flexible and statistically robust, it will not be used for model development in the present analysis. Logistic regression requires observations of the independent variables for instances of both success and failure. Thus, for archaeological site location modeling, this technique requires a measure of the environmental variables in areas where archaeological sites occur and in areas where sites are *known* to be absent. This is typically assumed to be the case when field investigation fails to recover archaeological materials in a survey parcel. However, as Kvamme points out,

> …even if thorough field investigation fails to encounter archaeological evidence at some locus, there is a *nonzero* probability that archaeological remains may actually be present; for example, they might be buried, be

> lying under vegetation, or simply have been overlooked [Kvamme 2006:24, emphasis added].

Accepting this caveat, logistic regression thus requires non-site parcels to be sampled from areas that have been surveyed and determined to be lacking in archaeological materials; otherwise, a random sample of non-site locales will include areas where sites do not occur and areas where sites may exist but have not been detected due to lack of survey. Unfortunately, the location of surveyed and un-surveyed areas is not available in digital format for the Francis Marion National Forest, and thus it is impossible to restrict the sampling universe.

Further compounding the problem are the numerous "isolated finds" recorded in the Forest (e.g., Cable 2002:38, 68, 125). An isolated find consists of a locale where "no more than two historic or prehistoric artifacts [are] found within a 30-meter radius" (Council of South Carolina Professional Archaeologists 2005:2). As such, they do not meet the requirements of an archaeological "site" in South Carolina and thus are not recorded in the State Site File. The inability to resolve the spatial location of isolated finds further hinders any effort to sample "non-site" locales.

Given these difficulties, a simpler approach to probabilistic modeling was adopted. The significant environmental variables were examined to determine the range of values indicative of archaeological site presence. Probability zones were then created by combining the relevant environmental parameters (Kvamme 1990; Mink et al. 2006). For example, it may be determined that areas that are on well-drained soils *or* within 100 m of streams have high potential for archaeological site presence. In addition to being relatively simple, flexible, and easy to implement, a model produced in this way has the

advantage of being of the same form as the existing Forest Service probabilistic model, thus facilitating comparison.

Summary

This chapter has presented the datasets and methodological framework employed in this thesis. As stated, the goals of this research are to evaluate and improve or replace the extant archaeological probabilistic model for the Francis Marion National Forest and to examine cultural or temporal variation in site distributions. A refined probabilistic model will be invaluable to Forest Service personnel, allowing them to effectively communicate avoidance areas to land use planners and to reduce person hours when evaluating cultural resources, while the detailed analysis of site distributions will contribute to archaeological understanding of past settlement organization and land use on the Lower Coastal Plain of South Carolina.

Chapter 4. Data Analysis

Evaluating the Extant Forest Service Probabilistic Model

The extant Forest Service probabilistic model defines high, medium, and low probability zones on the basis of three environmental variables: soil drainage, proximity to water, and proximity to ecotonal boundaries (i.e., boundaries between well- and poorly-drained soils). The precise parameters of the model have been modified over the past 20+ years, but the variables used in its construction have been relatively static. The efficacy of the extant probabilistic model was evaluated using the chi-square test, to determine whether significant relationships exist between the distribution of archaeological sites and the model probability zones. This was supplemented with the gain statistic which provides a standardized measure of the proportion of sites captured relative to the proportional area of the zone (see Chapter 3). Three separate tests were conducted using the entire site sample. The first examined the distribution of archaeological sites using the polygon centroids as the point location of sites, the second used polygonal representations of site boundaries, and the third calculated the site area captured by each probability zone.

The results of the first test indicate that there are significant differences in the distribution of archaeological sites in each probability zone (Table 11). The overall χ^2 value is highly significant (2 degrees of freedom, $p<.0001$). The high probability zone contains more sites than expected by chance, capturing 50.9 percent of sites in only 23.1 percent of the total area of the Forest. Similarly, the low probability zone contains far fewer sites than expected (37.0 percent of sites in 62.5 percent of the total area). However, contrary to expectations, the medium probability zone contains *fewer* sites than

Table 11. Test Statistics of the Extant Probabilistic Model for All Archaeological Sites as Points.

Zone	Area m^2	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
High	388136860	23.1	434.4	958	50.9	631.056	0.547
Medium	242247940	14.4	271.1	228	12.1	6.861	-0.189
Low	1052017513	62.5	1177.5	697	37.0	196.046	-0.689
Total	1682402313	100.0	1883	1883	100.0	833.964	-

*with 2 degrees of freedom and $\alpha = .05$, significance is indicated by $\chi 2 \geq 5.992$

expected. The zone has the lowest chi-square value, and thus it contributes little to the overall success of the model.

The model gain statistics confirm the conclusions reached by the chi-square test. The high probability zone exhibits the highest gain value, while the low probability shows a negative gain. The medium probability zone exhibits negative gain as well, reinforcing its poor performance in the model.

The second test of model success utilized site boundary polygons in tabulating observed site frequencies. The polygon test suggests that model success is greater than indicated by the point test (Table 12). The chi-square test is again highly significant (2 degrees of freedom, $p<.0001$), but the observed frequency is greater in both the high and medium probability zones and lower in the low probability zone than in the previous test. Consequently, the gain value is increased for both the high and medium zones, and decreased for the low probability zone. However, the criteria that were adopted to tabulate observed frequencies biased this test in favor of the model, so these results are not unexpected. Further, despite these biasing effects, the medium probability zone still captures fewer sites than expected, has a negative gain statistic, and exhibits the lowest chi-square value of any zone.

Table 12. Test Statistics of the Extant Probabilistic Model for All Archaeological Sites as Polygons.

Zone	Area m^2	% of Area	Expected Sites	Observed Sites	% of Sites	χ2	Gain
High	388136860	23.1	434.4	1216	64.6	1406.198	0.643
Medium	242247940	14.4	271.1	250	13.3	1.647	-0.085
Low	1052017513	62.5	1177.5	417	22.1	491.135	-1.824
Total	1682402313	100.0	1883	1883	100.0	1898.980	-

*with 2 degrees of freedom and $\alpha = .05$, significance is indicated by $\chi2 \geq 5.992$

The preceding tests of model performance produced mixed results. The extant model performs better when site boundary polygons are used to tabulate observed frequencies, though admittedly the criteria used have a biasing affect. In both cases the high and low probability zones performed well, respectively capturing greater and fewer sites than expected by chance. The medium probability zone, however, performed consistently poorly, capturing marginally fewer sites than expected. To mitigate the bias introduced by using site boundary polygons, and to more fully explore the effectiveness of the model, a third test was conducted using the total site area captured by each probability zone. The sample size is somewhat reduced in this analysis (n = 1847), as a small number of recently recorded sites in the state site file database are not represented as polygons and thus cannot be measured for area.

When accounting for site area, the probabilistic model does not perform as well as in either of the previous analyses (Table 13). The high probability zone still performs adequately, containing 44.7 percent of the total site area; however, its gain is lower than in the previous tests. The medium probability zone, which performed poorly under initial examination, is even less successful in this analysis. The medium probability zone

Table 13. Test Statistics of the Extant Probabilistic Model for Archaeological Site Area.

Zone	Area m^2	% of Area	Expected Site Area	Observed Site Area	% of Site Area	Gain
High	388136860	23.1	3348534	6482513	44.7	0.483
Medium	242247940	14.4	2089921	1023167	7.0	-1.043
Low	1052017513	62.5	9075964	7008738	48.3	-0.295
Total	1682402313	100.0	14514418	14514418	100.0	-

captures only seven percent of the total site area, resulting in a highly negative gain statistic.

The results of this analysis are particularly illuminating with regard to the low probability zone. The initial examinations (by site occurrence) indicated that the low probability zone contained between 22 and 37 percent of sites. However, nearly half of the total site area is contained within this zone. In fact, the low probability zone contains a greater proportion of the total site area than the high probability zone, and has a higher gain statistic than the medium probability zone. Two possible explanations may account for this. First, the sites in the low probability zone may be more areally extensive than those in the other zones. Alternatively, it is quite likely that some of the sites that were observed to fall in the high and medium zones extend into the low probability zone, and thus contribute to the site area contained by this zone.

Given the tenuous support of model success indicated by the preceding analyses, more detailed examination of the existing model is in order. The initial analyses used the entire site sample to evaluate the model. The next test, at a slightly finer scale of resolution, will examine model performance against historic and prehistoric sites. The results of this analysis are presented in Tables 14 and 15. Though the differences are

Table 14. Test Statistics of the Extant Probabilistic Model for Historic Archaeological Sites.

Zone	Area m^2	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
High	388136860	23.1	175.6	346	45.5	165.453	0.492
Medium	242247940	14.4	109.6	103	13.5	0.395	-0.064
Low	1052017513	62.5	475.9	312	41.0	56.423	-0.525
Total	1682402313	100.0	761	761	100.0	596.532	-

*with 2 degrees of freedom and $\alpha = .05$, significance is indicated by $\chi 2 \geq 5.992$

Table 15. Test Statistics of the Extant Probabilistic Model for Prehistoric Archaeological Sites.

Zone	Area m^2	% of Area	Expected Sites	Observed Sites	% of Sites	$\chi 2$	Gain
High	388136860	23.1	298.1	689	53.3	512.722	0.567
Medium	242247940	14.4	186.0	153	11.8	5.866	-0.216
Low	1052017513	62.5	807.9	450	34.8	158.547	-0.795
Total	1682402313	100.0	1292	1292	100.0	1588.981	-

*with 2 degrees of freedom and $\alpha = .05$, significance is indicated by $\chi 2 \geq 5.992$

slight, the model performs better for prehistoric sites than historic sites. The chi-square statistics indicate that the model is significant for both site classes, but the lower score for historic sites indicates that these are slightly more randomly distributed with respect to the probability zones. In neither case does the medium probability zone exhibit a significant relationship with site presence (i.e., the frequency of sites in this zone can be accounted for by random chance alone). Prehistoric sites are disproportionately overrepresented in the high probability zone, and underrepresented in the low probability zone. The same is true of historic sites, but the difference between the zones is not as pronounced. This pattern is confirmed by the gain statistic. The greatest gain is obtained in the high probability zone for prehistoric sites, while the lowest (i.e., most negative) gain value is in the low probability zone for prehistoric sites.

Thus, the extant probabilistic model attains the most success with prehistoric sites. What remains to be determined, however, is whether the model is more effective in locating sites of certain prehistoric temporal periods, and less effective in locating others. This would be expected, given the great amount of time encompassed in the prehistoric archaeological record and the concomitant changes in subsistence and, presumably, settlement patterns that occurred over this interval.

To explore this, the archaeological site database was again subdivided, this time into four temporal categories: Early/Middle Archaic (n = 54), Late Archaic (n = 161), Woodland (n = 604), and Mississippian (n = 119). While the chi-square test suggests that the model is statistically significant for all samples, the analysis indicates that the extant Forest Service probabilistic model is least effective at locating Early to Middle Archaic sites (Table 16). Comparing the results for the high probability zone, the percent of sites

Table 16. Test Statistics of the Extant Probabilistic Model for Prehistoric Site Subsets.

Site Class	Probability Zone	% of Area	Expected Sites	Observed Sites	% of Sites	χ2	Gain
Early/Middle Archaic	High	23.1	12.46	26	48.1	14.720	0.521
Late Archaic	High	23.1	37.14	91	56.5	78.090	0.592
Woodland	High	23.1	139.35	334	55.3	271.918	0.583
Mississippian	High	23.1	27.45	65	54.6	51.349	0.578
Early/Middle Archaic	Medium	14.4	7.78	7	13.0	0.077	-0.111
Late Archaic	Medium	14.4	23.18	13	8.1	4.472	-0.783
Woodland	Medium	14.4	86.97	72	11.9	2.577	-0.208
Mississippian	Medium	14.4	17.13	12	10.1	1.539	-0.428
Early/Middle Archaic	Low	62.5	33.77	21	38.9	4.827	-0.608
Late Archaic	Low	62.5	100.67	57	35.4	18.947	-0.766
Woodland	Low	62.5	377.69	198	32.8	85.486	-0.908
Mississippian	Low	62.5	74.41	42	35.3	14.118	-0.772

captured, gain, and chi-square are all noticeably lower for Early/Middle Archaic than later periods. Conversely, a greater percentage of Early/Middle Archaic sites occur in the low and medium probability zones than for any other sample.

The medium probability zone consistently underperforms, repeatedly returning fewer sites than expected by chance alone. The low probability zone is most effective for Woodland period sites. The lowest value for percent of sites captured and the most negative gain value are exhibited in the Woodland sample, as is the highest chi-square value.

Based on the above results, several conclusions can be drawn regarding the extant Forest Service probabilistic model. First, the medium probability zone is of universally poor utility, capturing fewer sites and less site area than expected by chance across all site classes. Second, the model is more effective at locating prehistoric than historic sites. Third, within the prehistoric sample, the model is least effective at predicting the probability of Early and Middle Archaic site occurrence. Therefore, it may be that Early

and Middle Archaic sites are underrepresented in the Forest, as surveys guided by the extant model have not effectively targeted these sites. Fourth, while the low probability zone contains only 22 to 37 percent of archaeological sites (by count), it captures nearly half of the total site area in the Forest. This suggests that the area classified as having a low probability of site occurrence was conducive to past human settlement and should be surveyed more intensively. Finally, the high probability zone does perform adequately, with the caveats noted above. However, modification to the parameters used in delineating zones would undoubtedly result in a more robust indicator of areas with a high probability of archaeological site occurrence (see Chapter 5).

Examining Archaeological Site and Background Environmental Parameters

The evaluation of the extant Forest Service probabilistic model indicates that development of a new probabilistic model is warranted. The first step in new model development is to evaluate the environmental characteristics of archaeological site locales to determine which variables differ significantly from the background environment, and thus may serve as indicators of high archaeological potential. Statistical tests employed to determine the significant environmental variables include the chi-square test for nominal data and the Wilcoxon Rank Sum and Kruskal-Wallis tests for ratio scale data (see Chapter 3). The first test compared the environmental associations of all sites versus a random sample of 1,883 points in the Francis Marion National Forest (Figures 7 and 8). These random sample points are used as an unbiased representation of the background environmental parameters in the vicinity of the Forest (Anderson and Smith 2003; Kellogg 1987).

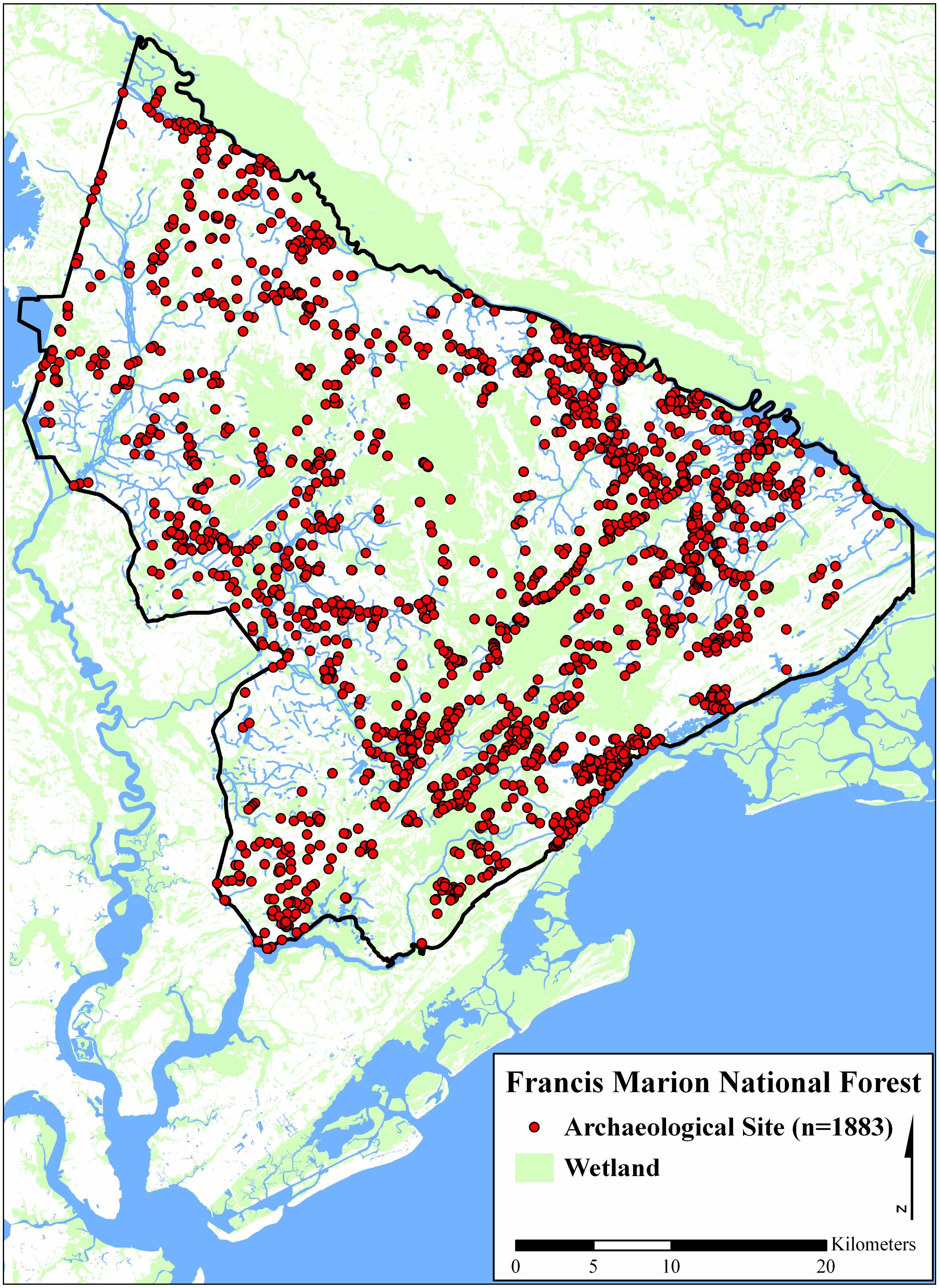

Figure 7. The location of all recorded archaeological sites in the Francis Marion National Forest.

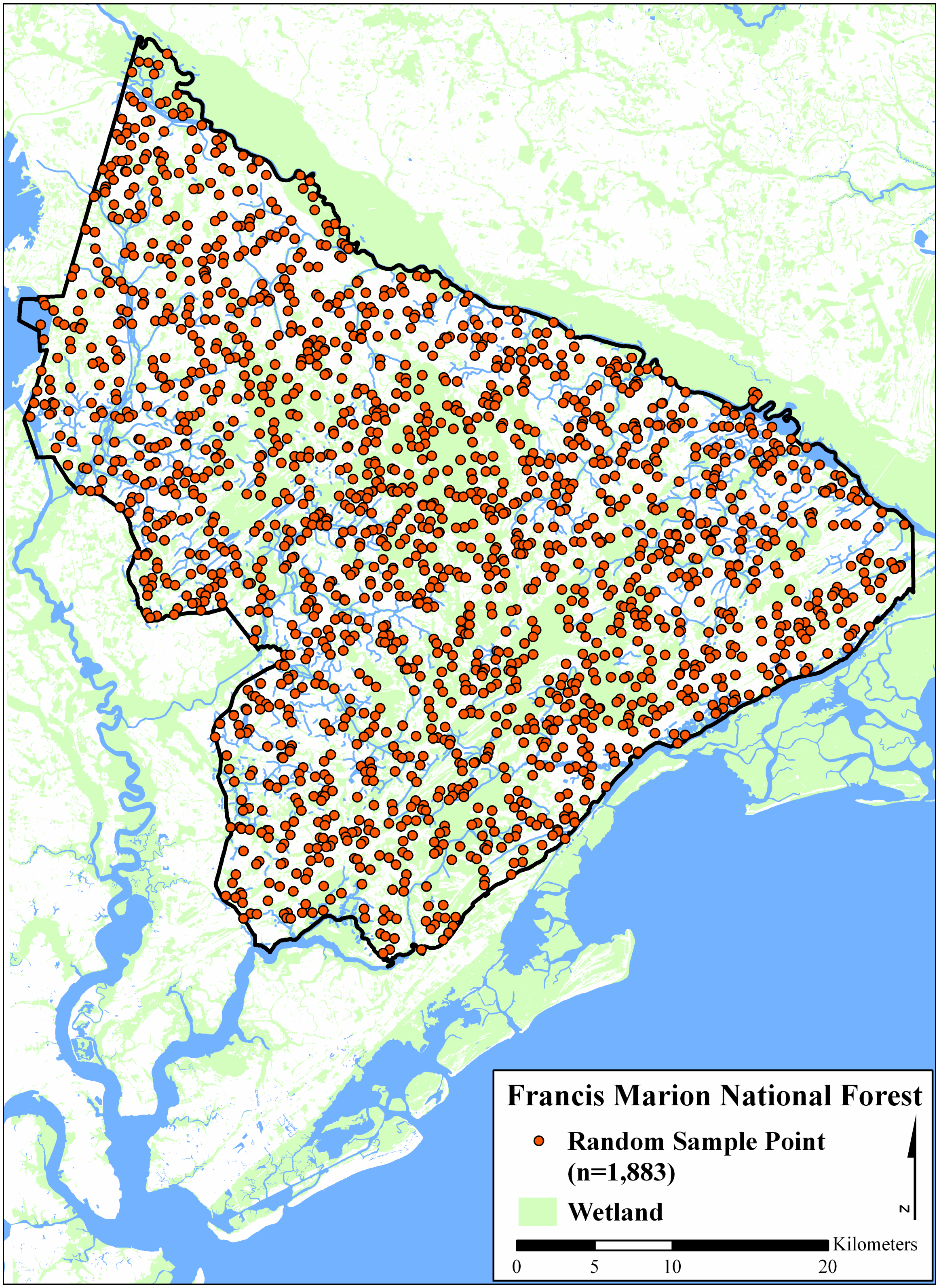

Figure 8. Random sample points used in the environmental analyses.

The only nominal scale environmental data evaluated was soil drainage class (Table 17). The expected and observed site frequencies were tabulated for each of the seven soil drainage classes. The resulting chi-square value is highly significant (six degrees of freedom, $p<.0001$), indicating a strong relationship between soil drainage class and archaeological site occurrence. The number of sites in the excessively-, well-, and moderately well-drained soil classes far exceeds the expected frequencies, while the poorly- and very poorly-drained soil classes have substantially fewer sites than expected by chance alone. Interestingly, the somewhat poorly-drained class (the most extensive drainage class in the Forest) has marginally fewer sites than expected. Applying the chi-square test to the somewhat poorly-drained class against all others does not yield statistically significant results (1 degree of freedom, $p = .4386$), and thus the observed frequency of sites could be explained by random chance.

The remaining environmental variables (elevation, slope, and a series of distance measures) are all ratio scale, and were examined using the Wilcoxon Rank Sum test. Summary statistics for site and background locales are presented in Table 18, and the results of the analysis in Tables 19 and 20. These tests indicate statistically significant differences between site and non-site locales for all variables except distance from major roads. Sites are underrepresented at higher elevations and at lower slopes, when compared to the background environment, and tend to be located closer to the coast, scarps, streams, perennial streams, and roads. Similarly, the results seem to suggest that archaeological sites are located closer to well-drained soils and further from wetlands, poorly- to very poorly-drained soils, and very poorly-drained soils. However, wetlands and poorly/very poorly-drained soils are extensive in the Forest, and the background

Table 17. Test Statistics of Soil Drainage Class for All Archaeological Sites.

