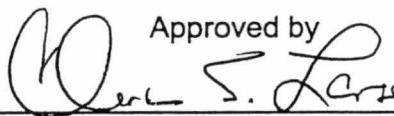


BIOLOGICAL DISTANCE AND THE ETHNOLINGUISTIC CLASSIFICATION OF LATE  
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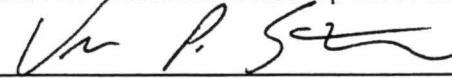
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Ann M. Kakaliouras

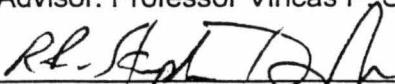
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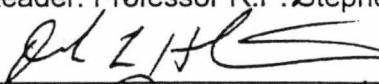
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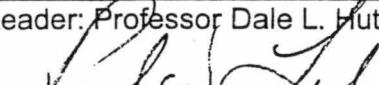
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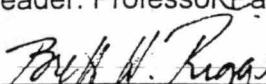
  
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## ABSTRACT

ANN M. KAKALIOURAS: Biological Distance and the Ethnolinguistic Classification of Late Woodland (AD 800-1650) Native Americans on the Coast of North Carolina  
(Under the direction of Clark Spencer Larsen and Vincas P. Steponaitis)

This dissertation is a critique and re-evaluation of the way Late Woodland (AD 800-1650) North Carolina coastal Native American people have been classified. To try to better understand the historical and cultural relationships between pre-contact Native groups and those who were described by English chroniclers in the 16th and 17th centuries, archaeologists have projected "ethnolinguistic" categories into the past, linking known groups to precontact burial sites. Based on material culture evidence and rough comparisons of skull size and robusticity, linguistic affiliations were assigned to ossuary sites pre-dating the colonial period by as much as six hundred years; burials containing long-headed individuals were classified as Iroquoian or Algonquian, and burials with short-headed individuals were categorized as Siouan. Thus, archaeologists and bioarchaeologists have envisioned North Carolina coastal Late Woodland peoples as essentially distinct from each other culturally, linguistically and biologically.

This project presents another model, dental biological distance (or biodistance), that charts interaction between burial populations from a genetic perspective using inherited

characters on the teeth. The results of this study, that no statistically significant differences exist among the North Carolina ossuary sites, indicate that while Late Woodland coastal Native North Carolinians may have been different linguistically, culturally and politically, they were not genetic isolates from each other as the ethnolinguistic model implies. Moreover, recent ethnohistoric studies suggest that kinship and other cultural practices among Southeastern Indians may have encouraged the maintenance of biological diversity across sociopolitical boundaries, mirroring the gene flow this study documented in the North Carolina coastal skeletal samples.

Further, this dissertation argues that assigning historic linguistic labels to precontact skeletal remains is methodologically incorrect bioarchaeology. Assumptions that biology and language move on the same trajectories are artifacts of developments within the intellectual history of anthropology and archaeology, especially English Enlightenment ideas about the importance of language to society, and early 20th century conceptions of the connections between race, language and culture. Archaeologists and bioarchaeologists should only posit such linkages when clear historical and material culture continuity is documented across the divide between precontact and colonial periods, for which evidence is lacking on the North Carolina coast.

## ACKNOWLEDGEMENTS

Although in this project I have closely examined a system of classification, I have not precisely catalogued every single interaction or conversation that fueled an idea, lit a conceptual fire, challenged a preconceived notion, or provided simple encouragement toward its completion. There are a few categories of thanks that I'll detail now, however, that include, broadly, my access to things, places, and the work and support of numerous people. The lesson I keep learning, though, is that all schemes of classification "work," even wrongly, to shape the ways specific people see particular parts of the world. Thus, here I reveal the way I see the sphere of support around my dissertation project -- a scheme that *should* always be open to critique and re-evaluation, but which, unfortunately, will remain static, permanently inked as it is below with all its flaws and omissions.

First, for access to osteological laboratory space and to the culturally unaffiliated skeletal collections within, I would like to thank Dr. Dale Hutchinson, formerly of East Carolina University and now of UNC-Chapel Hill, Dr. David Weaver of Wake Forest University, Drs. R.P. Stephen Davis, Brett Riggs and Vin Steponaitis of the UNC Research Laboratories of Archaeology, Dr. Billy Oliver of the Office of State Archaeology, and Scott Brewer and Rick Richardson of U.S. Marine Corps Base Camp Lejeune.

To Floyd, Pauline, and Mary Mattheis, of Greenville, North Carolina, I express my sincere thanks for taking in a close--yet distant--cousin during my research, and providing me with the most excellent North Carolina cuisine and Southern hospitality in a strangely familiar Minnesotan conversational environment. Their care made me feel very much a family member.

I'm also appreciative for the impromptu and numerous office conversations about North Carolina archaeology and bioarchaeology granted me by Dr. Joe Herbert, Dr. Dale Hutchinson, Dr. Mark Mathis (who also allowed me access to unpublished radiocarbon dates), Trawick Ward, Charles Heath, and Kristina Killgrove. The social and intellectual experiences involved in osteological data collection have always been as useful and illuminating to me as the work itself.

In terms of data collection and analysis, I would especially like to thank Dr. Mark Griffin for the use of his raw data, and his cordial replies to the emails of a very inexperienced biodistance researcher. Similarly, Dr. Guy Tasa provided critical troubleshooting help with a nifty computer program he wrote at a very critical time in my understanding of multivariate statistics.

Jan Kujawa, programmer extraordinaire, literally made the statistical analysis possible, by writing *Biodistance 1.0* (Appendix B) and helping me implement it, time and time again. His reasoned responses to my puzzled and sometimes frantic emails, and his willingness to "look it over just one more time," enabled a significantly smoother and more calm data analysis process.

For reading and commenting on fragments, chapter drafts, and all sorts of pieces and parts I principally credit two writing groups. The first, elegantly executed by Lesley Bartlett, Anne Marie Choup, and Rachel O'Toole, showed me that finishing was possible, even if I clearly wasn't ready to step in their fiery footprints. The second, with Mintcy D.

Maxham, enabled me to sprint to the end; her kind and prodding support helped to keep me going. I hope I did the same for her. Additionally, individuals who very speedily read and gave me valuable feedback on individual chapter drafts included: Melissa Bostrom, Celeste Gagnon, Malinda Maynor, Will Meyer, Rachel O'Toole, and Sara Simon.

My dissertation committee, including co-chairs Dr. Clark Spencer Larsen and Dr. Vin Steponaitis, Dr. R.P. Stephen Davis, Dr. Dale Hutchinson, Dr. Paul Leslie, and Dr. Brett Riggs, gave challenging feedback, asked the hard questions, and lent their time with productive comments. I especially appreciate Clark's detailed suggestions, and Vin's initiative to put on a technologically forward-looking defense, videoconferencing and all.

Additionally, much of this process has been about how I can learn to challenge, puzzle and aggravate my students more effectively. I thank all of them, from Human Evolution to Social Theory, for providing the same valuable service.

Although it seems that I've buried the "intangibles" here close to the end of my comments, I'd submit that the order of things isn't always the index to the rank of importance in a classification scheme. The structural support I received from professors, hosts, peers and colleagues is simply in a different category than the kind of help detailed below.

I thank my family, Marlene and Kathy Kakaliouras, for their encouragement in this strange endeavor I undertook. To my father, Ted Kakaliouras (1935-1996), you're right, the apple doesn't fall under the cherry tree. Thank you Cindy for still being you, even as my head got fatter and fatter. Thanks to Melissa Bostrom, Joy Salyers and Elaine Tola, for being the kind of girlfriends I've never had. And thanks to Catherine Francis and Mark Tripp, who enabled me to play, even perhaps when I shouldn't have. Also, since I haven't had a chance to thank them before in this way, I have to mention Cynthia Cone, Susan M.T. Myster and Barbara O'Connell of Hamline University. I still want to somehow turn out to be all three of you.

Drs. Judith Farquhar, Carole Crumley, Dorothy Holland, Catherine Lutz, Peter Redfield and Theda Perdue deserve special thanks for going out of their way to care, converse and support, even though we often communicated through veils of disciplinary confusion not necessarily of our making. Thanks to Stacey Langwick and Hager el Hadidi from my graduate cohort, who never fail to challenge my way of thinking and doing. I thank the UNC bioarchaeology women, past and present -- Liz Driscoll, Marianne Reeves, Amy Sullivan, and Tiffiny Tung, for showing me we all do it differently. I deeply appreciate Celeste Gagnon, Malinda Maynor and Rachel Watkins for their insight and unique geniuses. And, to Rachel O'Toole, how would I have finished this project without you?

Lastly, those of us who have used Native American skeletal remains to make claims about the past are deeply responsible for how, where, and why those statements resonate in the present; I will continue be mindful of my shifting place in that larger scheme.

No photographic images or representations of Native American skeletal remains appear in this dissertation.

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## **Chapter 1: Categories, classifications and interpretive implications in physical anthropology**

Recently, physical anthropologists have engaged in critical and fruitful arguments regarding the classifications of human remains. While all the social sciences classify, categorize and label people and institutions on political, economic, religious, ethnic, and cultural scales, physical anthropology is the only social science that has the distinction of classifying humans and human ancestors biologically. When we require in our basic courses that students know the difference between *Homo sapiens neanderthalensis* and *Homo neanderthalensis*, for example, we do not simply invoke a taxonomic quibble; we also point to contentious and complex ways of understanding the very label "human." Our interests in these distinctions are grounded in over a century of fossil collection and analysis, and span Virchow's late nineteenth-century misdiagnosis of the first Neanderthal as a pathological specimen (Trinkaus and Shipman 1992), to beyond the first publication of DNA sequences from the very same fossil (Krings et al. 1997). The energetic debates among paleoanthropologists over the taxonomic position of the Neanderthals come to a head annually at the national physical anthropology conference, as presenters advance new re-classifications and interpretations of the Neanderthal fossil evidence.

Similarly, recent challenges to the validity of the physical anthropological technique of determining race from skeletal remains also underscore the importance of how and what we classify to our methodologies and interpretations (Goodman 1997). Over the past few decades, most anthropologists have recognized that race is not a valid biological category, and that its social power, not its biological consistency, informed the construction of human racial taxonomies up until the 1960's (AAA 1998). In addition, Goodman found that one of the most frequently used discriminant functions for osteological racial classification works as well as randomly assigning races to a group of skulls (1997:22). Yet osteologists are still trained to determine the "race" (now called "population affinity" in many class contexts) of an individual skull from its morphological and metric attributes, though the actual techniques are now most frequently used in forensic anthropology (Gill and Rhine 1990, Myster personal communication 1996, Sauer 1992). Forensic researchers have argued that they are constrained by the social use of racial categories in the criminal justice system, which forces them to label individual skeletons as "black" or "white," for example (Gill 1998:294). Goodman's (1997) compelling interrogation of this usage in forensic anthropology largely goes unheeded by physical anthropologists who are also forensic practitioners; they generally believe that the value of their public service outweighs these sorts of methodological and classificatory issues (Gill 1998).

From paleoanthropology to paleopathology, though, physical anthropologists insist on employing rigorous naming schemes for skeletal and biological conditions based on human evolutionary and behavioral processes. In bioarchaeology, for example, we use specific chemical markers on the skeleton to determine whether a certain past human group was hunter-gatherers, agriculturalists or even intensive agriculturalists (Cohen and Armelagos 1984, Larsen 1997). Likewise, basic osteological data collection requires placing skeletal individuals into biological sex and age categories, ones based on developmental stages that osteologists have slowly standardized over the last half-century to help prevent interobserver error and maximize comparability across populations (Buikstra and Ubelaker 1994). These and other classification issues continue to be discussed and debated in physical anthropology.

Physical anthropologists no longer employ or produce scholarly research addressing certain biological categories, however, such as race and other strictly typological classification systems. Paleoanthropologists and paleolithic archaeologists have refined the ways in which they observe morphology and archaeological context, so that the chances that fossil Neanderthals would be put in the same category as individuals afflicted with rickets, as Virchow did over a century ago, are extremely low. Moreover, bioarchaeologists do not form taxonomic research hypotheses that make racial classification their only goal.

This dissertation is a bioarchaeological examination and re-evaluation of such a classification scheme, one that uses skeletal morphology as an independent index for linguistic and cultural identity on the Late Woodland (AD 800-1650) North Carolina coast. Many North Carolina archaeologists believe that the skeletal remains from Late Woodland ossuaries can be assigned a language group based on their size. Long, large skulls are thought to be Algonquian or Iroquoian-speakers, and small, short skulls are considered Siouan-speakers (Loftfield 1990, Phelps 1983, Herbert and Ward personal communications 1997). This "ethnolinguistic" model links colonial accounts of language groups on the coast with material culture and skeletal type, thereby projecting categories created in the 17th century eight hundred years into the past, to the beginning of the Late Woodland period (AD 800). While this synonymy has allowed researchers to construct culture areas for Late Woodland groups, I argue that the correlations between skeletal remains and historic linguistic affiliation are specious, have been applied inconsistently, conflict with material culture evidence, and employ an antiquated and inappropriate physical anthropological methodology.

Additionally, to further expand research possibilities I constructed a model for understanding relationships among precontact groups on the North Carolina coast, one that uses heritable traits on the teeth to estimate genetic distance. I collected data on over 40 dental traits from 13 coastal ossuaries and statistically compared the patterns of traits with

each other to see how similar or dissimilar each ossuary was from every other in the coastal region. I also compared the patterns from the North Carolina coast to those computed by Griffin for sites in Florida, Georgia and western North Carolina (Griffin et al. 2001) to place the North Carolina coastal groups in regional perspective.

The methodology this dissertation uses, called biological distance or "biodistance," is based on the premise that groups who show similar dental trait patternings will be more closely related to each other than groups who do not (Scott and Turner 1997). Biodistance has been employed on many different scales--to track worldwide population history, construct regional population profiles (as in this dissertation), and to elucidate familial relationships and residence patterns (Greenberg et al. 1986, Griffin et al. 2001, Lane and Sublett 1972, respectively). Biodistance is a relative measure of how the people represented in skeletal samples may have been sharing genes with each other; thus, the method charts interaction but does not in and of itself construct cultural taxonomies from skeletal remains.

#### **Scales of analysis I: Ethnolinguistic classification on the Late Woodland North Carolina coast**

Systems of classification are designed to articulate with specific scales of analysis. The competing taxonomic designations *Homo neanderthalensis* and *Homo sapiens neanderthalensis*, for example, are part of the well-known binomial scheme that Carolus

Linnaeus, the late-18th-century Swedish botanist, constructed to categorize all life on the planet. Likewise, the ethnolinguistic categories applied to Late Woodland North Carolina coastal groups are part of a larger system that 19th- and early-20th-century anthropologists believed worked on a worldwide scale. Deriving them first from racial, then ethnic, groupings, skeletal biologists used cranial morphology to order sets of biological “types,” which were compared to each other across the world and from different periods based on notions of purity, migration and the resulting admixture of original types (Lieberman 2001 and see Chapter 3).

North Carolina coastal archaeological literature, however, presents comparisons among crania in a way that obscures the wider historical context and intended scope of the ethnolinguistic model. Authors construct comparisons of North Carolina coastal skulls to types developed by Aleš Hrdlička (1916) and refined by Georg Neumann (1950, 1952), without explaining the hemisphere-wide context in which these types were designed to fit (i.e., Coe et al. 1982). That is, Hrdlička and Neumann correlated modern and historic Native American ethnic groups throughout North and South America with skull shapes and sizes from archaeological sites, and gave the categories type names, such as Otomid, Lenapid, Iswanid and Walcold. In this model, select North Carolina skulls have fallen into two of the eastern American categories: dolichocephalic (long-headed) Lenapids and brachycephalic (short-headed) Iswanids (Coe et al. 1982). To connect cranial dimensions

and type categories to linguistic affiliation, it was assumed that Algonquians were generally larger and more robust than Siouans, or that “physical differences” existed among the three language groups on the coast in the Late Woodland period, thus leaving the origins and significance of these differences uninvestigated (Loftfield 1990, Ward and Davis 1999: 210). Furthermore, as will be explained in Chapter 2, causal evidence between the skeletal traits and cultural characteristics is not provided.

This larger context around the ethnolinguistic system is missing from the archaeological literature. Such omissions, however, do not happen through willful ignorance or academic neglect. Rather, archaeological and bioarchaeological concerns have not articulated well with each other in the study of this region. Archaeologists have focused on identifying the precontact coastal people, the differences between their material technologies, and how they, as discrete groups, may have been linked to other contemporaneous peoples and to postcontact groups (e.g., Coe et al. 1982, Loftfield 1976, 1990, Phelps 1980, 1983, South 1976, Ward and Davis 1999). Previous physical anthropological and bioarchaeological studies of the North Carolina coast, however, were largely focused on paleopathology, specifically on the role of endemic syphilis (or treponematoses) in precontact North American life (e.g., Bogdan 1989, Bogdan and Weaver 1989, Piggot 1995), and on health and status differences within a single burial context (i.e., Driscoll 1995, Kakaliouras 1997). These parallel research interests have not been

integrated in order to consider whether the ethnolinguistic categories used to imagine the Late Woodland period on the coast present a valid system for interpreting skeletal or archaeological evidence.

Another aspect of this dissertation, then, is the elucidation of the historical precedents of the current ethnolinguistic system. The ethnolinguistic categories function to sort skulls by size, but do not accurately describe the people we seek to name. Further, the categories currently being used are a microcosm of a larger classification system that physical anthropologists and bioarchaeologists have since rejected for its conflation of cultural and biological traits, and its lack of evolutionary and adaptational perspectives (Armelagos et al. 1982).

### **Scales of analysis II: Biological distance and worldwide population history**

Dental biological distance, similar to the global orientation of earlier typological physical anthropology, has been employed to investigate past population movements and present relationships on a worldwide scale (i.e., Scott and Turner 1997). Studies from around the globe, using both archaeological and living populations, have allowed researchers to construct broad nonmetric trait categories, or those suites of traits most likely to occur in various populations, such as Turner's "Sunadont" and "Sinodont" dental divisions of Asian peoples (e.g., Turner 1985, 1987). Dental morphological data, in concert with

ancient DNA and other biological lines of evidence, have also contributed to theories regarding the peopling of the Americas (Crawford 1998). The consciously taxonomic purposes to which biodistance has been marshaled are useful templates for biological studies at more regional scales, such as the precontact American Southwest (Scott 1973) or Southeast (Griffin 1993).

Yet it is important to consider that biological distance is a direct measure of human morphology and genetic relationships, and only an indirect source for piecing together patterns of culture, ethnicity or language in the present or the distant past, especially at the regional level. Culture and expressions of culture, such as archaeological materials, may move on different trajectories themselves (Herbert 2002, Terrell 2001). Biological relationships, too, can differ and change through time in their own distinct ways, ones that do not articulate smoothly with cultural or linguistic divisions.

Those dental biodistance studies which have purported to successfully link cultural, linguistic and biological populations, then, have usually focused on population history and migration patterns on a global scale (Greenberg et al. 1986). Other historical linguists though, chafe at Greenberg et al.'s broad and deterministic conclusions, that all Native American groups fit into three major biological-linguistic categories:

A single language can be spoken by a genetically and/or culturally diverse community; a culturally and/or genetically homogeneous population can speak more than one language. That is, language shift and multilingualism are facts of linguistic (and cultural) life; genes neither cause nor cater to them [Campbell 1986:488].

That is certainly not to say that biology and culture never correspond in ways that can be documented by anthropologists, or that careful use of archaeology and historical analogy cannot assist in identifying distinct precontact cultures (Hudson 1978, Jones 1997, Perdue and Green 2001). To assume that a biodistance analysis will sort out linguistic or cultural relationships, however, is to fall into a well-worn conceptual trap in anthropology--that past (and indigenous) cultures always possessed inner coherence, and that biological differences are the natural markers delineating one culture from another (Sider and Smith 1997:5-7).

Physical anthropologists, whether they are paleopathologists, bioarchaeologists or biological distance researchers, always work in relation to and with an awareness of the range of biological variation present in the human species as a whole. Correspondence between biological, cultural and linguistic patterns of variation in past and modern populations, though, must be proven, and not a priori assumed. Especially when addressing questions of archaeological and historical significance regarding relationships between human groups, bioarchaeologists are regional specialists in similar ways as archaeologists. Thus, we need to separate our broadly taxonomic and global perspectives from our regionally-specific research orientations. This project endeavors to accomplish that goal by considering both regional archaeological and ethnohistoric lines of evidence in the re-evaluation of the North Carolina Late Woodland coastal ethnolinguistic categories and in the interpretations of the dental biodistance analysis.

### **Scales of analysis III: Population affinity and biological distance in historical perspective**

Until the middle of the 20th century, physical anthropologists who worked with archaeological materials commonly used basic differences between skull and skeletal size, in particular the difference between longheadedness and shortheadedness, to sort skeletal populations (e.g., Hrdlicka 1916, Morant 1925, Neumann 1952). That is, independent of archaeological and adaptational context, skeletal samples were labelled as one cultural group or another based on their cranial morphology, much as Late Woodland North Carolina coastal groups are classified. As skeletal biologists and bioarchaeologists shifted their research questions toward addressing morphological difference across regions and change through time in the 1970's and 1980's, this classification method changed. Skull and skeletal size were no longer employed as markers of cultural difference, but as signs of biological affinity and shifting behavioral adaptation (Jantz 1981, Molto 1983).

Within the fields of bioarchaeology and skeletal biology there is a schism between those researchers who prefer dental and cranial nonmetric traits (Armelagos et al. 1982, Turner 1987) for constructing biological population profiles, and those who prefer cranial metrics for the same purpose (Sparks and Jantz 2002). Each camp argues that its evidence base is heritable, not environmentally plastic, and reliable in making sample- or population-level discriminations between skeletal populations. Though researchers who use cranial metrics for the classification of individual skulls are often critiqued for relying on an older,

race-based dataset (Armelagos and Van Gerven 2003, Leathers et al. 2002), the differences between modern biological distance studies--whether they use nonmetric or metric data--and the cranial comparisons of the early and mid-20th century, represent a broader gulf than do the current arguments between biodistance researchers.

Recent advances in the study of cranial morphology do not simply increase the quantity of measurements and hone statistical methods. Rather, a focus on the population as the unit of analysis, population genetics, and evolution and adaptation place craniometry, broadly, in the same category as nonmetric biodistance, with the same inherent methodological weaknesses. Each evidentiary base, cranial metrics or dental nonmetrics, may be used in two central ways by a researcher to make arbitrary decisions about what constitutes an archaeological population, or to consciously or unconsciously replicate the taxonomies constructed by "skull scientists" such as Samuel Morton (1839, 1849 and see Bieder 1986), or the types and varieties defined by Hrdlička (1916) and Neumann (1952).

The first researcher decision is analytically pooling samples across long periods, which can erase important evolutionary and adaptational changes. The second is assigning a historic cultural label to a precontact burial sample, and then pooling samples across regions assumed to be in the range of that cultural label; often, historical cultural categories represent colonial creations that cannot be projected into the precontact period (e.g., Perdue and Green 2001). Thus, researchers' decisions distinguish between participating in the

construction of ahistorical taxonomies or articulating their data consistently with archaeological and ethnohistoric sources.

With these issues in mind, this study employs dental nonmetric traits to create research findings that are comparable to previous regional biodistance studies in the Southeastern United States (i.e., Griffin et al. 2001). Additionally, since the burial contexts of the Late Woodland North Carolina coastal skeletal samples in this study are all ossuaries, the samples have not been pooled across regions (i.e., inner coast, outer coast and southern coast) so as to not pre-determine the variation in the samples. Since one of the claims of the adherents to the ethnolinguistic system is that it is possible to look at the skulls from a single ossuary to determine its cultural affiliation (Ward personal communication 1996), this project compares ossuary samples to measure the interaction between the sites.

#### **Scales of analysis IV: Regional biodistance, ethnohistory, and archaeology**

While bioarchaeological work in the Southeast has run the gamut from strictly paleopathological (e.g., Bogdan 1989) to more comprehensive research on Native lifeways and concern for cultural and material changes through time (e.g., Lambert 2000), biological distance specifically has not been a prominent avenue for lifeway reconstruction in the Southeast, save one prominent example (Griffin et al. 2001). Recent ethnohistoric and archaeological work, however, can both contribute to and be informed by a biological distance that is focused on measuring interaction between groups.

For example, Griffin and coworkers' (2001) biodistance study documented a "bottleneck" between two historic cemetery samples at Spanish missions in Florida and Georgia, suggesting that disease and the cultural disruption of the *réduccions* also caused significant genetic changes in the mission populations, along with other biological changes observed by Larsen and coworkers (Larsen 1982, 1990, Larsen et al. 1990, Larsen 2001, Larsen et al. 2001). Griffin also established that a sample of pre- and postcontact groups in the Southeast were not necessarily biologically continuous populations (Griffin et al. 2001:252-253).

This kind of regionally specific biological distance research connects well with the newer archaeological and ethnohistoric studies focused on the American Southeast. Older studies of precontact Native American groups and cultures took a classificatory approach, typically charting the paths of specific historic ethnic groups and attempting to place them in a cultural context across the pre- to postcontact divide (e.g., Feest 1978, Mooney 1916, Mook 1944, Swanton 1946). More recent archaeological and ethnohistoric work has followed a different interpretive and research tradition, one that focuses on Native American worldviews and incorporates Native people into both pre- and postcontact political milieus, making them integral actors in the formation of the colonial Southeast (e.g., Ethridge and Hudson 2002, Hudson 1978, Galloway 1997, Gleach 1997, Perdue 1979, 2002, Riggs 1999, Rountree and Turner 2002).

One of the significant contributions of the above ethnohistoric work is a deeper appreciation of the role kin groups, or matrilineal and patrilineal lineage systems, played in the cultural and political lives of many Southeastern Native Americans, from before European contact to well into the colonial period. Membership in a strong lineage was an important marker of personal and group identity, and these familial groups often used marriage alliances to cement trade and political relationships, regardless of the race or ethnic identity of the person marrying into the lineage (i.e., Perdue 2002). Because biological distance can estimate how people interacted with each other genetically, it is possible that the kind of regional gene flow Griffin (1993), Killgrove (2002) and this project documented is material substantiation of the political and familial choices Southeastern people were making during the Late Woodland period.

#### **Scales of analysis V: The Late Woodland North Carolina coast**

The North Carolina coast is a fascinating and complex region with regard to both colonial and precontact Native American studies, principally because of its position as a space between other political and cultural centers. As a decidedly "Woodland" area, between Mississippian and powerful chiefdom cultures to the west, south and north respectively, the North Carolina coastal peoples maintained their technological and material cultural continuity up until contact with Europeans. As a diverse linguistic region, the North

Carolina coast was the confluence of three major Native American language families, yet it was the center of none of them. Additionally, during the colonial period the North Carolina coast was the geographic space between Jamestown and Charlestown, the southernmost extension of English influence in the contentious borderland between the English colonies and Spanish *La Florida*.

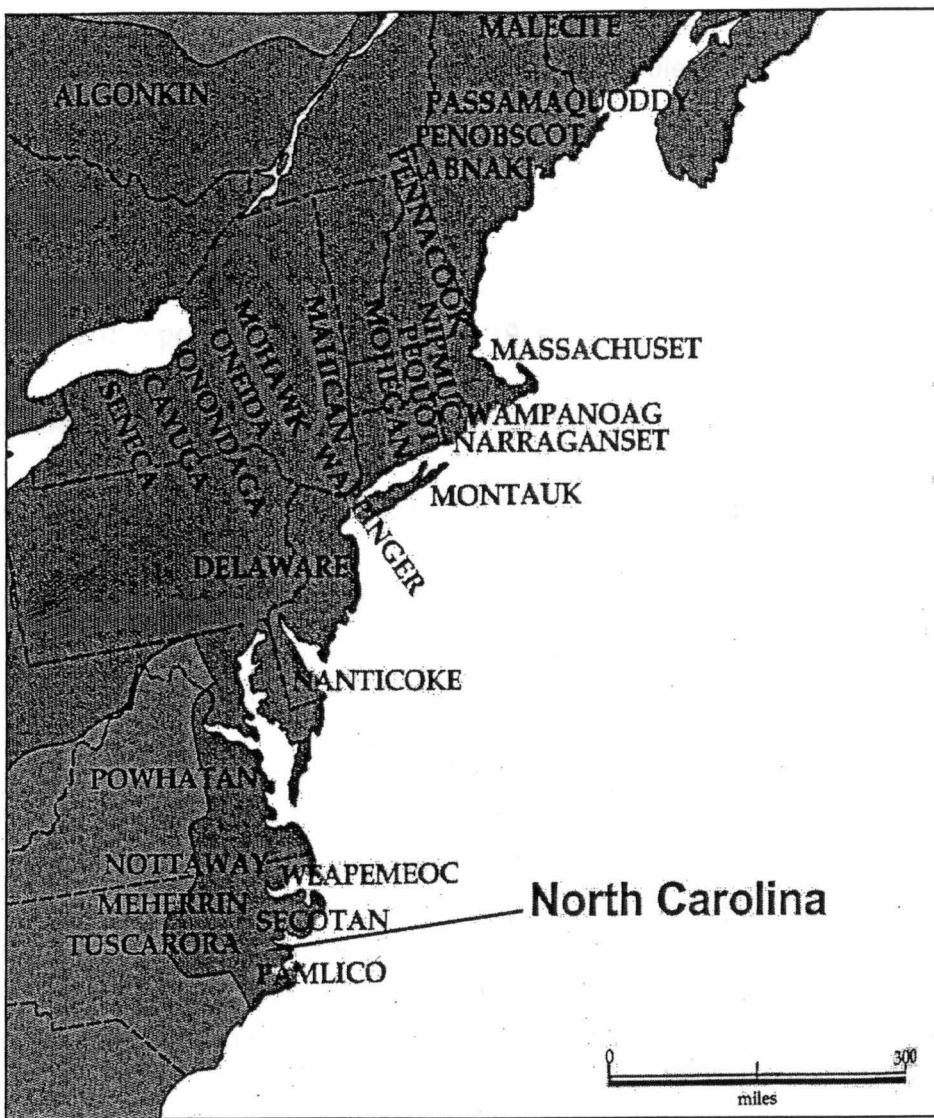
The Mississippian culture that dominated other areas of the Southeast from approximately AD 900-1300 was absent on the North Carolina coast. Mississippian iconography, architecture, and traded materials, such as shell gorgets, ornate earspools and stone axes, never gained favor among North Carolina coastal groups (Larson 1989, Phelps 1983). Throughout the period when mound centers flourished to the south (Coe 1995), and when--a few hundred years later--large settlements thrived in what is now northern South Carolina (DePratter 1983, 1986, 1994), the North Carolina coast remained a place where people organized themselves in smaller towns, some of which were fortified beginning around AD 1300 (Ward and Davis 1999).

Moreover, the matrilineal chiefdoms in southern Virginia, more widely known by the colonial period as the Powhatans, exerted their influence on some northern North Carolina groups (Mook 1944, Potter 1993), but apparently most of the coastal region remained independent of these larger political units. It is probable that the northern outer coast was similar politically and culturally to coastal Virginia, consisting of influential matri-lines that

organized themselves into clans; none of them, however, have become well-known in the historical or archaeological record as such.

Similarly, while at least three Native American linguistic families were spoken on the North Carolina coast--Siouan, Algonquian, and Iroquoian--the regional centers for Algonquian and Tuscaroran Iroquoian were located much further north, in New York, Pennsylvania and in the Northeast as a whole. A version of Siouan was spoken on the southern coast and in northern South Carolina, but this language originated even further north and west, in the Upper Midwest and on the Plains (Campbell 1997, Mithun 1999). This nexus of linguistic diversity is unique on the Eastern seaboard. In fact, in some sources on precontact Native American cultures, the North Carolina coast is included as part of a "Northeastern culture area" based on its language configuration, rather than as a part of the Southeast (Figure 1.1)

Another complicating (and related) factor for archaeologists with regard to interpreting the Late Woodland North Carolina coast is evidentiary in nature. Few historical and ethnohistorical works have focused on North Carolina coastal Native American people, either in colonial period or precontact contexts. Notably, Maurice Mook published "Algonquian Ethnohistory of the Carolina Sound" in 1944, and John Swanton included North Carolina coastal groups in his 1946 tome on Southeastern Indians. The next ethnohistoric work, however, to use different primary source documentation (previously uninterpreted



**Figure 1.1.** Coastal North Carolina as part of a Native American "Northeastern Culture Area," (Waldman 1985: 32).

court records) and to center on Native coastal peoples, is Kristen Fischer's *Suspect Relations: Sex, Race and Resistance in Colonial North Carolina* (2002). Though North Carolina archaeologists have called the coast the "least studied" and most poorly understood region of the state (Phelps 1983:1), there is actually much more published and synthesized archaeological work on coastal Native American groups than there is history or ethnohistory (Perdue personal communication 1999).

Because of the scarcity of coastal North Carolina Native ethnohistory, archaeologists and bioarchaeologists have generally used the summaries published in encyclopedic works such as *Handbook of North American Indians* (Feest 1978) or *The Indians of the Southeastern United States* (Swanton 1946) as their historical sources. Yet these and other "traditional" historical works have been challenged by ethnohistorians because of their uncritical acceptance of colonial categories and classifications (i.e., Galloway 1997). Alternatively, North Carolina archaeologists and bioarchaeologists have delved straight into the primary sources, principally Thomas Hariot's (1590) and John Lawson's (1709) accounts, which include impressions of the Native people with whom the chroniclers met and interacted. While the Hariot and Lawson travel accounts are rich sources of historical information, they are also fraught with the cultural biases of their authors (Fischer 2002, Perdue and Green 2001). These constraints have made drawing sure links between the colonial and precontact periods a decidedly difficult endeavor. This study will use historical

and ethnohistorical sources as they relate to the North Carolina coast with these caveats in mind, and without relying on earlier historical classifications to categorize ossuary sites, thereby creating cultural relationships from burial populations.

### **A measure of interaction**

This dissertation uses dental biodistance to estimate how coastal North Carolina Late Woodland groups interacted with each other. This framework for understanding genetic relationships between skeletal samples is a significant departure from the ethnolinguistic categorization system to which North Carolina archaeologists have previously subscribed. Biodistance can be used in conjunction with a number of populational and classificatory scales, but the methodology of this study fundamentally differs from the previous ethnolinguistic model. In this project, biodistance estimates interaction, rather than constructs cultural groups out of skeletal samples.

To begin the analysis, Chapter 2 surveys current archaeological knowledge about the Late Woodland North Carolina coast and highlights how ethnolinguistic classifications have impacted our interpretations of interaction in the past. Often, the language-biology linkage made by North Carolina archaeologists has conflicted with material culture evidence, leading to depictions of Late Woodland cultures as static and closed systems, a conclusion I believe we should be reluctant to draw.

Chapter 3 is an investigation of the underpinnings of the ethnolinguistic model. This chapter traces the history of the links between language and culture in interactions between Native Americans and English colonists, and also critiques the conflation of culture and biology characteristic of early and mid-20th-century physical anthropology. Neither of these previous conceptions of Native American people are consistent with modern bioarchaeology's population and context-specific focus.

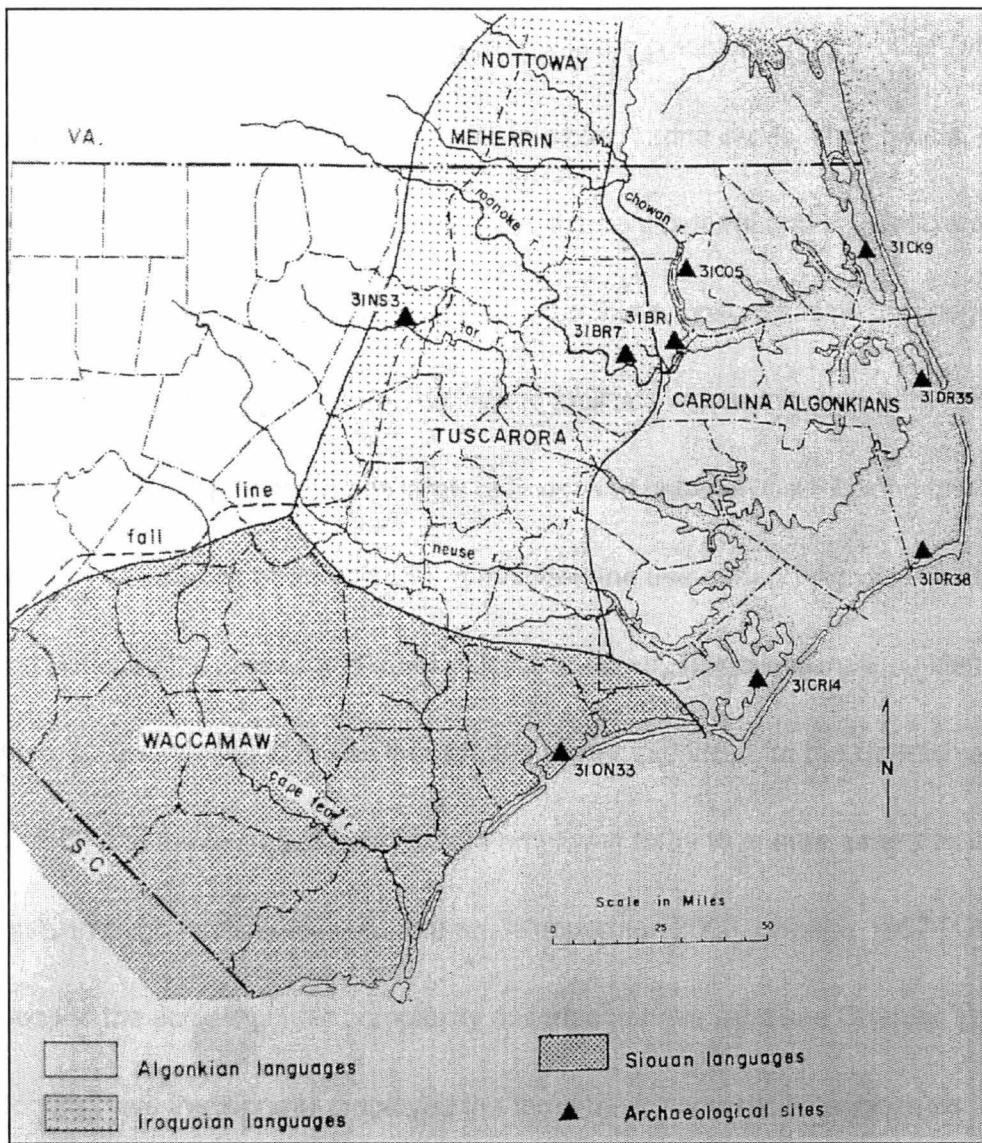
Chapter 4 outlines the materials used to examine genetic relatedness between groups on the Late Woodland North Carolina coast. This chapter discusses the North Carolina coastal ossuary tradition and describes each ossuary site and sample. In Chapter 5, previous biodistance research in the American Southeast is reviewed, the theoretical and historical foundations of biological distance research are presented, and the statistical models used to construct the sample comparisons are detailed.

Chapter 6 is an exposition of the results of the Late Woodland North Carolina coastal biodistance analysis, as well as a presentation of the results from the regional comparison with other Southeastern skeletal populations. Lastly, Chapter 7 includes interpretations of the biodistance analysis based on comparisons with other recent studies, considerations of how these results are informed by recent ethnohistoric source material, and directions for future bioarchaeological research.

## **Chapter 2: Ethnolinguistic categories and the archaeology of the Late Woodland North Carolina Coastal Plain**

The Late Woodland North Carolina Coastal Plain is viewed as a region marked by distinct cultural and linguistic areas; these differences have been defined by synthesizing colonial linguistic and ethnohistoric accounts (Mook 1944, Lawson 1967 [1709]). In the late 16th and early 17th centuries, Spanish explorers, then later English colonists, made their way into the coastal and piedmont regions of what is now North and South Carolina. Historical studies of these interactions have confirmed that the many Indian groups European colonists encountered on the North Carolina coastal plain spoke languages from three main families—Algonquian, Iroquoian, and Siouan (Campbell 1997, Mooney 1894, Swanton 1946). Algonquian-speaking groups were found along the central and northern coast up to the border with Virginia, Iroquoian-speakers occupied the northern inner coastal plain, and Siouans were encountered in the southern coastal region (Figure 2.1).

Political structures and interactions between these broad linguistic groups, however, were more complex and not necessarily based on the language differences (Hudson 1978, Loftfield 1990). Even within the three major language categories, historical linguists have documented that various dialects were mutually unintelligible (Campbell 1997, Gray 1999).



**Figure 2.1.** Ethnolinguistic culture areas on the Late Woodland North Carolina Coastal Plain. “Carolina Algonkians” = Algonquian linguistic area. “Tuscarora” = Iroquoian linguistic area. “Waccamaw” = Siouan linguistic area (modified from Phelps 1983:37).

Additionally, aggression between coastal Algonquian chiefdoms in southern Virginia and smaller Algonquian-speaking groups on the northern coast of North Carolina was common before Europeans arrived, and it persisted apace into the colonial period (Potter 1993).

Trade networks existed which enabled people to move marine shells, shell beads, copper, pottery vessels and other items widely across the different cultural and linguistic areas (Phelps 1983). Further, historians have documented that a system of sign language was in use before and at the time of European contact to facilitate communication between people who spoke different languages across large regions, and between neighboring towns who could not understand each other verbally. It included the use of hand signals, knotted strings and various gifts of food and other objects to convey basic information (Merrell 1989). Also, bi- and tri-lingual Indian interpreters were not difficult for the Spanish and English to find, and these Native people were employed to try to ensure safer passage for the colonists through terrain unknown to them (Kupperman 2000, Lawson 1967 [1709]).

Despite the sociolinguistic complexity described above (and see Chapter 3), archaeologists have traditionally employed the three basic linguistic categories as benchmark designations for the construction of ceramic chronologies, the interpretation of settlement patterns, the description and understanding of human morphological differences, and the representation of culture contact and change on the North Carolina coastal plain stretching as far back in time as AD 800. Until recently, the geographical boundaries set for

these groups in the Late Woodland period have been seen as fixed zones where some interaction may have taken place, but not enough to significantly affect the cultural, material, or even physiological development of these linguistic populations (Phelps 1983, Ward and Davis 1999, Herbert, Mathis and Oliver personal communications 1998).

The central difficulty with this ethnolinguistic model, from a bioarchaeological point of view, is that archaeologists attribute untested skeletal characteristics to the different language groups, specifically drawing linkages between cranial size and form to linguistic, and therefore cultural affiliation. The next chapter will argue that the ethnolinguistic model used to understand Late Woodland coastal Native North Carolinians is, theoretically speaking, a two-layered construction. The first is a projection of a post-Enlightenment English perspective regarding language on Native people, and the second is the use of a typological and comparative approach characterizing late-19th and early-20th-century anthropology. Both of these perspectives have been adopted by archaeology and physical anthropology at different times to understand relationships between ethnic or racial groups in the past. Independent of specific bioarchaeological and theoretical critiques, though, the influence of this ethnolinguistic model on the formation of archaeological theory and interpretation in this region cannot be understated, as is demonstrated in the following discussion of current archaeological understandings of the North Carolina coastal plain.

## **Late Woodland North Carolina coastal archaeology**

David Phelps (1983) outlines three ceramic phases for the Late Woodland period on the coastal plain, corresponding with the three language groups observed during the colonial period: the Colington phase, associated with Algonquian-speakers along the northern coast up to the border with Virginia, the Cashie phase, associated with Iroquoian-speakers of the northern inner coastal plain, and the Oak Island/White Oak phase, associated with the Siouan language family, in the southern coastal region.

Phelps describes the ceramic assemblage for the Colington phase as a shell-tempered ware with decorated rims, and the sites are commonly associated with large ossuaries containing generally robust individuals and few burial goods. The Cashie ceramic series includes vessels tempered with pebbles and sand that often exhibit rim designs. Phelps posits extensive trade between these groups, though he leaves the possible nature of such trade unexplored. The Oak Island/White Oak-phase ceramics (there is no difference between the two nomenclatures) that Phelps associates with the Siouan group are defined generally by shell-tempered ware, with cord-marked and simple stamped varieties. The character of Siouan-affiliated sites is still largely unknown, but Phelps suspects the burial mode would be similar to the Colington-phase burials (Phelps, 1983).

All three of these archaeo-linguistically defined groups exhibit ossuary burial patterns (presuming with Phelps that Siouan sites would be similar to Algonquian in this regard); few primary interments have ever been documented (Ward and Davis, 1999). Phelps describes

the Colington and Cashie-phase ossuaries as "local variants of the same basic cultural tradition," based on the mortuary feature that Colington-phase ossuaries are often large mass burials including up to 60 people (based on current osteological methodology, the largest single Colington-phase ossuary has been shown to have contained 134 individuals [Hutchinson 2002]). Cashie-phase ossuaries are more sparse secondary bundles that, because of their smaller size, "represent family rather than community burials" (Phelps 1983:46).

Burial sites that are associated with the Colington phase (Algonquian) include the Baum site (31Ck9), the Flynt site (31On305) and the Camp Lejeune site (31On309) (Driscoll 1995, and see Figure 2.2). Phelps also designates the Piggot site (31Cr14) as representative of the Algonquian form of ossuary (Phelps 1983, Truesdell 1995). Skeletal groups associated with the Cashie (Iroquoian) phase designation include San Souci (31Br5) (Bogdan 1989) and Jordan's Landing (31Br7) (Phelps 1983). The Siouan evidence for ossuary burial is the most sparse, with archaeologists only linking the Cold Morning site (31Nh28) and McFayden Mound (31Bw67) to this tradition (Coe et al. 1982).

In a more recent synthesis of archaeological work on the North Carolina coastal plain, Ward and Davis (1999) depart from Phelps's more strict characterizations of the three language groups by focusing their analysis on the ceramic phases present during the Late Woodland period. They also underscore the differences between the three cultures, ones



**Figure 2.2.** Late Woodland coastal North Carolina ossuary sites mentioned in the text (originally drawn by Susan Brannock-Gaul and used with permission from Dale Hutchinson [2002: 20]). Site key: 31Br5/Sans Souci, 31Br7/Jordan's Landing, 31Bw67/McFayden Mound, 31Ck9/Baum, 31Cr14/Piggot, 31Cr218/Broad Reach, 31Nh28/Cold Morning, 31On305/Flynt, 31On309, Camp LeJeune

that continued into the colonial period, by drawing numerous links between the archaeological and ethnohistoric evidence. They note, similar to Phelps, that shell-tempered pottery wares correspond with Algonquian occupations, while pebble-tempered wares are found at Iroquoian sites. However, diverging from Phelps's earlier work, they suggest the pottery of the Siouans, based on the current available evidence, follows the pattern of the Iroquoians who lived close to them on the interior coast. Similarly, they suggest that the Siouans living on the outer coast made shell-tempered pottery similar to that of their Algonquian neighbors.

As described by Ward and Davis, Colington-phase settlements were organized similarly to those of the more well understood Algonquian chiefdoms to the north in Virginia (Potter 1993). Unfortunately, the situation is as it was in 1983 when Phelps published his synthesis; no Colington-phase villages have been found archaeologically to provide credence to these assumptions. At the time of European contact, however, English surveyors produced descriptions and drawings of Algonquian villages located in North Carolina that corresponded to the patterns observed both archaeologically and historically in southern Virginia (Ward and Davis 1999, Potter 1993). Early English explorers of the 1584-1587 Raleigh expeditions described two different Algonquian village organizations in the northern coastal region (Hariot 1590, Hulton 1984). Watercolor drawings depict one village, Pomeiock, located on the mainland side of the Pamlico Sound near Lake Mattamuskeet, as

a tight cluster of eighteen longhouses surrounded by a stockade with an open central plaza. A second village, Secoton, located on the south bank of the Pamlico River, was drawn and described as a more open settlement of longhouses aligned along a wide central path, with a few other small structures scattered between what appear to be corn fields and stands of woodland (see Ward and Davis 1999:214-215 for these illustrations). At the time of European contact the Algonquians were organized into ranked societies, each having a hereditary ruler who lived in what the people considered the primary village of the governed territory. The towns were built primarily on major waterways, where people practiced a range of subsistence activities, including farming, fishing, hunting and gathering, and shellfish collection; distinct, perhaps seasonally used, shell-fishing sites have been reported as well (Phelps 1983:39).

Ward and Davis theorize that the population increase and aggregation that spanned much of the Late Woodland period led to the development of the types of large settlements in North Carolina that would have exhibited the two classic Algonquian traits: longhouses and large ossuary burials. The lack of direct evidence for the former, however, before European contact is a continuing problem for the reconstruction of Colington-phase culture.

Colington-phase ossuaries, though, have been well documented throughout the outer coastal plain. They typically contain 30 to 60 individuals and very few artifacts, with all ages and both sexes mixed indiscriminately throughout the burial pit (Hutchinson 2002,

Loftfield 1990, Phelps 1983). Archaeologists theorize that before burial the dead were placed in charnel houses or other structures reserved for that purpose, and then periodically individuals or groups were removed for permanent burial. Some evidence for this interpretation is found in the ossuaries themselves, where excavations have found some skeletal individuals partially or completely articulated within the pits (that is, there would have been some flesh remaining to preserve the correct anatomical positions of the bones), and other ossuaries are seemingly random jumbles of remains. These patterns suggest that some time passed from death to placement in a burial. So far there is no material evidence suggesting how long individuals were kept in above ground locations, or whether there was any differential treatment of remains based on gender, age or status in these potentially socially stratified communities.

The ossuaries of the Cashie phase (corresponding to Iroquoian-speaking peoples in the literature), as described above, are markedly different, and are considered ossuaries simply because they contained more than one individual. Ward and Davis note, like Phelps, that Cashie-phase ossuaries typically contain two to five distinct individuals who, after the flesh was removed from the bones, were placed in the pits in tightly organized bundles (Ward and Davis 1999). Additionally, while Colington-phase ossuaries rarely contained artifacts, all but one Cashie-phase burial has produced Marginella-shell beads in amounts

from 200 to 2,000 (Hutchinson 2002, Ward and Davis 1999). This difference in burial custom remains poorly understood.

Most of the other information regarding people of the Cashie phase comes from a single site, Jordan's Landing (31Br7), located on the north bank of the Roanoke River in Bertie County. Excavations conducted by East Carolina University spanning a number of years have established that the Cashie-phase communities who inhabited this site practiced a mixed foraging and farming subsistence strategy. Corn and beans were grown, and deer, turkey and other animals were hunted and then processed at the site. Fish from the river nearby were also a key resource for the people at Jordan's Landing throughout its Late Woodland occupation (Byrd 1997, Ward and Davis 1999).

It is in their discussion of the White Oak (or Oak Island) phase that Ward and Davis' volume diverges the most from Phelps' earlier view of the southern coast. While Phelps indicated that the White Oak phase should correspond directly with the cultures of Siouan-speaking peoples, Ward and Davis attribute similarities in settlement patterns and ossuary characteristics on the southern coast to Algonquian speakers. Thus, the territory of the coastal Algonquians would have overlapped the geographic boundary between the distribution of Colington and White Oak ceramic phases:

Although we have noted minor distinctions between the pottery of the Colington and White Oak phases, there are many more similarities than differences. The archaeological and ethnohistoric records also show many similarities in house types, as well as village size and internal organization. Both phases show evidence of a mixed economy with heavy reliance on shellfish and other marine resources. Similarities also exist in the size, form and content of the mortuary remains...And finally, when the skeletal remains from the White Oak phase ossuaries had been analyzed, they appeared to be Algonkian because of their large size and robusticity [Ward and Davis 1999:222].

Additionally, unlike in the northern coast where direct physical evidence for the use of longhouses has not been found, a number of longhouses have been excavated in the south and dated to the Late Woodland period. Ward and Davis postulate that Algonquian groups could have lived as far south as the border between present day Onslow and Pender counties. The Flynt site (31On305) and the Camp Lejeune ossuary (31On309) represent two large White Oak-phase ossuaries that exhibit mass burials similar to the Colington-phase ossuaries that are closer to the Virginia border. Moreover, the largest longhouse ever excavated in North Carolina was found at the Broad Reach site in Carteret County (Loftfield and Jones 1995), which is significantly further south than these Algonquian-style structures were expected to be found.

The Broad Reach site (31Cr218) is extremely unique in its mortuary pattern for a Late Woodland Coastal Plain site (Mathis 1993, Driscoll 1995) and deserves special mention. Instead of a single large ossuary, one of the graves at this site was composed of nine distinct and articulated bundle burials, each covered by layer of clam shells. Two of the burials had accompanying artifacts, an extremely rare feature for the outer North Carolina

Coastal Plain. Among the artifacts were two shell-tempered White Oak ceramic vessels, a small ground-stone cup, a number of clusters of marginella-shell beads, the skeleton of a small dog, and a turtle carapace. Another small ossuary was found at the Broad Reach site, and it contained the randomly mixed remains of four to six individuals and a cremation. The burial placements at Broad Reach have been interpreted as indicative of possible status differences in the population (Mathis 1993, Monahan 1995). The larger ossuary with the distinct, well-preserved bundles could have been reserved for higher status individuals. This pattern has not been observed at any other Colington or White Oak-phase burial site however, so there is no comparative context with which possible hierarchical distinctions in the living social groups can be inferred from the burial remains for the general phases.

### **The Siouan problem and coastal cranial robusticity**

The difficult to interpret mortuary variability at the Broad Reach site, as well as the existence of what, on the face of it, appear to be Algonquian occupations much further south than originally anticipated both lead to the question: Where are the Siouans? At the time of Phelps' publication (1983) only two burial sites were confidently placed within the White Oak-phase and associated with Siouan-speaking peoples—the Cold Morning site (31Nh28) and McFayden Mound (31Bw67). This state of affairs remains the same despite the excavation of four to five more ossuaries in the last few decades, all of which have been considered Algonquian due to mortuary patterns, the presence of longhouses, and the size

and robusticity of the skeletal remains. The human skeletal evidence for any group of people that would correspond to the ethnohistorically observed coastal Siouan-speakers remains elusive, though a short discussion of the Cold Morning site is in order to outline what differences are seen as archaeologically significant in this southern region during the Late Woodland period.

The Cold Morning site is located in New Hanover County at the southernmost tip of North Carolina. In terms of artifacts it produced a few Middle Woodland pottery sherds, and a concentration of sherds originally attributed to the Late Woodland White Oak phase near the small ossuary. Recent re-evaluation of the pottery from the southern coast (Herbert and Mathis 1996) has revealed that a good deal of the ceramics found in that region and originally identified as shell-tempered is actually limestone or marl-tempered. This means perhaps they have been misidentified as Late Woodland wares, and are actually from the earlier Middle Woodland period. This discovery spurred Herbert and Mathis to re-examine the sherds recovered from the Cold Morning ossuary, which appear to also have been limestone or marl-tempered. However, a radiocarbon date from a bone places this site in the early Late Woodland, at around 950 AD. Ward and Davis (1999) believe the close association of the ceramics and the skeletal remains validates the radiocarbon date, and therefore the Cold Morning site can still safely be considered Late Woodland, temporally speaking.

The burial itself contained the randomly scattered remains of 14 adults, and the bundled remains of a fetus. Though the lack of skeletal articulation and artifacts is consistent with many of the other ossuaries on the North Carolina coast, the features that archaeologists have used to distinguish this site are the small size of the ossuary and the small size of the individuals found within it (Coe et al. 1982). Based on the small size of the cranial remains, the Cold Morning site was classified as Siouan.

The Siouan affiliation ascribed to the Cold Morning site by Coe et al. (1982) was made on the basis of macroscopically observed cranial differences (i.e., Algonquians and Iroquoians are said to have big skulls, and Siouans comparatively smaller skulls [Coe et al. 1982, Ward pers. comm 1996]). Additionally, Coe et al. metrically compared three of the Cold Morning crania with six others from different Siouan sites from the Piedmont of North Carolina using a small set of cranial size indices originally employed by Hrdlička (1916), and later used by Neumann (1950, 1952), to differentiate various Indian "stocks" and eastern American Indian "races" from each other (see Chapter 3). Hrdlička studied a cemetery of a group in Delaware, and compared the crania from that group to a sample of crania from southeastern Canada to Virginia. He concluded that these collections, though there were many "showing admixture," belonged to a basic type that was known in the northeast as the Algonquian or Iroquoian (Hrdlička 1916:112).

Neumann (1950, 1952) used Hrdlicka's data to define the "Lenapid" and "Ishwanid"<sup>1</sup> varieties for the Eastern United States. He described the Ishwanids as metrically and morphologically small, with medium muscle attachments and small brow ridges. The faces of the Ishwanid variety would be gracile, with moderate facial dimensions, square to oblong eye orbits, and small to medium mandibles (jaws). The Lenapids were significantly different according to Neumann. The skulls were larger, more narrow, and more muscular in general. They had larger brow ridges and parietal eminences, moderately rugged faces and eye orbits that were more rhomboidal in shape. The mandibles were medium to large (Neumann 1950, 1952).