Soil Drainage Class	Area m^2	% of Total	Expected Sites	Observed Sites	% of Sites	χ2	Gain
Excessively	67155548	4.0	75	231	12.3	323.11	0.675
Well	98864312	5.9	111	238	12.6	146.57	0.535
Moderately well	235058621	14.0	263	477	25.3	173.94	0.448
Somewhat poorly	456560420	27.1	511	496	26.3	0.44	-0.030
Poorly	434929680	25.9	487	253	13.4	112.27	-0.924
Very poorly	385988629	22.9	432	180	9.6	147.00	-1.400
No data	3873920	0.2	4	8	0.4	3.10	0.458
Total	1682431131	100.0	1883	1883	100.0	906.44	-

*with 6 degrees of freedom and $\alpha = .05$, significance is indicated by $\chi 2 \geq 12.592$

Table 18. Summary Statistics for All Archaeological Sites and Random Sample Points.

	Site (n=1,883)			Non-site (n=1,883)		
Environmental Variable	Median	Mean	S.D.	Median	Mean	S.D.
Elevation	6.80	8.25	3.95	8.80	8.85	4.24
Percent slope	0.32	0.78	1.32	0.19	0.45	0.83
Distance from scarp	2855.84	3340.51	2598.41	3354.32	3620.29	2479.30
Distance from wetland	57.20	70.21	65.36	28.60	59.44	77.04
Distance from stream	269.80	423.71	425.26	406.46	607.75	619.12
Distance from perennial stream	383.69	669.07	762.15	606.66	930.04	933.74
Distance from poorly- or very poorly-drained soil	57.20	77.81	93.48	0.00	58.81	108.74
Distance from very poorly-drained soil	154.01	345.32	411.55	142.99	317.77	423.17
Distance from well-drained soil	28.60	164.17	360.23	180.90	411.03	543.25
Distance from road	114.39	167.46	165.93	183.12	246.37	226.82
Distance from major road	767.38	1098.08	1101.70	761.49	1073.19	987.53
Distance from coast	17252.0	19970.9	12558.7	20831.0	22869.5	13250.9

Table 19. Results of the Wilcoxon-Rank Sum Test of All Archaeological Sites and Random Sample Points.

Environmental Variable	Class	Count	Rank Sum	Mean Rank
Elevation	Non-site	1883	3687911	1958.53
Elevation	Site	1883	3405351	1808.47
Percent slope	Non-site	1883	3230917	1715.83
Percent slope	Site	1883	3862344	2051.17
Distance from scarp	Non-site	1883	3693847	1961.68
Distance from scarp	Site	1883	3399415	1805.32
Distance from wetland	Non-site	1883	3224155	1712.24
Distance from wetland	Site	1883	3869106	2054.76
Distance from stream	Non-site	1883	3846607	2042.81
Distance from stream	Site	1883	3246654	1724.19
Distance from perennial stream	Non-site	1883	3863140	2051.59
Distance from perennial stream	Site	1883	3230122	1715.41
Distance from poorly- or very poorly-drained soil	Non-site	1883	3109566	1651.39
Distance from poorly- or very poorly-drained soil	Site	1883	3983695	2115.61
Distance from very poorly-drained soil	Non-site	1883	3360054	1784.42
Distance from very poorly-drained soil	Site	1883	3733207	1982.58
Distance from well-drained soil	Non-site	1883	4204351	2232.79
Distance from well-drained soil	Site	1883	2888910	1534.21
Distance from road	Non-site	1883	3958562	2102.26
Distance from road	Site	1883	3134699	1664.74
Distance from major road	Non-site	1883	3576900	1899.58
Distance from major road	Site	1883	3516361	1867.42
Distance from coast	Non-site	1883	3769897	2002.07
Distance from coast	Site	1883	3323365	1764.93

Table 20. Statistical Significance of the Wilcoxon Rank Sum Results in Table 19 by Comparison to the Large Sample Normal Approximation.

Environmental Variable	S	Z	*p*
Elevation	3405350.5	-4.235	<.0001
Percent slope	3862344.0	9.501	<.0001
Distance from scarp	3399414.5	-4.413	<.0001
Distance from wetland	3869106.0	9.823	<.0001
Distance from stream	3246654.0	-8.992	<.0001
Distance from perennial stream	3230121.5	-9.487	<.0001
Distance from poorly- or very poorly-drained soil	3983695.0	13.455	<.0001
Distance from very poorly-drained soil	3733207.0	5.608	<.0001
Distance from well-drained soil	2888910.0	-20.224	<.0001
Distance from road	3134699.0	-12.359	<.0001
Distance from major road	3516361.0	-0.907	0.3642
Distance from coast	3323364.5	-6.692	<.0001

environmental measures for these variables are skewed by sample points with a distance of zero (i.e., points located in wetlands or poorly/very poorly-drained soils). Thus, what these results imply is that archaeological sites tend *not* to be located within wetlands or poorly/very poorly-drained areas. Further, the significance of distance from well-drained soils is likely biased by the high proportion of sites located in well-drained areas. To remedy this discrepancy, the Wilcoxon Rank Sum test was repeated for distance from wetlands, distance from poorly- to very poorly-drained soils, distance from very poorly-drained soils, and distance from well-drained soils, this time excluding sample points with zero values.

Reanalysis of these variables provided some interesting results (Tables 21 and 22). Distance from well-drained soils is still highly significant, illustrating that archaeological sites located in somewhat poorly- to very poorly-drained areas tend to be relatively close to well-drained areas. Distance from wetlands also retained its statistical significance, but in this case the conclusions are reversed. Whereas the initial test suggested that archaeological sites were located at a greater than average distance from wetlands, reanalysis with sample points located within wetlands excluded instead indicates that sites are located closer to wetlands. A similar situation holds for distance from poorly- to very poorly-drained soils, and distance from very poorly-drained soils. In both cases archaeological sites located in better drained areas tend to be located close to a boundary with poorer drained areas, though the statistical significance of these variables is reduced.

Table 21. Results of the Wilcoxon-Rank Sum Test of All Archaeological Sites and Random Sample Points, where Samples with Zero Values are Excluded.

Environmental Variable	Class	Count	Rank Sum	Mean Rank
Distance from wetland	Non-site	1101	1525868	1385.89
Distance from wetland	Site	1527	1928638	1263.02
Distance from poorly- or very poorly-drained soil	Non-site	939	1168170	1244.06
Distance from poorly- or very poorly-drained soil	Site	1450	1686685	1163.23
Distance from very poorly-drained soil	Non-site	1452	2360427	1625.64
Distance from very poorly-drained soil	Site	1713	2649769	1546.86
Distance from well-drained soil	Non-site	1443	1902089	1318.15
Distance from well-drained soil	Site	937	931301	993.92

Table 22. Statistical Significance of the Wilcoxon Rank Sum Results in Table 21 by Comparison to the Large Sample Normal Approximation.

Environmental Variable	S	Z	*p*
Distance from wetland	1525868.0	4.120	<.0001
Distance from poorly- or very poorly-drained soil	1168170.0	2.810	0.0050
Distance from very poorly-drained soil	2360426.5	2.418	0.0156
Distance from well-drained soil	931301.0	-11.253	<.0001

Thus, in comparison with the physical environment of the Francis Marion National Forest, the following conclusions can be drawn about archaeological sites in general:

1) Archaeological sites are underrepresented at higher elevations. This conclusion seems somewhat counter-intuitive, but is influenced by a greater proportion of sites located at 5-7 m in elevation, and fewer sites located between 12 and 25 m, relative to the random sample points.
2) Sites tend to be located on greater slopes, relative to the random sample points. Again, this is somewhat counter-intuitive as steeply sloped areas are not thought to have been conducive to past settlement. However, this result is skewed by the flat and low-lying environment of the Forest, and the correspondingly high preponderance of zero values for slope in the background environment sample points. Thus, this conclusion is misleading; in fact over 90 percent of archaeological sites are located in areas of less than two percent slope.
3) Sites tend to cluster near the erosional scarps of Pleistocene marine terraces, and are more frequent in areas nearer to the coast.
4) Archaeological sites tend to cluster near roads, wetlands, streams, and ecotones between well- and poorly-drained soils.
5) Distance from major roads, at least as defined in this analysis, is not a significant variable for discriminating areas conducive to archaeological site occurrence.

The above conclusions provide some guidance in constructing a new probabilistic model of archaeological site location in the Forest. However, it remains to be determined whether there is variability in the environmental associations of different temporal or

cultural site subsets that may bear on questions of site probability and theories of settlement organization and land use.

Environmental Associations of Temporal/Cultural Site Subsets

The next set of analyses investigates differences in the location of historic (Figure 9) and prehistoric (Figure 10) sites, again using the chi-square and Wilcoxon Rank Sum tests. Given its lack of statistical significance, distance from major roads was removed from consideration, and tests of distance from wetlands, poorly-drained soils, very poorly-drained soils, and well-drained soils exclude sample points with zero values.

The results of the chi-square test for soil drainage are presented in Tables 23 and 24. The test is significant for both historic and prehistoric sites, though the total chi-square value is higher for the prehistoric sample. In both cases observed site frequencies are greater than expected in the excessively- through moderately well-drained classes, and fewer than expected in the poorly- and very poorly-drained classes. The somewhat poorly-drained class exhibits observed frequencies consistent with what would be expected if sites were randomly distributed, and this zone contributes little to the overall significance of the tests. There is some indication that prehistoric sites are more highly associated with well-drained soils, as these areas capture a greater proportion of the prehistoric than historic sites, but the differences are slight.

The remaining environmental variables (Table 25) were examined using the Wilcoxon Rank Sum test (Tables 26 and 27). Significant differences are apparent in distance from wetland, distance from stream, distance from poorly- to very poorly-drained soils, distance from very poorly-drained soils, and distance from roads. For all

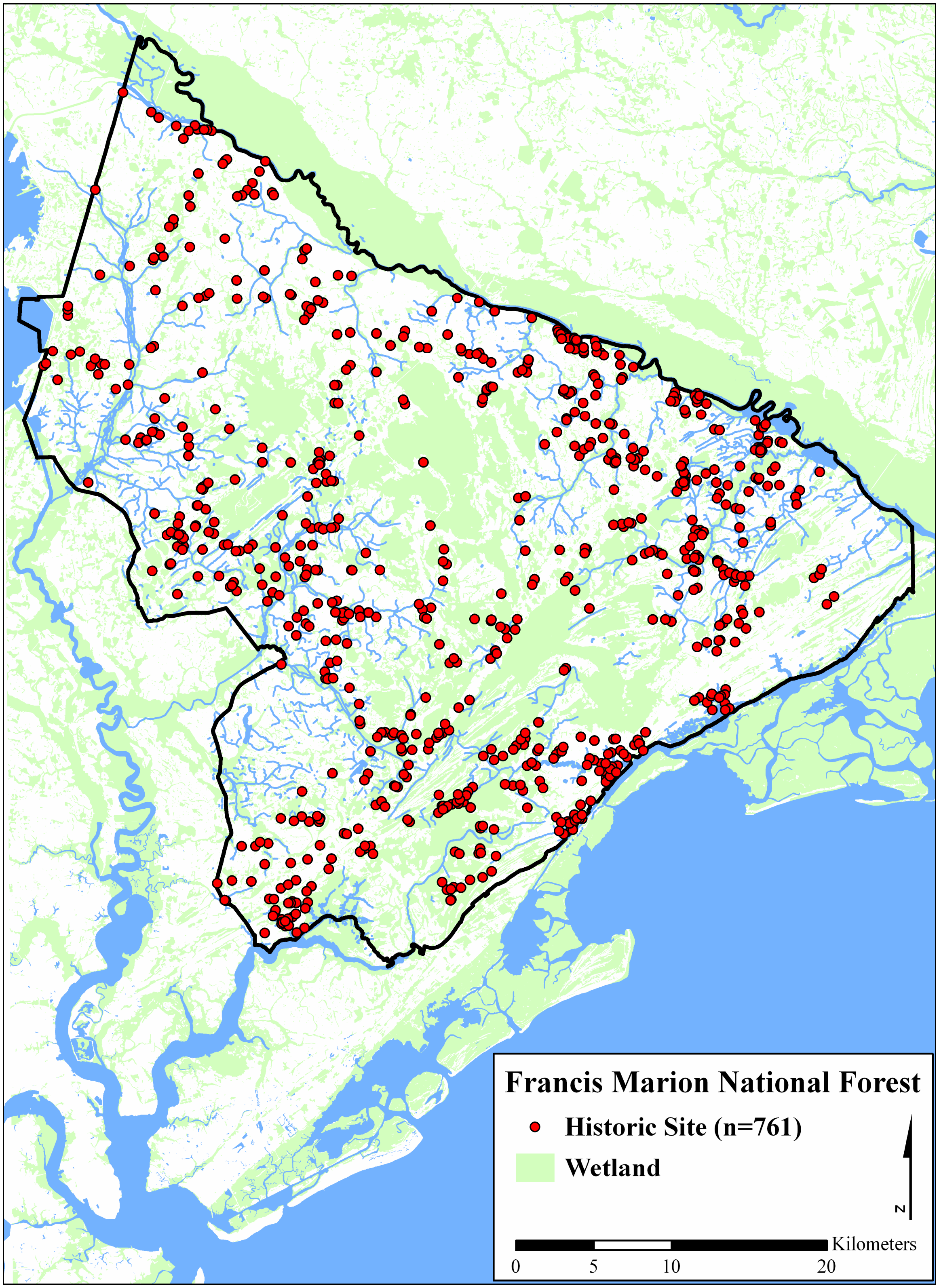

Figure 9. Historic sites in the Francis Marion National Forest.

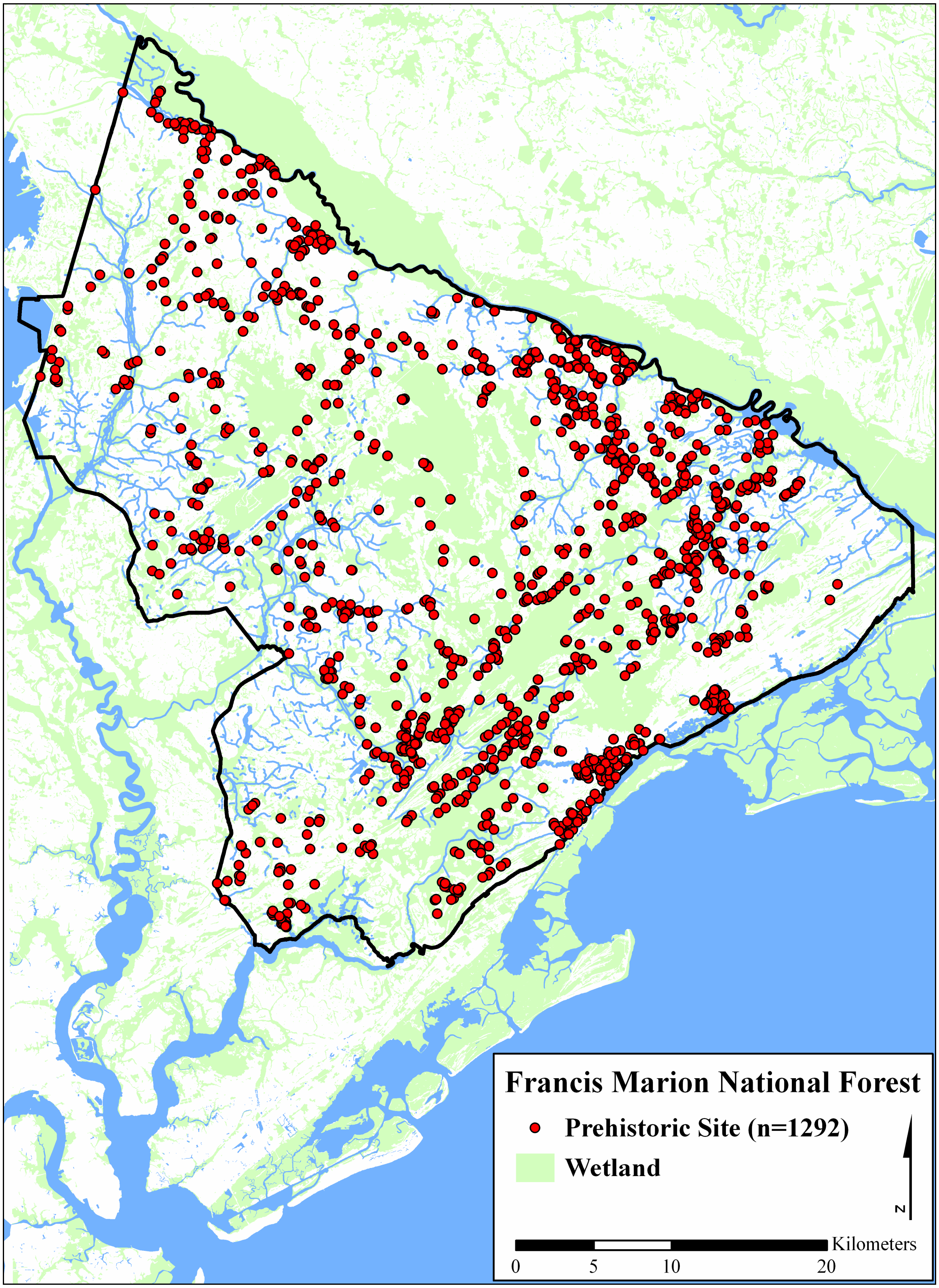

Figure 10. Prehistoric sites in the Francis Marion National Forest.

Table 23. Test Statistics of Soil Drainage Class for Historic Sites.

Soil Drainage Class	Area m^2	% of Total	Expected Sites	Observed Sites	% of Sites	χ2	Gain
Excessively	67155548	4.0	30	72	9.5	57.037	0.578
Well	98864312	5.9	45	94	12.4	54.310	0.524
Moderately well	235058621	14.0	106	212	27.9	105.038	0.498
Somewhat poorly	456560420	27.1	207	210	27.6	0.059	0.017
Poorly	434929680	25.9	197	116	15.2	33.127	-0.696
Very poorly	385988629	22.9	175	57	7.5	79.200	-2.063
No data	3873920	0.2	2	0	0.0	1.752	0.000
Total	1682431131	100.0	761	761	100.0	330.524	-

*with 6 degrees of freedom and $\alpha = .05$, significance is indicated by $\chi2 \geq 12.592$

Table 24. Test Statistics of Soil Drainage Class for Prehistoric Sites.

Soil Drainage Class	Area m^2	% of Total	Expected Sites	Observed Sites	% of Sites	χ2	Gain
Excessively	67155548	4.0	52	165	12.8	249.482	0.687
Well	98864312	5.9	76	177	13.7	134.571	0.571
Moderately well	235058621	14.0	181	313	24.2	97.244	0.423
Somewhat poorly	456560420	27.1	351	337	26.1	0.528	-0.040
Poorly	434929680	25.9	334	162	12.5	88.574	-1.062
Very poorly	385988629	22.9	296	133	10.3	90.091	-1.229
No data	3873920	0.2	3	5	0.4	1.378	0.405
Total	1682431131	100.0	1292	1292	100.0	661.870	-

*with 6 degrees of freedom and $\alpha = .05$, significance is indicated by $\chi2 \geq 12.592$

Table 25. Summary Statistics for Historic and Prehistoric Sites.

	Historic (n=761)			Prehistoric (n=1,292)		
Environmental Variable	Median	Mean	S.D.	Median	Mean	S.D.
Elevation	7.39	8.55	4.01	6.81	8.23	3.80
Percent slope	0.33	0.68	1.16	0.32	0.84	1.41
Distance from scarp	2855.55	3383.78	2655.49	2888.44	3397.69	2635.25
Distance from wetland	63.95	86.14	73.49	57.20	64.34	59.04
Distance from stream	304.01	434.63	413.91	257.39	429.95	443.68
Distance from perennial stream	398.33	640.20	673.23	371.78	683.63	792.59
Distance from poorly- or very poorly-drained soil	63.95	90.48	94.86	57.20	74.08	94.18
Distance from very poorly-drained soil	202.22	369.08	412.69	142.99	334.56	411.95
Distance from well-drained soil	0.00	158.84	353.58	0.00	164.33	379.62
Distance from road	85.80	146.57	151.31	117.91	174.74	169.04
Distance from major road	691.11	1043.06	1091.21	772.42	1128.68	1122.58
Distance from coast	17923.0	20433.5	12242.6	16982.0	19740.4	12804.7

Table 26. Results of the Wilcoxon-Rank Sum Test of Historic and Prehistoric Sites.

Environmental Variable	Class	Count	Rank Sum	Mean Rank
Elevation	Historic	761	801773	1053.58
Elevation	Prehistoric	1292	1306659	1011.35
Percent slope	Historic	761	776691	1020.62
Percent slope	Prehistoric	1292	1331741	1030.76
Distance from scarp	Historic	761	778697	1023.25
Distance from scarp	Prehistoric	1292	1329734	1029.21
Distance from wetland	Historic	646	616937	955.01
Distance from wetland	Prehistoric	1048	818729	781.229
Distance from stream	Historic	761	808903	1062.95
Distance from stream	Prehistoric	1292	1299529	1005.83
Distance from perennial stream	Historic	761	794924	1044.58
Distance from perennial stream	Prehistoric	1292	1313508	1016.65
Distance from poorly- or very poorly-drained soil	Historic	588	518749	882.226
Distance from poorly- or very poorly-drained soil	Prehistoric	992	730241	736.13
Distance from very poorly-drained soil	Historic	704	687752	976.92
Distance from very poorly-drained soil	Prehistoric	1154	1039259	900.571
Distance from well-drained soil	Historic	383	197708	516.208
Distance from well-drained soil	Prehistoric	637	323003	507.068
Distance from road	Historic	761	728684	957.53
Distance from road	Prehistoric	1292	1379748	1067.92
Distance from coast	Historic	761	805965	1059.09
Distance from coast	Prehistoric	1292	1302466	1008.1

Table 27. Statistical Significance of the Wilcoxon Rank Sum Results in Table 26 by Comparison to the Large Sample Normal Approximation.

Environmental Variable	S	Z	*p*
Elevation	801772.5	1.559	0.119
Percent slope	776690.5	-0.375	0.7076
Distance from scarp	778697.0	-0.220	0.8261
Distance from wetland	616936.5	7.146	<.0001
Distance from stream	808902.5	2.109	0.035
Distance from perennial stream	794923.5	1.031	0.3025
Distance from poorly- or very poorly-drained soil	518749.0	6.177	<.0001
Distance from very poorly-drained soil	687752.0	2.977	0.0029
Distance from well-drained soil	197707.5	0.481	0.6308
Distance from road	728683.5	-4.084	<.0001
Distance from coast	805965	1.882	0.0598

other variables the prehistoric and historic samples are equivalent. Prehistoric sites tend to be located closer to wetlands and interfaces with poorly- to very poorly-drained soils, while historic sites are located closer to roads. A less significant association is found with distance from streams, with prehistoric sites located marginally closer.