When Coe et al. compared the three skulls from the Cold Morning site to the other North Carolina sample, and to Hrdlicka's and Neumann's data, the Cold Morning crania were found to be very similar to those from the Siouan sites, and within the range of dimensions that described Neumann's Ishwanid group. Therefore the Cold Morning site was assigned a Siouan affiliation (Coe et al. 1982).

While Coe et al. used metric techniques to establish a cultural affiliation for the Cold Morning site, a non-quantitative descriptive technique has been the most broadly utilized biological measure in the archaeology of the North Carolina coastal plain. Comparisons of the general size of skulls from one site to another, and to an assumed range of robusticity for either Algonquian/Iroquoian or Siouan "types," were used to determine the cultural

affiliation of a single site in the absence of other material or historical evidence.

Researchers have also employed this method as a supplement to the analysis of ceramics and other material remains (Loftfield 1990, Phelps 1983, Ward and Davis 1999). As a prime example of this usage, in Loftfield's 1990 article outlining a hypothesis for Algonquian expansion into the southern coast of North Carolina, cranial size featured prominently in his determination that the skeletal populations under examination were essentially Algonquian:

Evidence from calvaria from both ossuaries suggest a long-headed population with supraorbital prominences typical of the robust Algonquian and Iroquoian populations of northeastern coastal North Carolina [Loftfield 1990:119].

The ossuaries to which Loftfield refers are 31On309-82 and 31On309-85 (collectively known as the Camp Lejeune ossuary), Late Woodland sites that exhibited attributes of Algonquian burial patterns in what was considered a traditionally Siouan region. At both these sites, the inclusion of a panther phalanx (there were no other identifiable artifacts) and the extremely robust skeletons pointed to an Algonquian affiliation, while the construction of the burials on sand ridges and the placement of clearly identifiable bundle burials in the pits pointed to a Siouan affiliation (Loftfield 1990). Loftfield's interpretation of the evidence is tacitly grounded in the assumption that gross skeletal robusticity is a prime indicator of population affiliation:

The stature of the skeletal population of Site 31On309 is clearly that of the large and robust Algonquians to the north. The presence of *Felis* phalanges is also reminiscent of the northern Algonquian tradition. However, the placement of the ossuary on a sand ridge (old dune) distantly removed from any habitation site...are traits that closely resemble the burial practices of the more fragile Siouan speaking populations living south of Camp Lejeune. The ossuary represents, thus, an example of acculturation [Loftfield 1990:120].

Further, Loftfield posits a theory that Algonquians, as they moved south along the rich estuarine environments of the outer coast, took up Siouan practices in evidence at these ossuaries as a result of prolonged exposure to Siouan culture. He argues that the boundary between Algonquian and Siouan territories had become "stable, permeable, and relatively long-standing," (Loftfield 1990:120). The hypothesized southward expansion of the Algonquians was halted at the southern tip of North Carolina, he theorizes, because of environmental constraints, as the riverine and coastal estuary system thought to have sustained the Algonquian fishing lifestyle ends near the two sites under investigation.

Clearly the character of the skeletal remains from these sites became the basis for an attempt to reconcile the apparent mix of features seen in the burials. While the idea that cultural contact and exchange took place between Algonquians and Siouans in southern North Carolina is sound, the difficulty in basing interpretations of cultural remains on skeletal size is that the essential identity of the group in question is, by definition, fixed. There is no question that the people interred at the Camp Lejeune ossuaries could have been any other "type" than Algonquian, due to their comparatively large crania, despite what cultural evidence may have existed to suggest otherwise.

Another example of the use of gross biological differences in making distinctions between Late Woodland North Carolina coastal culture groups is Ward and Davis' assertion that:

During the Late Woodland period, physical, cultural and linguistic differences emerged that can be traced to the ethnohistorically documented tribes who occupied the coast at the time of European contact [Ward and Davis 1999:210].

There are two interesting points about the above statement. First, the physical differences to which they refer are only used to make a distinction between the Cold Morning site and all the other sites that they discuss in their chapter on the Late Woodland coastal plain. These "physical differences" have clearly been important to the process of assigning cultural affiliation to ossuary burials on the North Carolina coast, yet the quantitative basis of their use is confined to a single site. Secondly, the ethnohistoric record available to present researchers was collected in the 17th and 18th centuries, and there are no records indicating how far into the past the different languages were spoken. Further, drawing links between language group membership and skeletal robusticity certainly has a long formal and informal history in archaeology and physical anthropology (see Chapter 3). Yet both the documentary and skeletal evidence have been applied inconsistently to North Carolina coastal ossuaries. These and other issues as they relate to bioarchaeological interpretations will be more fully developed in the next chapter.

## **Continuing challenges and new directions**

The model proposed by Phelps (1983), and modified by Ward, Davis (1999) and others, for understanding Late Woodland North Carolina coastal archaeology has been an effective tool for analyzing material culture remains, understanding settlement patterns, and tracing the region's rich ossuary burial tradition. The certainty with which ethnolinguistic categorization (linked to skeletal size) has been applied to the people interred in the coastal ossuaries, however, has limited the scope of archaeological interpretation to envisioning the culture groups as unchanging entities--in a dynamic period marked by population growth and aggregation, increased reliance on agriculture, and the emergence of complex political organization that persisted into the colonial period.

Furthermore, Herbert recently reevaluated the ceramic sequences for coastal North Carolina (2002). Unlike other researchers (i.e., Loftfield 1976, Phelps 1983, Ward and Davis 1999), he subsumes the outer coastal White Oak and Colington varieties under the Townsend series, a crushed shell-tempered ware originating in southern Virginia around AD 800 and continuing into the colonial period. Using a selectionist framework, where patterns in pot morphology are interpreted to be the result of the maximization of vessel performance under various environmental circumstances, he explains the similarity and stasis of pottery styles across the coast in the Woodland periods (Early, Middle and Late) as evidence of "transcultural communities of practice." That is, according to Herbert ceramic technology

may remain strikingly similar and stable across large regions and time periods despite the presence of many and diverse ethnic and linguistic groups.

Though Herbert's focus is consciously "evolutionary" (i.e., morphological traits in ceramics are selected for based on their functional utility) and he does not address the ethnolinguistic categories directly, his suggestions mark a significant departure from previous theorizing in regard to the relationships among North Carolina's precontact coastal peoples and their material culture. Hopefully more new archaeological research will invigorate our view of the people who inhabited the long Late Woodland period of the North Carolina coast.

In that spirit, the next chapter will argue that the theoretical and methodological bases of the ethnolinguistic categorization system are incongruent with modern archaeological and bioarchaeological practice. Besides the arcane physical anthropological methodology on which the ethnolinguistic classifications are based, the use of gross morphological differences to assign cultural identity has conflicted directly with other material evidence (especially in the case of the Camp LeJeune ossuaries) as well as prevented a meaningful analysis of possible trade patterns between the proposed linguistic groups (Herbert personal communication 1998). Though the precontact archaeological record may be more sparse on the coast relative to other areas of the state (Phelps 1983), continued archaeological reliance on the ethnolinguistic categorizations closes off important disciplinary connections to modern bioarchaeology and recent ethnohistoric investigation.

**Notes.**

1. These terms were constructed by anthropologists to specifically describe and compare groups of people solely based on cranial size over a large region. Any similarity to the names of actual cultural groups will depend on which group was considered, broadly, the "type specimen" for the traits used in the analysis.

### **Chapter 3: The archaeology of the ethnolinguistic categories -- Identity, language and morphology**

Human osteologists learn to identify distinct skeletal markers that point to an adult or juvenile individual's biological sex (Krogman and Isçan 1986, Phenice 1969, Weaver 1980). Cranial robusticity and the shape and angles of features on the innominate bones are particularly useful in adult osteological sex determination. Osteologists continue to disagree over the utility of some markers over others in correct sex identification, and others have critiqued the methodological links between sex determination and race determination (Gere 1999). Nonetheless, physical anthropologists estimate that biological sex can be determined correctly about seventy to ninety-five percent of the time when applying these methodologies to individual skeletons (Ubelaker 1989).

Determination of biological sex alone, however, does not illuminate details of an individual's cultural identity. Even when assumed gender-appropriate burial goods and material context are available, the osteologist or bioarchaeologist is not equipped to assert the gender practices associated with a particular biological sex. Or, more accurately, we cannot assume what being a certain sex signaled about the skeletal individual we just "sexed" in *their* cultural context. Archaeological context and historical evidence, when

carefully researched and considered, assists our efforts to reconstruct patterns of gender expression in the past, but morphological sex markers alone are inconclusive.

Cultural and regional specificity is also central in osteological reconstructions of sex and gender, as well as for other aspects of identity (Gilchrist 1999). For example, if a bioarchaeologist believes s/he has an adult, female skeletal individual from a Pre-Columbian burial context on the coast of North Carolina, it is possible--dependent on what historical images and associations are available--to imagine her phenotype, as expressed in dress, hairstyle, or other cultural adornments. Yet based on this information, general categories such as "Native American woman" or "Indian woman" do not adequately describe her regional position. Taking into account the individual's cultural and historical location, the most appropriate and specific category is "Pre-Columbian (or Late Woodland), coastal North Carolina adult female." Careful attention to archaeological and historical evidence allows bioarchaeologists to reconstruct an osteological individual in terms of identity category within a specific regional or cultural milieu. We are limited by the richness of that data, as well as by the extent to which identity classification is relevant to our research goals.

Bioarchaeologists, however, have generally relinquished the pursuit of accurate individual identity reconstruction to pursue a population approach in reconstructing past human behavior (Buikstra 1976, Larsen 1997). Case studies and individual reports dominated the first decades of osteological and paleopathological research, especially when

diagnosing disease conditions, defining basic human skeletal differences, and charting unique biological anomalies were the centers of skeletal biology's research orientation. In the 1950s though, Sherwood Washburn's "New Physical Anthropology" transformed the goals of the entire field of biological anthropology, and when bioarchaeology emerged as a discrete disciplinary focus in the 1970s, its research framework rested directly on the precept that behavioral interpretation is most meaningful in a population, rather than an individual, context (Armelagos et al. 1982, Armelagos and Van Gerven 2003, Larsen 1997).

A current focus in bioarchaeology on analyzing behavioral patterns in and across populations has not completely replaced a desire to piece together an individual's identity, however, nor should it. Individual cases of traumatic or occupational injury, disease, and genetic anomalies remain valuable to reconstructing human biological history. Further, many bioarchaeologists continue to use their analytical skills to contribute to the field of forensic anthropology, where reconstructing an individual's identity and unique circumstances of death is an important contribution to law enforcement and the communities they serve.

Archaeologists and physical anthropologists, though, have classified Late Woodland North Carolina Native Americans in a way that ignores current bioarchaeological and forensic classificatory practice. An adult female individual from a Late Woodland coastal ossuary should be classified as "Late Woodland coastal North Carolina adult female."

Instead, North Carolina coastal archaeologists have typically added another label, either "Algonquian-speaker," "Iroquoian-speaker," or "Siouan-speaker," to describe any skeleton found in the temporal context between AD 800-1650, and within the natural boundaries of the coastal plain. Unlike other precontact skeletal classifications, specialists of the North Carolina coast validate a methodology that assumes a "natural" or innate connection between skeletal morphology and linguistic affiliation. That is, large skulls/skeletons are supposed to belong to Algonquian or Iroquoian speakers, and small skulls belong to Siouan speakers.

In North Carolina Late Woodland archaeology, this labeling has been applied to individual skeletons within ossuary populations, as discussed in Chapter 2. The entire biological ossuary group took on an incorrect linguistic, and therefore cultural, identity implied by the linguistic marker. In the past, physical anthropologists asserted that it was possible to discern what language an individual spoke by the morphological character of her/his skeleton (e.g., Brinton 1891, Broca 1861, Morton 1842). Language group, moreover, was not the only feature of identity late 19th and early 20th century anthropologists believed they could ascertain from individual skeletons or groups of skeletons. As an example, Aleš Hrdlička used skeletal remains to determine that a New Jersey cemetery dated to the historic period:

[O]ne of the skeletons is that of a tall white man of Scandinavian or Nordic type, possibly one of the Dutch, English, or Swedes who reached the upper valley after 1614. As the remainder of the skeletons do not indicate any trace of admixture of white blood, the cemetery may be regarded as dating from the period of the earlier contact of the Indian and Caucasian races, or probably from the latter part of the seventeenth or the beginning of the eighteenth century" [Hrdlička 1916:14].

The methodological assumption that language, culture, and skeletal form are synonymous is grounded in an antiquated, individually-oriented brand of physical anthropology and should not be a part of modern bioarchaeological practice.

The system of classification that assigns language to skeletal bodies is based most broadly in two scientific trends: 1) A continual Enlightenment imperative to correlate language, nation and culture, and 2) an early 20th century physical anthropology that had perpetuated a curiously individualistic analytic orientation, one that firmly placed an individual within a "race" before attempting any other meaningful statements about his or her morphological and cultural identity. The rest of this chapter will trace those theoretical pathways to one of their specific ends: the ethnolinguistic categories employed by today's archaeologists in classifying Late Woodland coastal North Carolinians. The discussion concludes by proposing a new system for conceptualizing the relationships between North Carolina coastal Late Woodland peoples, one based in a bioarchaeological framework that replaces the imposition of linguistic and cultural identities on skeletons derived from gross morphological traits and historical analogy.

## **When language equals culture**

To begin the excavation of coastal skeletal categories, Karen Ordahl Kupperman (2000) notes that the English colonists of the late 16th and early 17th centuries were fascinated with Indian languages for both practical and philosophical reasons. For example, Thomas Hariot learned the Carolina Algonquian language from two Native American men, Manteo and Wanchese, who he brought to England in 1584. Later he included Algonquian names for plants and animals alongside the English words in his reports. He also stressed that full understanding of Indian culture and practices could only come from fluency in their language. Additionally, the Jamestown colonists of the early 1600's used full immersion in Indian village life to train young English boys as interpreters. Language acquisition would also ensure a more successful colonial venture, as early on the English depended on Native people for everything from building materials, to information regarding Spanish colonies to the south (Kupperman 2000:79-80).

Kupperman attributes this English interest in Native American languages not just to an everyday concern with effective communication, but to prevailing English definitions of civil society. The English were impressed with the orderliness of Indian village life, and took great interest in the ways Indian people denoted difference in social status, through dress, hairstyle and living arrangements. The English themselves preferred this kind of social arrangement and desired village life over isolated scattered homesteads, thus they also

valued it among Indian people (Kupperman 2000:144-146). Complex language—and the English admired the intricacy of Native languages—was a critical piece of an English view of sociality.

Further, the way 17th and early-18th-century English people recognized difference was via the “environmentalism” of the Enlightenment, and not by notions of biological differences between races. In fact, the English widely believed that Native Americans were born “white,” and that the “American” environment gradually darkened their skin—the same environment, it was thought, would eventually darken the skins of immigrant Europeans as well (Kupperman 2000, Lawson 1967 [1709]). Ethnohistorians continue to find evidence that neither Europeans nor Native Americans saw each other as different “races” in the strict way later promoted by scientists and early anthropologists in the 19th century (e.g., Fischer 2002, Frank 2001, Perdue 2002). Unlike the English colonists, Europeans would conceptualize race, and more specifically the idea of “natural” Anglo-Saxon superiority, as a central scientific category only in the 18th and early 19th centuries, with the shift to a biological conception of race beginning in the late 17th century (Horsman 1981, Jones 1997). Thus, rather than race, more central markers of difference during the early colonial period were status as Christian or non-Christian and difference in spoken language.

To wit, Edward Gray (1999) argues that an Enlightenment European expectation of language defining the borders of nations was challenged by the staggering number of

languages in North America, where 329 mutually unintelligible ones were spoken in the last five centuries. The linguistic diversity of North America produced a "wonder and confusion like almost nothing else about the New World" (Gray 1999:10). Yet he goes on to note:

There is little evidence that in the sixteenth and seventeenth centuries Europeans understood the linguistic diversity of America--or anywhere else--to be the result of fundamental racial difference...the broad variety of American languages was for many merely evidence of the failure of Native Americans to heed the divine mandate of repentance, salvation and unification [Gray 1999:21].

In other words, English people translated their experiences with those of different cultures and places through Biblical conceptions of human diversity. The Bible only allowed for 72 languages in the world, since this is the number proscribed by God after the Tower of Babel was felled. According to the Bible, the reunification of the world's people could only take place through a universal language of prayer. Missionizing efforts in the 17th and 18th centuries, argues Gray (1999), would center around this symbolic reunification for the peoples of the New World. English colonists believed, then, that with Christianization, the differences between themselves and Indians, even the exponential number of languages, would be erased (Kupperman 2000: 204-205).

As an illustration of the overall diversity of languages in America in comparison to Europe, Gray estimates that there were nearly 700,000 speakers for each language in use in Britain at the time of European contact with the Americas. In contrast, there would have been approximately 14,000 speakers for each Native American language, and even fewer if

some languages became extinct before they could be recorded (Gray 1999:18). On the east coast of North America, where Eastern Algonquian alone was made up of 18 mutually unintelligible languages, not dialects (Gray 1999:65), Thomas Hariot's observation that the "language of every [Native] government is different from any other, and the farther they are distant the greater is the difference," (Hariot 1972[1590]: 25) lends credence to Gray's views. Therefore, the English colonists became keenly interested in understanding as many Native languages as possible to further their trade contacts and material interests (Kupperman 2000).

Likewise, John Lawson, on his travels through North Carolina, was struck by the diversity of languages spoken by Indian people, once noting that:

[T]he Difference of Languages, that is found amongst these Heathens, seems altogether strange. For it often appears, that every dozen Miles, you meet with an Indian Town, that is quite different from the others you last parted withal; and what a little supplies this Defect is, that the most powerful Nation of these Savages scorns to treat or trade with any others (of fewer Numbers and less Power) in any other Tongue but their own, which serves for the Lingua of the Country, with which we travel and deal; as for Example, we see that the Tuskeruro's are most numerous in North-Carolina, therefore their Tongue is understood by some in every Town of all the Indians near us [Lawson 1967[1709]:233].

Lawson's observations also indicate that while diversity of spoken language was the norm on the North Carolina coast, there were political factors that led to the situational dominance of one over another, such as that of the Tuscaroran version of Iroquois over other languages. This linguistic hierarchy indicates Native people also learned other languages in

their political and economic dealings with each other, complicating any facile correlations between language and cultural identity.

Additionally, the primary documentation for different precontact language groups on the coast of North Carolina is slim, consisting of two word lists (Hariot 1972 [1590], Lawson 1967 [1709]), town and group names which suggest their linguistic affiliations, as well as accounts of relations between particular Native groups and the English (Barlowe 1898 [1584], Hakluyt 1972 [1589], Lane 1902 [1585], Lawson 1967 [1709]). As a result, historians rely heavily on these sources for their varied interpretations and classifications (e.g., Feest 1978, Mook 1944, Mooney 1894, Speck 1924). Further, historical linguists (Campbell 1997, Goddard 1978, Mithun 1999) agree with each other in terms of the regional boundaries for the three major language families in North Carolina, yet there is little evidence pointing to how many languages were spoken within the larger language categories (Algonquian, Iroquoian or Siouan) or whether there were mutually unintelligible languages within the general linguistic divisions on the inner or outer coast.

Recently, historians have documented that in the early colonial period people lived with each other across linguistic and cultural divisions (Gleach 1997, Perdue 1979, Rountree and Turner 2002). Historical and oral sources, however, are unspecific as to how long these types of relationships existed, or how common migration was a response to political and cultural upheaval either pre- or post-European contact. Therefore,

archaeologists and other historical researchers should hesitate to make assumptions regarding the nature of Native people's language use, or whether or not language, at the "family" level taxonomically (Campbell 1997), was a significant cultural marker restricting relationships between different peoples.

As an illustrative example from the contact era, Cedric Woods (2001) chronicles the tumultuous period between the two Powhatan uprisings in southern Virginia (1622 and 1644), when individual families of the Powhatan chiefdom emerge in land deed records as migrants into other cultural and linguistic areas. Specifically, he found Algonquian-speakers from Virginia, married to Iroquoian-speakers, leasing land from the Tuscarora in the mid-17th century. Woods uses Helen Rountree's notion of "spin-off" (1990, 1993) where families left their tribal groups, often becoming lost in the colonial environment, because Indians who left their land were assumed to have abandoned their culture. He postulates that small groups and families did "spin-off" as the result of various events, like the Powhatan Wars, but then spun back together in other areas, making new communities. Woods also notes that the shifting alliances between Indian groups of the early colonial period in Virginia and North Carolina are significantly de-emphasized in colonial documentation; English administrators defined Indian people by their membership in existing communities with ties to specific lands. The ways Indian people adapted to the social and political changes of

English colonization, then, often resulted in the erasure of their "Indianness" from the historical record (e.g., Bordewich 1996, Deloria 1998)

Based on older historical sources such as Mook (1944), Mooney (1894) and Swanton (1946), however, North Carolina coastal archaeologists (Coe et al. 1982, Loftfield 1990, Phelps 1983) have assumed that general linguistic boundaries were synonymous with cultural and material culture boundaries for the over eight hundred year duration of the Late Woodland (AD 800-1650) period. That historians and historical linguists have classified past peoples into language families does not directly imply that these groups were closed cultural systems based on linguistic affiliation (Gibbon 1989). The historical evidentiary constraints noted above prevent us from knowing exactly how Native people used language to distinguish themselves socially, politically and culturally on the Late Woodland North Carolina coast. The primary documentation (i.e., Hariot 1972 [1590], Lawson 1967 [1709]) suggests linguistic boundaries and a level of linguistic diversity that was confusing to English colonists. While Gray, using John Lawson's testimony, postulates that, "American Indians used linguistic difference to retain some control over local knowledge, cultural inheritance, and political difference, employing language much as one might employ a secret code," (1999:18), none of the available linguistic evidence positively draws fixed social boundaries around the living speakers. We should be reluctant, therefore, to unequivocably assume that language differences between Algonquians and Iroquoians, Iroquoians and Siouans, or

Algonquians and Siouans, would have either prevented or encouraged the movement of people, materials and ideas across their regional boundaries. Thus, language may not have been a barrier to gene flow, an interpretive conclusion implied by the ethnolinguistic model.

Considering North Carolina coastal linguistic complexity and the limitations of the historical evidence, the assignment of a language group to an ossuary population or skeletal sample from hundreds of years before European contact is an especially tenuous classificatory endeavor. Archaeologists and bioarchaeologists who continue to label ossuary sites by language family assume that linguistic differences would have discouraged interaction (little or no gene flow), and that in hundreds of years Native people did not change the ways they used language, conclusions that are not supported by either the historical or ethnohistoric records.

### **Race equals language equals culture**

The linkage archaeologists have made between language--and therefore cultural--group and skeletal robusticity on the North Carolina coast rests in a more recent, 20th century theoretical assumption in physical anthropology: that regional burial populations should represent a discrete group of native-born, culturally and physically (denoted by race or a within-race typological category) synonymous individuals. This section traces the

details of these assumptions through the work of Aleš Hrdlička and Georg Neumann, two researchers who used cranial morphology to classify precontact Native American skeletal remains according to race and language or cultural group, and whose work was used to construct the coastal North Carolina ethnolinguistic categories. Physical anthropologists applied these kinds of classifications to Indian skeletons throughout North America until the 1970s (see Robbins and Neumann 1972). For the most part, we have abandoned such typological methodology.

In 1916, Aleš Hrdlička published his study of the skeletal remains from a historic Lenape cemetery in New Jersey. In *Physical Anthropology of the Lenape or Delawares, and of the Eastern Indians in General*, he used 10 male and 13 female crania from a total skeletal population numbering 57 individuals to codify the placement of eastern Algonquian and Iroquoians in a single taxonomic category:

It is evident from the data presented above, that the eastern Algonquian (and Iroquois) Indians, while essentially of one type, approached purity of type much more in the northeastern Atlantic states and in southeastern Canada than further south [1916:123].

In essence, he observed that skulls from the northern and eastern part of the United States are longer (dolichocephalic) than those from the interior south and southeast (which he described as brachycephalic). He postulated that the “physical identity” (1916:127) of Algonquians and Iroquoians should be considered synonymous, despite their cultural and within-family language differences (Campbell 1997).

The concept of “physical identity” in Hrdlička’s work has no analogue in modern bioarchaeological or osteological practice. Bioarchaeologists and physical anthropologists currently understand physical identity through the lenses of evolutionary or phylogenetic position, adaptive or environmental relationships, functional significance and genetic distance. The criteria used to establish “relatedness” in the scheme of early-20th-century physical anthropologists are unquestionably rooted in the notion that pure physical types, unchanged by adaptation, are the desired objects of analysis. Hrdlička’s framework for analyzing ancient remains was one of estimating racial position, comparing of physical type to linguistic stocks, tracking the diffusion of basic types across time and landscapes, and citing admixture. The notion of “admixture,” a poorly defined measure of interaction between pure races, is the single biological interaction with which Hrdlička was concerned.

More specifically, Hrdlička applied a pre-Mendelian evolutionary theory to his work, where the manipulation of ‘protoplasm’ in the blood resulted in the codification of heritable traits and developmental changes in different human groups (Hrdlička 1921). An individual’s response to Darwinian selection was, in this framework, already determined by their racial position--nonwhite races already possessed a package of traits that was significantly less-developed and behind that of the white race (Baker 1998, Blakey 1987, Hrdlička 1925). Hrdlička, then, believed that biological races were the original and immutable units of difference between human groups.

So strict was Hrdlička's adherence to this notion of physical identity that he explained the presence of skulls that did not conform to "type" as resulting from either admixture or even adoption:

The individuals whom such [brachycephalic or short-skulled] specimens represent were probably recent accretions by the tribes through marriage or adoption. Other increments of similar nature doubtless occurred in the past, and, blending more or less thoroughly with the tribes, modified the physical types of these to a greater or less extent [1916:113].

Hrdlička consistently explained cranial variation within a single cemetery context as the contribution of outsiders, who then would have mixed with the original people, changing the morphology of the once pure type. In these studies, the archaeological context is only used to establish historic linkages to a presumed cultural identity. No discussion of artifacts, mortuary pattern, settlement data or place of burials in time is present.

Similar to Hrdlička, though nearly a half century later, Georg Neumann also studied cranial variation in Native American populations, though he was not as prolific and did not publish the theoretical underpinnings of his research. In *Archaeology and Race in the American Indian*, Neumann constructed "eight type series" from a total of 471 cranial samples (1952:13). Neumann identified fixed types of American Indians within what he believed to be a taxonomically significant human subspecies:

All groups dealt with in this paper are regarded on the level of zoological varieties of the subspecies *asiaticus* of *Homo sapiens*...[A]t present we sidestep the issue as to whether there are any morphological traits that set off all American Indians from any of the Mongoloid races of Asia [Neumann 1952:14].

He identified the long-headed Lenapids (Algonquian/Iroquoian) and short-headed Iswanids (Siouans) using 54 and 33 crania respectively, and came to the same general conclusions as Hrdlička in regards to their size and form differences. As such, Neumann replicated Hrdlička's biological categories and typological series.

As early as 1966 the categories that Neumann assigned to explain Native American racial variation, however, were challenged in the anthropological literature (Long, 1966). Joseph K. Long piloted multivariate statistical discriminant analysis to specifically evaluate Neumann's four Eastern U.S. subtypes (Iswanid, Walcoldid, Otamid and Lenapid). Though his study did not take interobserver error into account, a significant factor affecting data collection and analysis, the results are suggestive that the construction of human varieties and types on the basis of skull form is an invalid research practice.

Long's findings were that three of the four racial categories (Walcoldid, Otamid and Lenapid) defined by Neumann from sites throughout the Eastern United States did not have classificatory value archaeologically. The types occur randomly through time, each appearing erratically from the Archaic to the Mississippian periods throughout the Eastern United States. Long established that the fourth, the "Iswanid variety," because of its time-depth, was the "original stock" from which the other varieties diverged (1966:459). That is, Long found that the Iswanids are ancestral to the other three eastern types, thus calling into question the entire classificatory system and suggesting that the significant differences in

"type" (between Iswanid and all the others) are actually the result of adaptational or evolutionary change through time. Though Long persists in using typological terminology, his inclusion of time as a variable undermines Neumann's ahistorical taxonomic methodology. As Long's article highlights, Neumann ignored evolution, any kind of environmental or adaptational issues, and any agent for change that was not diffusionistic or focused on the mixing of fixed types.

Common to both Hrdlička and Neumann are their assignments of historic culture group identities to skeletal collections without having considered the archaeological evidence across temporal periods. They routinely collapsed samples from different time periods into the same types. This construction of types across time is a problematic methodological move, as it assumes a static group identity, ignores change over time, and is divorced from any meaningful archaeological context. In the last twenty to thirty years bioarchaeologists have recognized these omissions and rejected methodologies which call for placing skeletal groups in typological frameworks based on race or arbitrary "varieties" (Armelagos et al. 1980, Larsen 1997).

In 1982, however, Coe et al. applied this typological method to skeletal remains from the Late Woodland North Carolina coast. They took a set of cranial measurements and compared three skulls from the Cold Morning Site (31NH28) to regional samples Hrdlička

(1916) and Neumann (1952) had used to define the various "types" of precontact Native Americans on the east coast, as described above:

A few measurements and observations on cranial morphology were taken and compared to certain available physical descriptions of Algonkins and Siouans. In addition, the crania were compared to a small sample from historic Siouan sites in North Carolina and to a small sample of crania from counties near the Nh28 ossuary [Coe et al. 1982:66, and see their Table 17].

In relatively straightforward language, Coe et al. equate their morphological analysis with Neumann's classifications and his usage of Hrdlicka's data to define the racial categories with which he described all available Native American skeletal populations (Neumann 1950, 1952). From their comparisons, Coe et al. concluded that:

[T]he present ossuary sample is closest in cranial dimensions and morphology to the Siouan population, the description of Ishwanids by Neumann, and to the cranium from Bw 67 than to the specimens from Pender and Onslow counties which are more similar to the Algonkins [sic] as described by Hrdlicka and Neumann [Coe et al. 1982:70].

Coe et al.'s addition of skulls into Hrdlicka's and Neumann's models replicates their typological methodology by placing five crania from archaeological sites nearly eight hundred years apart into the same category. Likewise, Coe et al. assume that the similarity in size between the crania from the Cold Morning site (31Nh28), the skull from the McFayden Mound (31Bw67) and those from the historic Siouan context can be attributed to the same source of variation, namely linguistic and cultural affiliation.

Cranial morphology, though, is neither a direct function of language nor of cultural identity. Conversely, language group membership cannot be ascertained from skull size and shape. The variables that cause change in cranial morphology are environmental, evolutionary and adaptational (Larsen 1997). Recent bioarchaeological research has explored differences in cranial form and shape between groups not to assert cultural distinctions between populations, but to ascertain the mechanical effects of different dietary adaptations. As an example, Larsen found that gracilization of the craniofacial skeleton in prehistoric Georgia coast populations was due to an increasing reliance on soft foods, especially maize (Larsen 1997). The skulls of a population will reduce in overall size as a group adapts to processed foods, thus reducing the need for more robust muscles of mastication. Large, robust crania would associate more strongly with those populations not exploiting an agricultural lifeway (i.e., foragers or hunter-gatherers).

Another bioarchaeological example of cranial size changing as a result of dietary adaptation comes from a century of research on skeletal remains from the Nile Valley in Egypt and Nubia. In the mid-to-late nineteenth century, early anthropologists speculated on the origins of human groups in the region. Following Samuel Morton's influential study of cranial size and shape, *Crania Aegyptica* (1844), anthropologists believed that two biologically and culturally distinct groups occupied the Nile Valley, one after the other. In Nubia, Morant (1925) thought he had found an earlier "Upper Nile type" with predominantly

"Negroid" features (a long, low skull form) and a later "Lower Nile Type" which exhibited more "Caucasoid" features (a short, higher skull form). Morant explained the population change through migration and conflict; the short-headed Caucasoid population invaded and completely replaced the more long-headed Negroid group (and see Larsen 1997).

More recent skeletal analyses of these samples using discrete inheritable traits, however, suggest that these earlier and later Nubian populations were essentially the same genetic group, though exploiting different sets of ecological resources (Calcagno 1989, Greene 1982). Therefore, the skeletal and cultural evidence does not unequivocably support the hypothesis of violent conflicts that might have preceded a theorized population replacement (cf. Irish and Turner 1990, Irish 1993). Nubian foragers and early agriculturalists have flat and elongated skull vaults with well-developed supraorbital tori and occipital protuberances, and the later intensive agriculturalists have more rounded vaults with smaller, less projecting faces, more gracile muscle attachment sites, and smaller temporomandibular joint sizes (Carlson and Van Gerven 1977, Larsen 1997). Moreover, tracking adaptational changes and physical evolution on the basis of food intake is not a measure of biological race.

Offering a more compelling challenge to the use of cranial size in determining cultural affiliation is research that problematizes the use of anthropometric dimensions to define and classify distinct "types" of human beings (Blakey 1987). As early as 1912, Franz

Boas demonstrated that the head shape of American-born immigrants—based on a ratio of head length to breadth (the cephalic or cranial index)—was significantly different from that of their European-born parents (Boas 1912, 1940). Boas argued that this degree of plasticity in cranial form in the span of a single generation indicated that anthropologists could not use cranial size and shape to link past skeletal populations with living human groups.

Boas' landmark study of cranial plasticity, however, was recently critiqued by Sparks (2001, Sparks and Jantz 2002); then, it was reaffirmed by Gravlee and coworkers (2003), underscoring the importance of Boas' work in the methodological history of physical anthropology. In his masters thesis, Sparks (2001) re-evaluated Boas' data on European immigrants using updated statistical methods; he found that there were no statistical differences in cranial size and form between Boas' sample of European-born immigrants and their American-born descendants. Sparks and Jantz (2002) conclude that "[O]ur analysis reveals high heritability in the family data and variation among the ethnic groups, which persists in the American environment," (2002:14637). They acknowledge that significant changes in cranial size and form over time do take place in humans, but that because of Boas' over-emphasis on plasticity and the developmental environment (in the individual), the genetic factors influencing cranial morphology have been ignored in the anthropological literature. In a similar study, however, Gravlee and coworkers (2003) contradicted Sparks

and Jantz, affirming Boas' general conclusions that statistically significant differences exist in the cephalic index between U.S.-born children and their foreign-born parents.

Though all these results are compelling, neither Sparks and Jantz nor Gravlee and coworkers explain the variable of the "American environment." If the American environment was not significantly different from the European environment in the early 20th century (e.g., in foodways, socioeconomic and living conditions, etc.) we should not expect rapid and significant changes in developmental cranial or bodily form. The nature of the environmental context should be examined to assess whether the material conditions in New York City were actually different than those in Eastern Europe, and whether America would have had the capacity to act as a unique environment in the first place.

Similarly, until such systematic research is applied to crania from the North Carolina coast, biological and cultural associations based on differences in cranial size should be abandoned. There have been no region-wide analyses of skeletal robusticity for Late Woodland burial populations from North Carolina. Without information on the actual boundaries between groups with regard to cranial size and research on patterns of environmental adaptations, biological difference based on skull size cannot be explained. Furthermore, since the foundation of the ethnolinguistic categories used on the North Carolina coast is a typological model based on atemporal and even racial precepts, this project does not construct hypotheses to test that model. Testing whether "Algonquian"

skulls are actually larger and more robust than “Siouan” skulls would only reinscribe the notion that gross morphological features are indices to cultural and linguistic identity.

The measure of biological relationship this dissertation uses for the North Carolina coastal skeletal samples, then, draws on a clearly heritable and richer source of material data--the teeth (Scott and Turner 1997). Dental biological distance, or biodistance, uses heritable traits on teeth to estimate interaction between skeletal populations. Biological distance will not illuminate cultural or linguistic affiliation, and it will not establish a new morphological taxonomy, countering Armelagos and Van Gerven's (2003) recent assertion that biological distance studies are, by definition, explorations in “racial history” (60). Biological distance can show to what extent (if at all) genetic associations fit within the framework of Late Woodland material culture differences, or whether or not people shared genes with each other along the same trajectories they shared materials or technologies. In the next chapter, the reasons for this methodological choice will be outlined, and the way in which a biodistance profile for the Late Woodland North Carolina coast contributes to Southeastern bioarchaeological research will be detailed.

In conclusion, bioarchaeologists are excellent at tracking morphological differentiation across both time and space; however, we err when we ascribe *cultural* meaning to these differences beyond the context in which they occur. Skeletal collections are biological data; they do not themselves bear culture (or language). One of the very

innovations of bioarchaeology is that burials and the skeletal individuals which come from them are material evidence for aspects of sociocultural behavior, which are specific to a certain place and time (Larsen 1997). The mistaken notion of past typological classifications this project avoids is that skeletal remains in and of themselves will be a proxy to culture and identity in the same way they are an index to physiology, dietary behavior, or even genetic relationships.

## **Chapter 4: A framework for biological relationships between precontact North Carolina Coast peoples, I - Materials**

This study has so far argued that when archaeologists have applied linguistic labels to ossuary populations from the Late Woodland North Carolina coast, they have incorrectly created linguistic and cultural boundaries out of skeletal remains. Giving a skull the label "Algonquian," as we have done in the past for the North Carolina coast, calls on a classification system used by early and mid-20th century anthropologists, one that relied on considering biological groups as static and easily typed into unchanging categories. Early anthropologists used this framework in an effort to determine the cultural identity of the people buried in a mortuary context. When researchers, such as Morton, Morant, Hrdlička, and Neumann, encountered different morphologies, they concluded that those differences pointed to the presence of culturally and biologically distinct peoples.

Archaeological theories and methodologies which trace specific cultures through time have a long history to be sure, from the cultural historical approach (Kehoe 1998, Willey and Sabloff 1993 [1974], Trigger 1989), to the recent archaeologies of identity and ethnicity (e.g., Graves-Brown et al. 1995, Jones 1997). These approaches use the material traces of culture--artifact styles and technologies, settlement patterns, foodways, as well as

household composition--in an attempt to place cultural identity in time. The ethnolinguistic categorization scheme used for the Late Woodland North Carolina coast, however, focuses on the size of skeletal remains, using bones as direct evidence for an "ethnic" identity.

As contended in Chapter 3, skeletal remains as a singular object of analysis are not material culture. Cultural and behavioral practices and conditions do leave marks on bones, through patterns of articular pathologies, health and disease, as well as skeletal changes such as cranial deformation, defleshing marks, tooth wear, and even intentional tooth modification (Ubelaker 1989). In the absence of these more telling markers, though, as is the case for the Late Woodland North Carolina Coast, cultural and linguistic identity is not determinable solely from skeletal evidence.

Thus, because bones are often not direct windows to culture, the framework proposed here to replace the ethnolinguistic categories, nonmetric dental biological distance, cannot determine, for example, if one ossuary is Algonquian, or another is Siouan. Biological distance estimates how closely related skeletal groups were genetically, through the pooling and comparison of hereditary traits. Biological distance is not inherently synonymous to cultural distance; morphological similarity can coexist with linguistic and cultural differences, and vice versa (e.g., Campbell 1997, Carlson and Van Gerven 1977). Biological distance traces the movements of and distinctions between biological populations

and charts their change through time (Buikstra et al. 1990), features which may or may not be synchronous with material culture evidence.

As in most archaeological or bioarchaeological endeavors, though, all of the available evidence comprises but a sliver of people's cultural and biological lives. To wit, Hutchinson (2002:61-67), using ethnographic and archaeological analogy, showed that the age-at-death structure present in a number of North Carolina coastal ossuaries (Baum, Hatteras Village, Hollowell, Jordan's Landing, San Souci, West #2, Dickerson and Knotts Island--the first six of which are considered in the present analysis) is not representative of currently living populations or of other ossuary samples (see below for ossuary descriptions).

Because teeth preserve more readily than other skeletal elements, dental nonmetric biological distance allows one to compare as many individuals as possible from burial samples. This allows for the construction of as real a measure of interaction as possible, considering the evidence available (Scott and Turner 1997). However, similar to Hutchinson's conclusions about the North Carolina sample, of the total of 944 individuals from the 13 ossuary sites for which I collected data, 41% ( $n=388$ ) were represented by teeth. This proportion is still suitable for the biodistance comparison (Molto 1983), but it is important to recognize that archaeological skeletal samples at their best represent only those deceased people who were interred and then adequately preserved.

The rest of this chapter includes a consideration of the ossuary tradition on the North Carolina coast and individual ossuary descriptions. The next chapter details the history and the specifics of the methodologies used to construct the dental biological distance comparisons between Late Woodland North Carolina coastal ossuaries.

### **Material context of the Late Woodland North Carolina Coast: The ossuaries**

Both archaeologists (e.g., Loftfield 1990, Mathis 1993, Phelps 1980a, Ward and Davis 1999) and bioarchaeologists (e.g., Bogdan 1989, Truesdell 1995, Hutchinson, 2002) have remarked on the uniqueness of Late Woodland North Carolina coastal burial practices. The predominant mode of burial was the ossuary, loosely defined as a grave or pit holding the secondarily deposited skeletal remains of multiple individuals (Curry 1999, Ubelaker 1974). Individual primary burials have also been documented on the coast, though they are much more rare. Ward and Davis (1999) speculated that the relative lack of primary burials may be the result of an over-emphasis on the ossuary tradition by archaeologists, though taphonomic processes may also account for the better preservation of mass burials in the sandy soils of the coast.

Ossuaries represent the culmination of an often long and involved ritual cycle, where entire communities may be involved in the preparation and deposition of their recently deceased members (Curry 1999, Hutchinson and Aragon 2002). In his recent synthesis of

Late Prehistoric Native American ossuaries in Maryland, Curry states that typically an ossuary was created in a single burial event or “feast” on a ten or twelve year cycle. Between these events, the bodies of the recently deceased were either buried, or allowed to skeletonize on scaffolds or other structures built especially for that purpose. Then the remains or bones were exhumed or removed from their initial resting places and buried en masse in the ossuary pit.

Though an ossuary pattern of burial was practiced all across the eastern seaboard and as far west as the Great Lakes area during the late precontact and early colonial periods (Curry 1999, Feest 1978), North Carolina coastal ossuaries are some of the oldest, dating as early as AD 900-1100 (Coe et al. 1982, Mathis personal communication 2002). Additionally, the mortuary patterns of the North Carolina ossuaries are exceptionally varied and have often defied easy assignments of cultural affiliation, either through archaeological or historical lines of investigation.

To illustrate, although images of Late Woodland North Carolina coastal ossuaries have been popularized in the prints produced by De Bry from John White’s 1585 drawings (Hariot 1972 [1590]), the breadth of burial styles that archaeologists have excavated, photographed, described and interpreted are not fully addressed by White’s charnel house depictions. For example, the large Baum site (31Ck09) was comprised of 5 separate ossuaries, each of which contained numerous disarticulated and undifferentiated individuals.

The Hollowell site (31Co5), on the interior coast, exhibited a pattern of distinct groups of bone bundles within a single pit. The Broad Reach site (31Cr218), on the southern coast, had a quite distinctive mortuary pattern, with a few single primary burials among small groups of bundles containing two or three individuals each (Hutchinson 2002, Mathis 1997).

The Jordan's Landing (31Br07) and Sans Souci sites (31Br05), both interior coastal sites, are characterized by a number of small ossuaries, each containing just a few individuals.

Many researchers have defined the differences between inner and outer coastal ossuaries based on whether or not discrete skeletal bundles occur in the burial (Hutchinson 2002, Truesdell 1995, or Algonquian and Iroquoian ossuaries; cf. Phelps 1983).

Archaeologists have interpreted the larger and more undifferentiated outer coastal ossuaries as community burials, and the smaller collections of inner coastal burial groups as "family" units. However, discrete burial groups within the central pit also occur at a few outer coastal sites, such as Piggot (31Cr14), Camp LeJeune (31On309) and Broad Reach, complicating the above interpretation (Truesdell 1995, Loftfield 1990, and Mathis 1993, respectively).

There are also a number of methodological problems underlying the process by which researchers have inferred region-wide cultural behavior from these burials. First, some ossuaries were excavated very rapidly after having been disturbed by wave action, weather events such as hurricanes, and road construction. Though concerted efforts were made to record the details of burial placements (Egloff 1971a, 1971b, Phelps 1983), often

portions of ossuaries had already been lost to the traumatic events which disturbed them, and time constraints sometimes restricted the level of detail recorded in excavation notes and maps. Likewise, once removed to curation facilities, bones were sometimes sorted and boxed by skeletal element (i.e., skulls in one box and pelvises in another) so that association between cranial and postcranial remains became nearly impossible (Hutchinson, personal communication 1999). Lastly, no archaeologist or bioarchaeologist has undertaken a systematic and detailed regional comparison of mortuary variability among all the Late Woodland burial sites on the North Carolina coast, leaving each subsequent researcher to summarize the same initial descriptions and interpretations of the excavators (see also Truesdell 1995, Bogdan 1989, Hutchinson 2002).

Adding to these constraints are late 19th and 20th century historians' varied interpretations of the Spanish and English accounts of coastal Native people's precontact lifeways and spiritualities (Mook 1944, Mooney 1894, Swanton 1946). For example, John Swanton, in his numerous publications on Southeastern Indians, used the words "quiozogon," "ossuary," "temple," and "mound" interchangeably to describe burial practices where multiple individuals were involved. Furthermore, Ubelaker (1974) notes that 19th and early 20th century historians used the term "ossuary" as a general label for any burial of more than one individual. Descriptions of Native American ossuaries on the North Carolina coast focused mainly on supposed elite burials in charnel houses and ossuaries (Mooney

1894, Mook 1944). It is clear from the demographic diversity represented in the North Carolina coastal ossuaries, however, that status differences of the sort highlighted in these histories are not reflected in the burial populations (Hutchinson 2002).<sup>1</sup>

Lastly, and arguably most crucial, is that despite the many points of contact between explorers, surveyors, colonists, and Native coastal North Carolinians, an ossuary ritual or deposition event was never recorded in either Spanish or English accounts from the early colonial period. While John White saw a charnel house of the presumed coastal elite in 1585, and John Lawson recorded individual burial ceremonies in 1700, as far as is known, there are no written records documenting the creation of either the small village-based, or large regionally significant ossuary burials (Hariot 1972 [1590], Lawson 1967 [1709]). It is clear however, that many North Carolina Native groups gave special treatment to their dead and preserved their ancestors' remains, perhaps for later ritual burial. As Hutchinson notes:

In those societies that practice collective burial, final interment is often part of a lengthy ritual cycle that incorporates temporary storage or temporary burial... The ritual cycles can last a decade or more between death and final interment due to the immense wealth often required for final mortuary rites. The final ceremonies include cleaning of the remains, family or community feasts and ceremonies and final interment or cremation [2002:49].

That many North Carolina coastal ossuaries had within them material evidence of their ritual importance (e.g., cremations, a panther mask at the Baum site, a so-called "shaman's kit" at the Jordan's Landing site [Hutchinson 2002], and the complex structure and rich artifacts from the Broad Reach site [Mathis 1993, Driscoll 1995]) is a significant feature. Direct

observer accounts though, are more reliable for ethnohistoric and archaeological interpretations, despite their inherent cultural biases, than those garnered from other regions and later time periods (Perdue and Green 2001).

Accounts of ossuary rituals in other regions do exist (e.g., that of Brebeuf [1636] among the Huron in New York [Tooker 1964]), but their applicability to the political and temporal context of coastal North Carolina is limited. Historical accounts and cross-cultural comparisons from other regions and times can be useful, but they should not be used as direct evidence or as proxies for what may have occurred on the Late Woodland North Carolina coast (Perdue and Green 2001). One reason for the lack of direct ethnohistoric evidence may be the vagaries of colonial observation. In other words, either Europeans simply never observed then recorded ongoing ossuary ritual events, those in the position to record an ossuary ritual were not allowed to attend, or the oral histories of those who may have participated in ossuary creation events were never collected.<sup>2</sup> Yet whatever challenges exist for understanding its significance, secondary ossuary burial was a crucial element of cultural expression for North Carolina's Late Woodland coastal peoples.

### **Ossuary site descriptions**

This section comprises short descriptions of the 13 sites included in this analysis, with emphasis on the site location, MNI (minimum number of skeletal individuals), and burial

pattern (i.e., placement of burials in the ossuary or at the site). The sites are described in temporal order, from the earliest to the most recent (see Table 4.1 for dates and ceramic phase associations, and Fig 4.1 for site locations). More details about the excavation and analysis of cultural features and material remains from these ossuaries can be found in Phelps (1983), Ward and Davis (1999), and Killgrove (2002).

Though cultural affiliation has been reckoned for these sites by associating them with historic linguistic identities (see Killgrove 2002:67), this project does not aim to substantiate those labels, but to measure the interactions between the people who are represented in the ossuary burials (see Chapter 1). Taken as region, or as a single scale of analysis, there are more similarities than differences between the material cultures of the ethnolinguistic groups on the North Carolina coast (Ward and Davis 1999). Although each site is treated as a single analytical unit for the biodistance comparison, they will not be pre-sorted into linguistic groupings and thereby reinscribed into a system of classification to which archaeologists and physical anthropologists should not subscribe (see Chapter 3).

Moreover, although differences in the size and patterns of Cashie (inner coastal small ossuaries with distinct burial groups) and Colington sites (larger, less differentiated outer coastal ossuaries) certainly exist, the overlap between Cashie and Colington ossuaries, represented by the Hollowell site--which is both a larger ossuary and one showing distinct groupings within the pit--has yet to be fully explored. The similarities in

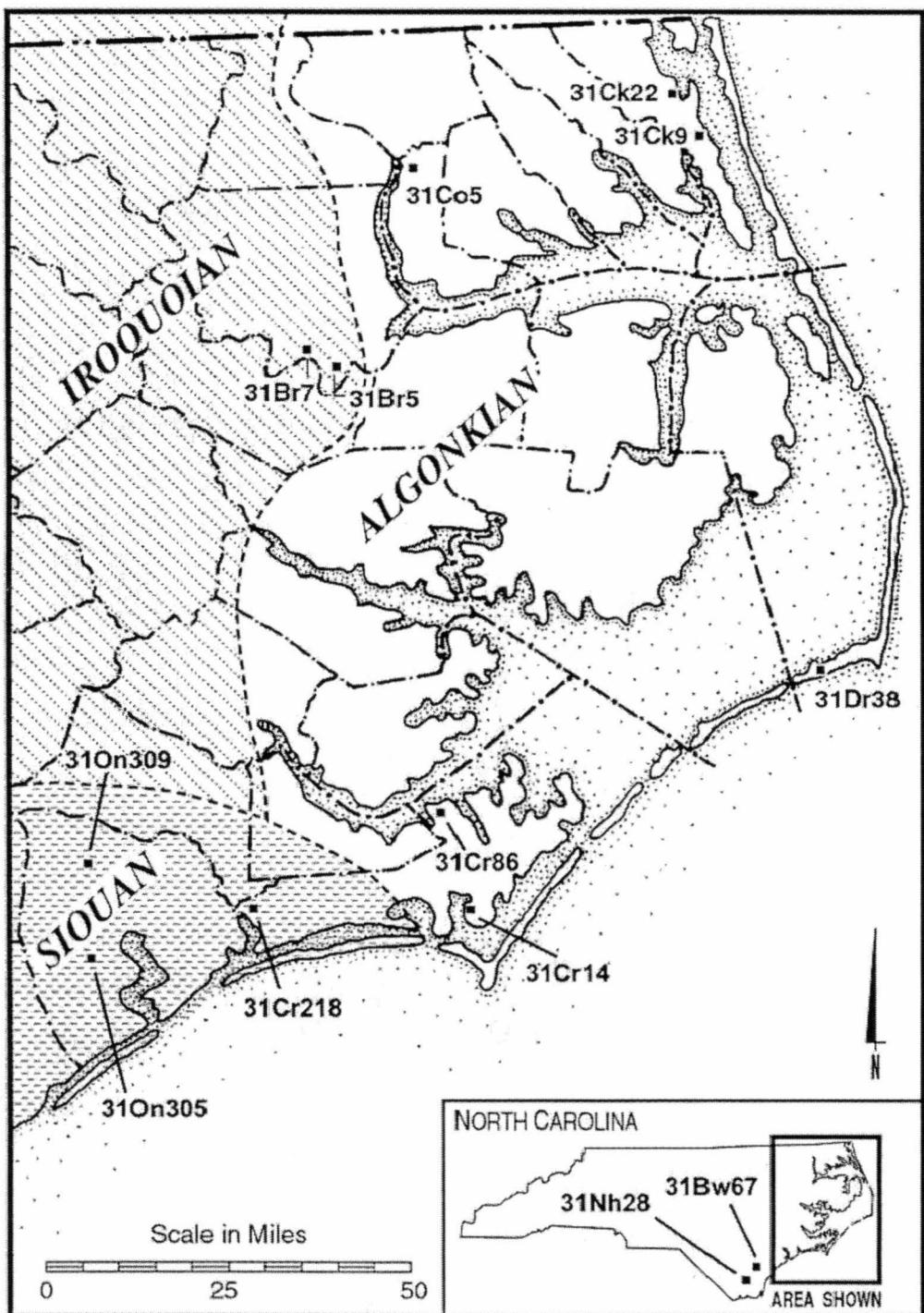
burial pattern between Colington and White Oak (southern coastal) ossuaries also leave us with more questions than answers about their respective cultural affiliations. Additionally, the earliest burials are found on the southern coast (Cold Morning and McFayden Mound), and they are also small, not unlike the later Cashie ossuaries. Thus, while the ceramic sequences for the southern coast are still under review (Herbert 2002), and the mortuary patterns for the entire region are at present poorly understood, this study takes a conservative route by ordering descriptions by the temporal sequence for the Late Woodland Period.

#### *31Nh28/Cold Morning site*

There are a minimum of 15 individuals associated with this site, which is located on a sand dune near Barnard's Creek in New Hanover County, south of Wilmington, North Carolina (Coe et al. 1982). Dated at AD 950, the Cold Morning site is the oldest ossuary that has been classified as Late Woodland on the entire North Carolina coast (Ward and Davis 1999; and see Chapter 2).

#### *31Bw67/McFayden Mound*

Located in Brunswick County approximately 15 miles west of Wilmington, North Carolina, the McFayden Mound is not considered an "ossuary" in the classic sense (see



**Figure 4.1.** Late Woodland coastal North Carolina ossuary site locations (originally drawn by Susan Brannock-Gaul and used with permission from Dale Hutchinson [2002: 20]).

**Site key:**

31Br5/Sans Souci, 31Br7/Jordan's Landing, 31Bw67/McFayden Mound, 31Ck9/Baum,  
31Ck22/West #2, 31Co5/Hollowell, 31Cr14/Piggot, 31Cr86/Garbacon Creek, 31Cr218/Broad  
Reach, 31Dr38/Hatteras Village, 31Nh28/Cold Morning, 31On305/Flynt, 31On309/Camp  
LeJeune

**Table 4.1.** Late Woodland North Carolina ossuary sites

Site	Dates	Ceramic Phase	MNI	Reference for MNI <sup>4</sup>
31Nh28/Cold Morning	AD 950 (984 <sup>1</sup> )	White Oak/Hamp's Landing	15	Coe et al. 1982
31Bw67/McFayden	circa AD 1100	Cape Fear	10	South 1966
31Cr218/Broad Reach	AD 1168 <sup>1</sup>	White Oak	36	Mathis 1993
31Dr38/Hatteras Village	AD 1350 <sup>2</sup>	?	38	Hutchinson 2002
31On305/Flynt	AD 1361 <sup>1</sup>	White Oak	158	Bogdan 1989
31On309/Camp LeJeune	AD 1368 <sup>1</sup>	White Oak	(37-) 68	Loftfield 1990
31Ck9/Baum (Bur. 1, 5, 7)	AD 1410 <sup>2,3</sup>	Colington	204	Hutchinson 2002
31Br7/Jordan's Landing	AD 1425 <sup>2</sup>	Cashie	43	Hutchinson 2002
31Co5/Hollowell	AD 1430 <sup>2</sup>	Cashie/Colington	90	Hutchinson 2002
31Cr14/Piggot	AD 1460 <sup>1</sup>	Colington	84	Truesdell 1995
31Cr86/Garbacon Creek	post AD 1300	Colington	31	Kakaliouras 1997
31Ck22/West	Late Woodland	Colington	134	Hutchinson 2002
31Br5/Sans Souci	Late Woodland	Cashie	33	Hutchinson 2002
Total skeletal individuals			944	

<sup>1</sup>Radiocarbon dates (<sup>14</sup>C intercept) courtesy of Mark Mathis (personal communication 2002)<sup>2</sup>Radiocarbon dates from Hutchinson 2002<sup>3</sup>Human bone from Baum Burials 1 and 5 both yielded dates of AD 1410. Burial 7 has not been dated radiometrically.<sup>4</sup>Also see Phelps 1983 and Ward and Davis 1999 for syntheses of many of the coastal plain ossuaries listed above.