Given the vast expanse of time encompassed by the prehistoric sample, and presumed changes in settlement organization over this interval, the prehistoric sites were examined in greater detail. Four temporal subsets were taken from the prehistoric sites: Early/Middle Archaic (Figure 11), Late Archaic (Figure 12), Woodland (Figure 13), and Mississippian (Figure 14). The environmental associations of these subsets were compared using the chi-square and Kruskal-Wallis tests.

Soil drainage associations were tested for each period using the chi-square test. Results of this analysis are presented in Tables 28 through 31. For this analysis the excessively- and well-drained classes were collapsed into a single category. This was necessary because of the smaller sample sizes in the temporal subsets, and justified by

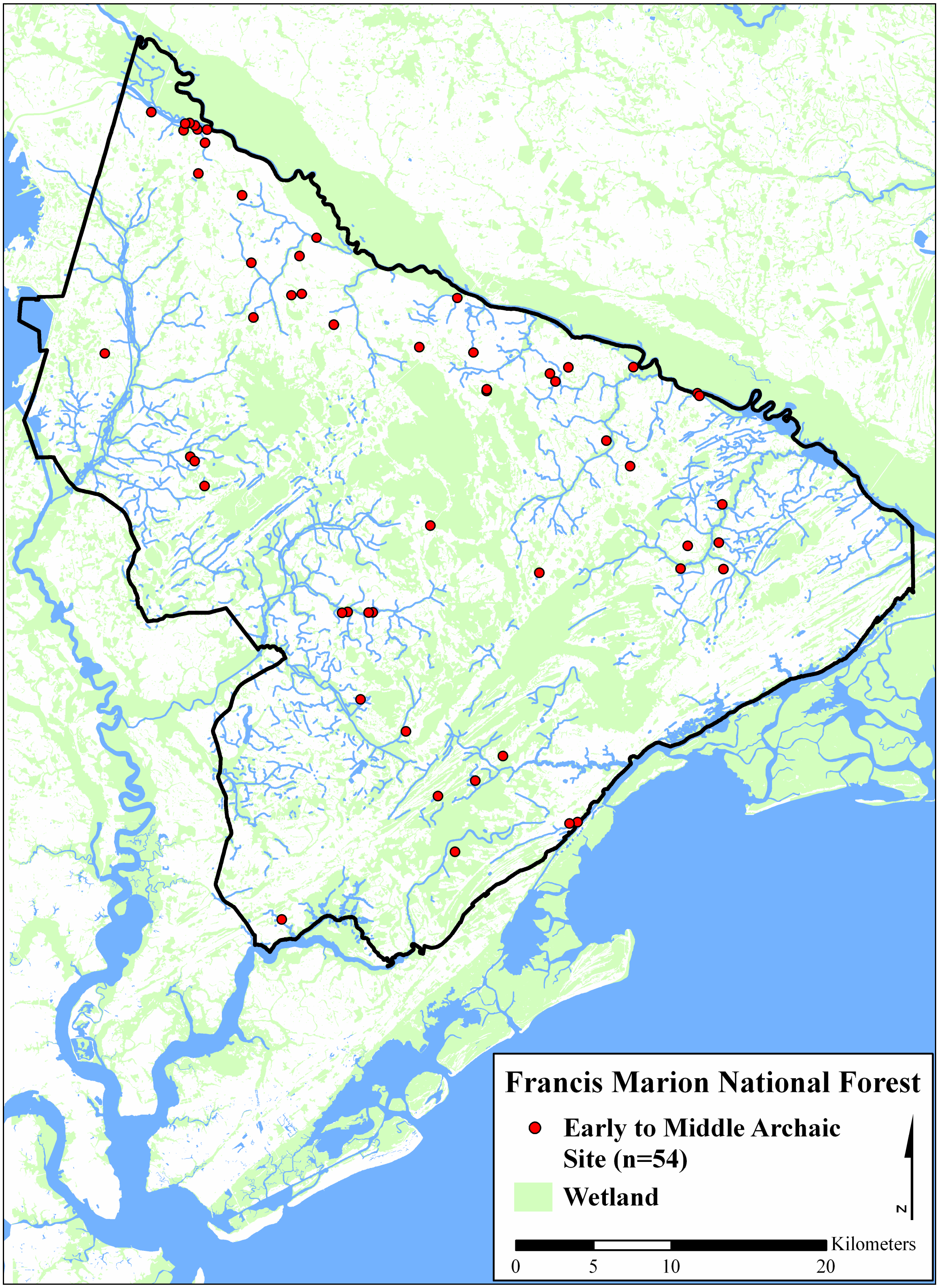

Figure 11. Early and Middle Archaic sites in the Francis Marion National Forest.

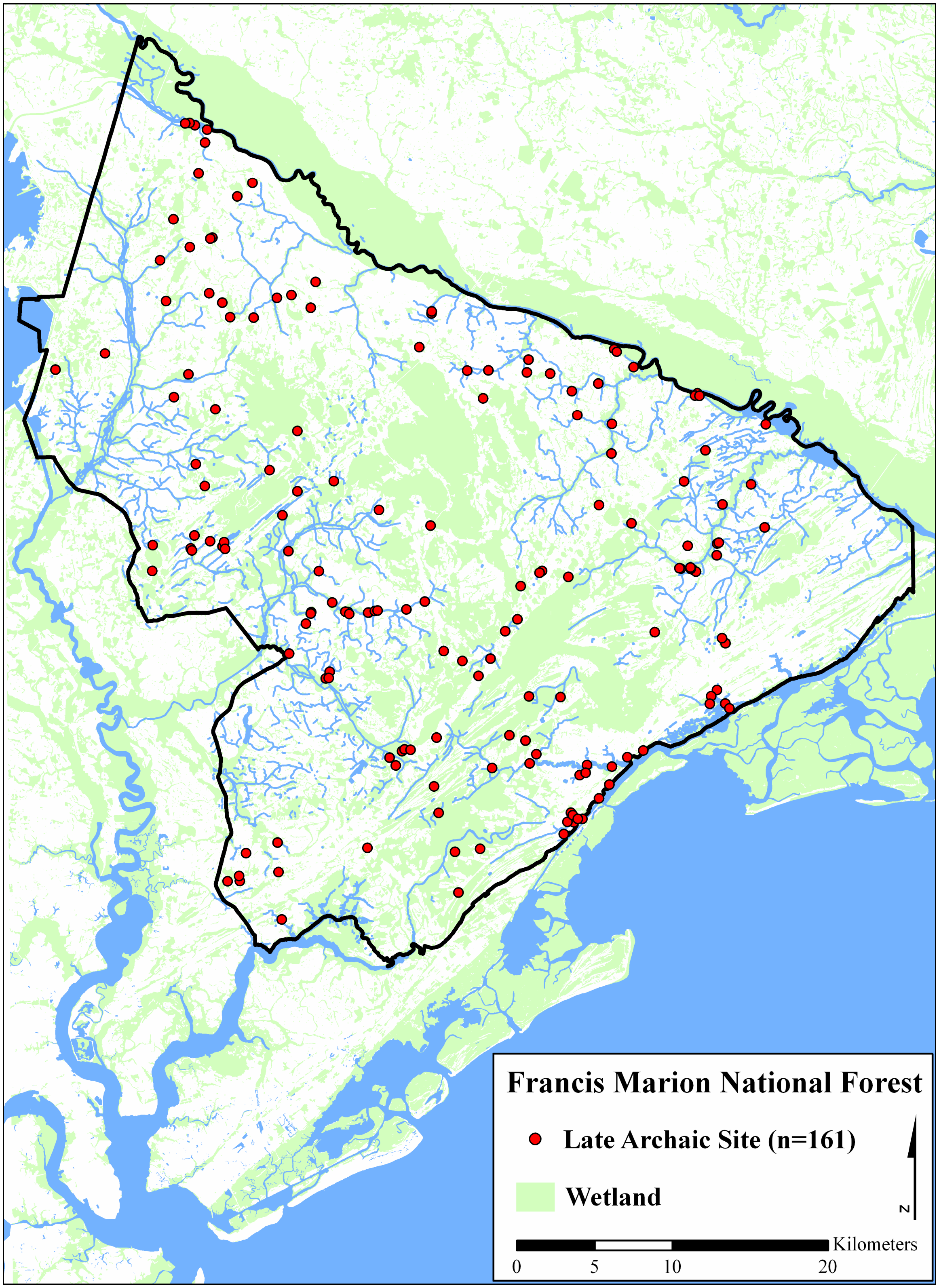

Figure 12. Late Archaic sites in the Francis Marion National Forest.

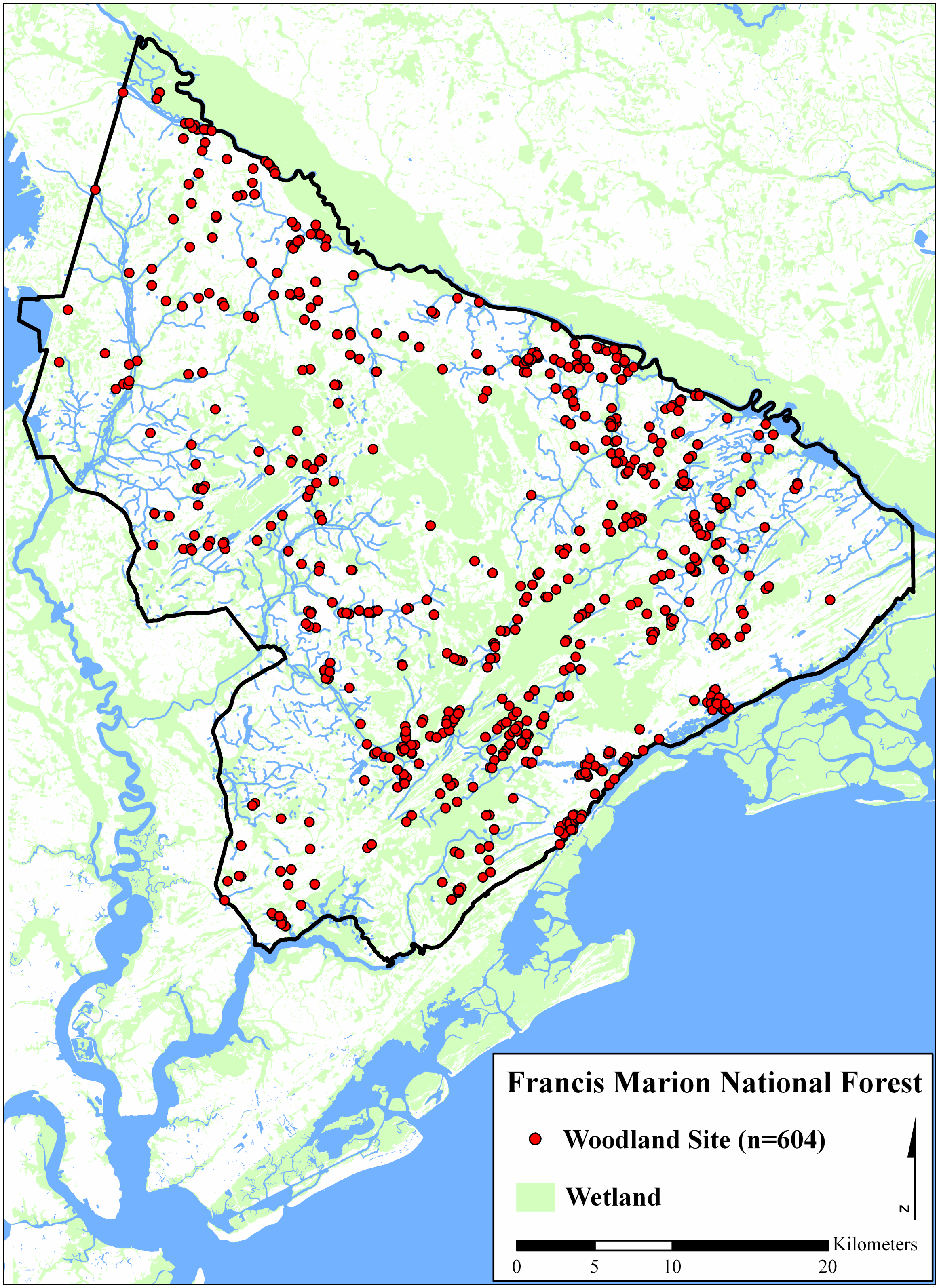

Figure 13. Woodland sites in the Francis Marion National Forest.

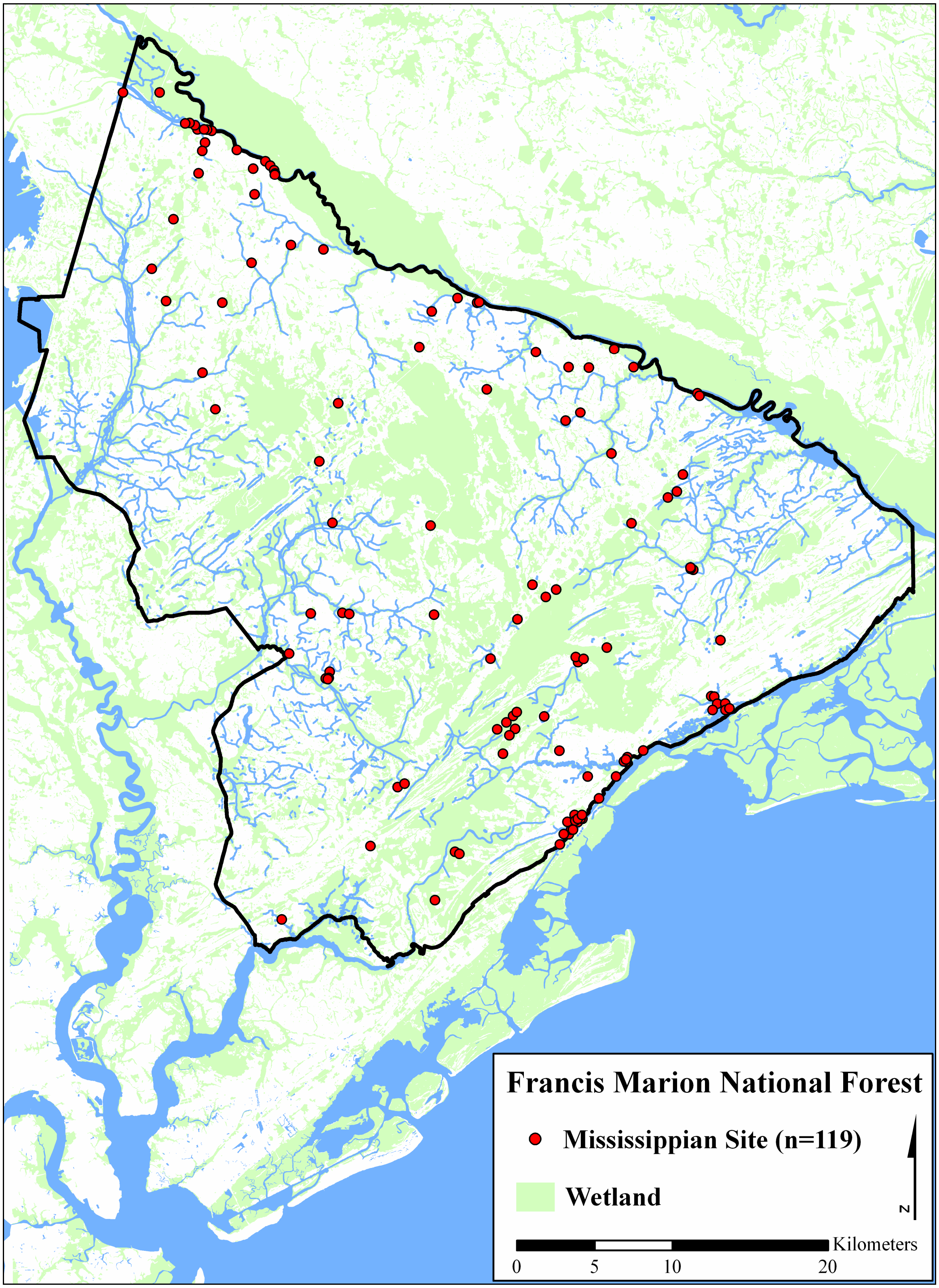

Figure 14. Mississippian sites in the Francis Marion National Forest.

Table 28. Test Statistics of Soil Drainage Class for Early to Middle Archaic Sites.

Soil Drainage Class	Area m^2	% of Total	Expected Sites	Observed Sites	% of Sites	χ2	Gain
Excessively-well	166019860	9.9	5.33	17	31.5	25.564	0.687
Moderately well	235058621	14.0	7.54	12	22.2	2.631	0.371
Somewhat poorly	460434340	27.4	14.78	11	20.4	0.966	-0.343
Poorly	434929680	25.9	13.96	9	16.7	1.762	-0.551
Very poorly	385988629	22.9	12.39	5	09.3	4.407	-1.478
Total	1682431131	100.0	54	54	100.0	35.330	-

*with 4 degrees of freedom and $\alpha = .05$, significance is indicated by $\chi2 \geq 9.488$

Table 29. Test Statistics of Soil Drainage Class for Late Archaic Sites.

Soil Drainage Class	Area m^2	% of Total	Expected Sites	Observed Sites	% of Sites	χ2	Gain
Excessively-well	166019860	9.9	15.89	50	31.1	73.246	0.682
Moderately well	235058621	14.0	22.49	41	25.5	15.225	0.451
Somewhat poorly	460434340	27.4	44.06	34	21.1	2.297	-0.296
Poorly	434929680	25.9	41.62	23	14.3	8.331	-0.810
Very poorly	385988629	22.9	36.94	13	8.1	15.512	-1.841
Total	1682431131	100.0	161	161	100.0	114.612	-

*with 4 degrees of freedom and $\alpha = .05$, significance is indicated by $\chi2 \geq 9.488$

Table 30. Test Statistics of Soil Drainage Class for Woodland Sites.

Soil Drainage Class	Area m^2	% of Total	Expected Sites	Observed Sites	% of Sites	χ2	Gain
Excessively-well	166019860	9.9	59.60	157	26.0	159.163	0.620
Moderately well	235058621	14.0	84.39	152	25.2	54.173	0.445
Somewhat poorly	460434340	27.4	165.30	153	25.3	0.915	-0.080
Poorly	434929680	25.9	156.14	81	13.4	36.161	-0.928
Very poorly	385988629	22.9	138.57	61	10.1	43.424	-1.272
Total	1682431131	100.0	604	604	100.0	293.836	-

*with 4 degrees of freedom and $\alpha = .05$, significance is indicated by $\chi2 \geq 9.488$

Table 31. Test Statistics of Soil Drainage Class for Mississippian Sites.

Soil Drainage Class	Area m^2	% of Total	Expected Sites	Observed Sites	% of Sites	$\chi2$	Gain
Excessively-well	166019860	9.9	11.74	36	30.3	50.109	0.674
Moderately well	235058621	14.0	16.63	20	16.8	0.685	0.169
Somewhat poorly	460434340	27.4	32.57	35	29.4	0.182	0.070
Poorly	434929680	25.9	30.76	17	14.3	6.157	-0.810
Very poorly	385988629	22.9	27.30	11	9.2	9.733	-1.482
Total	1682431131	100.0	119	119	100.0	66.866	-

*with 4 degrees of freedom and $\alpha = .05$, significance is indicated by $\chi2 \geq 9.488$

their similar performance in the previous analyses. The overall chi-square values are significant for all time periods, with greater than expected site frequencies in the excessively- to well-drained class, and fewer than expected in the poorly- and very poorly-drained classes. Interestingly, the moderately well-drained class exhibits significantly greater than expected frequencies for all periods except the Mississippian. Comparing the proportion of sites represented in this drainage class, the Mississippian sample has the lowest value with only 16.8 percent of sites. This is coupled with an increase in the percentage of sites captured by the somewhat poorly-drained class. In fact, there is a small but steady increase in the proportion of sites in the somewhat poorly-drained class from Early/Middle Archaic through Mississippian. Whether this was allowed or necessitated by fluctuating drainage conditions, shifting cultural needs (e.g., changing requirements with a shift to agriculture), or some other factor is unclear. However, it seems unlikely that this pattern is the result of rising sea level, as we would expect what are now somewhat poorly-drained soils to have been *more* accessible during earlier periods when sea level was lower, and thus we might expect to see a decrease in the proportion of sites in these soils through time. Further, this pattern may reflect sample

bias or greater archaeological visibility of more recent sites, rather than increasing exploitation of this microenvironmental zone.

Thus, there are some interesting patterns, but no major differences, in the role that soil drainage played site location throughout prehistory. There is some indication that Mississippian settlement was less constrained by well-drained soils, and made greater use of areas of marginal drainage. However, overall, archaeological sites of all periods are more frequently located on better drained than poorly drained soils.

The Kruskal-Wallis test was used to compare the remaining environmental variables. Summary statistics are presented in Table 32, the results of the tests in Table 33, and pairwise comparisons for significant environmental variables in Tables 34 through 36. Only three variables were found to differ significantly between temporal periods: elevation, slope, and distance from coast. Distance from stream is nearly significant ($p = .0503$), so I have included the pairwise comparisons for this variable in Table 37. These analyses show that Mississippian sites tend to be at lower elevations and in areas of slightly greater slope than sites of other periods. Meanwhile, Early/Middle Archaic sites tend to be located further inland (and possibly at higher elevations) than later sites. While distance from streams was not significant at the $\alpha = .05$ level, the results do suggest that Mississippian sites tend to be closest to streams, and Woodland sites furthest.

Moving to a still finer scale of analysis, differences were examined between the diagnostic artifact categories used to extract the temporal subsets. The goal of this analysis was to explore cultural and temporal variability in settlement location in more detail. Groups were again compared with the Kruskal-Wallis tests. Soil drainage was not

Table 32. Summary Statistics for Prehistoric Site Subsets.

	Early/Middle Archaic (n=54)			Late Archaic (n=161)			Woodland (n=604)			Mississippian (n=119)		
Environmental Variable	Median	Mean	S.D.	Median	Mean	S.D.	Median	Mean	S.D.	Median	Mean	S.D.
Elevation	8.97	9.07	3.86	7.80	8.75	4.12	7.16	8.31	3.63	6.04	7.20	3.73
Percent slope	0.43	1.54	2.38	0.36	1.01	1.64	0.35	0.88	1.44	0.60	1.58	2.06
Distance from scarp	3525.60	3932.80	2863.76	3119.00	3605.26	2675.73	2861.00	3409.76	2664.10	2448.00	3254.68	2924.35
Distance from wetland	48.82	63.50	54.83	57.20	56.02	48.50	57.20	59.56	51.78	57.20	59.35	52.95
Distance from stream	200.20	403.48	437.39	171.60	356.14	405.43	242.70	409.68	413.05	180.90	327.80	377.62
Distance from perennial stream	282.70	687.37	766.48	244.30	678.31	938.15	334.70	653.84	760.56	269.80	559.00	655.92
Distance from poorly- or very poorly-drained soil	57.20	73.97	82.66	40.44	65.00	71.47	57.20	71.62	99.75	40.40	78.27	134.21
Distance from very poorly-drained soil	266.70	358.32	345.12	121.30	310.33	386.45	119.60	331.24	417.59	103.10	301.02	396.02
Distance from well-drained soil	0.00	98.38	164.62	0.00	163.95	459.26	0.00	168.32	405.03	28.60	246.56	581.90
Distance from road	96.77	150.64	150.95	121.33	162.66	159.68	121.30	174.68	166.20	145.80	178.80	184.17
Distance from major road	919.50	1192.48	1224.49	600.60	926.89	1112.93	723.50	1059.20	1075.21	791.00	1016.22	990.01
Distance from coast	25887.0	28099.2	14774.5	19840.0	21128.6	13439.7	17094.0	19808.8	12729.0	16892.0	20862.2	17128.7

Table 33. Results of the Kruskal-Wallis Tests Comparing Prehistoric Site Subsets.