Curry 1999). The burials were secondarily interred in a low sand mound instead of placed in a pit below the surface. This site contained the remains of a minimum of 10 individuals. It suffered periodic disturbance over the course of the middle 20th century, and was excavated by Stanley South over a two day timespan (South 1962). South believed that the McFayden Mound was not the result of a single deposition event, as some of the 10 burial features were placed in pits, while others were set on the ground level and then covered. Based on ceramics the mound is dated to approximately AD 1000 - 1200 (Mathis personal communication 2002).

#### *31Cr218/Broad Reach site*

The Broad Reach site, found in Carteret County near the Bogue Sound (Ward and Davis 1999) represents by far the most diverse burial assemblage in terms of mortuary pattern on the coast of North Carolina, in one of the smaller sites in terms of number of individuals. Present at this site were two ossuaries, three primary burials, six secondary burials and four burial pits containing human bone fragments (Mathis 1993). Ossuary #1 contained the partial and disturbed remains of a minimum of five individuals. There was also evidence of a cremation. Ossuary #2 contained the bundled remains of at least 9 adults and five infants. The total MNI for this site is 36. The artifacts found around the burials suggest a Late Woodland context. No radiocarbon dates are available for Ossuary #1, but a date of

AD 990-1280 (2-sigma range) is associated with Ossuary #2 and derived from a number of skeletal fragments (Hutchinson 2002). There is an additional calibrated radiocarbon date of AD 1444 from maize found in a smudge pit near the long house associated with this site.

#### *31Dr38/Hatteras Village*

The eroded ossuary from this site, located on Hatteras Island on the Outer Banks, was salvaged in 1974 by archaeologists from East Carolina University (Hutchinson 2002). A radiocarbon date from human bone was calibrated at AD 1395 (A.D. 1350 +/-70). There are a minimum of 38 individuals present, but little other material culture information is available.

#### *31On305/Flynt site*

Archaeologists from East Carolina University excavated this large ossuary located in Onslow County near Sneads Ferry (Bogdan and Weaver 1989). There are a possible 158-305 individuals present, although many of the remains are very fragmentary. Bogdan and Weaver (1989) analyzed the remains at Wake Forest University, and Trimble (1996) obtained stable isotope data indicating those buried at the site consumed a diet composed of both marine sources and maize. A radiocarbon date of AD 1361 was obtained from bone (Mathis, personal communication 2002).

*31On309/Camp Lejeune*

The Camp Lejeune site, which is also known as the Jarretts Point ossuary (Phelps 1983, Mathis, personal communication 2002) is on the Camp Lejeune Marine Corps base on the New River (Loftfield 1990). There are a minimum of 37 individuals present at this site, with a range up to 68, taking into account additional material found during further salvage (U.S. Army Corps of Engineers 1999). A radiocarbon date of AD 1368 situates this site firmly in the Late Woodland period (Mathis personal communication 2001). See above (Chapter 2) for further discussion of the cultural position of the Camp Lejeune skeletal remains.

*31Ck9/Baum site*

The Baum Site, located on the Currituck Sound and north of Poplar Branch, is the largest ossuary site on the North Carolina coast, and also shows evidence of a lengthy history of occupation, from perhaps before 300 BC into the historic period (Hutchinson 2002). The site is composed of 8 different burial groups, three of which are sizable Late Woodland ossuaries (Burials 1, 5 and 7). The site has a small Middle Woodland component representing about 12 individuals, but the total number of skeletal individuals from the Late Woodland component of the site is 204 (Hutchinson 2002). Radiocarbon dates of AD 1310-1400±60 were obtained from four of the burials.

*31Br7/Jordan's Landing*

An ossuary containing 43 individuals was excavated at the Jordan's Landing village site in Bertie County on the Roanoke River (Phelps 1983). A radiocarbon date of AD 1425 was obtained from a cooking area on the site. Byrd (1991, 1997) analyzed the subsistence patterns at this interior coastal plain site, and found a diverse diet comprised of both domesticated and wild food resources.

*31Co5/Hollowell site*

The skeletal remains of at least 90 individuals were excavated by David Phelps and East Carolina University (Phelps 1983) from a single ossuary in Chowan County on the Chowan River. There is a radiocarbon date of AD 1460±60 associated with this site, calibrated at AD 1430 (Hutchinson 2002). Phelps believed that nine distinct burial groups existed within the ossuary and that they represented kinship groups, though no cultural or biological information has corroborated this assertion.

*31Cr14/Piggot Ossuary*

Archaeologists from East Carolina University excavated this ossuary at the southern end of the Neuse River in Carteret County in 1975. Truesdell (1995) analyzed the skeletal remains of the 84 individuals from this site. Curiously, 57 of the 84 individuals present are

subadults under the age of five, yet no researchers have arrived at definitive conclusions about the cause of this unique demographic sample. A radiocarbon date of AD 1540 (+/-50) was obtained from human bone, and calibrated dates of AD 1420 - 1640 were measured (Truesdell 1995).

#### *31Cr86/Garbacon Creek site*

The commingled remains of at least 31 individuals are represented at this site, which was eroding out of a bank in Carteret County at the Pamlico Sound after Hurricane Ginger in 1971 (Egloff 1971b). No radiocarbon dates are available, though a small Colington pot was found on the west end of the site that led Davis and Herbert (personal communication 1998) to the conclusion that the Garbacon Creek site is from the Late Woodland Period.

Additionally, Egloff delineated 7 separate "localities" of skeletal remains within the ossuary, though some individuals were reconstructed with remains that came from separate areas of the site; the burials had been significantly disturbed before they were salvaged (Kakaliouras, 1997).

#### *31Ck22/West site (#2)*

The West site is located north of the Baum Site on the Currituck Sound, and was excavated by Mark Mathis in 1994. West represents another sizable Late Woodland

ossuary; a minimum of 134 individuals were found in 13 different burial groups (Hutchinson 2002). Radiocarbon dating analysis has not been performed on this ossuary, but both burial form and ceramic remains are consistent with a Late Woodland cultural context.

### *31Br5/Sans Souci*

It is unclear how many ossuaries made up this site in Bertie County, near Sans Souci, since there is no formal site report and the remains were donated to East Carolina University in 1973 (Hutchinson 2002). Hutchinson calculated that there are a minimum of 33 individuals present. No radiocarbon dates are available, but both the site location and Cashie phase ceramics found at the site suggest a Late Woodland temporal context.

### **Conclusion: North Carolina ossuaries in a biodistance comparison**

Despite the ethnohistoric and evidentiary challenges discussed above, these Late Woodland North Carolina coastal ossuaries represent rich sources of archaeological and biological information. One of the ways that archaeologists have understood the people buried within the ossuaries is to classify them by cultural group, through linking skeletal robusticity to language affiliation; as discussed in Chapter 3, this method is neither supported by the ethnohistoric data available, nor by recent shifts in bioarchaeological practice. Further, older classification schemes that directly link skeletal biology to culture,

like the ethnolinguistic categories applied to the burials of the Late Woodland North Carolina coast, were used and reproduced with an unfounded methodological confidence that differences in skeletal morphology are an index to differences in culture and basic cultural identity (Hrdlička 1916, Neumann 1952, Stocking 1968). In terms of Late Woodland North Carolina coastal archaeology, the interpretive goal was to determine the cultural identity of the people found in the ossuaries (Phelps 1983). The ethnolinguistic model provided an answer to that question, however untenable, and was employed especially when definitive material cultural context was lacking (see Chapter 2; i.e., Coe et al. 1982, Loftfield 1990). The line of evidence used in this study--dental nonmetric traits-- has its own theoretical and methodological foundations that will be fully developed in the next chapter.

For this study, the dental remains from these 13 Late Woodland North Carolina coastal ossuaries were analyzed to estimate biological interactions between the people buried within them. Biodistance charts morphological similarity or difference between groups using skeletal metric or nonmetric traits (Saunders 1989). Therefore, calculating skeletal biological distance, like comparing skeletal robusticity across sites, is not an analytical process that will independently reveal a workable system of cultural classification. The results of a biodistance analysis, though, can be interpreted in light of

archaeological, cultural, and ethnohistoric data to give a fuller picture of past population structure (Buikstra et al. 1990).

The long ossuary tradition on the North Carolina coast is an important feature of the Late Woodland period, one for which little synthetic research has been completed (Phelps 1983, Hutchinson 2002, Hutchinson and Aragon 2002). The last three chapters of this study, therefore, detail the methods, then present and interpret the results of a dental biodistance analysis of the ossuaries described above in an effort to contribute scholarly attention to this region by examining and re-evaluating the way Late Woodland North Carolina coastal people have been classified.

## **Notes.**

1. Mathis (1993) has suggested that completeness of skeletal remains may be a good indicator of status in some of the larger, "community" ossuaries of this time period. His rationale is that more complete and articulated remains may point to an increased level of care and attention given to the remains before burial. However, this hypothesis has not been tested, and many ossuaries were excavated for the purpose of salvaging remains that were eroding out of the sand and into water or other external hazards. Reconstructing distinct individuals from remains recovered under these conditions is challenging. Further, inferring social status with any degree of certainty directly from the skeletal elements, or from field photographs, is not possible with the osteological evidence that currently exists. That is not to say that more detailed mortuary analyses, including both archaeological and skeletal evidence, could not illuminate status differences among these groups.
2. Another more compelling yet controversial speculation is that the ossuary tradition practiced by Native coastal North Carolinians had already ceased to be practiced before the late 17th or 18th century. The most recent date for a coastal ossuary is AD 1640, the Piggot site (Truesdell 1995). That late date is the upper range of the radiocarbon assay; the calibrated date for the ossuary is AD 1540. Taphonomic issues could account for the lack of representation of even later ossuaries; perhaps those were the first to be lost to the sea or the sounds. Another interesting avenue for research however, would be to investigate possible correlations between the lack of later ossuaries and the effects of European contact and colonization on coastal populations. In other words, Native village life on the coast was disrupted at some point as a result of migration (Rountree 1993, Swanton 1946), depopulation due to disease (Lawson 1967 [1709]) and slave-raiding practices (Fischer 2002, Merrell 1989). While Ward and Davis (1999:259) have shown that North Carolina Piedmont peoples continued to carefully bury their dead, even during harsh epidemic conditions, the same may not have held true for the coastal peoples.

## **Chapter 5: A framework for biological relationships between precontact North Carolina Coast peoples, II - Analytical Context and Methodology**

Skeletal biological distance, or biodistance, is the study of morphological divergence between human groups (Buikstra et al. 1990, Buikstra et al. 2003, Larsen 1997:302). Biodistance researchers compare the occurrence or nature of polygenic traits, either metric or nonmetric, and between or within skeletal samples, to estimate population “relatedness” (Buikstra et al. 1990, Saunders 1989). The concept of relatedness has generally been understood to mean biological similarity with regard to the complex interplay between genetic and environmental factors that produce polygenic skeletal traits (Buikstra et al. 1990). This chapter describes the regional and analytical context for the use of biodistance to evaluate interaction between precontact North Carolina skeletal samples, and sets out the specific methods used in the analysis.

Biodistance has been stringently critiqued for being inherently “racial” in research disposition (e.g., Armelagos and Van Gerven 2003: 60-61). Although biodistance, as a method that marshals skeletal morphology to speak to questions of migration, ancestry, adaptation, and evolution, is the theoretical descendant of the typological morphological studies described in Chapter 3, the method is neither essentially taxonomic, nor easily confined to the category of “racial history” (Armelagos and Van Gerven 2003:61). As

discussed in Chapter 1, when researchers make decisions to pool samples over large regions and time periods, or to associate various patterns of traits with racial, ethnic, linguistic, or cultural groups, then biodistance takes on an unequivocably typological orientation. Deciphering patterns of trait expression or continuums of morphology in past groups does not automatically invite the matching of modern cultural categories to discrete sets of trait patterns, though such classification does occur (e.g., Cavalli-Sforza 2000, Turner 1969). Therefore, biodistance can be used to support assumptions that language, culture and biology are static and always related to each other in the same ways, even in radically different populations (Schindler 1985); though, the method is, fundamentally, an adaptable tool for interpreting morphological difference and change in past populations (Larsen 1997).

One of the most important contributions studies of biological distance have made to anthropology is in the category of population origins and history. A good deal of this work has dealt with late Pleistocene and early to mid-Holocene era population migrations throughout the world (e.g., Greene 1982 and Irish and Turner 1990 in Africa; Lukacs and Hemphill 1993, Hemphill et al. 1991 and Turner 1979, 1985 in areas of Asia; and Greenberg et al. 1986 and Turner 1987 for the peopling of the New World).

Turner has established general categories for the classification of diversity in Native American tooth morphology, subsequently linking Native American populations to three proposed migrations of ancestral groups from Asia. These categories are: Eskaleut

(Eskimos and arctic Aleuts), Nadene (groups native to northwestern North America), and Macro-Indian (comprising all other Native Americans, from North, South and Central America) (Turner 1987, Scott and Turner, 1997). Greenberg and coworkers (1986) claim that Turner's groupings show a realistic correspondence with linguistic divisions between Native Americans and genetic evidence from living Native populations. This claim has been controversial though, and Turner's lack of specificity in categorizing his "Macro-Indian" group is not informative for discriminating between groups from the eastern United States (Campbell 1997, and see Larsen 1997:320-321).

The bulk of previous regional biological distance research for the western hemisphere has been done in the western and middle United States. The work in the midwestern United States has charted the population history and divergences of groups in Illinois via craniometric and non-metric traits (Buikstra 1975, Konigsberg 1990, Konigsberg and Buikstra 1995). Jantz and other researchers have focused on the Plains and Upper Midwest (Jantz 1977, Jantz et al. 1981), tracking the relationships between Native populations from the Paleoindian period up until European contact.

Biological distance studies of skeletal populations from the southeastern United States have been undertaken by Berryman (1975, 1980), Boyd (1984, 1986), Boyd and Boyd (1991), Droessler (1981), Wilson (1988), Hutchinson (1979), Turner (1980), Wright (1974), and most recently, Griffin (Griffin 1993, Griffin and Nelson 1996, Griffin et al. 2001)

and Killgrove (2002). Berryman's and Boyd and Boyd's work focuses on the biological affinities between three principal Late Prehistoric central and eastern populations from Tennessee. Previously, archaeologists had linked the Middle Cumberland, a central Tennessee phase, to Mouse Creek, an eastern phase (Kneberg 1952). Boyd and Boyd's research, combining biological, archaeological and historic information, concluded that the two eastern phases (Dallas and Mouse Creek) are more closely related to each other than they are to the Middle Cumberland, invalidating previous conceptions of biological relatedness and population movements in the middle and eastern Tennessee regions.

In addition, Wilson (1988) conducted a biological distance study of North Carolina Piedmont Siouan populations as a part of her dissertation on Siouan mortuary practices. She examined possible links between precontact and historic Siouan groups, and evaluated northern and southern Siouan cultural divisions using a suite of skeletal and dental metric and nonmetric traits. Her results indicated that although no definite link between precontact and historic populations could be made with the available evidence, a morphological division between northern (Virginian) Siouan groups and southern (North Carolinian) groups was tentatively supported.

More recently, Griffin (1993, 2001) has evaluated populations from Spanish Florida, in conjunction with research by Larsen and others (see Larsen 1997 for a full suite of references from this regional area). He analyzed dental and cranial morphological traits for

groups comprising two time periods for Guale, a region of coastal southern Georgia and Florida, then placed these groups in a wider regional context with others from North Carolina, Tennessee, Georgia and Florida. Griffin collected data on two of the samples included in this project, the Baum (31Ck9) and Piggot (31Cr14) sites. In his analysis, the North Carolina coastal samples clustered distinctly from any of the other groups in his study. This study recomputed Griffin's dental data (as published in Griffin et al. 2001) and compared it to the data set for the Late Woodland North Carolina Coast. The reasons for this strategy were twofold: to situate the North Carolina coastal ossuaries in both temporal and regional perspective, and to test the reliability of the statistical methods Griffin piloted in his dissertation and subsequent research (see below).

Lastly, Killgrove (2002) used cranial nonmetric traits to examine two Virginia ossuary groups, as well as many of the ossuary samples from the coast of North Carolina included in this dissertation (Killgrove 2002:33-63). She found no statistically significant differences between the Late Woodland samples. She also used a comparative analysis with a portion of the Terry Collection, a modern American skeletal sample curated at the Smithsonian institution, to substantiate that the Native American groups are biologically distinct from the modern individuals in her study (Killgrove 2002: 65). A discussion of how the dental nonmetric results articulate with her cranial nonmetric data appears in Chapter 7.

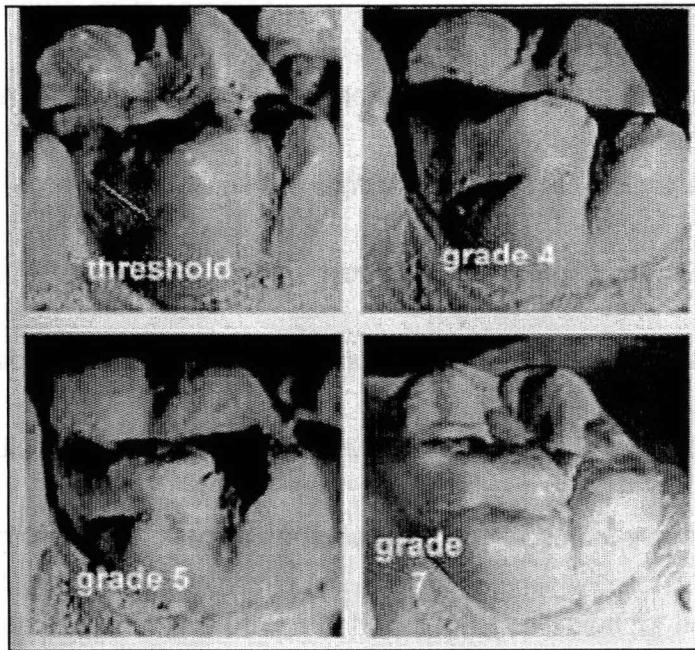
## **Dental biodistance theory and statistical methodology**

Before the statistical foundations for the analysis of dental nonmetric traits are detailed, a brief discussion of the mechanics of their heritability and variation is in order. Although tooth size has been found to vary significantly as a result of differing environmental conditions and physiological insults, the expression of nonmetric morphological traits has not (Scott and Turner 1997). Moreover, even though it is recognized that these traits vary due to genetic influences, numerous attempts to link crown traits with simple modes of genetic inheritance have all failed. Scott and Turner (1997) provide an extensive review of the history of research in dental morphological genetics. The following discussion will focus on current conceptions of the genetics of dental morphology, and examples of the traits considered important for this type of analysis.

Various lines of evidence (e.g., twin and family studies, and population variation studies) demonstrate that genes are the central factor controlling dental trait variation (Biggerstaff 1970, Harris and Bailit 1980). The development of tooth crown and root morphology takes place in a highly regulated fashion, with six morphological stages occurring before the final mineralization and eruption (see Hillson 1996 and Scott and Turner 1997 for a full discussion of dental ontogeny). An individual's genes do not produce differentiation in morphology of crowns or roots directly; rather, they control the onset, rates, and general timing of the processes that result in a normal, mature tooth.

Decades of research have shown that dental morphological traits follow a pattern of quasicontinuous variation (Gruneberg 1952). This type of variation can be described as a continuum encompassing the presence and absence of the trait in question, with a threshold marking the onset of its presence. Variation in the presence of a certain trait is then conceptualized with a categorical scale of severity (Turner et al. 1991). Traits often appear to be exhibiting a simple autosomal dominant mode of inheritance, especially when they are found in high frequencies (Scott 1973). Conversely, traits found in low frequencies appear to be following a simple recessive pattern of inheritance. This frequency patterning, though, is more accurately conceptualized as two ends of a continuum, with significant variation in expression at points between them. Figure 5.1 illustrates the continuum of variation for a particular maxillary molar crown trait--Carabelli's cusp (Scott and Turner 1997, Turner et al. 1991).

The ranges of variation for 35-40 dental traits have been documented and standardized over the course of the last half century, using thousands of archaeological and modern individuals to create amalgamations of the typical variation in a certain trait (i.e., Dahlberg 1956, Scott and Turner 1997, Turner et al. 1991). Copies of these casts are readily available through the anthropology laboratory at Arizona State University. Many of the dental morphological variants considered appropriate for charting difference between populations occur on the complex crowns of all types of teeth. The traits may take the form



**Figure 5.1.** Portion of the continuum of expression of Carabelli's cusp, an upper molar nonmetric trait (modified from Scott and Turner 1997:43)

of extra ridges, additional cusps, and variation in cusp number and form. Additionally, variations in root number and shape are also often considered valid for making distinctions between samples. Dental traits commonly used in population comparisons are scored on different continuums, as discussed above, ones specific to each trait's pattern of expression. Carabelli's cusp, an accessory cusp on the lingual side of upper molars, is scored on a scale from 0 (absence) to 7 (free-standing cusp). However, the metaconule, a small cusp that can occur on the distal occlusal surface of upper molars, varies on a continuum from 0 (absence) to 4 (medium-sized cusp) [Hillson 1996]. Although it is possible to compare the pattern of fluctuation of each trait across population samples with univariate statistics, this type of analysis is cumbersome given the number of traits collected for each individual (Griffin, Konigsberg, personal communications 1998). Table 5.1 lists the dental traits collected for this biodistance study.

There are a number of statistical procedures that are appropriate for estimating biological distance using these kind of data. In the interest of consistency and maximum comparability, this project follows the analytical methods used by Griffin (1993, 2001) in his nonmetric biodistance study of Georgia and Florida pre- and postcontact Native groups. In addition, I also recalculated Griffin's dental data from Central and Western North Carolina to compare his results to those obtained from the North Carolina coastal samples (see Chapter 6).

**Table 5.1.** Dental nonmetric traits collected for the biodistance analysis of the Late Woodland North Carolina coast.

Trait	Teeth	Central references (and see Scott and Turner 1997)
Maxillary dentition		
Winging	Central incisors	Enoki and Dahlberg 1958; Dahlberg 1963
Shoveling	Incisors	Hrdlička 1920; Dahlberg 1963; Moorrees 1957
Double-shoveling	Central incisors	Dahlberg 1956; Turner 1967
Curvature	Central incisors	Nichol et al. 1984
Interruption groove	Lateral incisors	Turner 1967
Peg-shaped incisor	Lateral incisors	Turner et al. 1991
Tuberculum dentale	Lateral incisors	Turner et al. 1991
Canine distal accessory ridge	Canines	Scott 1973; Turner et al. 1991
Premolar accessory cusps	Premolars	Turner 1967
Tri-cusped premolars	Premolars	Turner et al. 1991
Distosagittal ridge	Premolars	Morris et al. 1978
Odontome	Premolars	Alexandersen 1970
Premolar root number	Premolar 3	Turner 1967
Metacone	3 <sup>rd</sup> molars	Turner et al. 1991
Hypocone	1 <sup>st</sup> and 2 <sup>nd</sup> molars	Scott 1973; Turner et al. 1991
Metaconule	1 <sup>st</sup> and 2 <sup>nd</sup> molars	Turner et al. 1991
Carabelli's cusp	1 <sup>st</sup> and 2 <sup>nd</sup> molars	Dahlberg 1963; Scott 1973
Parastyle	3 <sup>rd</sup> molar	Turner et al. 1991
Enamel extensions	1 <sup>st</sup> and 2 <sup>nd</sup> molars	Harris and Bailit 1980
Molar root number	2 <sup>nd</sup> molars	Turner 1967
Peg-shaped molar	3 <sup>rd</sup> molar	Turner et al. 1991

**Table 5.1 continued.**

Trait	Teeth	Central references (and see Scott and Turner 1997)
Mandibular dentition		
Canine root number	Canines	Turner 1967
Tomes' root	1 <sup>st</sup> premolar	Tomes 1923; Turner et al. 1991
Premolar lingual cusp variation	1 <sup>st</sup> and 2 <sup>nd</sup> premolars	Kraus and Furr 1953; Scott 1973
Odontome	Premolars	Alexandersen 1970
Anterior fovea	1 <sup>st</sup> molar	Hrdlička 1924; Turner et al. 1991
Groove pattern	1 <sup>st</sup> and 2 <sup>nd</sup> molars	Hellman 1929
Cusp number	1 <sup>st</sup> and 2 <sup>nd</sup> molars	Hellman 1929
Deflecting wrinkle	1 <sup>st</sup> molars	Weidenreich 1937; Turner et al. 1991
Distal trigonid crest	1 <sup>st</sup> molars	Hrdlička 1924
Protostyliid	1 <sup>st</sup> and 2 <sup>nd</sup> molars	Dahlberg 1963; Turner 1967
Cusps 5, 6 and 7	1 <sup>st</sup> and 2 <sup>nd</sup> molars	Turner 1970; Turner et al. 1991
Molar root number	1 <sup>st</sup> and 2 <sup>nd</sup> molars	Turner 1967; Turner et al. 1991
Torsomolar angle	3 <sup>rd</sup> molar	Turner et al. 1991
Radical (root) number	All teeth	Turner 1967
Palatine torus	Palate	Turner et al. 1991
Mandibular torus	Mandible	Morris 1970

Moreover, as discussed, one possible object of a biological distance analysis is to estimate relatedness between population samples. Single trait comparisons can pinpoint significant differences in the expression of traits across samples, but such analysis does not allow anything meaningful to be said about the relative distance between the samples as a whole. Therefore, multivariate methods which express the difference between populations with a single numerical value have been adopted by biological distance researchers. This value is derived from the sum of squared differences between variates of population samples (Smith 1972, Sofaer et al. 1986). Because the raw data used in dental biological distance studies is comprised of frequencies of trait expressions across different continuums, the frequencies must be dichotomized to express presence vs. absence (Turner 1987). Although more minute variation across grades for each trait is lost by expressing them as present or absent, the variance that is significant for distinguishing between populations happens between slight and extreme trait expressions.

Another challenge in biodistance studies is achieving a stabilization of variance across sample sizes. In order for the traits for a given site to be effectively pooled and compared to the same set of traits for a different site, variance as a result of differing sample sizes must be minimized. The most effective operation for stabilizing variance across samples is an angular transformation developed by Freeman and Tukey (1950) and suggested by Green and Suchey (1976) for use in biodistance studies:

$$\theta = \frac{1}{2}\sin^{-1}(1 - 2k/(n+1)) + \frac{1}{2}\sin^{-1}(1 - 2(k+1)/(n+1))$$

where  $k$  is the number of individuals scored as positive for a given trait, and  $n$  is the total number of individuals scored for said trait in the population. This transformation was used in this study, following Griffin (1993) who chose to do so after he reviewed a number of other transformations, all of which were found to be less reliable in minimizing variance produced by small sample sizes.

Along with their utility in the Mean Measures of Divergence equation, as explained below, these arcsine transformed values are also the units for a cluster analysis, specifically using Ward's minimum variance method, an operation which classifies values based on a set of variables (Griffin 1993:180-181, Ward 1963). The groups constructed by a cluster analysis are expressed graphically in a two-dimensional dendrogram--which looks like a set of branches or a phylogenetic tree--from the closest clustered groups to the least alike groups. With a high level of intercorrelation however, the cluster analysis becomes less reliable, so the dental traits selected for the comparison are checked for high correlations using a Tau-B correlation coefficient before analysis (Goodman and Kruskal 1954, 1959, 1963 and Griffin 1993:129). Additionally, cluster analysis places all the values into its new groups, thus the procedure assumes a normal distribution.

Cluster analysis is a general way to measure biological distance based on the dental trait frequencies, but a more powerful tool is the Mean Measures of Divergence (MMD) itself. After the trait values are dichotomized and then arcsine transformed using the above operation, they are applied to the MMD statistic, one of the more commonly used operations in dental nonmetric biological distance studies between skeletal populations (Molto 1983, Scott and Turner 1997, Sjøvold 1977):

$$MMD = \frac{\sum_{i=1}^r (\theta_{1i} - \theta_{2i})^2 - [1/(n_{1i} + \frac{1}{2}) + 1/(n_{2i} + \frac{1}{2})]}{r}$$

In this equation  $r$  is the number of traits used in the comparison, the theta values are the transformed frequencies of the  $i^{\text{th}}$  trait in the groups being compared, and  $n_{1i}$  and  $n_{2i}$  are the number of individuals that were scored for the trait. This statistic produces a single value for the comparison of a number of traits between two groups or among samples.

The variance and standard deviation of the Mean Measures of Divergence are calculated using equations suggested by Sofaer et al. 1986 and used by Griffin (1993, 2001) as well:

$$Var_{MMD} = \frac{2}{r^2} \sum_{i=1}^r \left( \frac{1}{n_{1i} + \frac{1}{2}} + \frac{1}{n_{2i} + \frac{1}{2}} \right)^2$$

$$sd_{MMD} = \sqrt{Var_{MMD}}$$

Here again, r is the number of traits used in the comparison, and n represents the number of individuals scored. An MMD value is considered statistically significant if it is twice as large as its standard deviation (Molto 1983, Sjøvold 1977)

The MMD equation is essentially the sum of squared differences between the theta values for each trait, with the assumed variance removed (the second expression in the numerator). Dividing an MMD value by its standard deviation produces a "standardized MMD," a value which is analogous to a Z score in basic statistics (Tabachnik and Fidell 1996). When more than two samples are used in the analysis, as in this study, where 13 discrete samples are being compared, the MMD and standardized MMD values are placed into a dissimilarity matrix which is then the object of a multidimensional scaling analysis. MMD values may be interpreted based solely on their statistical significance without graphical representation, but the multidimensional scaling analysis provides a way in which to evaluate the relative distances between samples in two or three-dimensional euclidean space, which allows more general patterns to be interpreted (Wilkinson 1988).

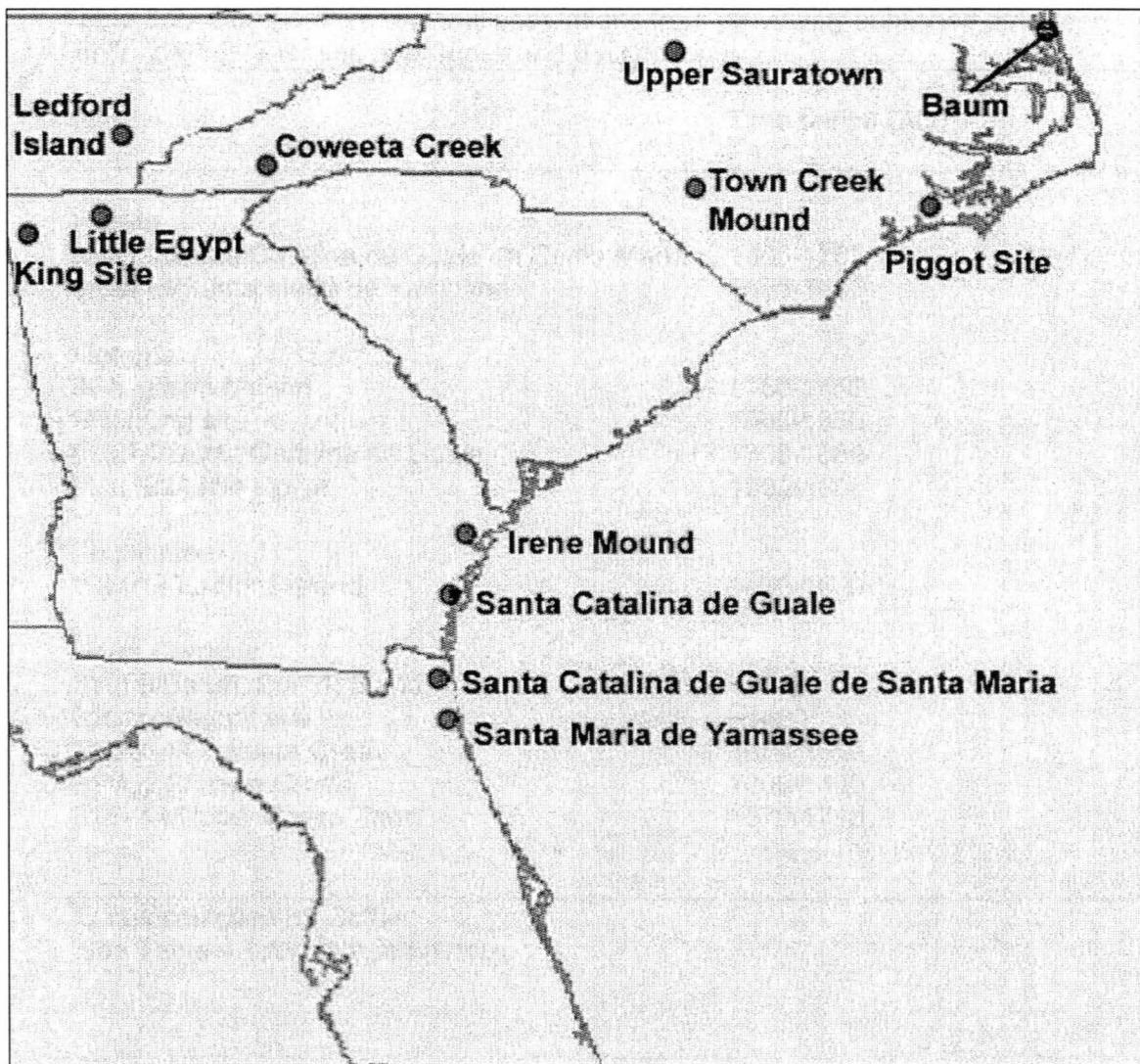
#### **Biodistance procedures: the Late Woodland North Carolina coast comparisons**

The specific steps for setting up the biodistance comparisons using dental samples from Late Woodland North Carolina coastal ossuaries are described below. The importance of each procedure lies in its capability to either maximize the strength of the final

comparisons, minimize the possible errors, or in some cases, both. Additionally, this project articulates with regional comparisons of another researcher (Griffin 1993, 2001), thus particular procedures were tailored to fit the structure of the North Carolina coastal data as well as possible with that of previously published data from Griffin's research in Florida, Georgia and western North Carolina (see Figure 5.2 and Table 5.2 for information on these comparative samples). As detailed above, I followed the same statistical procedures piloted by Griffin (1993) for the Southeast as a region. Thus, the final comparisons are as robust as possible with regard to the research context previously in place for the Late Woodland and historic Southeastern United states. Following the procedural descriptions, results and interpretations of the statistical analyses are presented.

### **Data collection and initial processing**

Dental morphological observations were conducted on the 44 traits that are listed in Table 5.3 (some traits grouped by tooth type), the same basic trait list Griffin developed (1993:95-97; see Table 5.1 for references and Appendix A for recording forms). There are three main methods of tooth observation in dental morphology: total tooth count, unilateral count and individual count (Scott 1980). Total tooth count refers to collecting data on both the left and right sides of an individual's mouth, and this method tends to inflate sample sizes artificially. Unilateral count is only collecting data on one antimere, or scoring on only



**Figure 5.2.** Sites utilized for the regional comparison (drawn from Griffin et al. 2001:228)

**Table 5.2.** Comparative regional populations from previously published data (see Griffin 2001:229 for site references and descriptions)

Site	Time period (AD) <sup>1</sup>
<i>Florida</i>	
8Na41/Santa Catalina de Guale de Santa Maria	1686-1702
8Na41d/Santa Maria de Yamasee	1675-1683
<i>Georgia</i>	
9Ch1/Irene Mound	1150-1550
9Fl5/King site	1500-1650
9Li274/Santa Catalina de Guale	1608-1680
9Mu102/Little Egypt	1350-1500
<i>Tennessee</i>	
16By13/Ledford Island	1400-1600
<i>North Carolina</i>	
31Ck9/Baum, Bur. 1, 5 and 7	~1410 <sup>2</sup>
31Cr14/Piggot site	~1460 <sup>2</sup>
31Ma34/Coweeta Creek	1620-1650
31Mg2,3/Town Creek	1200-1400
31Sk1a/Upper Saura Town	1670-1710

<sup>1</sup>Dates compiled by Griffin.

<sup>2</sup>See Table 4.1 for date references.

**Table 5.3.** Dental nonmetric traits considered for the biodistance analysis of the Late Woodland North Carolina coast

Trait	Teeth
<b>Maxillary dentition</b>	
Winging	Central incisors
Shoveling	Incisors
Double-shoveling	Central incisors
Curvature	Central incisors
Interruption groove	Lateral incisors
Peg-shaped incisor	Lateral incisors
Tuberculum dentale	Lateral incisors
Canine distal accessory ridge	Canines
Premolar accessory cusps	Premolars
Tri-cusped premolars	Premolars
Distosagittal ridge	Premolars
Odontome	Premolars
Premolar root number	Premolar 3
Metacone	3 <sup>rd</sup> molars
Hypocone	1 <sup>st</sup> and 2 <sup>nd</sup> molars
Metaconule	1 <sup>st</sup> and 2 <sup>nd</sup> molars
Carabelli's cusp	1 <sup>st</sup> and 2 <sup>nd</sup> molars
Parastyle	3 <sup>rd</sup> molar
Enamel extensions	1 <sup>st</sup> and 2 <sup>nd</sup> molars
Molar root number	2 <sup>nd</sup> molars
Peg-shaped molar	3 <sup>rd</sup> molar
<b>Mandibular dentition</b>	
Canine root number	Canines
Tomes' root	1 <sup>st</sup> premolar
Premolar lingual cusp variation	1 <sup>st</sup> and 2 <sup>nd</sup> premolars
Odontome	Premolars
Anterior fovea	1 <sup>st</sup> molar
Groove pattern	1 <sup>st</sup> and 2 <sup>nd</sup> molars
Cusp number	1 <sup>st</sup> and 2 <sup>nd</sup> molars
Deflecting wrinkle	1 <sup>st</sup> molars
Distal trigonid crest	1 <sup>st</sup> molars
Protostyloid	1 <sup>st</sup> and 2 <sup>nd</sup> molars
Cusps 5, 6 and 7	1 <sup>st</sup> and 2 <sup>nd</sup> molars
Molar root number	1 <sup>st</sup> and 2 <sup>nd</sup> molars
Torsomolar angle	3 <sup>rd</sup> molar
Radical (root) number	All teeth
Palatine torus	Palate
Mandibular torus	Mandible

one side of the mouth consistently through one's data collection procedure. This method tends to radically reduce sample size due to the fact that tooth loss, carious lesions, postmortem breakage and other factors can often make data collection impossible for a single antimere, or side of the mouth. The individual count method, the one used for this project, denotes the observation of both sides of the mouth, and the preservation of the highest of the two scores for analysis for a single individual. Turner and Scott (1977) believe that this procedure realistically represents the genetic potential of a certain trait in an individual.

Because most North Carolina ossuary MNI's (minimum number of individuals) were 100 or fewer, the individual count method was the most effective, since significant loss of sample size would have jeopardized the whole biodistance comparison. Likewise, inflation of the sample sizes would have unnecessarily damped the degree of variation present in the samples.

Since many skeletal individuals from the North Carolina coastal ossuaries had lost teeth postmortem, every effort was made to match individual teeth to maxillae and mandibles from the same or similar excavation locations within sites. When large samples of loose teeth were encountered, they were sorted into individuals by tooth type. Single teeth which could not be attached to a skeletal or dental individual were not included in the analysis. For the dichotomization of morphological traits into presence and absence

Turner's (1987) cut-off values were used, the same employed by Griffin for his analysis (Table 5.4).

Biodistance researchers have become aware of the detrimental effect tooth wear, or attrition, may have on both morphological and metric data collection (Turner et al. 1991). Following Burnett et al.'s (1998) recommendations in their interobserver wear study of four morphological traits, attrition data was collected on 8 of the 13 Late Woodland North Carolina coastal ossuary samples. Based on Smith's (1984) wear categories, I found that morphological traits were consistently adversely affected (up to a 40% loss of data) with grades 3 and 4 on anterior teeth and 4 and 5 on posterior teeth. Thus all teeth worn at and beyond those attrition categories were omitted from the biodistance analysis. Many clearly older individuals were excluded from the analysis because of dental wear, yet the statistical effect of mis-scoring the morphological traits would have been more grave than accepting a slight age bias for the comparisons (see below).

#### **Intra- and interobserver error**

Osteological and bioarchaeological data collection is susceptible to both intra- and interobserver error; researchers have labored intensively to minimize as much of this type of data collection error as possible (e.g., Buikstra and Ubelaker 1994). Intraobserver error, that produced by fluctuations in one's data collection procedures, can be measured by

**Table 5.4.** Cut-off values for the dichotomization between presence and absence for dental nonmetric traits (from Turner 1987).

Trait	Score for presence
Shoveling I2	>2
Double shoveling I1	>1
Interruption groove I2	>0
Metacone M3	>1
Hypocone M2	>1
Metaconule M1	>0
Carabelli's trait M1	>1
Carabelli's trait M2	>1
Cusp number M1	>4
Parastyle M3	>0
Peg-shaped incisor	>0
Peg-shaped molar	>0
Groove pattern M1	>1
Groove pattern M2	>1
Cusp number M1	>5
Cusp number M2	>4
Protostyloid M1	>0
Cusp 5 M2	>1
Cusp 6 M2	>1
Cusp 7 M1	>0
Cusp 7 M2	>0

calculating the differences between repeated observation sessions. If one person collects all the data for a certain study, interobserver error is not an issue, but as is the case for this and many other biodistance analyses, another researcher's data is employed to serve as a comparative sample. Dental traits are particularly susceptible to both types of error, thus I measured intraobserver error, as well as selected traits for the regional comparison that minimized interobserver error (Nichol and Turner 1986).

For the intraobserver test, methods were followed that were suggested by Nichol and Turner (1986) to evaluate intraobserver data collection trends over time. Data was collected on the Baum 1 ossuary ( $n \sim 50$ ) in two separate sessions, approximately 6 months apart. There were four different percent values collected for each trait between these two sessions:

1. Percentage of teeth observed in one session but not in the other
2. Percentage of times when the score for a trait differed between sessions
3. Percentage of times when the difference in score was greater than one grade
4. Percentage of cases when a trait was scored present in one session and not another

Table 5.5 details the results of the intraobserver reliability test. Means across 44 traits for the four different subtests are comparable to those Griffin obtained (1993:135), and lower than those from other dental nonmetric studies (Molto 1983, Nichol and Turner 1986, Scott 1973). These results indicate that the pattern of intraobserver error should not adversely affect the statistical comparisons.

**Table 5.5.** Intraobserver reliability test for data collected on the Baum 1 ossuary (n=~50)

Trait	N of teeth	Observed one session only	Different score between sessions	Greater than one grade of difference	Present vs. absent scoring
Winging	10	0.000	0.000	0.000	0.000
Shoveling I1	6	0.000	0.333	0.000	0.000
Shoveling I2	4	0.000	0.250	0.000	0.000
Curvature	8	0.000	0.000	0.000	0.000
Double shoveling	11	0.000	0.181	0.090	0.090
Interruption groove	15	0.000	0.000	0.000	0.000
Peg-shaped incisor	32	0.031	0.000	0.000	0.000
Tuberculum dentale	10	0.000	0.200	0.000	0.000
Canine mesial ridge	5	0.000	0.000	0.000	0.000
Distosagittal ridge	8	0.000	0.000	0.000	0.000
Upper odontome	27	0.074	0.000	0.000	0.000
PM root number	17	0.000	0.000	0.000	0.000
Metacone	12	0.000	0.167	0.000	0.000
Hypocone M1	23	0.043	0.087	0.043	0.000
Hypocone M2	21	0.000	0.095	0.047	0.000
Metaconule M1	15	0.000	0.000	0.000	0.000
Metaconule M2	13	0.000	0.000	0.000	0.000
Carabelli's M1	15	0.067	0.020	0.000	0.000
Carabelli's M2	9	0.111	0.000	0.000	0.000
Parastyle	8	0.000	0.000	0.000	0.000
Enamel extensions	21	0.095	0.238	0.000	0.095
Molar root number	19	0.000	0.000	0.000	0.000
Peg-shaped molar	30	0.000	0.000	0.000	0.000
Canine root number	31	0.129	0.000	0.000	0.000
Tomes' root	10	0.000	0.000	0.000	0.000
PM lingual variation	36	0.111	0.111	0.138	0.027
Lower odontome	35	0.114	0.000	0.142	0.000
Anterior fovea	6	0.000	0.000	0.333	0.000
Groove pattern M1	14	0.000	0.000	0.000	0.000
Groove pattern M2	25	0.000	0.000	0.000	0.000
Cusp number M1	21	0.000	0.142	0.000	0.000
Cusp number M2	24	0.000	0.167	0.000	0.000
Protostyloid M1	34	0.117	0.088	0.000	0.000
Protostyloid M2	19	0.000	0.000	0.000	0.000
Deflecting wrinkle	6	0.167	0.000	0.000	0.000
Distal trigonid crest	7	0.000	0.000	0.000	0.000
Cusp 5 M1	34	0.058	0.147	0.000	0.088
Cusp 5 M2	22	0.090	0.045	0.000	0.181
Cusp 6 M1	18	0.000	0.000	0.000	0.167
Cusp 6 M2	21	0.000	0.000	0.000	0.000
Cusp 7 M1	14	0.000	0.000	0.000	0.000
Cusp 7 M2	17	0.000	0.000	0.000	0.000
1 <sup>st</sup> molar root number	26	0.000	0.077	0.000	0.000
2 <sup>nd</sup> molar root number	21	0.000	0.000	0.000	0.000
Means of variance across 44 traits		0.027 (2.7%)	0.053(5.3%)	0.015(1.5%)	0.014(1.4%)

In terms of interobserver error, the challenges are more difficult to overcome. While standards exist for the data collection of dental nonmetric traits (Turner et al. 1991), there is a great deal of interobserver variability in trait scoring. Nichol and Turner (1986:312), then, only advise the use of the following 13 traits in interobserver comparisons: parastyle, metaconule, molar cusp number, metacone, hypocone, winging, odontomes, maxillary torus, incisor shoveling, double-shoveling, cusp 6, accessory cusps on the upper 3rd premolar, and lower premolar lingual cusp number. In the biodistance comparison of the North Carolina coastal samples and those Griffin collected then, all of the above traits were used except winging, odontomes, UP3 accessory cusps and lower premolar cusp number (as available in Griffin 2001:267-272). Griffin collected data on the Baum (31Ck9) and Piggot (31Cr14) sites as well, but as he pooled those sites for his extra-regional analysis, direct comparisons with that raw data are not possible.

#### **Sex/age trait linkages, intercorrelations and trait elimination**

One of the constraints of the use of a dental biodistance comparison with ossuary samples is that the preponderance of the dental individuals could not be sexed positively. Out of a total of 715 individuals from 8 northern coastal Late Woodland ossuaries, Hutchinson reports sex identifications of male or female for 156 of them, while the rest are indeterminate (Hutchinson 2002:62-63). Similarly, in one of the smaller southern ossuaries,

the Garbacon Creek site (31Cr86), only 9 out of 20 individuals were able to be positively sexed, and 4 of those sexed had no teeth represented (Kakaliouras 1997). These numbers preclude being able to perform a definitive analysis of sex-linked dental nonmetric traits that would be significant to the comparison. Griffin was able to run correlative statistics on dental traits from the larger population samples in his study, but he found only very weak associations between most of the traits and sex identification (Griffin 1993:118).

Further, cranial nonmetric traits change over the course of an individual's lifetime since the skeleton remodels continuously (e.g., Corruccini 1974, Ossenberg 1969); however, the teeth, once calcified, change only due to attrition, pathology or antemortem breakage and loss. Therefore, age would only be linked to dental trait frequencies in a single population if significant genetic difference was present between older and younger individuals. As previously discussed, individuals with higher wear scores were removed from the distance analysis due to inconsistent trait expression. While it is possible for younger individuals to show significant dental attrition (Larsen 1997:247-248), wear increases with age, and the North Carolina coastal ossuaries are not marked by wear so severe that numerous younger adult individuals were eliminated from the biodistance comparison.

A more compelling cause for concern in setting up a dental biodistance analysis is trait intercorrelation. Biodistance statistics assume that traits are not significantly correlated,

yet many researchers have found the opposite pattern is actually the case--traits are often significantly correlated because of similar developmental etiologies or because they are distinct expressions of the same underlying genetic variable (Griffin 1993, Molto 1983). The North Carolina coastal samples were tested for intercorrelations with Tau-B correlation coefficients (Griffin 1993:129) using a cut-off of .400, meaning that 40% of the time one trait was present, so was another (Table 5.6). The following traits were found to be significantly positively or negatively correlated: first and second incisor shoveling, central incisor curvature and double-shoveling, first molar and second molar hypocones, first and second molar cusp numbers, lower first molar cusp number and lower first molar cusps five and six, lower second molar cusp number and lower second molar cusps 5 and 6, and lower first molar cusp 5 with cusp 6 on the same tooth.

These correlations are not surprising, since often one trait's presence depends on that of another. First and second molars within an individual can be expected to have similar cusp numbers or configurations since they arise from the same developmental genetic environment (Hillson 1996). Negative correlations are also common. For example, in the case of incisor curvature, which occurs on the labial side of the central incisors, its presence is dependent on the absence of double-shoveling, thus these traits are almost always significantly negatively correlated.

**Table 5.6.** Tau-B correlation coefficients, dental traits from the Late Woodland North Carolina Coast ossuaries

	SHOV1	SHOV2	CURV	DSHOV	IGROV	METAC	HYP01	HYP02	MIC5	M2C5	CARA1	CARA2	PARA	PSM	AF
SHOV1	1.000														
SHOV2	<b>0.555</b>	1.000													
CURV	-0.127	-0.054	1.000												
DSHOV	0.299	0.344	<b>-0.566</b>	1.000											
IGROV	-0.001	-0.102	0.043	0.087	1.000										
METAC	0.048	-0.310	0.021	-0.354	0.118	1.000									
HYP01	0.065	0.112	-0.044	0.111	0.223	-0.011	1.000								
HYP02	0.022	0.003	0.033	0.158	0.327	-0.250	<b>0.487</b>	1.000							
MIC5	0.276	-0.166	0.002	0.081	-0.121	-0.263	-0.078	0.115	1.000						
M2C5	0.065	-0.003	0.003	0.002	-0.277	-0.229	0.004	0.151	0.322	1.000					
CARA1	0.188	-0.029	-0.115	0.001	0.083	-0.112	0.123	-0.317	0.114	0.063	1.000				
CARA2	0.132	0.146	0.066	0.192	-0.291	-0.067	-0.044	0.277	0.015	-0.021	0.170	1.000			
PARA	0.034	-0.091	0.155	-0.055	-0.172	0.003	0.047	0.069	0.127	0.090	0.026	-0.043	1.000		
PSM	-0.042	0.151	0.077	-0.283	-0.110	0.028	0.050	-0.302	-0.262	0.199	0.256	-0.065	0.021	1.000	
AF	0.067	0.111	-0.233	-0.002	0.063	0.225	0.222	0.278	0.006	0.235	0.054	0.033	-0.173	0.034	1.000
GPM1	-0.043	0.083	-0.187	-0.093	0.121	0.133	0.004	0.125	0.163	0.011	0.344	0.042	0.114	-0.012	0.088
GPM2	0.113	0.300	-0.228	0.032	0.135	0.332	0.005	-0.172	0.255	0.021	-0.327	-0.112	-0.143	0.000	0.144
CNM1	0.105	-0.059	0.004	-0.365	-0.244	0.152	-0.021	0.056	0.143	0.248	0.034	0.073	0.269	0.002	0.132
CNM2	0.099	-0.127	0.011	0.042	0.041	-0.021	-0.088	0.053	-0.072	0.230	-0.040	0.089	0.334	-0.048	0.211
DW	0.012	0.075	0.055	0.004	-0.099	0.211	0.111	0.002	0.098	0.166	-0.000	-0.111	0.127	0.004	0.176
DTC	-0.147	-0.145	-0.076	0.199	0.175	0.003	0.132	0.007	0.017	0.016	0.023	-0.121	0.322	0.221	0.030
PM1	0.055	0.182	0.176	0.178	-0.022	-0.103	0.189	0.158	0.267	-0.112	0.167	0.017	0.149	0.063	0.235
C5M1	-0.092	0.038	0.028	-0.073	0.171	0.001	0.088	0.122	0.047	0.043	-0.002	0.002	0.031	-0.110	0.177
C5M2	0.005	-0.083	0.090	0.002	0.182	0.051	-0.010	0.188	0.067	0.152	0.055	0.042	0.050	0.007	0.067
C6M1	0.173	0.022	-0.073	0.288	-0.233	-0.111	-0.023	0.192	0.004	0.254	0.098	0.005	0.077	-0.023	0.099
C6M2	0.085	0.187	-0.075	-0.321	-0.329	-0.104	-0.024	-0.082	0.032	-0.032	0.055	0.044	0.113	-0.022	0.003
C7M1	-0.078	-0.299	-0.023	0.199	-0.099	0.140	-0.045	-0.041	0.283	0.086	0.099	0.061	0.060	-0.035	0.056
C7M2	-0.061	0.218	0.129	0.102	-0.274	-0.080	-0.072	-0.144	-0.094	-0.043	-0.064	-0.015	0.032	-0.057	0.031
	GPM1	GPM2	CNM1	CNM2	DW	DTC	PM1	C5M1	C5M2	C6M1	C6M2	C7M1	C7M2		
GPM1	1.000														
GPM2	0.069	1.000													
CNM1	-0.063	0.101	1.000												
CNM2	0.101	-0.119	<b>0.421</b>	1.000											
DW	0.077	0.168	0.111	0.146	1.000										
DTC	0.002	0.112	0.143	0.177	0.147	1.000									
PM1	0.109	0.086	0.065	0.087	0.142	0.200	1.000								
C5M1	-0.105	0.003	<b>-0.644</b>	-0.001	-0.043	0.063	0.026	1.000							
C5M2	0.106	0.001	-0.044	<b>0.533</b>	0.030	0.050	-0.111	0.225	1.000						
C6M1	-0.051	0.090	<b>0.793</b>	0.344	0.187	0.011	0.088	<b>-0.544</b>	-0.036	1.000					
C6M2	0.087	0.088	0.333	<b>0.864</b>	0.166	0.221	0.081	-0.254	-0.277	0.303	1.000				
C7M1	-0.057	0.013	0.252	0.299	0.134	0.201	0.072	-0.032	0.013	0.040	-0.022	1.000			
C7M2	-0.077	0.191	0.082	0.085	0.155	-0.011	0.015	-0.058	-0.116	0.054	0.048	-0.003	1.000		

While some researchers have suggested that these types of correlations will not adversely affect sample comparisons (Sjøvold 1977), here the approach of Buikstra (1976), Griffin (1993), and Molto (1983) was followed, in removing highly positively or negatively correlated variables. Highly correlated variables have the potential to destabilize the variance, especially in the smaller samples. Thus, among the pairs of correlated traits, those which were not included on Turner's list of "key traits" in Native American populations (i.e., traits with the greatest potential to discriminate between the pattern of traits in Native American vs. non-Native groups [Scott and Turner: 270]) were eliminated.

The last consideration for trait elimination are those which are generally more poorly preserved, or difficult to observe, and therefore cannot be considered as representative of the majority of individuals present for data collection. To illustrate, often anterior teeth are less well preserved than posterior teeth, rare crown traits wear quickly or break off, and many teeth remain fully rooted in bone; thus, roots can be difficult to observe. For the North Carolina coastal ossuary groups then, these more poorly preserved traits include: incisor winging, the canine crown traits, tuberculum dentale, all root numbers, odontomes, enamel extensions, Tomes' root, anterior fovea, mandibular and maxillary tori, and torsomolar angle. The final list of traits used in the North Carolina coastal biodistance comparison appears in Table 5.7.

**Table 5.7.** Dental nonmetric traits used in the biodistance analysis of the Late Woodland North Carolina coast (n=20)

Trait	Teeth
<b>Maxillary dentition</b>	
Shoveling	Lateral incisors
Double-shoveling	Central incisors
Interruption groove	Lateral incisors
Peg-shaped incisor	Lateral incisors
Metacone	3 <sup>rd</sup> molars
Hypocone M1	1 <sup>st</sup> molars
Hypocone M2	2 <sup>nd</sup> molars
Metaconule M1	1 <sup>st</sup> molars
Carabelli's cusp M1	1 <sup>st</sup> molars
Carabelli's cusp M2	2 <sup>nd</sup> molars
Parastyle	3 <sup>rd</sup> molar
Peg-shaped molar	3 <sup>rd</sup> molar
<b>Mandibular dentition</b>	
Groove pattern M1	1 <sup>st</sup> molars
Groove pattern M2	2 <sup>nd</sup> molars
Protostyloid	1 <sup>st</sup> and 2 <sup>nd</sup> molars
Cusp 5	2 <sup>nd</sup> molars
Cusp 6	2 <sup>nd</sup> molars
Cusp 7	1 <sup>st</sup> and 2 <sup>nd</sup> molars

Thus, the next chapter presents the results and interpretations of the Late Woodland North Carolina coastal dental biodistance analysis. As a brief reiteration, the first goal of this dissertation was to evaluate the efficacy of employing ethnolinguistic categories to make distinctions between skeletal samples on the Late Woodland North Carolina coast. The second aim then, is to replace the ethnolinguistic system with a methodological framework that is neither taxonomic nor typological, one which evaluates whether or not Late Woodland coastal North Carolina Native Americans related to each other biologically (i.e., shared genes with each other across time and space). Dental biodistance provides such a materialist framework, using clearly heritable traits to make realistic multivariate comparisons between ossuary samples.