Environmental Variable	*kw*	*p*
Elevation	13.800	0.0032
Percent slope	12.708	0.0053
Distance from scarp	4.354	0.2257
Distance from wetland	1.599	0.6596
Distance from stream	7.800	0.0503
Distance from perennial stream	2.643	0.4500
Distance from poorly- to very poorly-drained soil	1.613	0.6565
Distance from very poorly-drained soil	4.974	0.1737
Distance from well-drained soil	1.097	0.7778
Distance from road	2.029	0.5664
Distance from coast	16.707	0.0008

Table 34. Pairwise Comparisons of the Kruskal-Wallis Mean Rank Values for Elevation (Significant differences emboldened).

Site Class	Mean Rank	Early/Middle Archaic	Late Archaic	Woodland	Mississippian
	Mean Rank	521.426	495.183	473.658	390.084
Early/Middle Archaic	521.426	0.00	26.24	47.77	**131.34**
Late Archaic	495.183	26.24	0.00	21.53	**105.10**
Woodland	473.658	47.77	21.53	0.00	**83.57**
Mississippian	390.084	**131.34**	**105.10**	**83.57**	0.00

Table 35. Pairwise Comparisons of the Kruskal-Wallis Mean Rank Values for Percent Slope (Significant differences emboldened).

Site Class	Mean Rank	Early/Middle Archaic	Late Archaic	Woodland	Mississippian
	Mean Rank	494.528	455.699	455.352	548.626
Early/Middle Archaic	494.528	0.00	38.83	39.18	54.10
Late Archaic	455.699	38.83	0.00	0.35	**92.93**
Woodland	455.352	39.18	0.35	0.00	**93.27**
Mississippian	548.626	54.10	**92.93**	**93.27**	0.00

Table 36. Pairwise Comparisons of the Kruskal-Wallis Mean Rank Values for Distance from Coast (Significant differences emboldened).

Site Class	Mean Rank	Early/Middle Archaic 608.213	Late Archaic 484.441	Woodland 457.888	Mississippian 445.277
Early/Middle Archaic	608.213	0.00	**123.77**	**150.33**	**162.94**
Late Archaic	484.441	**123.77**	0.00	26.55	39.16
Woodland	457.888	**150.33**	26.55	0.00	12.61
Mississippian	445.277	**162.94**	39.16	12.61	0.00

Table 37. Pairwise Comparisons of the Kruskal-Wallis Mean Rank Values for Distance from Stream (Significant differences emboldened).

Site Class	Mean Rank	Early/Middle Archaic 477.667	Late Archaic 438.165	Woodland 486.06	Mississippian 424.134
Early/Middle Archaic	477.667	0.00	39.50	8.39	53.53
Late Archaic	438.165	39.50	0.00	47.90	14.03
Woodland	486.06	8.39	47.90	0.00	61.93
Mississippian	424.134	53.53	14.03	61.93	0.00

examined in these analyses, as sample sizes are generally too small to satisfy the requirements of the chi-square test.

The first set of analyses explored the diagnostic artifacts of the Archaic period. The Early/Middle Archaic sample was subdivided into four groups (Early Archaic, Kirk/Stanly Stemmed, Morrow Mountain, and Guilford; Figures 15 through 18), as was the Late Archaic sample (Savannah River Stemmed, Gary/Mack Stemmed, Stallings, and Thoms Creek; Figures 19 through 22). The Kruskal-Wallis tests yielded significant differences for only two variables, distance from very poorly-drained soils and distance from coast (Table 38). The pairwise comparisons for these are presented in Tables 39 and 40, and suggest that Guilford (and perhaps Morrow Mountain) hafted bifaces tend to be located further inland than either Stallings or Thoms Creek pottery. Further, although none of the pairwise comparisons are significant, Guilford and Morrow Mountain bifaces appear to be less associated with ecotonal boundaries between well- and poorly-drained soils. This is not surprising, however, given the different drainage conditions present in the Forest with lowered sea levels.

The next tests explored the transitional Late Archaic/Early Woodland period, comparing Stallings, Thoms Creek, and Refuge sites (Figures 21 through 23). Only one variable differed significantly among these sites, distance from streams (Tables 41 and 42). Refuge sites tend to be located at a greater distance from streams than Thoms Creek sites, while Stallings sites are intermediate between the two.

The Woodland period was broken into nine categories: Refuge, Deptford, Yadkin, Santee, Sand-tempered Cord Marked, Sand-tempered Fabric Impressed, Wilmington,

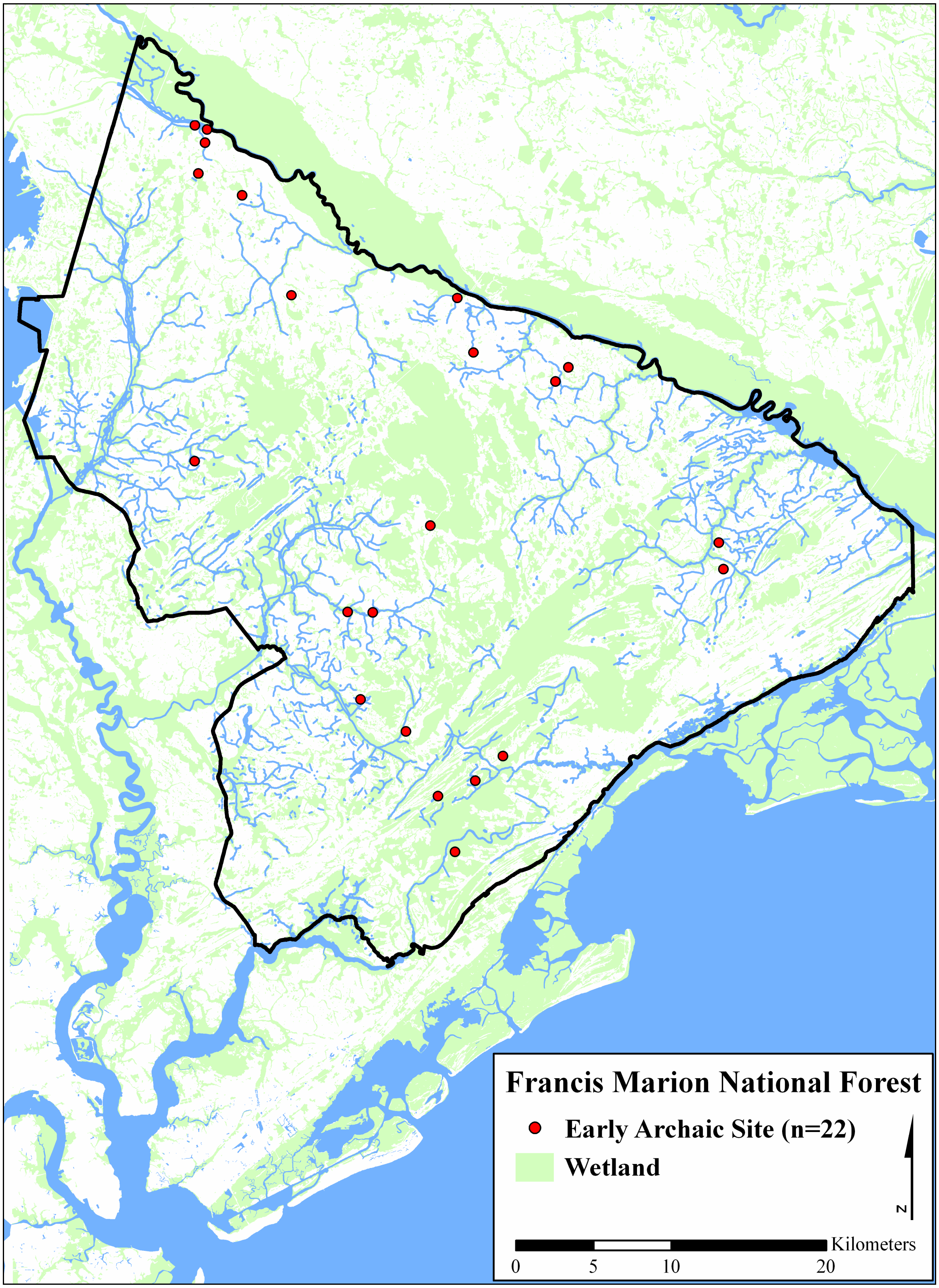

Figure 15. Early Archaic Sites in the Francis Marion National Forest.

Figure 16. Stanly Stemmed and Kirk Stemmed/Serrated bifaces in the Francis Marion National Forest.

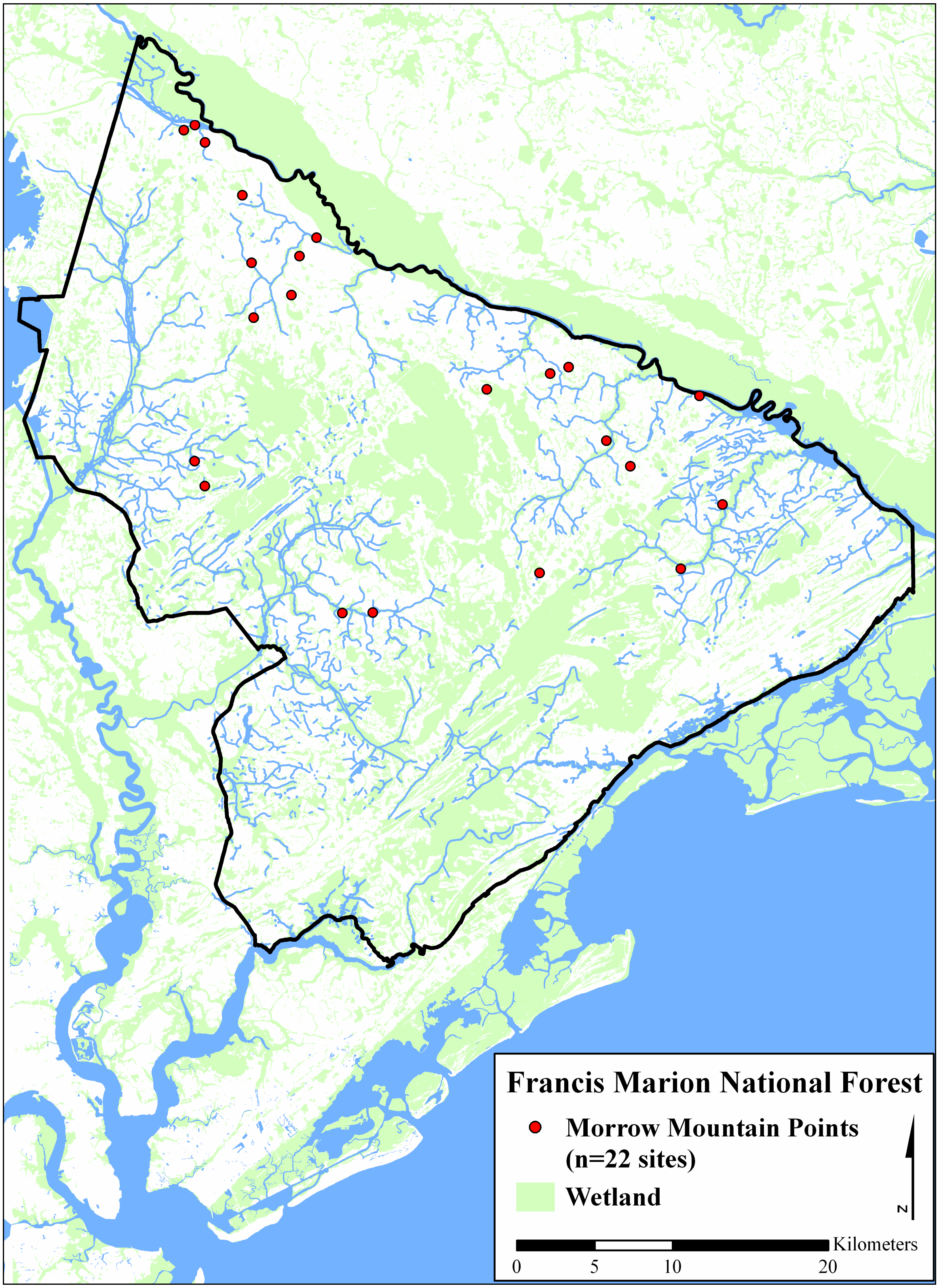

Figure 17. Morrow Mountain bifaces in the Francis Marion National Forest.

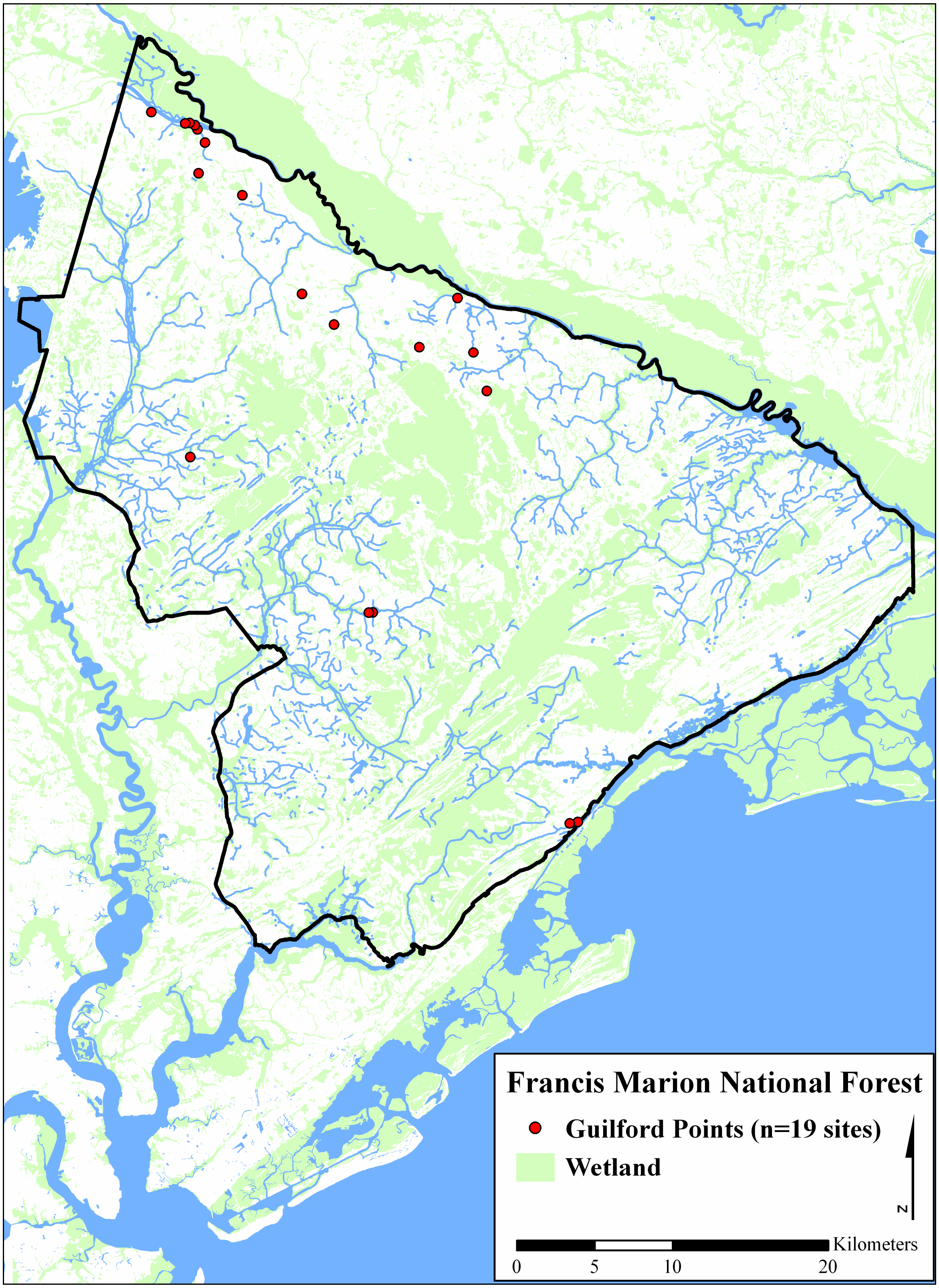

Figure 18. Guilford Lanceolate bifaces in the Francis Marion National Forest.

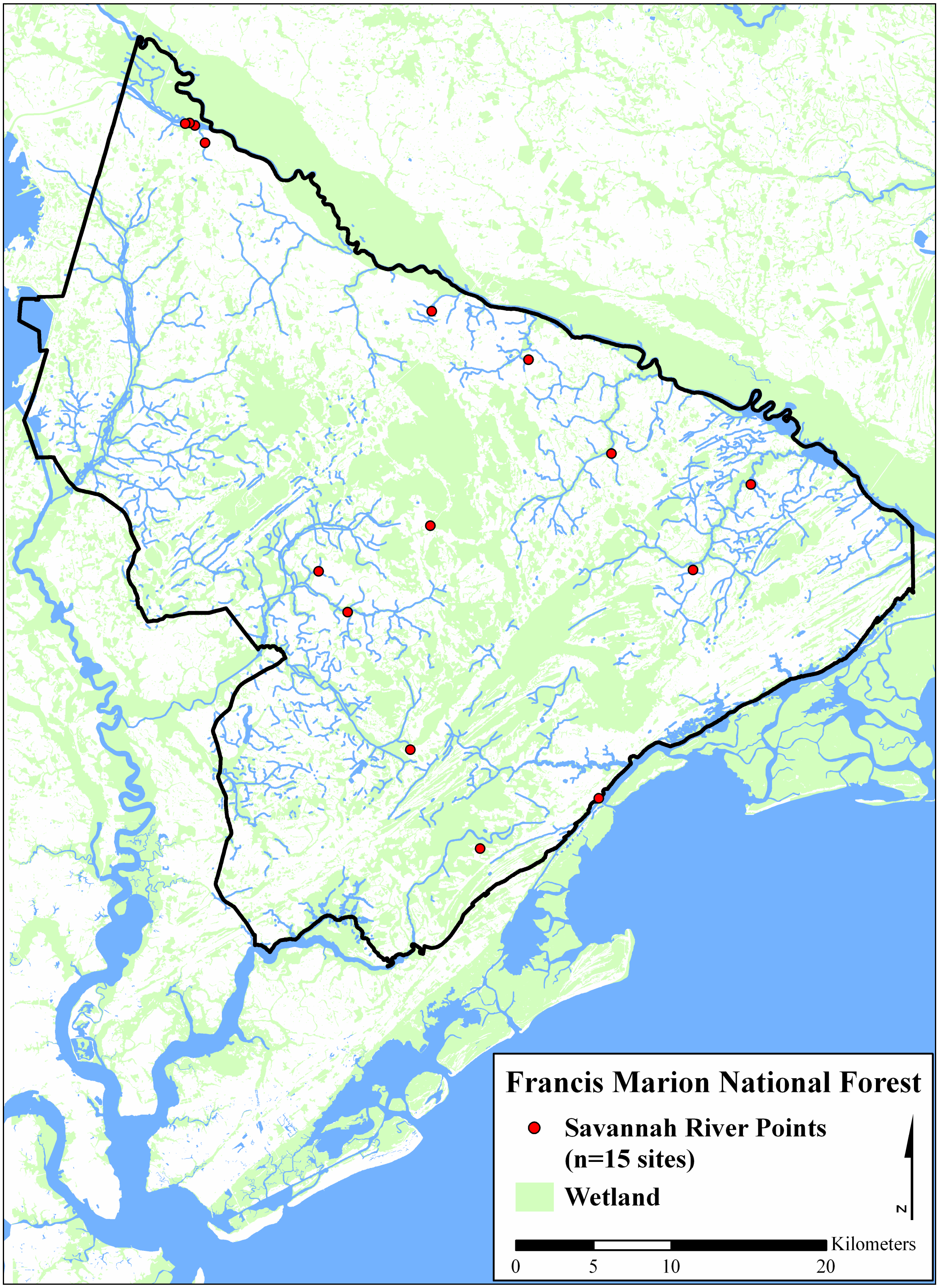

Figure 19. Savannah River Stemmed bifaces in the Francis Marion National Forest.

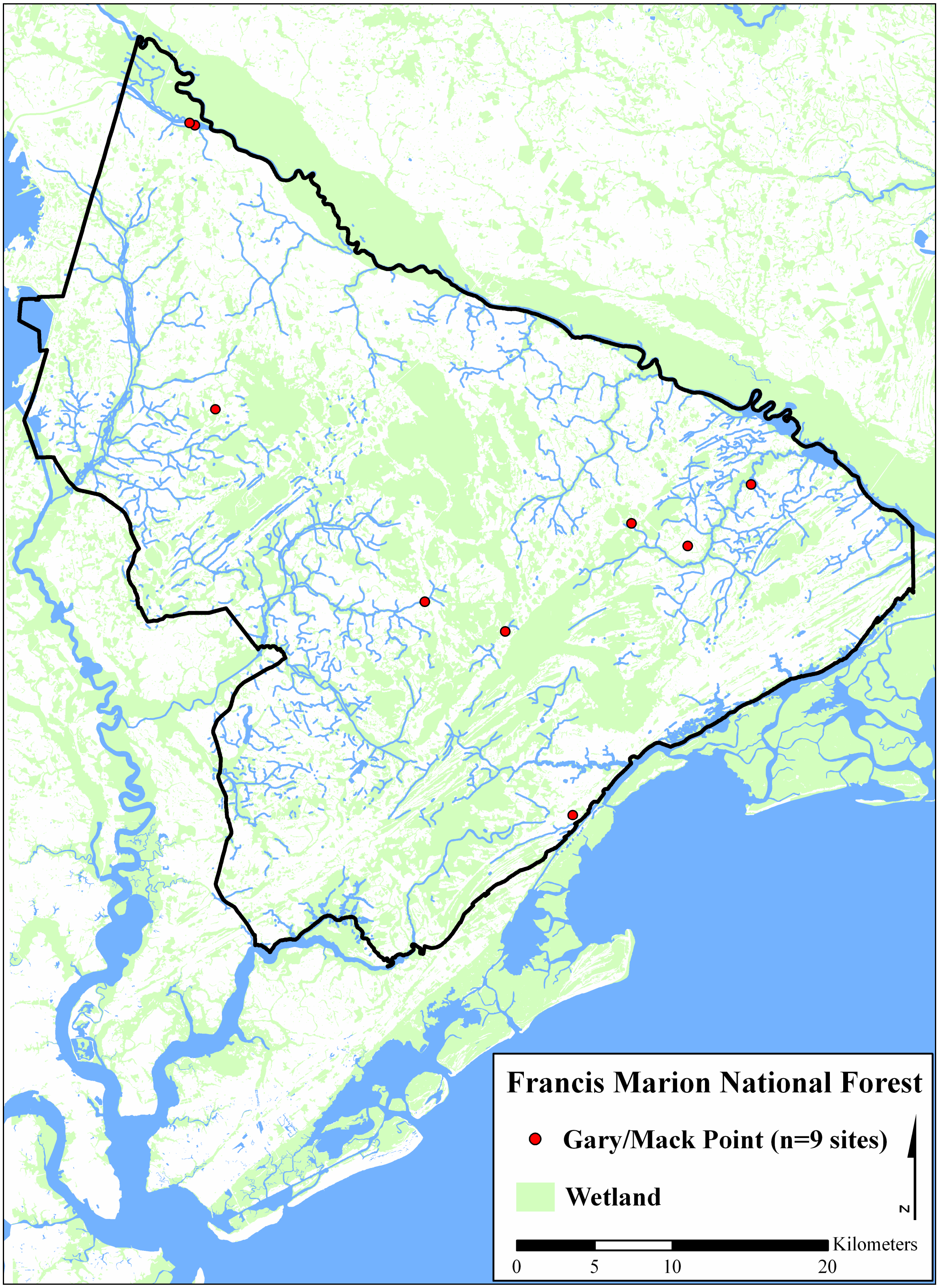

Figure 20. Gary/Mack Stemmed bifaces in the Francis Marion National Forest.

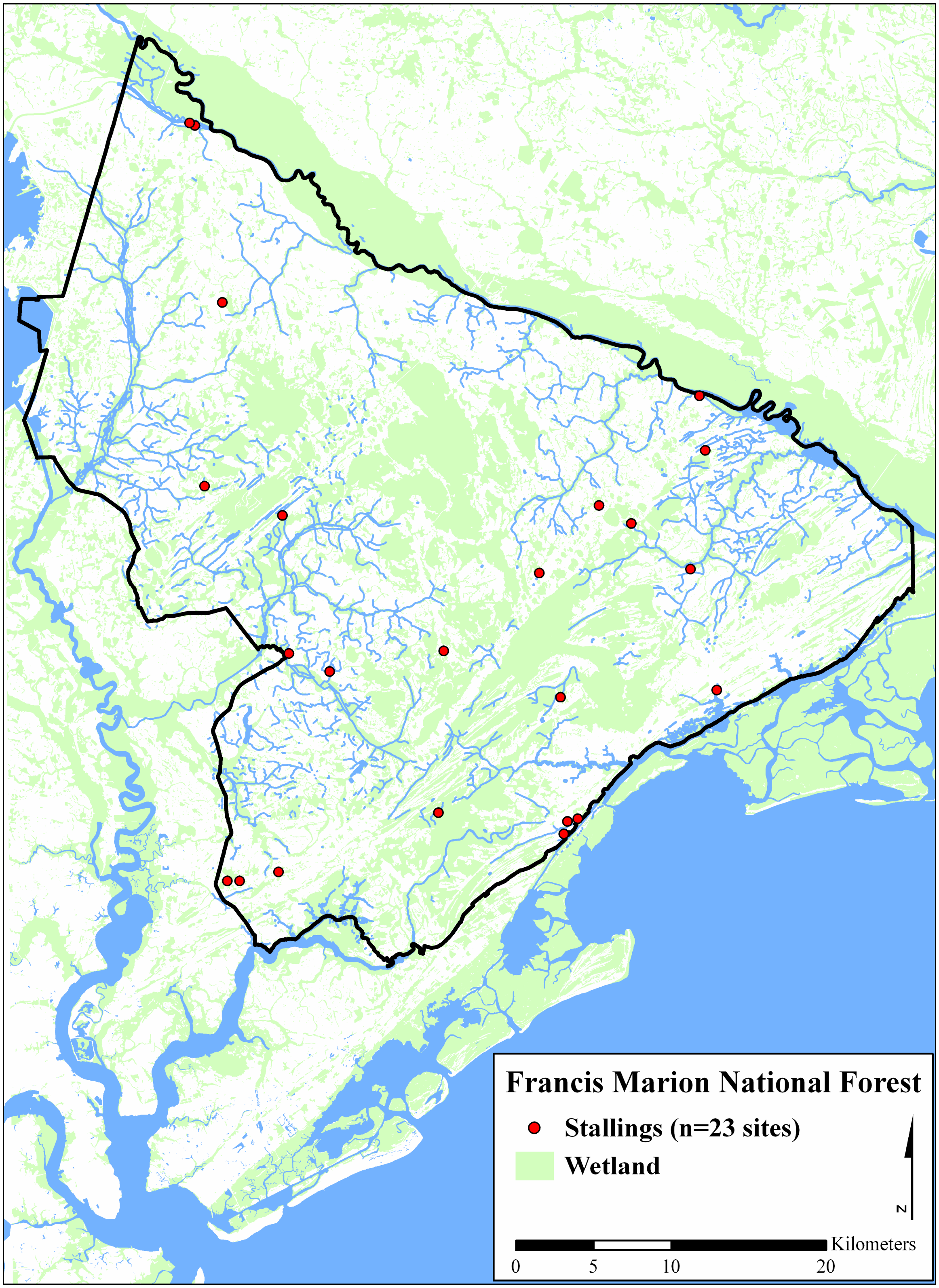

Figure 21. Stallings sites in the Francis Marion National Forest.

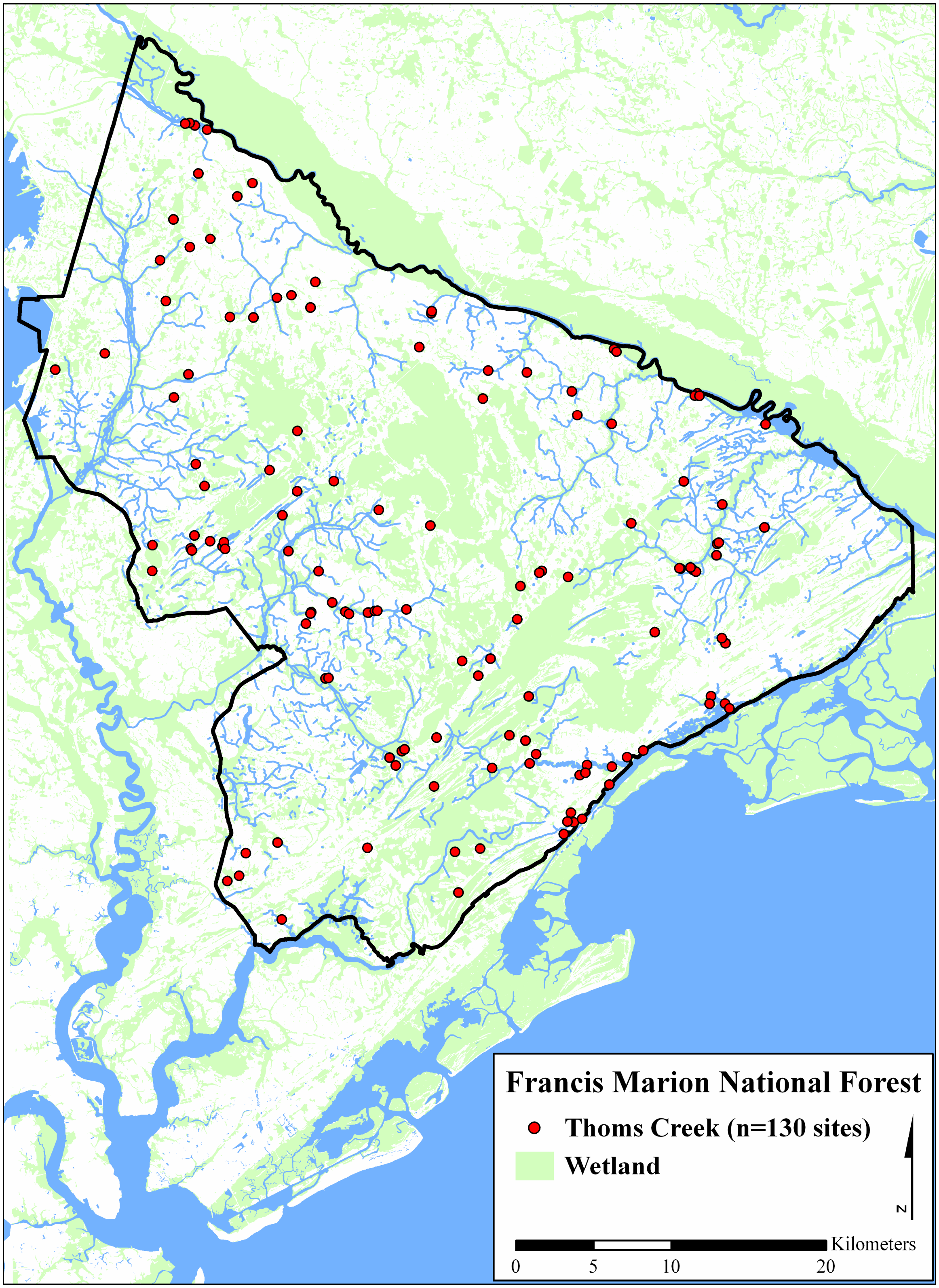

Figure 22. Thoms Creek sites in the Francis Marion National Forest.

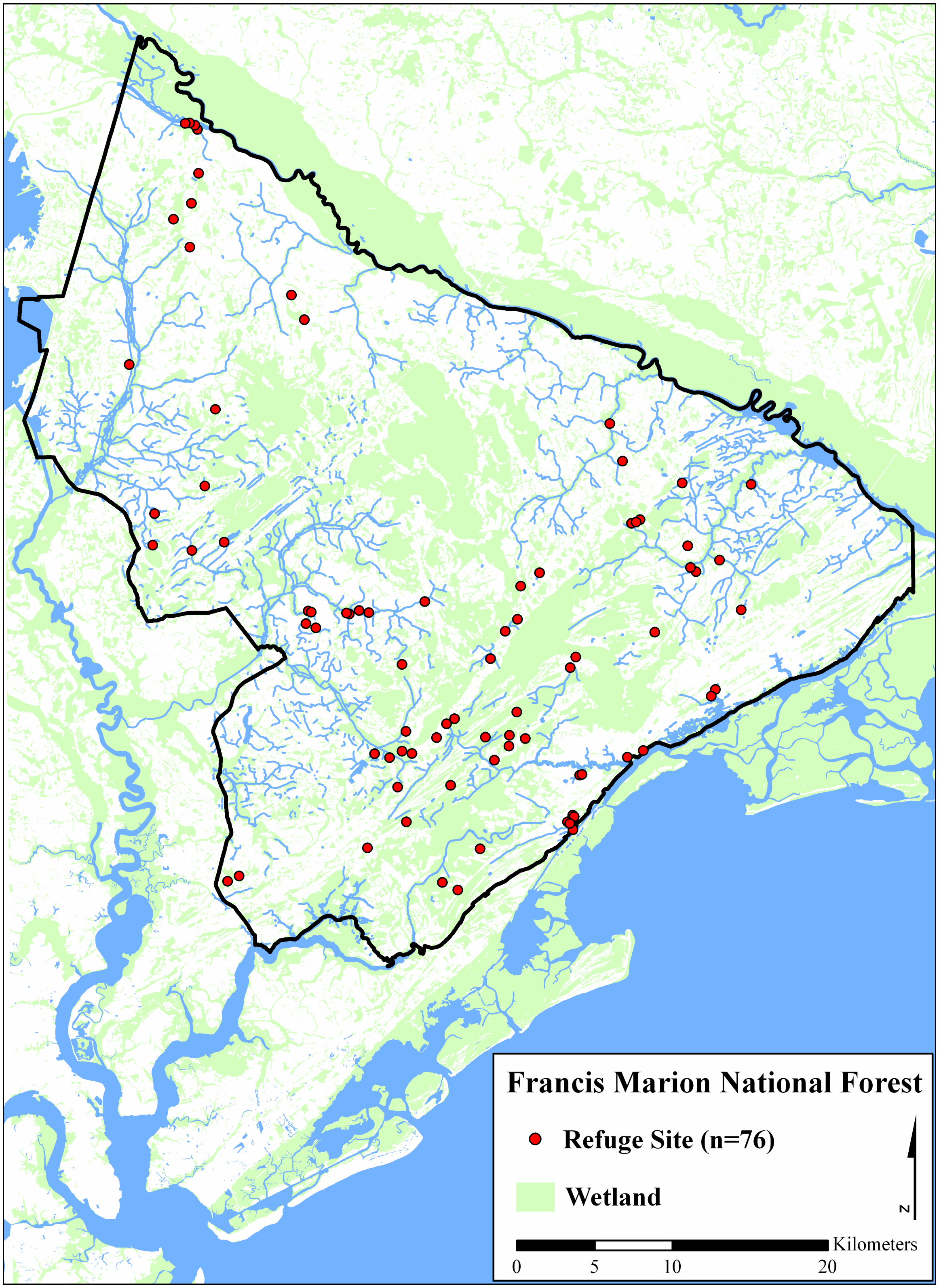

Figure 23. Refuge sites in the Francis Marion National Forest.

Table 38. Results of the Kruskal-Wallis Tests Comparing Archaic Subsets.

Environmental Variable	*kw*	*p*
Elevation	5.6257	0.5841
Percent slope	8.6696	0.2773
Distance from scarp	11.3864	0.1226
Distance from wetland	1.8531	0.9675
Distance from stream	3.7576	0.8072
Distance from perennial stream	4.3859	0.7344
Distance from poorly- to very poorly-drained soil	3.5992	0.8246
Distance from very poorly-drained soil	15.4682	0.0304
Distance from well-drained soil	1.6614	0.9762
Distance from road	4.2274	0.7532
Distance from coast	22.1401	0.0024

Table 39. Pairwise Comparisons of the Kruskal-Wallis Mean Rank Values for Distance from Very Poorly-drained Soils (Significant differences emboldened).

Site Class	Mean Rank	Early Archaic	Kirk/Stanly Stemmed	Morrow Mountain	Guilford	Savannah River	Gary/Mack Stemmed	Stallings	Thoms Creek
		120.0	88.0	146.214	140.875	124.821	91.625	87.659	105.702
Early Archaic	120.0	0.00	32.00	26.21	20.88	4.82	28.38	32.34	14.30
Kirk/Stanly Stemmed	88.0	32.00	0.00	58.21	52.88	36.82	3.63	0.34	17.70
Morrow Mountain	146.214	26.21	58.21	0.00	5.34	21.39	54.59	58.56	40.51
Guilford	140.875	20.88	52.88	5.34	0.00	16.05	49.25	53.22	35.17
Savannah River	124.821	4.82	36.82	21.39	16.05	0.00	33.20	37.16	19.12
Gary/Mack Stemmed	91.625	28.38	3.63	54.59	49.25	33.20	0.00	3.97	14.08
Stallings	87.659	32.34	0.34	58.56	53.22	37.16	3.97	0.00	18.04
Thoms Creek	105.702	14.30	17.70	40.51	35.17	19.12	14.08	18.04	0.00

Table 40. Pairwise Comparisons of the Kruskal-Wallis Mean Rank Values for Distance from Coast (Significant differences emboldened).

Site Class	Mean Rank	Early Archaic	Kirk/Stanly Stemmed	Morrow Mountain	Guilford	Savannah River	Gary/Mack Stemmed	Stallings	Thoms Creek
		132.273	129.875	158.045	173.158	131.167	116.333	100.174	110.577
Early Archaic	132.273	0.00	2.40	25.77	40.89	1.11	15.94	32.10	21.70
Kirk/Stanly Stemmed	129.875	2.40	0.00	28.17	43.28	1.29	13.54	29.70	19.30
Morrow Mountain	158.045	25.77	28.17	0.00	15.11	26.88	41.71	57.87	47.47
Guilford	173.158	40.89	43.28	15.11	0.00	41.99	56.83	**72.98**	**62.58**
Savannah River	131.167	1.11	1.29	26.88	41.99	0.00	14.83	30.99	20.59
Gary/Mack Stemmed	116.333	15.94	13.54	41.71	56.83	14.83	0.00	16.16	5.76
Stallings	100.174	32.10	29.70	57.87	**72.98**	30.99	16.16	0.00	10.40
Thoms Creek	110.577	21.70	19.30	47.47	**62.58**	20.59	5.76	10.40	0.00

Table 41. Results of the Kruskal-Wallis Tests Comparing Late Archaic-Early Woodland Subsets.

Environmental Variable	*kw*	*p*
Elevation	0.0878	0.9571
Percent slope	3.0097	0.2220
Distance from scarp	4.7538	0.0928
Distance from wetland	0.0698	0.9657
Distance from stream	7.0456	0.0295
Distance from perennial stream	3.5621	0.1685
Distance from poorly- to very poorly-drained soil	1.6933	0.4289
Distance from very poorly-drained soil	2.4485	0.2940
Distance from road	0.0354	0.9825
Distance from well-drained soil	0.4519	0.7978
Distance from coast	2.7676	0.2506

Table 42. Pairwise Comparisons of the Kruskal-Wallis Mean Rank Values for Distance from Stream (Significant differences emboldened).

Site Class		Stallings	Thoms Creek	Refuge
	Mean Rank	111.783	106.035	131.309
Stallings	111.783	0.00	5.75	19.53
Thoms Creek	106.035	5.75	0.00	**25.27**
Refuge	131.309	19.53	**25.27**	0.00

Woodland Stemmed hafted bifaces, and Large Triangular hafted bifaces (Figures 23 through 31). Significant differences are apparent for elevation, distance from stream, distance from very poorly-drained soils, and distance from the coast (Tables 43 through 47). Most of these differences can be attributed to the hafted biface distributions, with Woodland Stemmed bifaces located at a greater distance from the coast and very poorly-drained soils, and at higher elevations than other categories. In contrast, Large Triangular bifaces have the lowest mean rank for distance from streams, though none of the individual comparisons are significant.

The final set of tests compared Late Woodland Santee Simple Stamped sites with Mississippian Triangular bifaces and Complicated Stamped pottery (Figures 26, 32, and 33). Three variables were determined to vary significantly between the samples: elevation, distance from streams, and distance from the coast (Tables 48 through 51). Interestingly, the differences can again be largely attributed to the hafted biface distribution. Mississippian small triangular bifaces tend to be found further inland and at higher elevations than sites bearing Santee Simple Stamped or Mississippian Complicated Stamped pottery. The individual comparisons for distance from stream are not significant, but Mississippian small triangular has the lowest mean rank.

Discussion

The above analyses provide some interesting insights to probabilistic modeling efforts and shifting settlement patterns in the Francis Marion National Forest. The greatest divergence in environmental association is between historic and prehistoric sites, which differ significantly on five variables. Prehistoric sites tend to be located nearer to

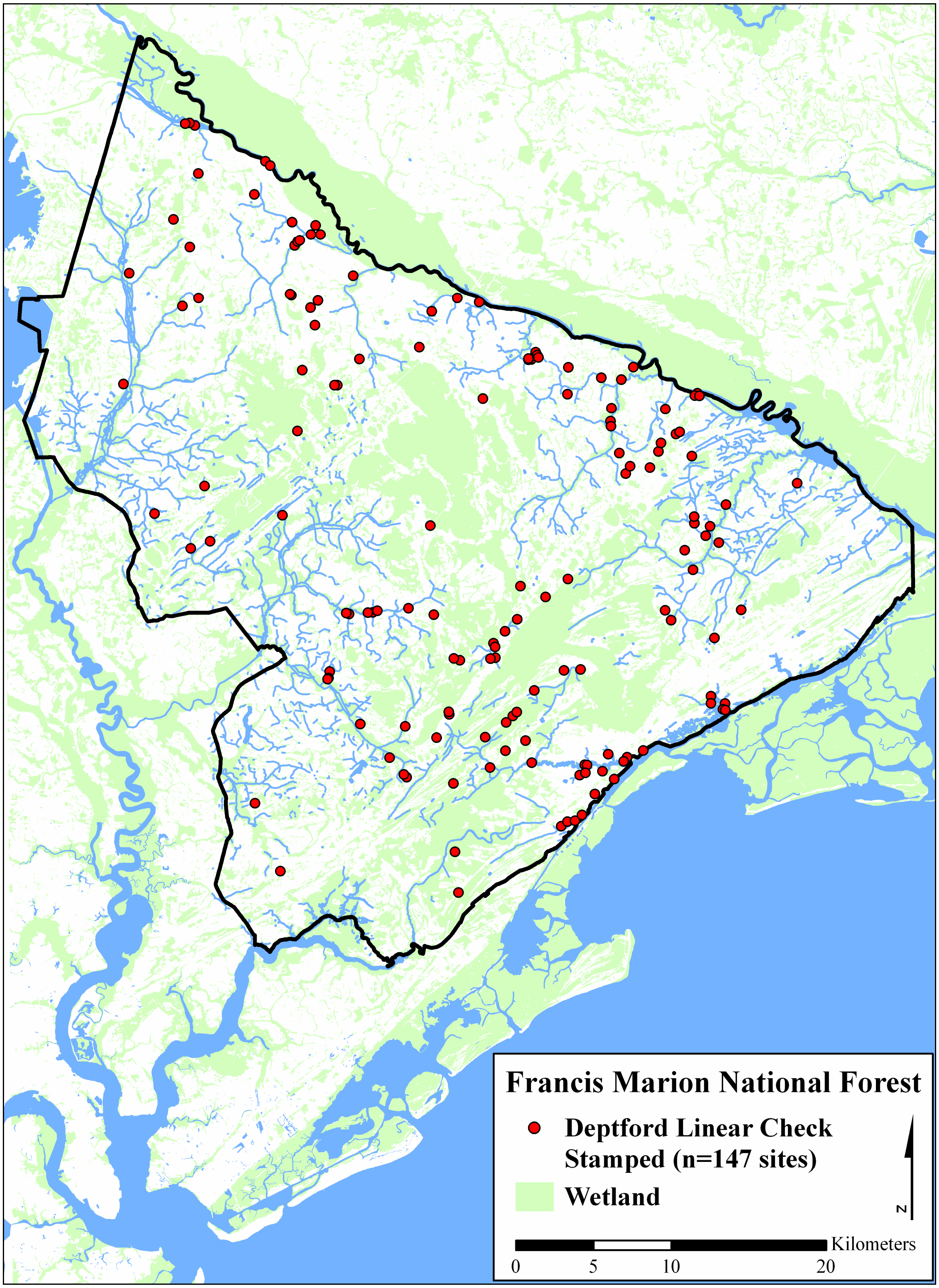

Figure 24. Deptford sites in the Francis Marion National Forest.