## **Chapter 6: Biological interactions between Late Woodland North Carolina Coast peoples -- Results and Interpretations**

### **The comparisons**

As previously discussed, besides assessing the relationships among all the Late Woodland North Carolina ossuaries in the dental biodistance analysis, they were also included in a regional context using Griffin and coworkers' previously published data (2001:268-272). Table 6.1 lists the traits used in those interobserver comparisons (Nichol and Turner 1986). For some comparisons, the Baum site (31Ck9) Late Woodland component burials 1, 5 and 7 were pooled into a single variable to evaluate any effects treating Baum as a single site would have on the results. As well, I also pooled all of the North Carolina coastal ossuaries into one variable to see how the Late Woodland coast clusters in the interobserver comparison as a region. Griffin (1993, 2001) pooled the two North Carolina coastal ossuaries on which he collected data--Baum (31Ck9) and Piggot (31Cr14)--into a single variable. These data are also included in the broader regional comparison to verify the positions of the sites on which I collected data, as well as to check for further interobserver error. Table 6.2 lists the abbreviations assigned to the sites when

**Table 6.1.** Dental nonmetric traits used in the regional biodistance comparison (n=10)

Trait	Teeth
Maxillary dentition	
Shoveling	Lateral incisors
Double-shoveling	Central incisors
Metacone	3 <sup>rd</sup> molars
Hypocone M1	1 <sup>st</sup> molars
Hypocone M2	2 <sup>nd</sup> molars
Metaconule M1	1 <sup>st</sup> molars
Parastyle	3 <sup>rd</sup> molar
Mandibular dentition	
Cusp number	1 <sup>st</sup> and 2 <sup>nd</sup> molars
Cusp 6	2 <sup>nd</sup> molars

**Table 6.2.** Variable names for the cluster and multidimensional scaling analyses

Variable abbreviation	Site
Late Woodland coastal North Carolina samples	
BAUM1	Baum Burial 1 (31Ck9)
BAUM5	Baum Burial 5
BAUM7	Baum Burial 7
BAUMSITE	Baum Burials 1, 5, and 7
BROAD	Broad Reach (31Cr218)
CAMP	Camp LeJeune (31On309)
COLD	Cold Morning (31Nh28)
FLYNT	Flynt (31On305)
GARB	Garbacon Creek (31Cr86)
HATT	Hatteras Village (31Dr38)
HOLLO	Hollowell (31Co5)
JORD	Jordan's Landing (31Br7)
MCFAY	McFayden Mound (31Bw67)
PIGG	Piggot (31Cr14)
SANS	Sans Souci (31Br5)
WEST	West #2 (31Ck22)
NCTOTAL	All sites
Comparative regional samples (Griffin et al. 2001)	
COWEE	Coweeta Creek (31Ma34)
IRENE	Irene Mound (9Ch1)
GRIFFNC	Baum Burials 1, 5, 7 (31Ck9) and Piggot (31Cr14)
LED	Ledford Island (16By13)
LEGYPT	Little Egypt (9Mu102)
KING	King (9Fl5)
SCDG	Santa Catalina de Guale (9Li274)
SCDGSM	Santa Catalina de Guale de Santa Maria (8Na41)
SMDY	Santa Maria de Yamasee (8Na41d)
TCREEK	Town Creek (31Mg2,3)
UPSAU	Upper Sauratown (31Sk1a)

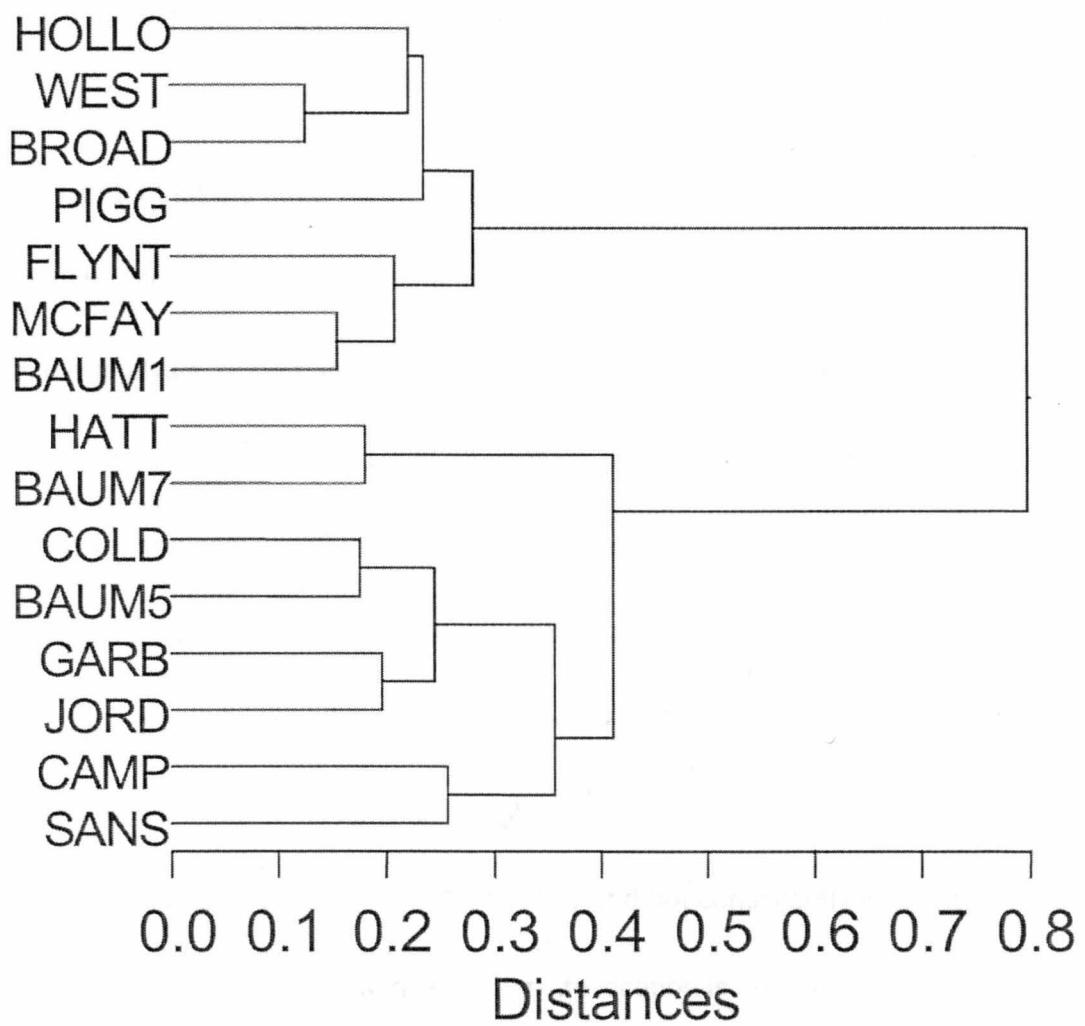
they occurred as variables in the data analysis, principally for the cluster and multidimensional scaling operations.

## Results

### *Cluster analysis*

The first method for comparing dental trait frequencies across the North Carolina coastal and Southeast regional samples is cluster analysis (see Chapter 5). Here the arcsine transformed dental trait frequencies are input for a SYSTAT (v.10) cluster analysis using Ward's minimum variance method in relative euclidean distance (after Griffin 1993:180-182). The arcsine transformation was calculated using a Java program for the Macintosh, *Biodistance 1.0*, programmed and tested by Jan Kujawa (see Appendix B for source code and credits). Another reason highly intercorrelated traits have been removed (see Chapter 5) is to try to make the clustering process as reliable as possible. Cluster analysis, it must be remembered, assumes a normal distribution, thus forcing classification without tests for goodness of fit of the data. Results, starting with the North Carolina coastal Late Woodland samples, are presented in Figures 6.1-6.7.

Figure 6.1 includes all the Late Woodland North Carolina coastal skeletal samples. There are three main clusters present, one including mostly outer coastal (West, Piggot, Baum 1) and southern coastal sites (Broad Reach, Flynt, and McFayden Mound). The Hollowell site (31Co5), an inner coastal northern site is also in this cluster. Hatteras Village

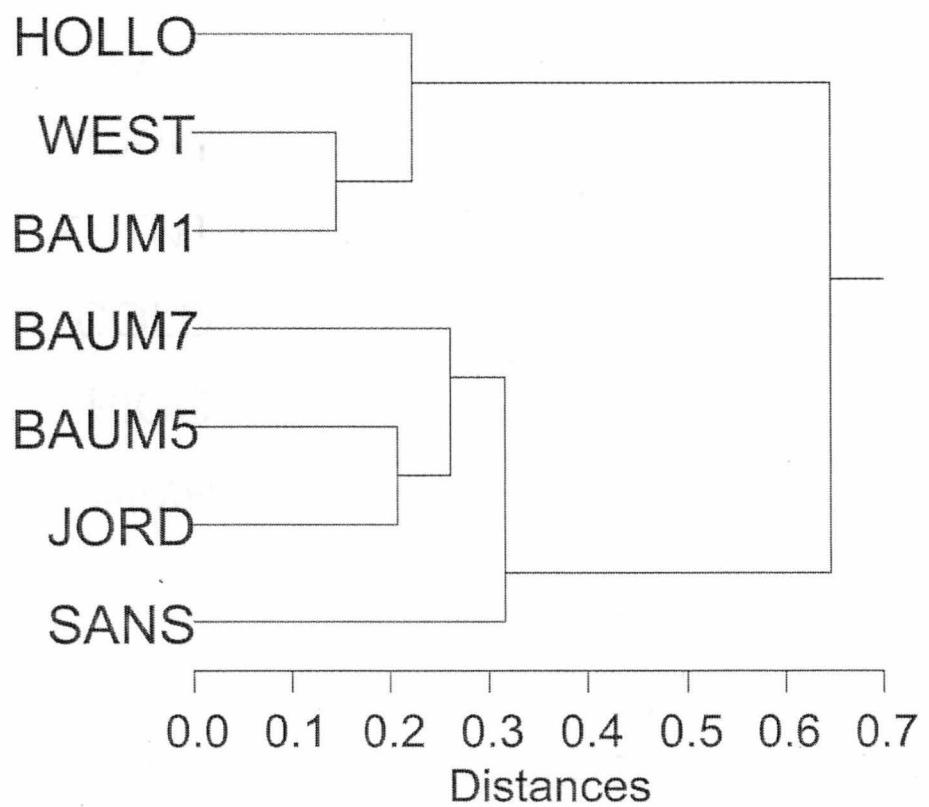


**Figure 6.1.** Cluster analysis results, Late Woodland North Carolina Coast dental samples

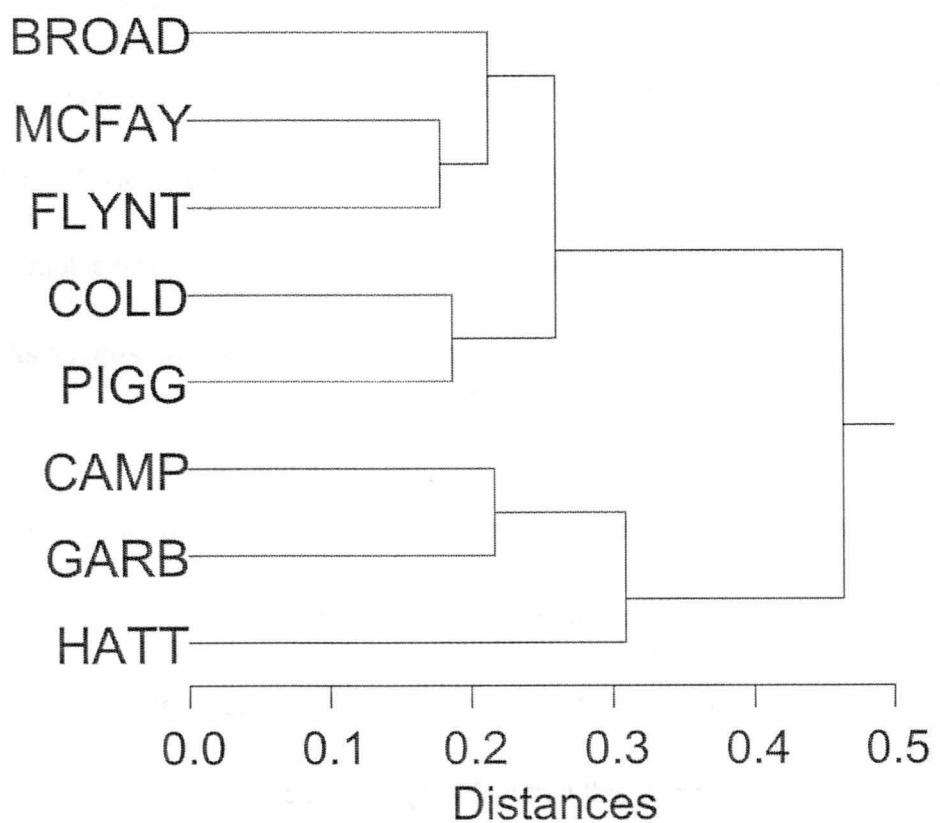
and Baum Burial 7 occupy another, seemingly isolated cluster. Lastly, the third cluster contains mostly southern coastal (Cold Morning, Camp LeJeune, Garbacon Creek, and inner coastal sites (Sans Souci and Jordan's Landing). Baum Burial 5 also clusters with this group.

The fact that the three Baum Burials (1, 5 and 7), all from the very northern and outer coast, cluster all over the configuration, could indicate a general similarity between all of the sites in the analysis, or perhaps a problem with sample size, as most of the larger samples occur in the top cluster. Figure 6.2 is an analysis of only the northern coastal samples, which followed the same pattern as Figure 6.1 however. While the Hollowell site (31Co5), an inner coastal site, has clustered with West #2 (31Ck22) and Baum Burial 1 (31Ck9), the other two Baum burials (5 and 7) clustered with the inner coastal sites (Jordan's Landing [31Br7] and Sans Souci [31Br5]). Additionally, Figure 6.3 includes only the southern coastal sites, yet they also cluster with each other widely and not consistently in terms of location on the coast. This data patterning suggests that site location is not an accurate predictor of biological relationships.

Additionally, in these three configurations, neither sample size nor temporal position has appeared to have affected the clustering, as one of the smallest and oldest samples, the McFayden Mound (31Bw67, MNI=10, circa AD 1100) clustered with two of the largest and most recent sites, the Baum 1 ossuary (31Ck9, MNI=~50, AD 1410) and the Flynt site



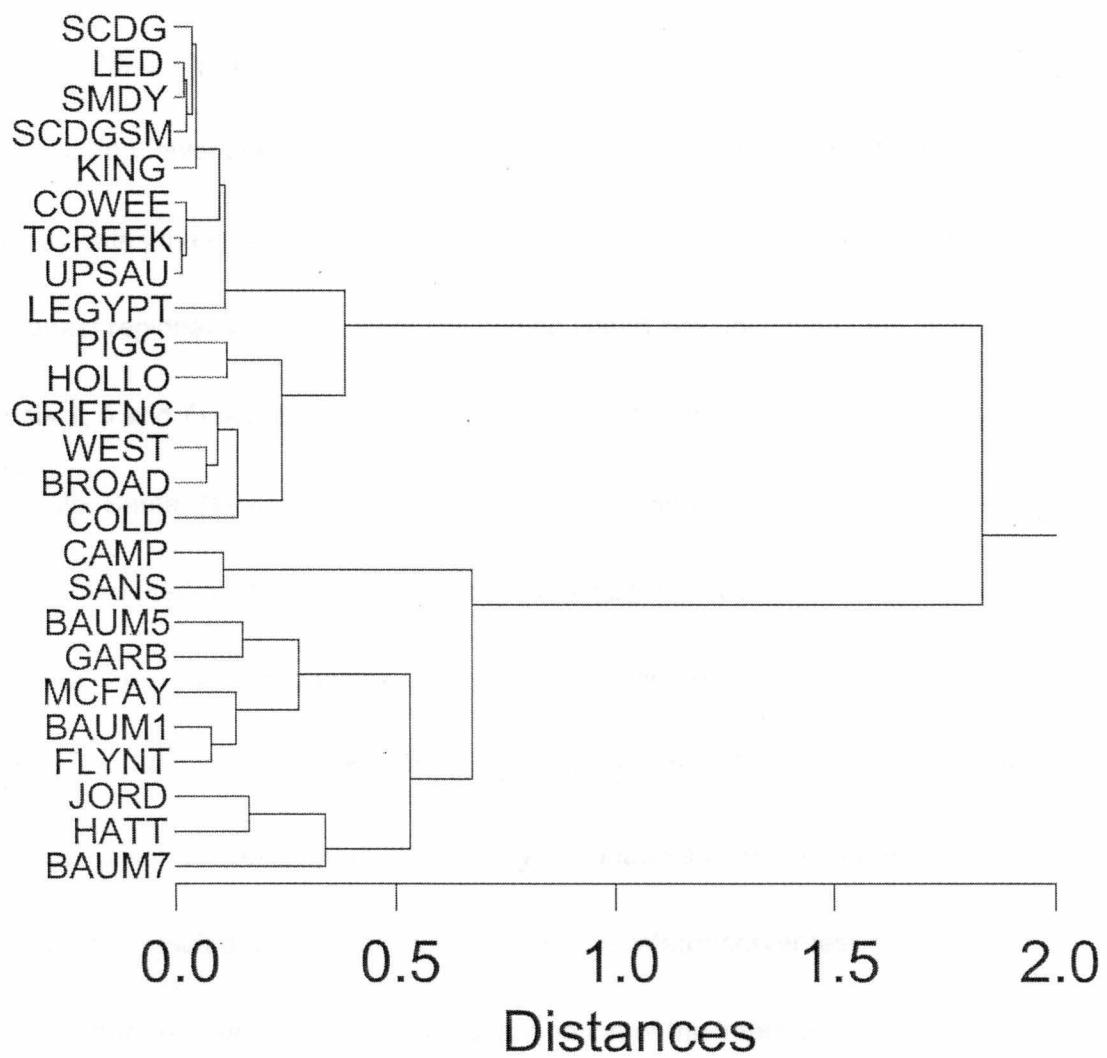
**Figure 6.2.** Cluster analysis results, northern coastal ossuary samples



**Figure 6.3.** Cluster analysis results, southern coastal ossuary samples

(31On305, MNI=158, AD 1361). Similarly, the West site #2 (31Ck22, MNI=134, no radiocarbon date), located on the very northern and outer coast, clustered first with the Broad Reach site on the southern coast (31Cr218, MNI=36, AD 1168). Also notable is the cluster containing the Cold Morning site (31Nh28, MNI=15, AD 984) and the Piggot site (31Cr14, MNI=84, AD 1460). Cold Morning is the southernmost and oldest site on the coast, and while Piggot is also on the southern coast, it is the most recent site in that region. These results suggest that sites cluster with or away from each other without respect to their age.

Further, Figure 6.4 shows the results of the interobserver comparison with Griffin and coworkers (2001). These results are consistent with Griffin's conclusion that the North Carolina coastal samples cluster separately from others in the southeast, though the patterning appear slightly different due to the fact that this comparison included only 10 dental traits, while the North Carolina coastal samples alone included 22 different traits. The fact that a small cluster of North Carolina coastal sites joins with the other Southeast samples before a number of the other NC coast sites though, could be indicative of a sample size issue in this comparison. The North Carolina coastal samples are smaller than those from Griffin's research, thus making the clustering process more unreliable. Yet, this result is not inconsistent with Griffin et al.'s (2001:249), where the small North Carolina group on which they collected data in fact clustered with groups containing the colonial

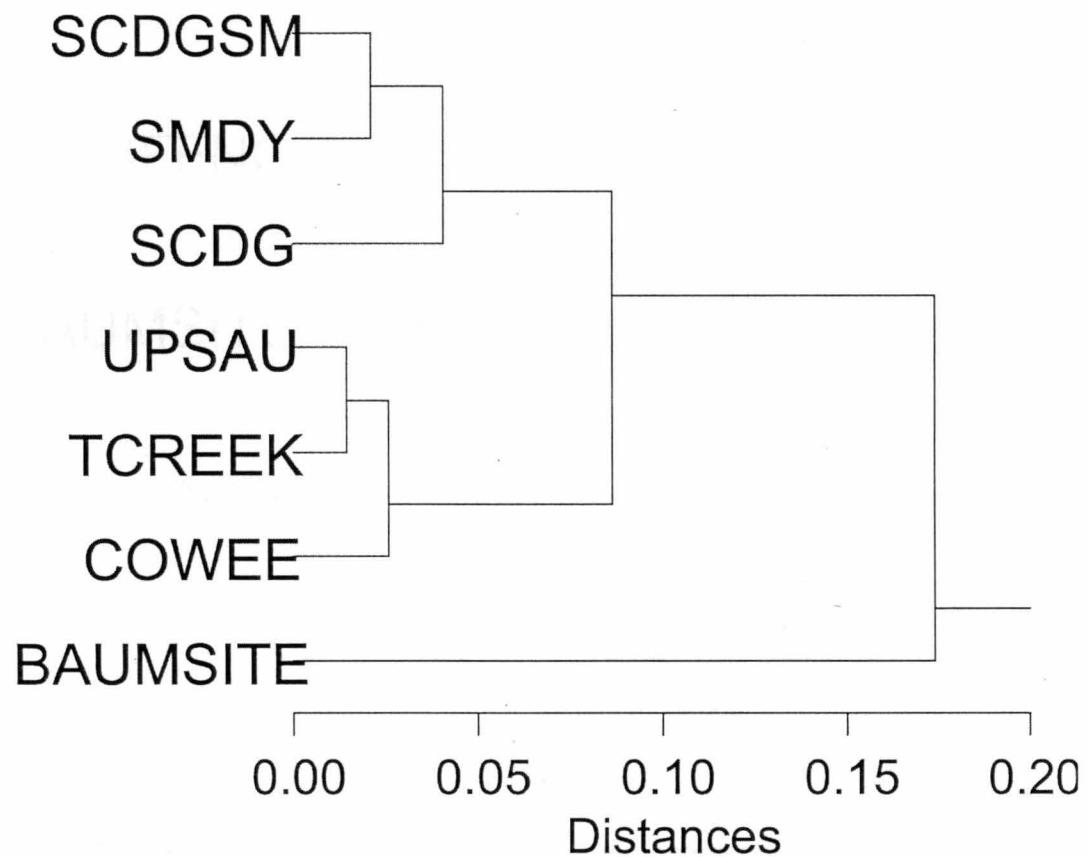


**Figure 6.4.** Cluster analysis results, North Carolina Coast and regional samples

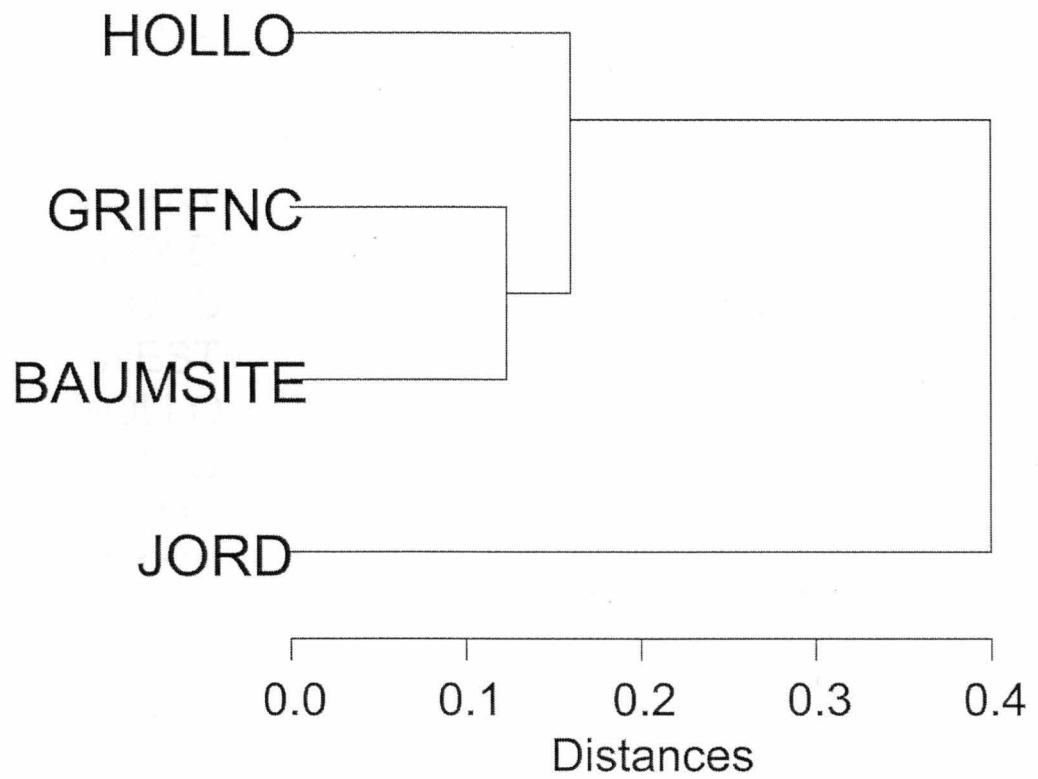
Florida, Ceweeta Creek, and Little Egypt sites (western North Carolina and northwestern Georgia, respectively), before joining with clusters containing the Piedmont North Carolina and Irene Mound (north Georgia coast) sites.

Using fewer sites in the analysis however, such as in the results pictured in Figure 6.5, replicates the result that the North Carolina coastal sites cluster away from the other Southeast regional samples. Here the pooled Baum site (including Late Woodland Baum Burials 1, 5 and 7) occupies its own cluster, while the Florida colonial sites (Santa Catalina de Guale, Santa Catalina de Guale de Santa Maria, and Santa Maria de Yamasee) and western and piedmont North Carolina precontact sites (Upper Sauratown, Town Creek and Ceweeta Creek) cluster together. The close affiliation between Town Creek and Upper Sauratown is exactly the result Griffin and coworkers obtained, though in their analysis Ceweeta Creek clustered more closely to the Florida samples. Again the divergence is probably the result of the use of fewer traits in this interobserver test.