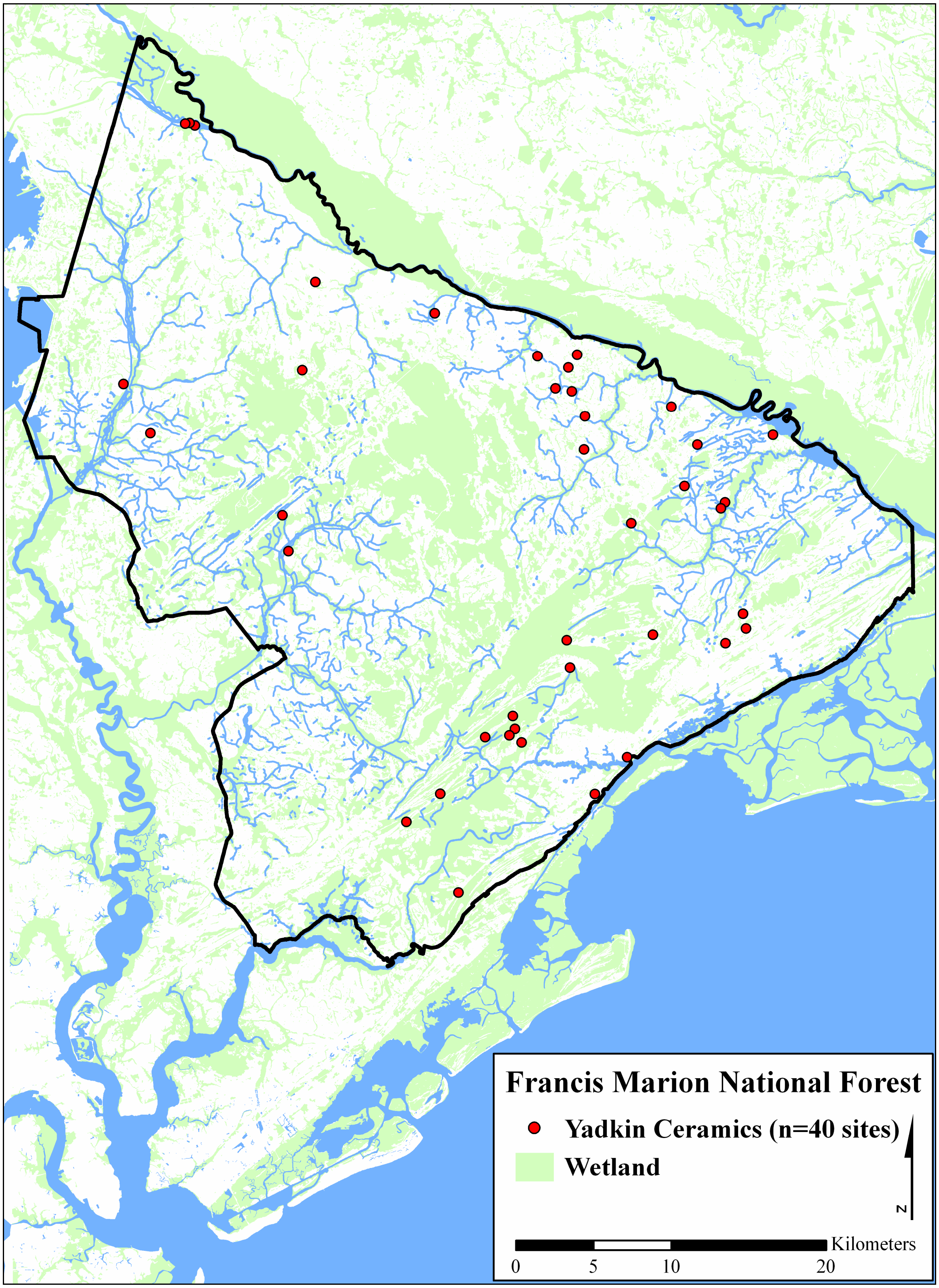

Figure 25. Yadkin sites in the Francis Marion National Forest.

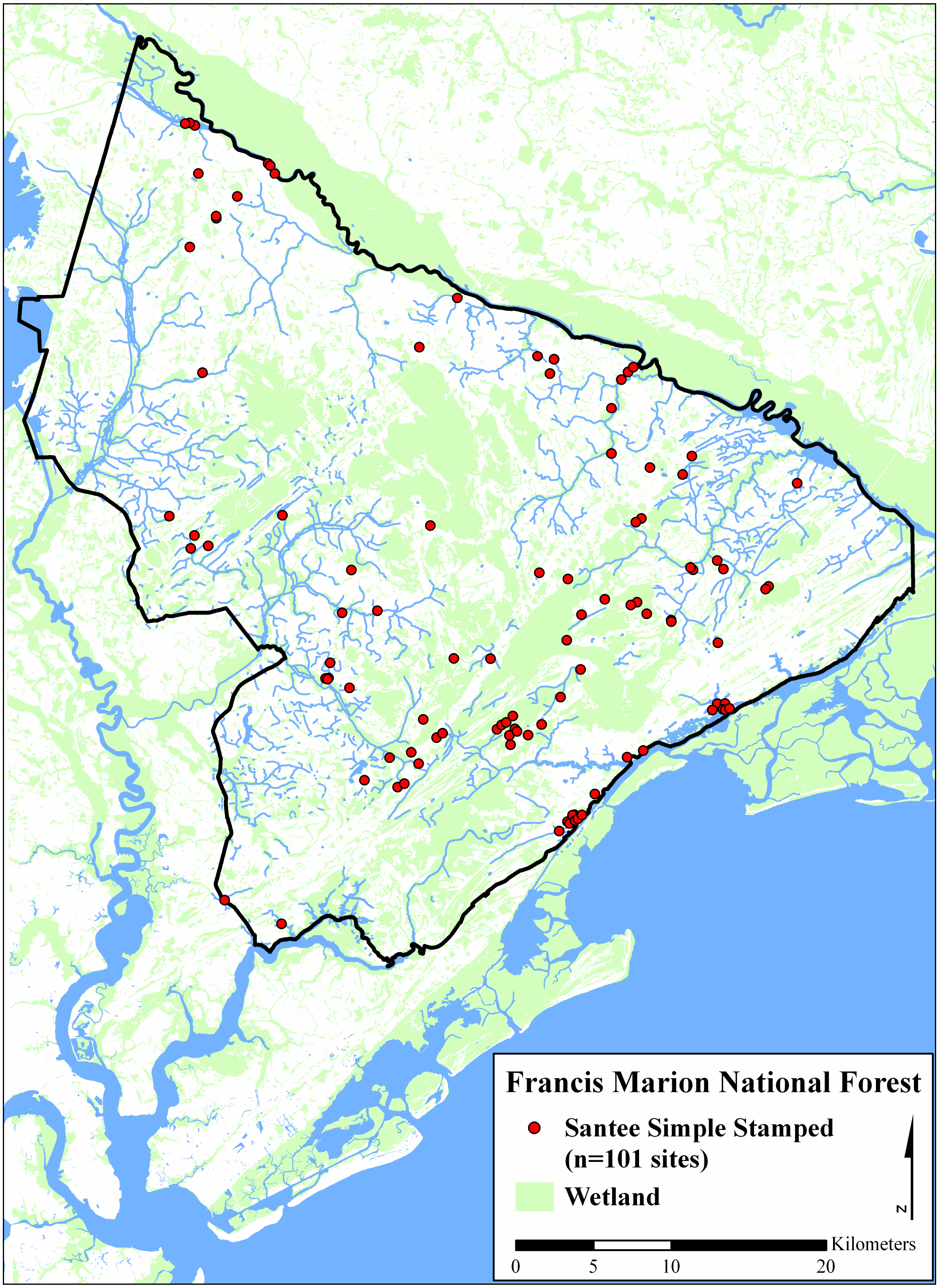

Figure 26. Santee sites in the Francis Marion National Forest.

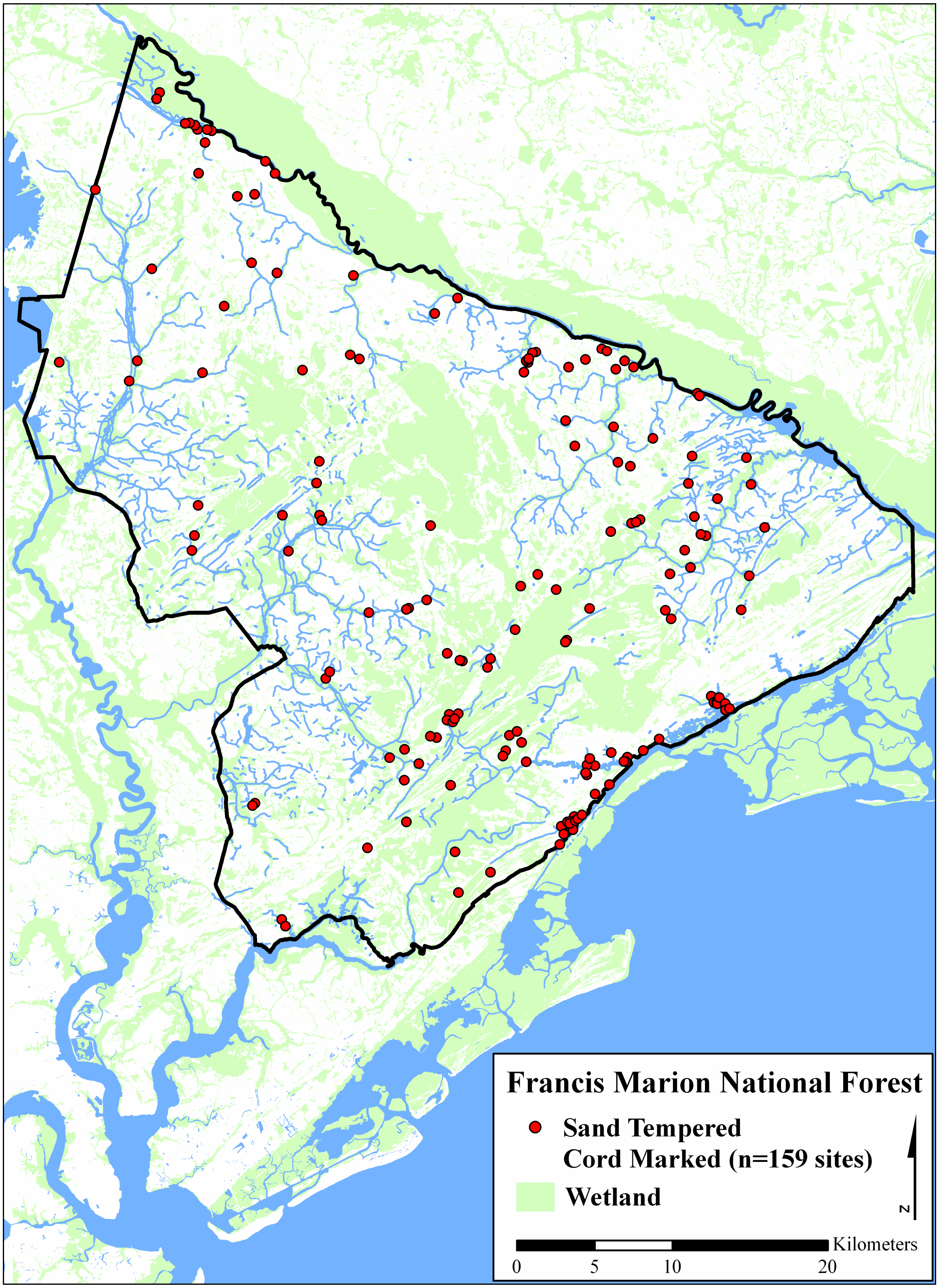

Figure 27. Sand-tempered cord marked ceramics in the Francis Marion National Forest.

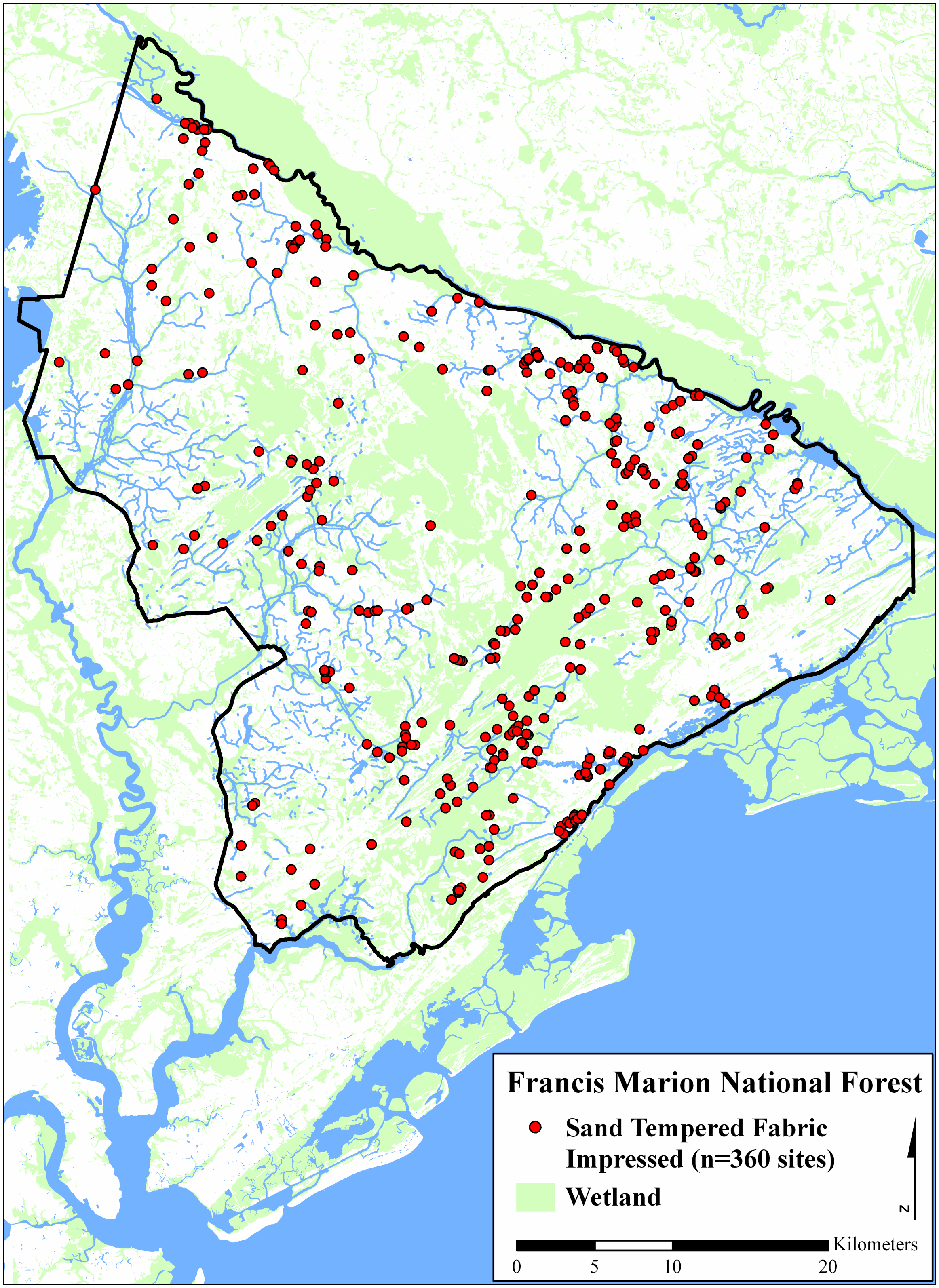

Figure 28. Sand-tempered fabric impressed ceramics in the Francis Marion National Forest.

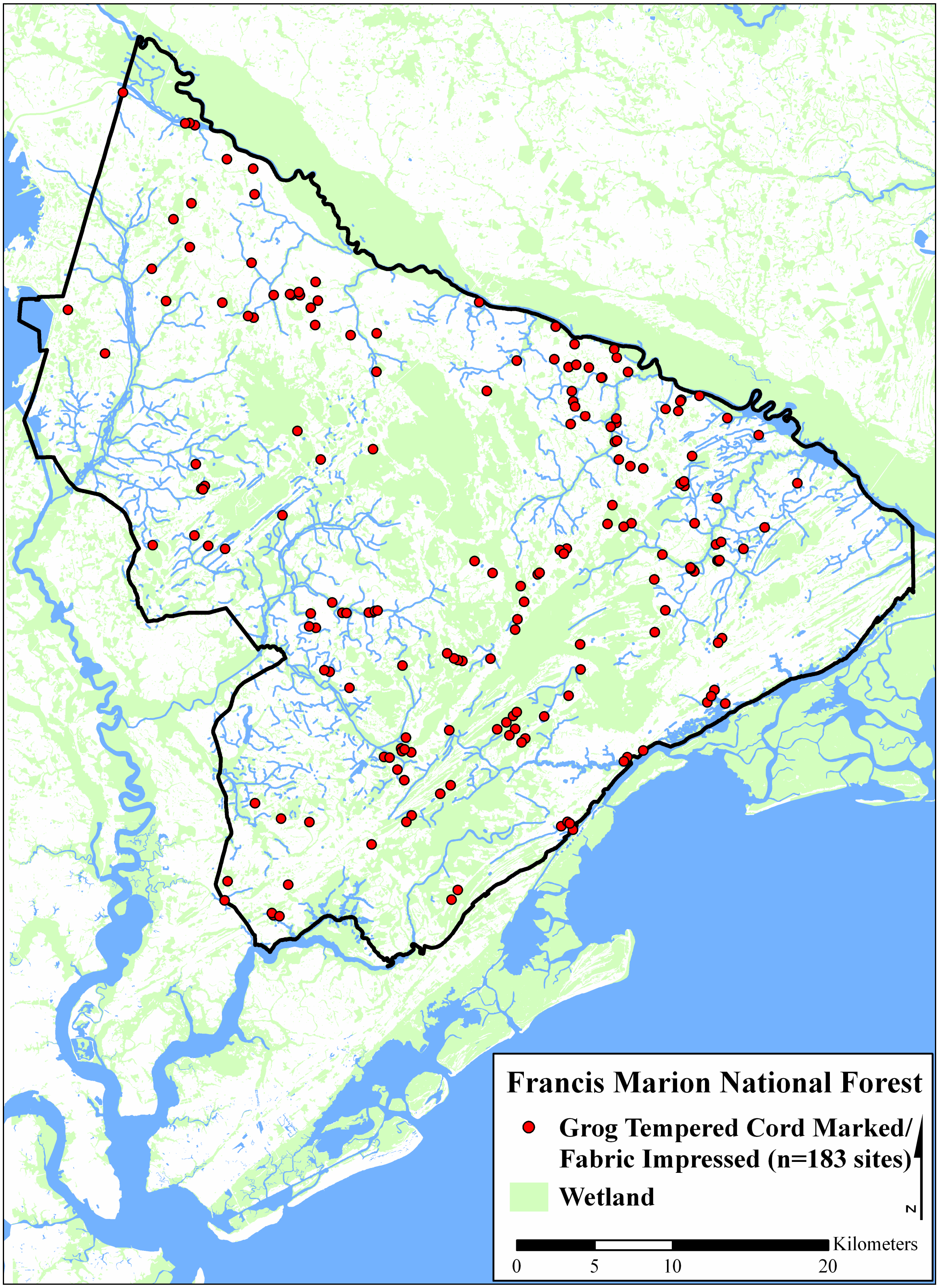

Figure 29. Grog-tempered (Wilmington) ceramics in the Francis Marion National Forest.

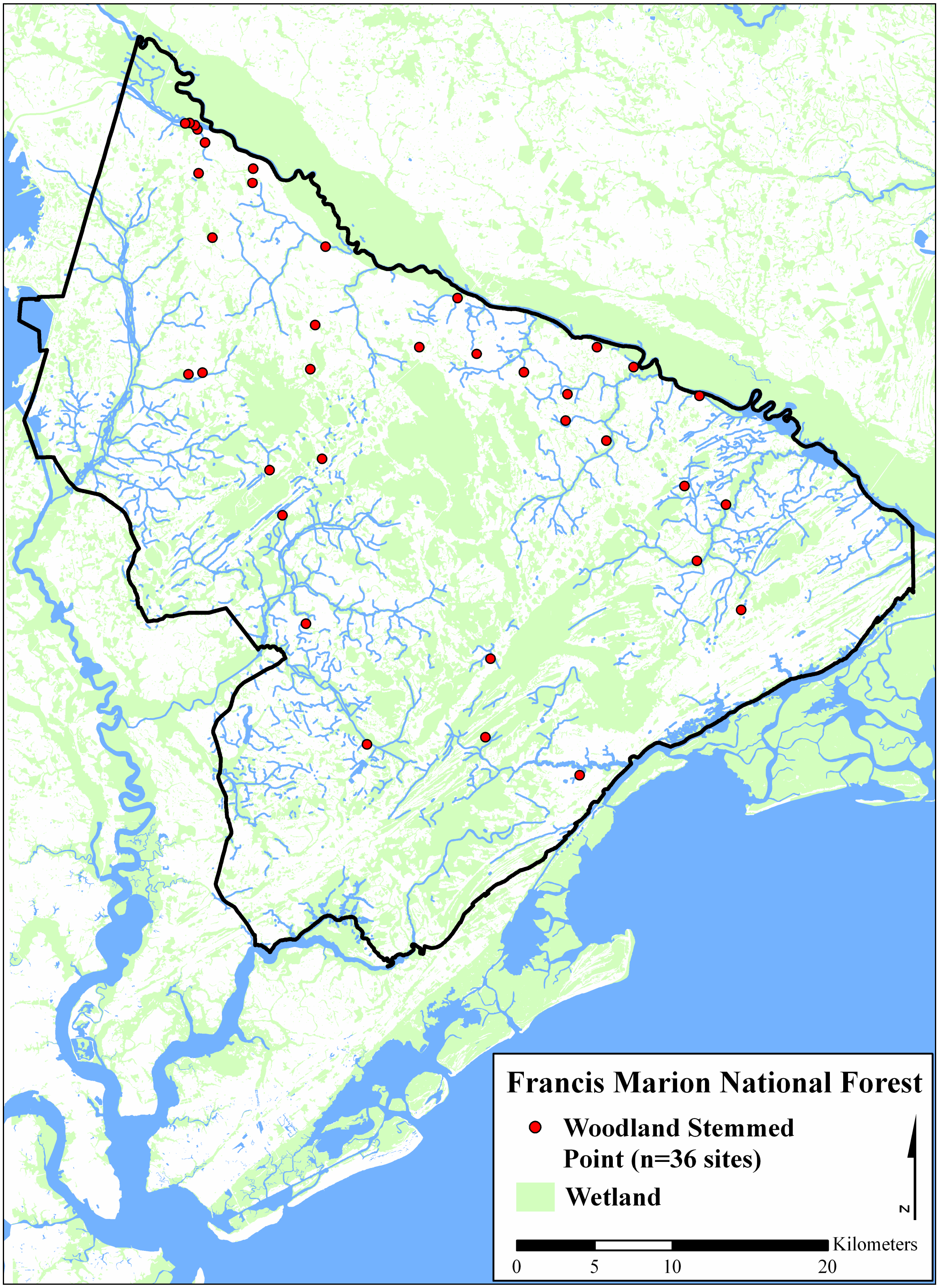

Figure 30. Woodland stemmed bifaces in the Francis Marion National Forest.

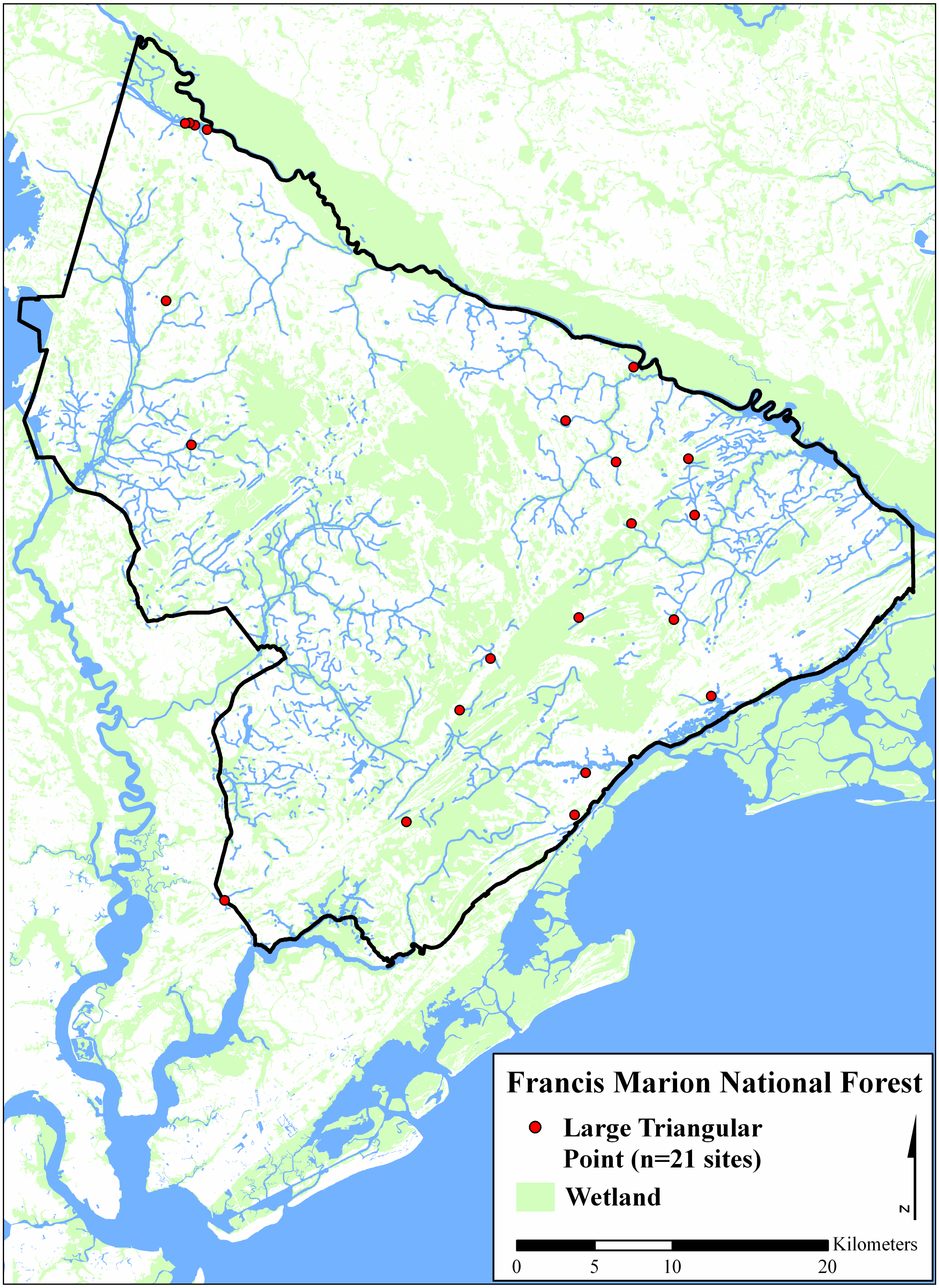

Figure 31. Woodland large triangular bifaces in the Francis Marion National Forest.

Table 43. Results of the Kruskal-Wallis Tests Comparing Woodland Subsets.

Environmental Variable	*kw*	*p*
Elevation	19.4249	0.0127
Percent slope	9.1305	0.3314
Distance from scarp	11.8137	0.1597
Distance from wetland	11.2588	0.1875
Distance from stream	16.7718	0.0326
Distance from perennial stream	15.0654	0.0579
Distance from poorly- to very poorly-drained soil	6.9773	0.5391
Distance from very poorly-drained soil	17.6338	0.0241
Distance from road	3.2324	0.9189
Distance from well-drained soil	5.3907	0.7151
Distance from coast	31.5335	0.0001

Table 44. Pairwise Comparisons of the Kruskal-Wallis Mean Rank Values for Elevation (Significant differences emboldened).

Site Class	Mean Rank	Refuge 617.75	Deptford 557.745	Yadkin 562.425	Santee 534.688	Sand Cord 505.075	Sand Fabric 545.036	Wilmington 611.923	Woodland Stemmed 696.278	Large Triangular 577.143
Refuge	617.75	0.00	60.01	55.33	83.06	112.68	72.71	5.83	78.53	40.61
Deptford	557.745	60.01	0.00	4.68	23.06	52.67	12.71	54.18	138.53	19.40
Yadkin	562.425	55.33	4.68	0.00	27.74	57.35	17.39	49.50	133.85	14.72
Santee	534.688	83.06	23.06	27.74	0.00	29.61	10.35	77.24	161.59	42.46
Sand Cord	505.075	112.68	52.67	57.35	29.61	0.00	39.96	106.85	**191.20**	72.07
Sand Fabric	545.036	72.71	12.71	17.39	10.35	39.96	0.00	66.89	151.24	32.11
Wilmington	611.923	5.83	54.18	49.50	77.24	106.85	66.89	0.00	84.36	34.78
Woodland Stemmed	696.278	78.53	138.53	133.85	161.59	**191.20**	151.24	84.36	0.00	119.14
Large Triangular	577.143	40.61	19.40	14.72	42.46	72.07	32.11	34.78	119.14	0.00

Table 45. Pairwise Comparisons of the Kruskal-Wallis Mean Rank Values for Distance from Stream (Significant differences emboldened).

Site Class	Mean Rank	Refuge 617.717	Deptford 540.925	Yadkin 661.613	Santee 583.564	Sand Cord 512.377	Sand Fabric 560.907	Wilmington 588.369	Woodland Stemmed 544.194	Large Triangular 409.619
Refuge	617.717	0.00	76.79	43.90	34.15	105.34	56.81	29.35	73.52	208.10
Deptford	540.925	76.79	0.00	120.69	42.64	28.55	19.98	47.44	3.27	131.31
Yadkin	661.613	43.90	120.69	0.00	78.05	149.24	100.71	73.24	117.42	251.99
Santee	583.564	34.15	42.64	78.05	0.00	71.19	22.66	4.81	39.37	173.95
Sand Cord	512.377	105.34	28.55	149.24	71.19	0.00	48.53	75.99	31.82	102.76
Sand Fabric	560.907	56.81	19.98	100.71	22.66	48.53	0.00	27.46	16.71	151.29
Wilmington	588.369	29.35	47.44	73.24	4.81	75.99	27.46	0.00	44.18	178.75
Woodland Stemmed	544.194	73.52	3.27	117.42	39.37	31.82	16.71	44.18	0.00	134.58
Large Triangular	409.619	208.10	131.31	251.99	173.95	102.76	151.29	178.75	134.58	0.00

Table 46. Pairwise Comparisons of the Kruskal-Wallis Mean Rank Values for Distance from Very Poorly-drained Soils (Significant differences emboldened).

Site Class	Mean Rank	Refuge 458.096	Deptford 502.581	Yadkin 513.681	Santee 444.103	Sand Cord 504.262	Sand Fabric 513.223	Wilmington 518.841	Woodland Stemmed 676.621	Large Triangular 612.833
Refuge	458.096	0.00	44.49	55.59	13.99	46.17	55.13	60.75	**218.53**	154.74
Deptford	502.581	44.49	0.00	11.10	58.48	1.68	10.64	16.26	174.04	110.25
Yadkin	513.681	55.59	11.10	0.00	69.58	9.42	0.46	5.16	162.94	99.15
Santee	444.103	13.99	58.48	69.58	0.00	60.16	69.12	74.74	**232.52**	168.73
Sand Cord	504.262	46.17	1.68	9.42	60.16	0.00	8.96	14.58	172.36	108.57
Sand Fabric	513.223	55.13	10.64	0.46	69.12	8.96	0.00	5.62	163.40	99.61
Wilmington	518.841	60.75	16.26	5.16	74.74	14.58	5.62	0.00	157.78	93.99
Woodland Stemmed	676.621	**218.53**	174.04	162.94	**232.52**	172.36	163.40	157.78	0.00	63.79
Large Triangular	532	73.90	29.42	18.32	87.90	27.74	18.78	13.16	144.62	80.83

Table 47. Pairwise Comparisons of the Kruskal-Wallis Mean Rank Values for Distance from Coast (Significant differences emboldened).

Site Class	Mean Rank	Refuge 521.349	Deptford 580.735	Yadkin 557.963	Santee 487.475	Sand Cord 527.975	Sand Fabric 552.631	Wilmington 601.951	Woodland Stemmed 799.292	Large Triangular 607.405
Refuge	521.349	0.00	59.39	36.61	33.87	6.63	31.28	80.60	**277.94**	86.06
Deptford	580.735	59.39	0.00	22.77	93.26	52.76	28.10	21.22	**218.56**	26.67
Yadkin	557.963	36.61	22.77	0.00	70.49	29.99	5.33	43.99	**241.33**	49.44
Santee	487.475	33.87	93.26	70.49	0.00	40.50	65.16	114.48	**311.82**	119.93
Sand Cord	527.975	6.63	52.76	29.99	40.50	0.00	24.66	73.98	**271.32**	79.43
Sand Fabric	552.631	31.28	28.10	5.33	65.16	24.66	0.00	49.32	**246.66**	54.77
Wilmington	601.951	80.60	21.22	43.99	114.48	73.98	49.32	0.00	**197.34**	5.45
Woodland Stemmed	799.292	**277.94**	**218.56**	**241.33**	**311.82**	**271.32**	**246.66**	**197.34**	0.00	191.89
Large Triangular	607.405	86.06	26.67	49.44	119.93	79.43	54.77	5.45	191.89	0.00

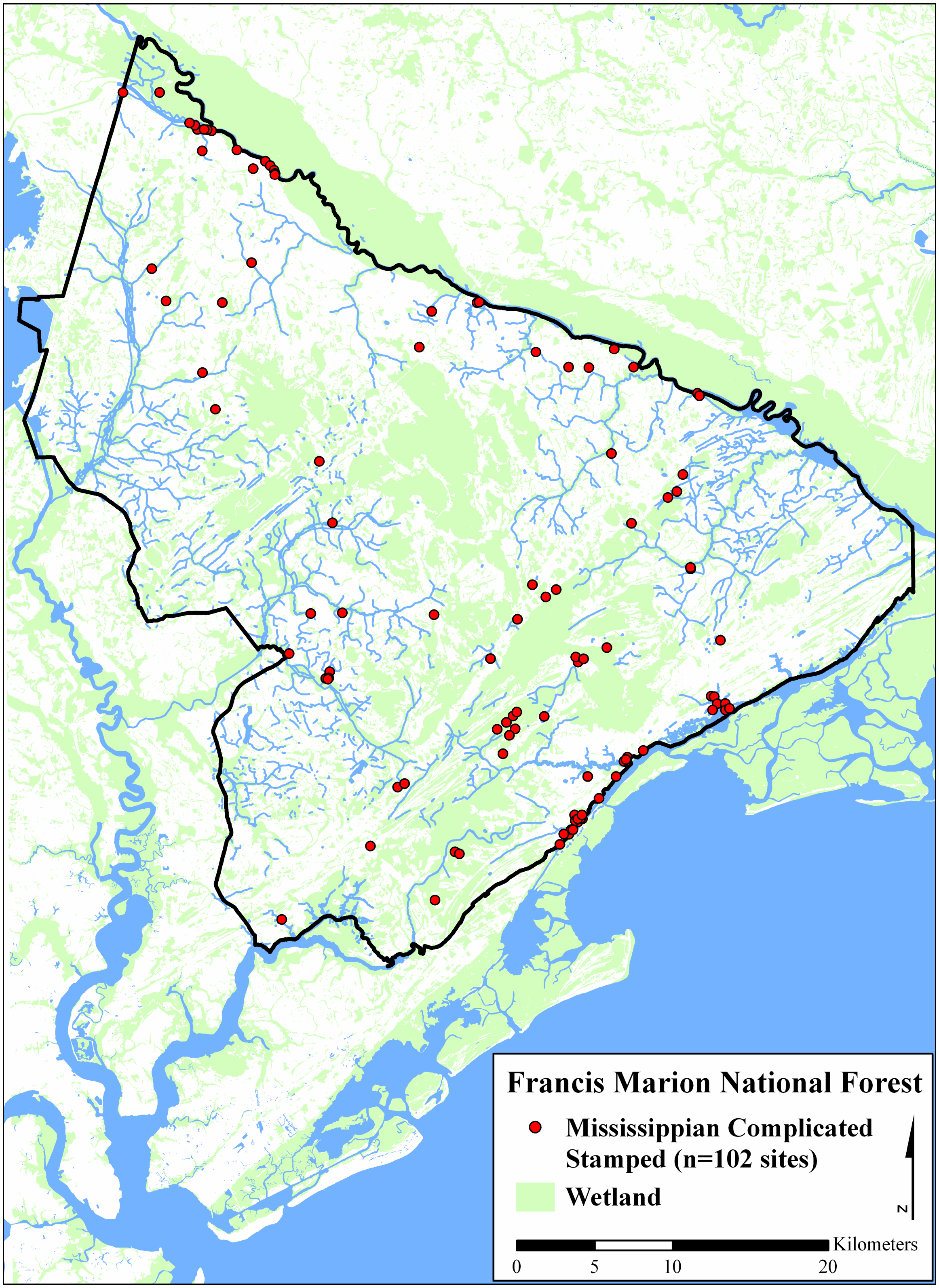

Figure 32. Mississippian complicated stamped ceramics in the Francis Marion National Forest.

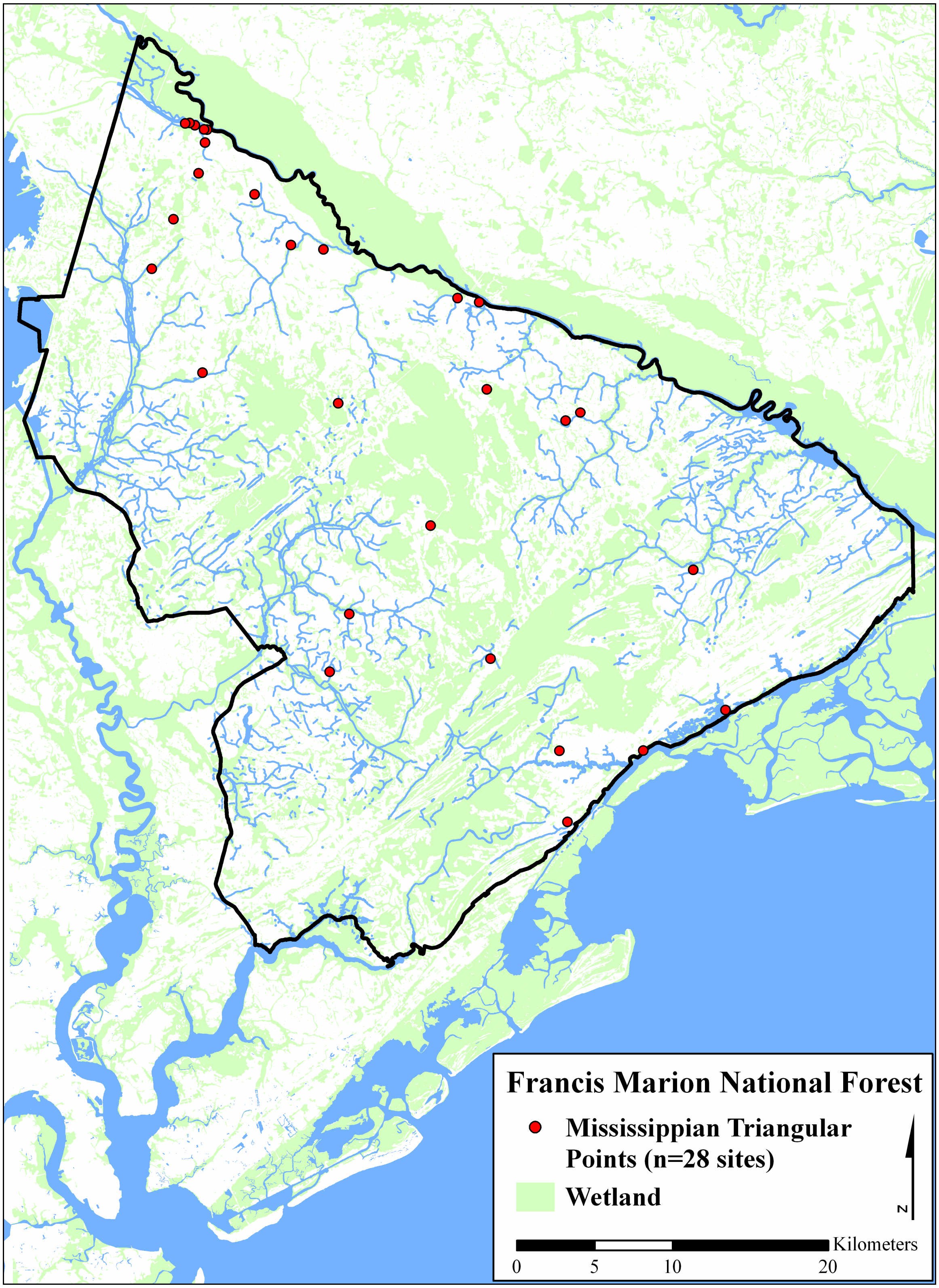

Figure 33. Mississippian small triangular bifaces in the Francis Marion National Forest.

Table 48. Results of the Kruskal-Wallis Tests Comparing Late Woodland-Mississippian Subsets.

Environmental Variable	*kw*	*p*
Elevation	11.0818	0.0039
Percent slope	5.7392	0.0567
Distance from scarp	1.7945	0.4077
Distance from wetland	1.7240	0.4223
Distance from stream	6.1017	0.0473
Distance from perennial stream	0.7244	0.6962
Distance from poorly- to very poorly-drained soil	0.8074	0.6679
Distance from very poorly-drained soil	4.2188	0.1213
Distance from road	1.0875	0.5806
Distance from well-drained soil	0.1565	0.9247
Distance from coast	13.4482	0.0012

Table 49. Pairwise Comparisons of the Kruskal-Wallis Mean Rank Values for Elevation (Significant differences emboldened).

Site Class	Mean Rank	Santee Simple Stamped 122.946	Complicated Stamped 101.319	Mississippian Triangular 144.429
Santee Simple Stamped	122.946	0.00	21.63	21.48
Complicated Stamped	101.319	21.63	0.00	**43.11**
Mississippian Triangular	144.429	21.48	**43.11**	0.00

Table 50. Pairwise Comparisons of the Kruskal-Wallis Mean Rank Values for Distance from Stream (Significant differences emboldened).

Site Class	Mean Rank	Santee Simple Stamped 128.134	Complicated Stamped 107.873	Mississippian Triangular 101.839
Santee Simple Stamped	128.134	0.00	20.26	26.30
Complicated Stamped	107.873	20.26	0.00	6.03
Mississippian Triangular	101.839	26.30	6.03	0.00

Table 51. Pairwise Comparisons of the Kruskal-Wallis Mean Rank Values for Distance from Coast (Significant differences emboldened).

Site Class	Mean Rank	Santee Simple Stamped 109.748	Complicated Stamped 110.275	Mississippian Triangular 159.411
Santee Simple Stamped	109.748	0.00	0.53	**49.66**
Complicated Stamped	110.275	0.53	0.00	**49.14**
Mississippian Triangular	159.411	**49.66**	**49.14**	0.00

water sources – wetlands and streams – than historic sites. This is perhaps not surprising with the adoption of well technology by European colonists. Also unsurprising is the close association of historic sites and roads. In this analysis the distance from all roads was measured as distance from major roads was not found to be significant. However, greater success would undoubtedly be achieved by measuring the distance only to known historic roads.

Interestingly, no Paleoindian sites are recorded in the Forest. This is somewhat surprising given the proximity of the Santee River, as Paleoindian sites are known to occur along major drainages in the region (Anderson 1996b). However, several fluted bifaces are recorded for Berkeley and Charleston counties in the Paleoindian Database of the Americas[4] (Anderson et al. 2005). Previous examination of the regional distribution of Paleoindian materials found that they are far less frequent in the Atlantic Coastal Plain than the interior Southeast (O'Donoughue 2007). It was hypothesized that the present day Coastal Plain was underexploited by Paleoindians, who focused on the resources of the Fall Line and the now inundated coast. This may explain the paucity of Paleoindian

[4] http://pidba.utk.edu

materials in the Forest, although we would still expect the Santee River to serve as an important coastal/inland travel corridor.

Few significant differences were obtained between the prehistoric subsets. Early and Middle Archaic sites are relatively rare compared to later periods. This is likely due to a combination of lower population densities, an inability to resolve these components in the absence of diagnostic hafted bifaces, and the likelihood that some components are deeply buried and thus not detectable by traditional shallow shovel testing procedures. Cable (2002:450-455) has recently begun identifying pre-ceramic Archaic components through close interval controlled shovel testing of (relatively) deeply buried lithic scatters:

> At first, hints of Archaic occupations were recognized when isolated lithic material was recovered in unconsolidated sands at depths below that at which Woodland and Mississippian occupations were normally found. Subsequent excavations confirmed that these finds were almost invariably associated with small pre-ceramic Archaic campsites rarely surpassing 3 to 5 m in diameter [Cable 2002:450].

If it can be widely applied, this technique holds significant potential to increase our knowledge of Archaic occupation of the Forest. However, detailed knowledge of local depositional regimes is required, and the suitability of subsurface testing procedures must be continually assessed for the different microenvironmental settings of the Forest.

The environmental associations suggest that Early and Middle Archaic sites tend to be more concentrated away from the coast where elevations are higher. This pattern is most striking for Morrow Mountain and Guilford bifaces, which are also the least

tethered to soil drainage ecotones. Further, while Early Archaic and Morrow Mountain sites are relatively widespread in the Forest, Guilford sites are more heavily concentrated along the Santee River and its tributaries (Figures 15 through 18).

Late Archaic sites are much more frequently encountered than earlier sites in the Forest, no doubt due in part to increased archaeological visibility with the advent of pottery. Stallings ceramics are relatively rare in the Forest, and assemblages are dominated by plain wares. Within the Late Archaic, Savannah River and Gary/Mack hafted bifaces seem to be located further inland than ceramic-bearing sites. However, it is impossible to determine if this represents temporal or behavioral variability, or simply sampling error. Late Archaic sites are consistently intermediate in the environmental comparisons between temporal samples, and thus no significant differences can be inferred.

Woodland sites are by far the most ubiquitous in the Forest. Little difference was observed between the environmental associations of Woodland diagnostics, and indeed settlement patterns appear to have been relatively homogenous throughout this period. There is some indication that Refuge and Santee sites are clustered closer to the coast, and interestingly these types bracket the Woodland period. Further, Woodland hafted bifaces seem to be clustered in the interior of the Forest. This may represent increased hunting activity away from the coast, or perhaps greater reliance on shell tools along the coastal margin.

Mississippian sites are apparently located at lower elevations than sites of other periods, though precisely why this would be so is not clear. This may reflect greater exploitation of floodplain locales. Another possibility is that agricultural fields were

located on better-drained soils and settlements were moved to lower, more marginally-drained areas. The pattern of hafted bifaces concentrated further inland continues into the Mississippian.

The results detailed above also provided important information for the development of a new model of archaeological site occurrence on the Francis Marion National Forest. The analyses suggest that differences between site subsets are few enough that a single model should adequately encapsulate them. Historic resources may require consideration of proximity to roads, as this is an important factor in historic site location. Environmental differences between the prehistoric subsets generally involve proximity to the coast and elevation. However, since elevation generally increases away from the coast these variables are expected to co-vary. The application of these results to model development is addressed in the next chapter.

Chapter 5. Probabilistic Model Development

This chapter describes the development of a new probabilistic model of archaeological site occurrence in the Francis Marion National Forest. The development of this model is justified by the evaluation of the extant Forest Service probabilistic model in Chapter 4. This analysis showed that while the high probability zone is effective, the medium probability contains marginally fewer sites than expected by chance alone, and contributes little to the overall significance of the model. Further, though the proportion of sites occurring in the low probability zone is significantly less than expected, this zone nevertheless contains a high number of archaeological sites and an even greater amount of site area.

New Model Development

The analyses of environmental associations outlined in Chapter 4 provide an inroad to the development of an improved probabilistic model for the Francis Marion National Forest. All but one of the environmental variables examined show significant differences between archaeological site locales and the background environment of the Forest. Distance from major roads is the lone insignificant variable, and as such was excluded from the more detailed analyses. The remaining variables – soil drainage, elevation, percent slope, distance from scarp, distance from wetland, distance from stream, distance from perennial stream, distance from poorly- to very poorly-drained soil, distance from very poorly-drained soil, distance from well-drained soil, distance from road, and distance from coast – are all significant and therefore potentially important indicators of archaeological site occurrence. Further, though significant differences in

environmental association between site subsets were few, these analyses do suggest that proximity to roads is an important factor in the location of historic sites, and that certain classes of prehistoric sites tend to be clustered at different elevations or greater distances from the coast.

However, as an improved probabilistic model is intended to be useful to Forest Service personnel for land use planning and cultural resource assessments, a relatively simple model is preferred for ease of application (i.e., a model with fewer variables). Further, several of the environmental variables are redundant (e.g., distance from poorly- to very poorly-drained soil and distance from poorly-drained soil), or tend to co-vary (distance from stream and distance from perennial stream), thus justifying the removal of some variables from consideration.

Variables were selected for exclusion based on their lack of utility for defining probability zones and for presumed difficulty of measurement in the field. The first variables removed were distance from scarp and distance from coast. While these measures are instructive of differences between temporally/culturally distinct site subsets, they are relatively coarse measures that are not particularly useful in constructing probability zones for the Forest due to their wide range (e.g., distance from coast median value is 17,252 m). Also excluded from model development were elevation and percent slope. Though these are undoubtedly important variables, it was felt that minor fluctuations and exact measures would be difficult to discern in the field (and indeed may be masked by the resolution of the data).

To correspond to the extant Forest Service model, the improved model contains three probability zones: high, medium, and low. The gain statistic was used to assemble

the probability zones. Areas with a gain of greater than .50 were classified as high probability, areas with a gain of zero to .49 as medium probability, and areas with negative gain as low probability.

As is clear from the tests of environmental association, soil drainage is consistently significant across all site subsets. In fact, a reasonable model could be constructed using this variable alone. Considering this, and that previous research has demonstrated the strong association of soil drainage and site location in the Lower Coastal Plain, soil drainage class was used as the primary variable in model construction. The above analyses indicate that several drainage classes tend to perform similarly, and thus the seven classes initially defined were collapsed into four: exceptionally to well-drained, moderately well-drained, somewhat poorly-drained, and poorly- to very poorly-drained (Table 52). The exceptionally to well-drained class exhibits a gain of .603, and thus can be included in the high probability zone without further modification. Moderately well-drained areas show a gain of .448 and could be included in the medium probability zone. However, some modification of this class may boost the gain and produce an area suitable for inclusion in the high probability zone. The remaining classes – somewhat poorly- and poorly- to very poorly-drained – exhibit a negative gain and could be classified as having a low probability of archaeological site occurrence. However, these zones collectively contain nearly 50 percent of the archaeological sites. Thus, though excessively- and well-drained areas can be included in the new model, the remaining soil drainage classes require modification.

Table 52. Test Statistics for Collapsed Soil Drainage Classes.

Soil Drainage Class	Area m	% of Total	Expected Sites	Observed Sites	% of Sites	χ2	Gain
Excessively-Well	166019860	9.9	186	469	24.9	431.596	0.604
Moderately Well	235058621	14.0	263	477	25.3	173.944	0.448
Somewhat Poorly	456560420	27.1	511	496	26.3	0.440	-0.030
Poorly-Very Poorly	820918309	48.8	919	433	23.0	256.845	-1.122
No Data	3873920	0.2	4	8	0.4	3.097	0.458
Total	1682431131	100.0	1883	1883	100.0	865.922	-

*with 4 degrees of freedom and $\alpha = .05$, significance is indicated by $\chi 2 \geq 9.488$

Wilcoxon Rank sum tests were conducted for the environmental associations of site and background locales within the soil drainage classes, in an effort to identify significant environmental variables and zones of greater and lesser probability of site occurrence within each. As all of the remaining environmental variables are distance measures, significant variables were investigated by constructing proximity buffers in ArcGIS. The minimum buffer size was set at 60 m, as smaller buffers tend to produce areas that are impractical to survey. Buffer size was increased in 30 m increments to reflect the typical interval between shovel tests and transects in the Forest. The gain statistic was calculated for each buffered area, and the buffer with the highest gain was selected (though in some cases a buffer with a marginally lower gain was selected to increase the percent of sites captured).

Within moderately well-drained areas, the only significant variable is distance from wetland ($p = .0014$). A buffer of 90 m around wetlands captures 58.9 percent of the sites in this zone, and returned an overall gain of .546. This area was thus added to the high probability zone. Areas of moderately well-drained soils that are greater than 90 m from a wetland have a gain of .307 and are included in the medium probability zone.

Several variables differed significantly between site and non-site locales in areas of somewhat poorly-drained soils, including distances from wetland, stream, very poorly-drained soil, well-drained soil, and road (Table 53). Of the significant variables, only distance from very poorly-drained soil is not significant at $\alpha = .01$, so it was excluded to reduce the complexity of the model. Distance from stream was also excluded, as this variable has a high median value, and requires exceedingly large buffers to maximize gain. Distance from wetland was found to be most effective with a buffer of 90 m, with a gain of .267. Similarly, the highest gain for distance from road (.297) was returned with a buffer of 90 m, while distance from well-drained soil was most effective with a 60 m buffer (gain = .301). These three buffers were then collapsed into a single zone, capturing 21.4% of all sites in 17.9% of the Forest area for a gain of .165. Thus, areas of somewhat poorly-drained soils that are within 90 m of a wetland, or within 90 m of a road, or within 60 m of well-drained soils are classified in the medium probability zone. All other areas of somewhat poorly-drained soil are classified as low probability (gain = -1.113).

In poorly- to very poorly-drained areas, four variables were significant: distance from stream, perennial stream, well-drained soil, and road. However, neither distance from stream nor distance from perennial stream returned positive gain statistics. Distance from well-drained soil returned the highest gain with a 60 m buffer, but ultimately 90 m was selected as the optimal buffer size for this variable, sacrificing some efficiency in the model to increase the percentage of sites captured. Distance from roads was found to be most effective with a 60 m buffer. The remainder of the area of poorly- to very poorly-drained soils is classified as having low probability of site occurrence (gain = -3.204).

Table 53. Statistical Significance of the Wilcoxon Rank Sum Test of Environmental Parameters in Somewhat Poorly-drained Soils, by Comparison to the Large Sample Normal Approximation.

Environmental Variable	S	Z	*p*
Distance from wetland	174757.5	2.7878	0.0053
Distance from stream	264092	2.96356	0.003
Distance from perennial stream	259287	1.91594	0.0554
Distance from poorly- or very poorly-drained soil	254442	0.8646	0.3873
Distance from very poorly-drained soil	260122.5	2.10005	0.0357
Distance from well-drained soil	264144	2.97579	0.0029
Distance from road	274475.5	5.23296	<.0001

Based on the above results, a relatively straightforward high probability zone can be constructed from exceptionally to well-drained areas and moderately well-drained areas within 90 m of a wetland. However, the medium probability zone is more complex, containing a greater number of variables and differing buffer sizes. The majority of buffers in this zone are 90 m in width; only two are 60 m. Thus, to further simplify the model, these buffers were increased to 90 m. While this does reduce the efficiency of the model, it increases the percentage of sites captured and provides more consistent criteria for application in the field.

Thus, the new probabilistic model for the Francis Marion National Forest consists of three zones, defined on the basis of four variables: soil drainage, distance from wetland, distance from road, and distance from well-drained soils (Figure 34). The high probability zone consists of:

1) All areas of excessively- to well-drained soils, as defined by the NRCS.
2) Areas of moderately well-drained soils that are within 90 m of a wetland.

The medium probability zone is defined as:

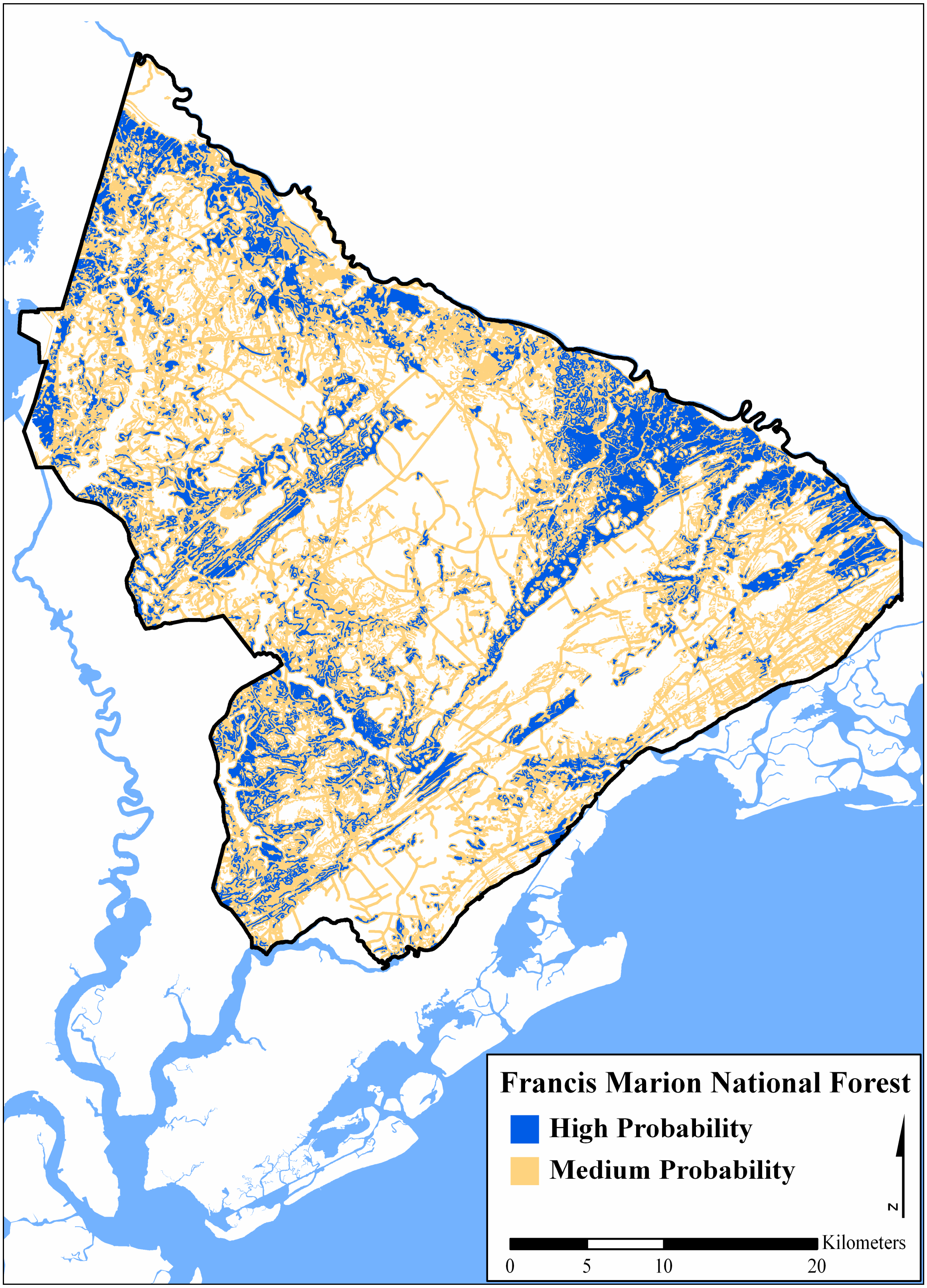

Figure 34. New model of archaeological site occurrence in the Francis Marion National Forest.

1) Areas of moderately well-drained soils that are more than 90 m from a wetland.
2) Areas of somewhat poorly-drained soils that are less than 90 m from a wetland.
3) Areas of somewhat poorly, poorly, or very poorly-drained soils that are less than 90 m from a road.
4) Areas of somewhat poorly, poorly, or very poorly-drained soils that are less than 90 m from excessively-, well-, or moderately well-drained soils.

The low probability zone consists of all other areas:

1) Areas of somewhat poorly-drained soils that are more than 90 m from a wetland, and more than 90 m from a road, and more than 90 m from excessively-, well-, or moderately well-drained soils.
2) Areas of poorly or very poorly-drained soils that are more than 90 m from a road, and more than 90 m from excessively-, well-, or moderately well-drained soils.

Discussion

The probabilistic model outlined above was generated through comparison of the entire sample of archaeological sites in the Francis Marion National Forest with the background environment. In addition, temporally/culturally distinct site subsets were examined to search for deviations from general patterns in site location. However, it remains to be determined if this new model is an improvement over the extant Forest Service probabilistic model. The relevant statistics for the extant and new models are

presented in Tables 54 and 55. Several quantitative differences between the two models are apparent. First, the size of the probability zones has changed. Relative to the extant model, the new model has a larger medium probability zone, and comparatively smaller high and low probability zones. The chi-square statistic indicates that both models are significant, but the value for the new model is higher. The gain statistic is particularly informative with regards to model performance. The new model exhibits higher gain values for both the high and medium zones, and a more negative value for the low probability zone. Further, the new model captures a greater proportion of sites in the high and medium zones, while minimizing the number of sites in the low probability zone. Thus, the new probabilistic model is both more efficient, capturing a greater proportion of sites relative to the area of the high and medium probability zones, and more effective, capturing a greater absolute number of sites within these zones.

In addition to these quantitative differences, there are some qualitative differences between the models. While soil drainage is the primary variable in each model, the remaining variables differ. The extant model is primarily a combination of soil drainage and distance from an interface (i.e., ecotone) with poorly- or very poorly-drained soils. The new model does not include distance from poorly- or very poorly-drained soil, but rather uses distance from wetland as a measure of proximity to an ecotone. However, this criterion only applies to moderately well- and somewhat poorly-drained soils in the new model. All areas of excessively- to well-drained soils are considered high probability.

Further, the new model applies additional variables to better delineate zones of greater and lesser probability of site occurrence in somewhat poorly-drained areas, distance from roads, and distance from excessively- to moderately well-drained soils.

Table 54. Test Statistics for the Extant Probabilistic Model.

Zone	Area m	% of Area	Expected Sites	Observed Sites	% of Sites	χ2	Gain
High	388136860	23.1	434.4	958	50.9	631.056	0.547
Medium	242247940	14.4	271.1	228	12.1	6.861	-0.189
Low	1052017513	62.5	1177.5	697	37.0	196.046	-0.689
Total	1682402313	100.0	1883	1883	100.0	833.964	-

*with 2 degrees of freedom and $\alpha = .05$, significance is indicated by $\chi2 \geq 5.992$

Table 55. Test Statistics for the New Probabilistic Model.

Zone	Area m	% of Area	Expected Sites	Observed Sites	% of Sites	χ2	Gain
High	280445914	16.7	313.9	750	39.8	605.946	0.581
Medium	716876619	42.6	802.4	904	48.0	12.878	0.112
Low	685079781	40.7	766.8	229	12.2	377.156	-2.348
Total	1682402313	100.0	1883	1883	100.0	995.980	-

*with 2 degrees of freedom and $\alpha = .05$, significance is indicated by $\chi2 \geq 5.992$

Distance from roads is an important factor as historic archaeological sites tend to be located in proximity to roads. Distance from excessively- to moderately well-drained soils is an additional measure of proximity to an ecotone. Again, the extant model measures distance from an interface with poorly- to very poorly-drained soils, but in areas of relatively poor drainage, proximity to better drained soils is apparently a more important factor. Finally, the extant model makes no attempt to identify areas of greater potential for archaeological sites within poorly- or very poorly-drained soils. The new model corrects this deficiency, applying the criteria of proximity to roads and proximity to better drained soils.

Summary

This chapter outlined the development of a new probabilistic model of archaeological site occurrence in the Francis Marion National Forest. The new model incorporates four variables – soils drainage class, distance from wetland, distance from road, and distance from excessively-, well-, or moderately well-drained soils – to produce high, medium and low probability zones. This model represents an improvement over the extant Forest Service probabilistic model, while minimizing the number of variables used in its construction to provide a relatively simple and effective model. The chi-square test indicates greater statistical significance, and increased gain values in the high and medium probability zones combined with decreased gain in the low probability zone indicate a more efficient model. Further, the high and medium zones capture a greater proportion of archaeological sites than the corresponding zones of the extant model. The model developed here has been filed with the USDA Forest Service as a GIS data layer.

It will be an invaluable tool for Forest Service personnel and should prove more effective than the model currently in place.

Chapter 6. Summary and Conclusions

Settlement pattern studies and probabilistic modeling have a long history in archaeology, from Gordon Willey's (1953) classic study in the Viru Valley of Peru, to more recent research utilizing robust statistical techniques and GIS technology (e.g., Warren and Asch 2000). Though a certain degree of debate surrounds the statistical validity of these models and their potential to rekindle environmental determinism (e.g., Ebert 2000), they are nonetheless powerful tools for those involved in land use planning, impact assessments, and resource management decisions.

The development of such a model for the Francis Marion National Forest has been one of the central goals of this thesis. This was predicated on an evaluation of the extant probabilistic model employed by the Forest Service, which was found to be inadequate. Detailed analyses of the environmental parameters of archaeological site locales and the background environment of the Forest showed significant differences for the majority of variables explored. Given that the intended use of the model is as a planning tool for Forest Service personnel, an effort was made to develop a relatively simple model that is both easy to apply in the field and flexible enough to accommodate localized environmental conditions. Ultimately, soil drainage, distance from wetlands, distance from roads, and distance from soil drainage ecotones were selected as the critical variables for the model. The result is a highly effective probabilistic model that captures nearly 90 percent of all known archaeological sites in less than 60 percent of the area of the Forest.

Though the model developed herein is quite effective, improvements can nevertheless be suggested. First, project areas need to be digitized so that survey intensity can be controlled for in future modeling efforts. This will help control for bias introduced by modern survey practices and allow detailed examination of areas where archaeological sites are absent or infrequent. Second, the location of isolated finds should be recorded and investigated. These are undoubtedly important to our understanding of past settlement organization and landscape use, and their absence from this analysis may be obscuring significant patterns. Finally, the data used to generate the new probabilistic model suffers from a certain lack of independence, as many of the recorded sites were located using prior models that favored well-drained areas in proximity to water and soil drainage ecotones. Thus, whether, or to what degree, the new model reflects actual patterns of past settlement or modern archaeological survey practices is unclear. The model must be tested with a random sample survey, which includes areas that are typically avoided or minimally investigated (e.g., saturated areas/wetlands). Past environmental conditions in the Forest were far different from modern circumstances, and areas that are inaccessible today were not necessarily so in the past. This is particularly true for early prehistory, when lower sea levels would have reduced wetland extent and expanded favorable drainage conditions.

In addition to probabilistic model development, this research also explored cultural and temporal variability in environmental associations and settlement location. These patterns were explored at increasing levels of resolution, from a broad historic/prehistoric dichotomy to an evaluation of individual diagnostic artifact distributions. The results of these analyses were somewhat disappointing, in that few

significant differences were found. This may be partially a result of the non-parametric statistical tests used, which involve fewer assumptions but sacrifice some discriminatory power. Alternatively this may relate to the difficulties of modeling settlement in an homogenous environment (Whitley 2006). In either case, it appears that by and large soil drainage was the primary constraining factor in past settlement. However, as Brooks and Scurry (1978; also Brooks et al. 1989; Colquhoun and Brooks 1986; Scurry 2003) point out, soil drainage conditions in the Lower Coastal Plain are strongly influenced by sea level, especially at lower elevations. Modeling the relationship of sea level, drainage conditions, and wetland extant should produce more detailed inferences of past occupation in the Forest and allow temporally specific archaeological resources to be more effectively targeted.

The analyses presented here have only begun to explore the potential of the archaeological database of the Francis Marion National Forest. In depth analyses of site assemblage composition, site function, raw material distributions, and temporally specific settlement-subsistence organization can and should be attempted in the future. The robust data generated from the Francis Marion National Forest have implications for regional archaeological problems that can profitably be explored. The lack of Paleoindian sites on the Forest is notable, as it is reflective of a trend demonstrated throughout the Coastal Plain (O'Donoughue 2007). Addressing this apparent under-utilization of the Coastal Plain requires that greater effort be directed towards locating buried deposits where Paleoindian materials are potentially preserved.

Several Archaic period research problems can be investigated with these data. Proposed organizational differences between Middle Archaic populations in the Coastal

Plain and Piedmont (e.g., Sassaman 1991) can be evaluated through detailed examination of site location, assemblage diversity, and inter-site variability. The nature and function of Late Archaic shell rings, and their relationship to interior sites is another potential avenue of research on the Francis Marion National Forest (Edwards 1965; Russo and Heide 2003). Further, the presence of both Stallings and Thoms Creek ceramics provides an opportunity to examine the adoption of pottery in the region and to resolve questions of the temporal and cultural relatedness of these wares.

Woodland ceramic typology in the vicinity of the Francis Marion National Forest includes an amalgamation of southern (e.g., Deptford, Refuge) and northern (e.g., Deep Creek, Mt. Pleasant) types. Much work remains to be done to determine if this variability is the result of past human behavior or modern typology. Examining the spatial co-occurrence of these types may help eliminate redundant ceramic types while analysis of assemblage composition can help resolve whether differences are functional, cultural, or temporal in nature.

It is hoped that the research presented in this thesis will prove useful to Forest Service personnel in land use planning and cultural resource management activities. Additionally, the robust archaeological datasets generated should provide sufficient fodder for researchers to test theories of settlement organization and land use, and further explore past occupation of the Forest. The Francis Marion National Forest has produced one of the most extensive archaeological records of any region of South Carolina. This has importance not only for localized archaeological studies, but for regional research as well. Unfortunately, as much of this data has seen limited publication in cultural resource

management reports, it has been largely understudied. This thesis has been but one step in rectifying the situation.

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Vita

Jason Michael Gerald O'Donoughue was born in Hickory, North Carolina on December 13, 1979. After several moves, he spent his formative years in Fredonia, New York before relocating to Jacksonville, Florida. He graduated from Allen D. Nease High School in 1998. In the Fall of 1999 Jason enrolled at the University of Florida, where he graduated with a Bachelor of Arts degree in Anthropology in 2004. He received his Master of Arts degree in Anthropology from the University of Tennessee in August 2008. Jason is currently pursuing a Ph.D. in Anthropology at the University of Florida.