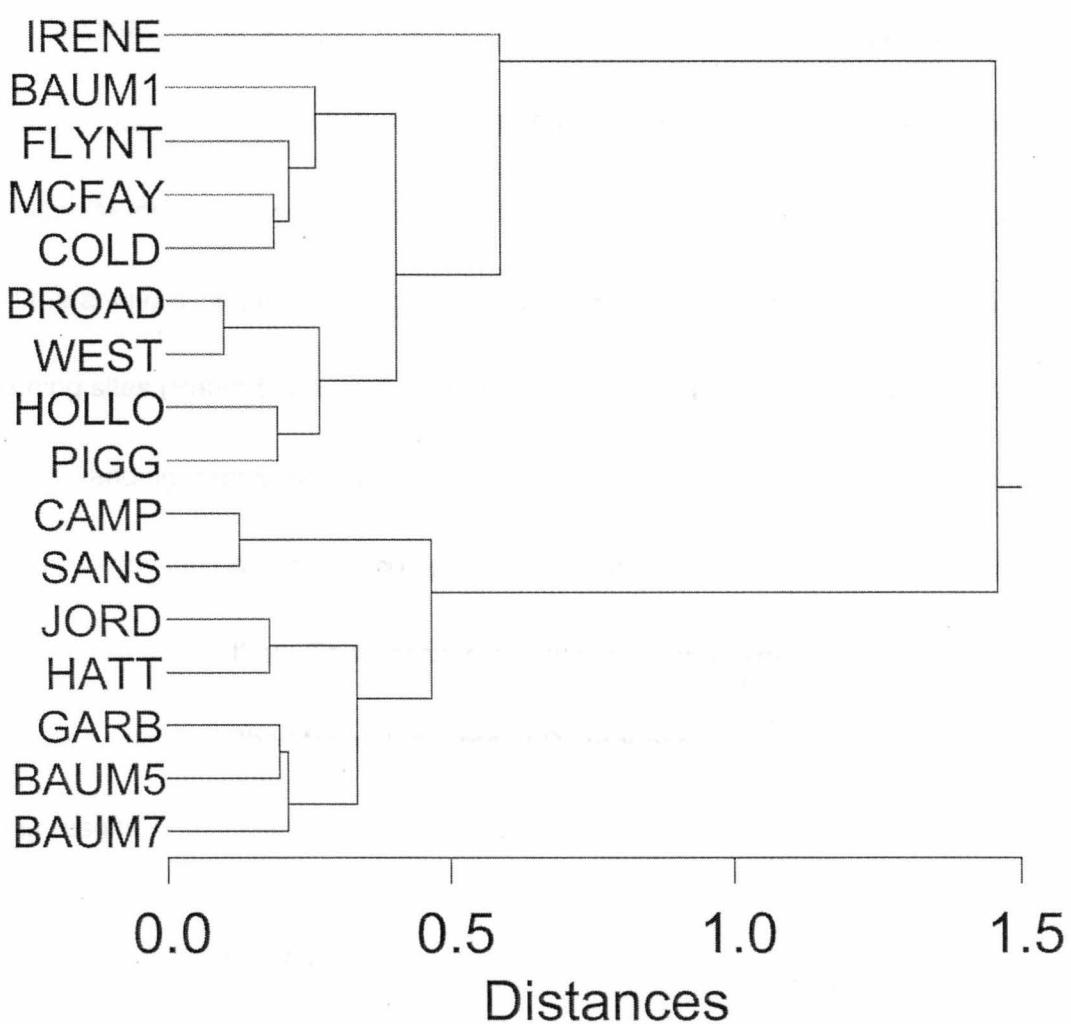
Figure 6.6 represents a closer examination of the interobserver reliability of the analysis. The data collected by Griffin (1993) for the North Carolina coast, including the Baum (31Ck9) and Piggot (31Cr14) sites clustered first with the data I collected on the entire Baum site (the pooled Burials 1, 5 and 7). The Hollowell site (31Co5), which clustered with the outer coastal sites in my analysis, does so again here, with the Jordan's Landing site (31Br7), another inner coastal site, in its own cluster. These results indicate that the data



**Figure 6.5.** Cluster analysis results, Southeast regional and pooled coastal North Carolina Baum site samples.



**Figure 6.6.** Cluster analysis results, interobserver error test with North Carolina Coast samples.



**Figure 6.7.** Cluster analysis results, North Carolina Coast samples and Irene Mound.

used for the regional comparison is consistent with both the previously published results (Griffin et al. 2001) and with the analysis included in this project.

Another cluster analysis (Figure 6.7) shows the Irene Mound, a large Georgia coastal precontact site (9Ch1, MNI=248, AD 1150-1550), clustering with a sample of the Late Woodland North Carolina coastal sites before the rest of the North Carolina coastal sites finish the analysis. Again, this suggests problems with the small sample sizes of the remaining sites (Baum 5, Baum 7, Camp LeJeune, Garbacon Creek, Hatteras Village, Jordan's Landing, and Sans Souci). The rest of the patterning remains consistent with the previous North Carolina coastal comparison however, again suggesting that these sites are very similar to each other. This possible sample size constraint will be also discussed below, as it relates to the Mean Measures of Divergence (MMD) and multidimensional scaling results.

#### *MMDs and multidimensional scaling*

The cluster analysis employed the arcsine transformed dental trait frequencies, as previously discussed in Chapter 5. The second multivariate statistical technique used for evaluating biological distance in this project is multidimensional scaling. To briefly revisit the statistical methodology, for this analysis the arcsine transformed trait frequencies are placed in a mean measures of divergence equation (Green and Suchey 1976), from which MMD's and standardized MMD's are calculated (Griffin 1993, Sofaer et al. 1986). A statistically

significant mean measure of divergence ( $p < 0.05$ ) must be twice its standard deviation (Molto 1983, Sofaer et al. 1986).

Mean measures of divergence and standardized MMD's were also calculated using the Java program *Biodistance 1.0*. Table 6.3 reports the mean measures of divergence and standardized MMD's for the Late Woodland North Carolina coastal ossuary samples. Immediately obvious is the fact that all of the numbers are negative. Negative MMD's were rejected by Constandse-Westermann (1972), since common reasoning is that the distance between two points should be either zero, or a positive value. Later analysis and verification however, substantiates the existence and meaning of negative MMD values (Molto 1983, Sjovold 1977). In essence, because the distance estimate is based on samples, not populations, and these samples have been refined in the angular (arcsine) transformation to minimize random sampling error, it makes sense mathematically to see values which fluctuate around zero, or are negative, when there is no significant divergence.

Yet non-significant distance does not automatically mean that the samples come from the same population; to wit, it is biologically impossible for noncontemporaneous groups to be a "breeding population." As Molto notes, "[L]ack of significance could be real because they could represent sampling from a common population that changed gradually through time and that was continuous across space due to gene flow," (Molto 1983:186). Considering that the results comparing all the North Carolina ossuaries and those which

**Table 6.3.** Mean measures of divergence (above diagonal) and standardized mean measures of divergence (below diagonal) for the Late Woodland North Carolina Coastal ossuary samples

	BAUM1	BAUM5	BAUM7	JORD	HOLLO	WEST	HATT	SANS
BAUM1	0.000	-0.143	-0.111	-0.161	-0.110	-0.126	-0.142	-0.066
BAUM5	-1.756	0.000	-0.280	-0.330	-0.180	-0.173	-0.245	-0.337
BAUM7	-1.375	-2.528	0.000	-0.261	-0.112	-0.122	-0.244	-0.245
JORD	-1.828	-2.721	-2.209	0.000	-0.203	-0.178	-0.268	-0.337
HOLLO	-1.998	-2.040	-1.330	-2.153	0.000	-0.142	-0.143	-0.139
WEST	-2.535	-2.099	-1.523	-1.999	-2.471	0.000	-0.137	-0.097
HATT	-1.860	-2.317	-2.265	-2.375	-1.778	-1.805	0.000	-0.227
SANS	-0.677	-2.586	-1.924	-2.473	-1.335	-0.982	-1.852	0.000
PIGG	-1.502	-2.362	-1.486	-2.390	-2.304	-2.285	-1.616	-1.799
FLYNT	-2.139	-2.429	-1.953	-2.600	-2.241	-2.287	-2.130	-1.653
BROAD	-2.111	-2.127	-1.581	-2.140	-2.371	-2.831	-1.710	-1.210
GARB	-1.218	-2.749	-2.264	-2.678	-1.588	-1.718	-2.077	-2.315
COLD	-1.630	-2.793	-2.033	-2.516	-2.352	-2.261	-1.818	-2.024
MCFAY	-2.356	-2.281	-2.054	-2.282	-2.203	-2.586	-2.206	-1.261
CAMP	-0.727	-2.515	-1.782	-2.389	-1.446	-1.284	-1.891	-2.443

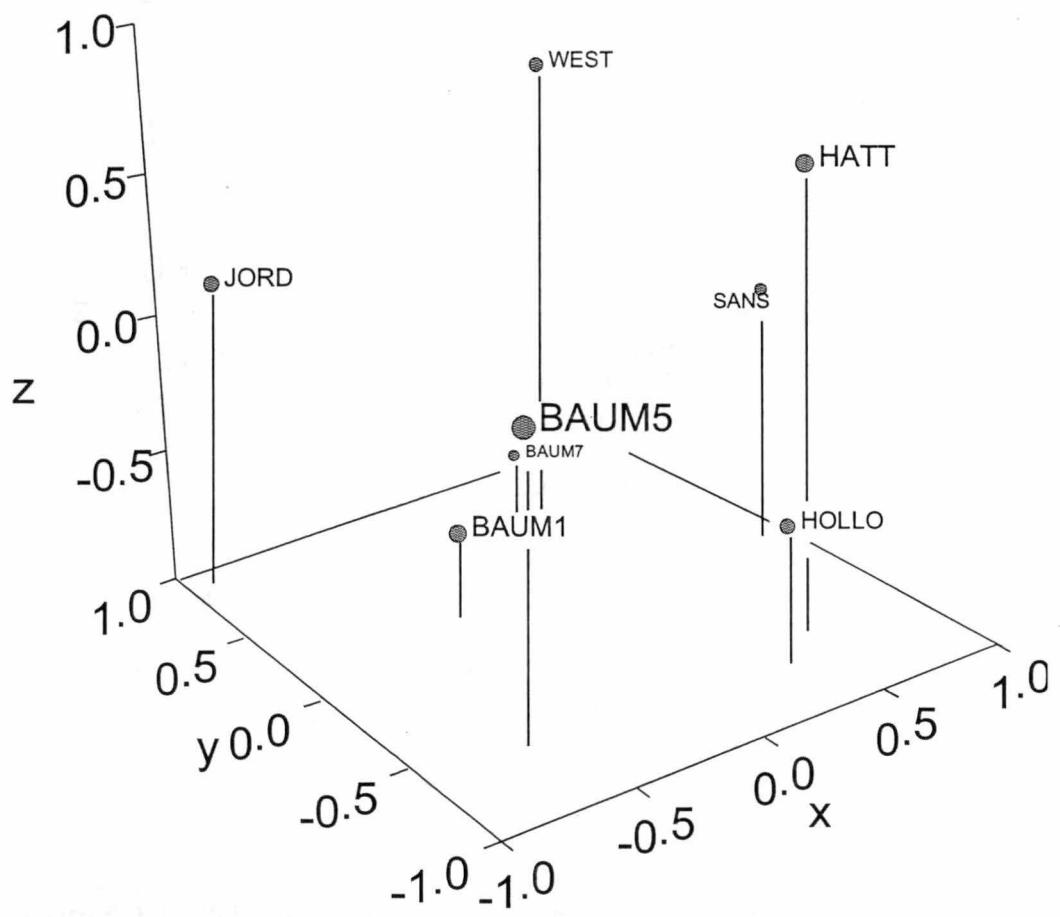
**Table 6.3. continued.**

	PIGG	FLYNT	BROAD	GARB	COLD	MCFAY	CAMP
BAUM1	-0.110	-0.134	-0.120	-0.091	-0.104	-0.139	-0.063
BAUM5	-0.247	-0.229	-0.193	-0.294	-0.272	-0.208	-0.300
BAUM7	-0.151	-0.178	-0.137	-0.240	-0.190	-0.187	-0.211
JORD	-0.264	-0.263	-0.207	-0.305	-0.260	-0.224	-0.300
HOLLO	-0.185	-0.156	-0.153	-0.127	-0.171	-0.145	-0.137
WEST	-0.172	-0.144	-0.169	-0.129	-0.149	-0.155	-0.114
HATT	-0.160	-0.186	-0.138	-0.209	-0.163	-0.192	-0.216
SANS	-0.218	-0.181	-0.129	-0.284	-0.230	-0.134	-0.332
PIGG	0.000	-0.202	-0.205	-0.224	-0.230	-0.173	-0.225
FLYNT	-2.337	0.000	-0.166	-0.191	-0.196	-0.174	-0.155
BROAD	-2.539	-2.381	0.000	-0.159	-0.181	-0.166	-0.130
GARB	-2.306	-2.202	-1.908	0.000	-0.220	-0.179	-0.282
COLD	-2.577	-2.518	-2.452	-2.453	0.000	-0.167	-0.199
MCFAY	-2.102	-2.417	-2.509	-2.105	-2.244	0.000	-0.150
CAMP	-2.033	-1.560	-1.368	-2.493	-1.921	-1.510	0.000

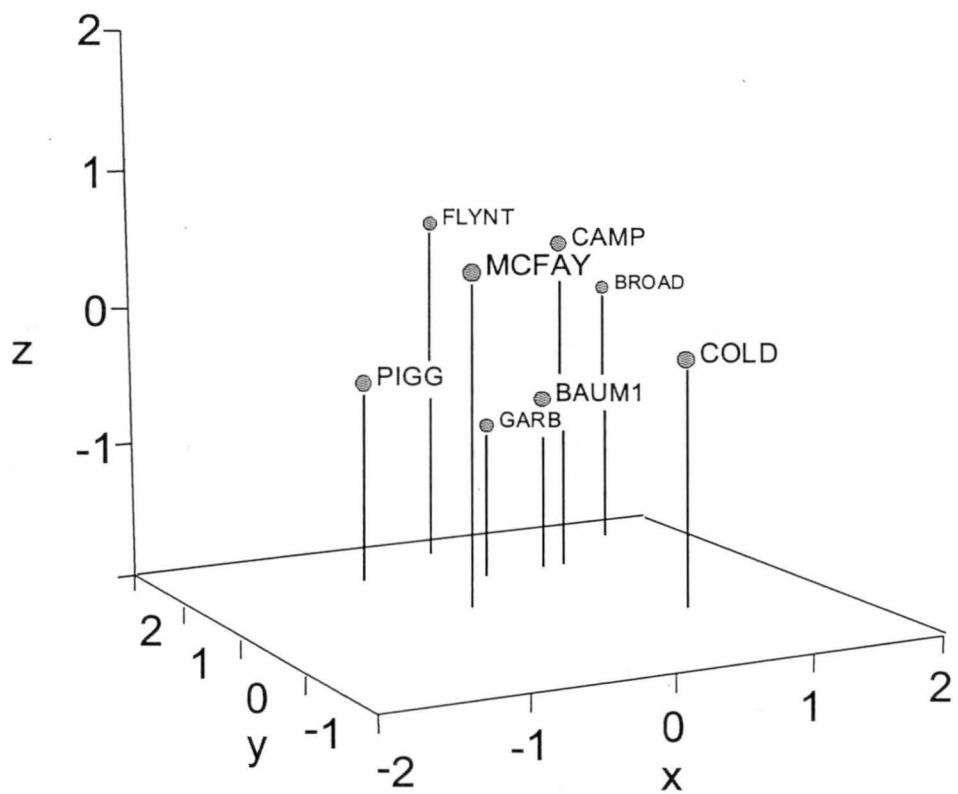
compare them to other Southeastern samples are quite congruent (see below), it seems likely that the similarities are real. Moreover, both Griffin's (1993, Griffin et al. 2001) and my results also indicate gene flow in the Southeast as a whole.

Despite the lack of significance between the North Carolina coastal ossuary samples, it is still possible to examine the patterns of distance between them with multidimensional scaling. Standardized mean measures of divergence were used for the analysis as they are better units where sample sizes vary considerably, as is the case for both the North Carolina coastal samples, and those used for the Southeastern regional comparison (Griffin 1993, and see Chapter 5). Figures 6.8 and 6.9 are the results of the multidimensional scaling for the North Carolina coastal Late Woodland samples. The results are subdivided into northern and southern samples because the configuration with all the samples included was extremely difficult to read since the sites clustered so tightly around zero. These results confirm that the Baum site burials are very similar, and that the Hollowell site appears more similar to the outer coastal, than the inner coastal groups--even though Hollowell is located on the inner coast. The southern coastal samples (Figure 6.9) group even more closely together around zero than the northern ones, suggesting there could have been even more gene flow between them.

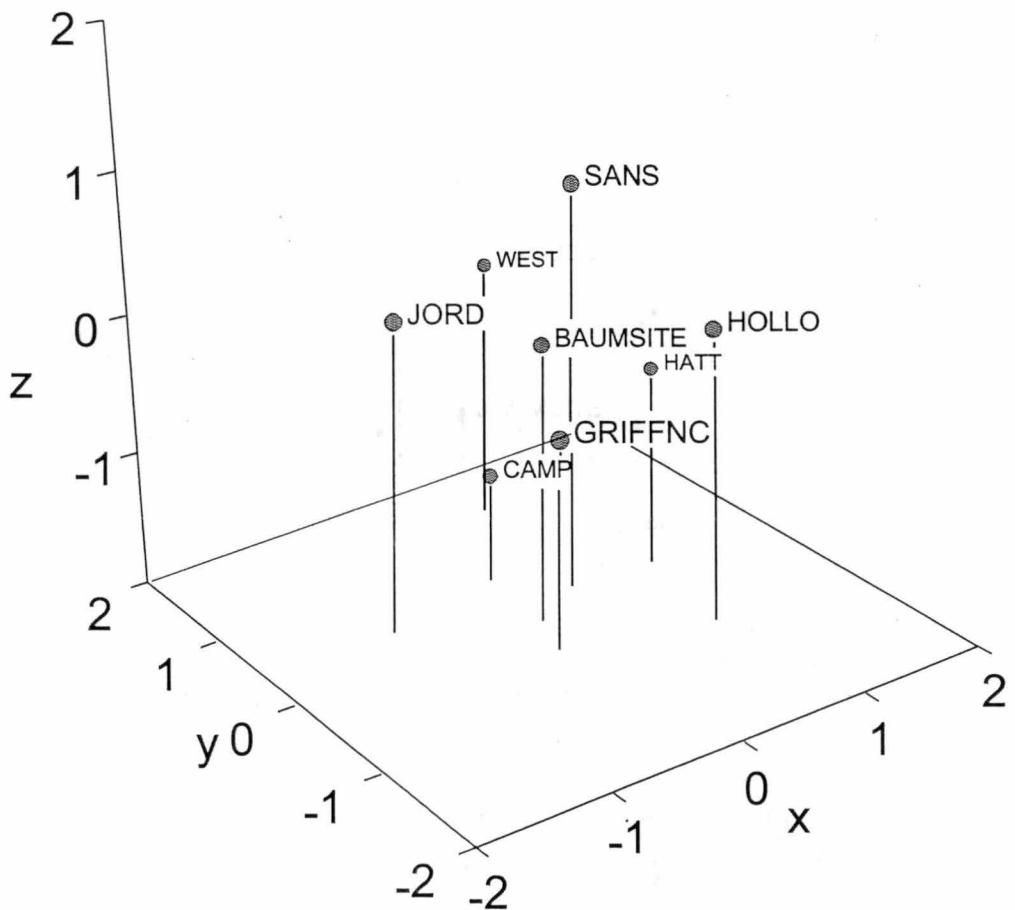
Additionally, Figures 6.10 and 6.11 show results of multidimensional scaling analyses for the interobserver analysis, including other Southeastern samples. Figure 6.10 shows



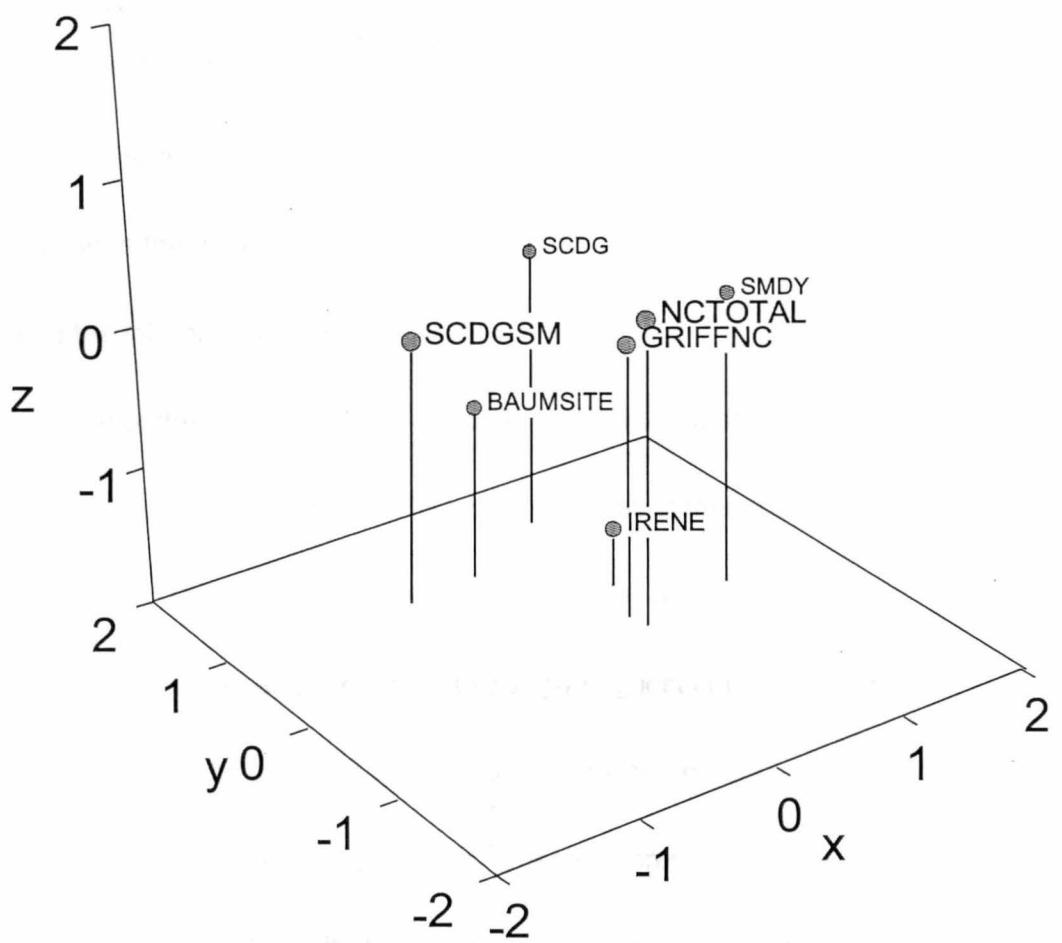
**Figure 6.8.** Multidimensional scaling analysis, results of northern North Carolina Coast samples.



**Figure 6.9.** Multidimensional scaling analysis, results of southern coastal samples with the Baum 1 site.



**Figure 6.10.** Multidimensional scaling analysis, results of selected coastal North Carolina sites and data collected by Griffin and coworkers (2001) [GRIFFNC]



**Figure 6.11.** Multidimensional scaling analysis, results of Florida historic, North Carolina Coast and Irene Mound (Georgia precontact) sites.

Griffin et al.'s North Carolina coastal data clearly articulating with that collected for this project. Figure 5.12 includes the variable constructed that includes all the samples from the Late Woodland North Carolina coast. For this analysis, statistically significant MMDs were found between both the "NCTOTAL" pooled sample and the other Southeastern samples. Additionally, the pooled variable representing the entire Late Woodland North Carolina coast is very close to the data collected by Griffin on the Baum and Piggot ossuaries, further validating the interobserver results.

Some of the individual North Carolina coastal ossuaries were found to be significantly different from the variable representing all of them pooled together--NCTOTAL (see Table 6.4). This result includes all the ossuaries suspected for small sample size difficulties in the cluster analyses, and it strongly suggests that variability seen in those ossuaries, at least with the traits used for the interobserver test, cannot be considered reliable in terms of the region as a whole. These differences could also be attributable to the well-known biological maxim that there is more variability within populations than between them (Barbujani et al. 1997, Lewontin 1972, Jorde et al. 2000), but considering that the patterns are similar between both multivariate analyses, that does not seem likely.

The root of the sample size problem may be isolated within the MMD equation. The assumed variance of the arcsine-transformed traits is removed using the operation highlighted here:

**Table 6.4.** Mean measures of divergence (above diagonal) and standardized mean measures of divergence (below diagonal) for the Late Woodland North Carolina Coastal ossuary samples and regional totals. Bold text = p > .05

	BAUM1	BAUM5	BAUM7	JORD	HOLLO	WEST	HATT	SANS
BAUM1	0.000	-0.143	-0.111	-0.161	-0.110	-0.126	-0.142	-0.066
BAUM5	-1.756	0.000	-0.280	-0.330	-0.180	-0.173	-0.245	-0.337
BAUM7	-1.375	-2.528	0.000	-0.261	-0.112	-0.122	-0.244	-0.245
JORD	-1.828	-2.721	-2.209	0.000	-0.203	-0.178	-0.268	-0.337
HOLLO	-1.998	-2.040	-1.330	-2.153	0.000	-0.142	-0.143	-0.139
WEST	-2.535	-2.099	-1.523	-1.999	-2.471	0.000	-0.137	-0.097
HATT	-1.860	-2.317	-2.265	-2.375	-1.778	-1.805	0.000	-0.227
SANS	-0.677	-2.586	-1.924	-2.473	-1.335	-0.982	-1.852	0.000
PIGG	-1.502	-2.362	-1.486	-2.390	-2.304	-2.285	-1.616	-1.799
FLYNT	-2.139	-2.429	-1.953	-2.600	-2.241	-2.287	-2.130	-1.653
BROAD	-2.111	-2.127	-1.581	-2.140	-2.371	-2.831	-1.710	-1.210
GARB	-1.218	-2.749	-2.264	-2.678	-1.588	-1.718	-2.077	-2.315
COLD	-1.630	-2.793	-2.033	-2.516	-2.352	-2.261	-1.818	-2.024
MCFAY	-2.356	-2.281	-2.054	-2.282	-2.203	-2.586	-2.206	-1.261
CAMP	-0.727	-2.515	-1.782	-2.389	-1.446	-1.284	-1.891	-2.443
NCTOTAL	0.519	2.324	2.746	2.119	1.814	0.260	2.058	3.702
BAUMSITE	-0.090	-0.804	-0.434	-0.753	-1.228	-2.351	-0.912	0.566

Table 6.4. continued.

	PIGG	FLYNT	BROAD	GARB	COLD	MCFAY	CAMP	NCTOTAL	BAUMSITE
BAUM1	-0.110	-0.134	-0.120	-0.091	-0.104	-0.139	-0.063	0.014	-0.090
BAUM5	-0.247	-0.229	-0.193	-0.294	-0.272	-0.208	-0.300	<b>0.139</b>	-0.056
BAUM7	-0.151	-0.178	-0.137	-0.240	-0.190	-0.187	-0.211	<b>0.162</b>	-0.030
JORD	-0.264	-0.263	-0.207	-0.305	-0.260	-0.224	-0.300	<b>0.141</b>	-0.058
HOLLO	-0.185	-0.156	-0.153	-0.127	-0.171	-0.145	-0.137	0.064	-0.054
WEST	-0.172	-0.144	-0.169	-0.129	-0.149	-0.155	-0.114	0.007	-0.089
HATT	-0.160	-0.186	-0.138	-0.209	-0.163	-0.192	-0.216	<b>0.112</b>	-0.059
SANS	-0.218	-0.181	-0.129	-0.284	-0.230	-0.134	-0.332	<b>0.284</b>	0.049
PIGG	0.000	-0.202	-0.205	-0.224	-0.230	-0.173	-0.225	0.099	-0.043
FLYNT	-2.337	0.000	-0.166	-0.191	-0.196	-0.174	-0.155	<b>0.104</b>	-0.054
BROAD	-2.539	-2.381	0.000	-0.159	-0.181	-0.166	-0.130	0.022	-0.082
GARB	-2.306	-2.202	-1.908	0.000	-0.220	-0.179	-0.282	<b>0.196</b>	-0.001
COLD	-2.577	-2.518	-2.452	-2.453	0.000	-0.167	-0.199	<b>0.128</b>	-0.033
MCFAY	-2.102	-2.417	-2.509	-2.105	-2.244	0.000	-0.150	0.045	-0.084
CAMP	-2.033	-1.560	-1.368	-2.493	-1.921	-1.510	0.000	<b>0.240</b>	0.034
NCTOTAL	1.888	2.570	0.595	3.695	2.971	1.162	3.578	0.000	-0.010
BAUMSITE	-0.690	-1.057	-1.758	-0.022	-0.622	-1.744	0.440	-0.617	0.000

$$MMD = \frac{\sum_{i=1}^r (\theta_{1i} - \theta_{2i})^2}{r} - \frac{[1/(n_{1i} + \frac{1}{2}) + 1/(n_{2i} + \frac{1}{2})]}{r}$$

The variable  $n$  represents the number of individuals scored for each trait. If this number is low, the total subtracted from the sum of squared differences between the traits will actually be large, since the  $n$ 's occur in the denominators of that operation. As this number gets larger, it can create significant differences between small and large samples. The MMD equation is, then, fairly sensitive to sample size. All of the North Carolina ossuaries that exhibit significantly different MMD's in comparison to the region as a whole (the "NCTOTAL" variable), are the smallest samples in terms of total minimum number of individuals. Despite their inclusion in the pooled region-encompassing variable, these ossuaries can still be different from the whole because of the MMD's sample-size sensitivity.

The first and central result, however, that among all the North Carolina ossuaries there are no significant distances, remains sound and supported by both the North Carolina and regional comparative data; there are no detectable differences between samples with regard to dental trait patterns. In the next chapter, the meaning of this result will be discussed in the context of North Carolina archaeology and Southeastern ethnohistory.

## **Chapter 7: Discussion, Conclusions, and Bioarchaeological Directions**

A dental biological distance analysis of ossuary samples from the Late Woodland (AD 800-1650) North Carolina coast reveals that there are no significant differences in the patterns and frequencies of dental traits observable at these sites. Though, because of sample size problems, some of the smaller ossuaries were potentially unreliable inclusions for the larger regional analysis, such a constraint does not affect the central result. The dental nonmetric trait patterns do not support the biological divisions implied by the ethnolinguistic model. Rather, the Late Woodland skeletal samples from the North Carolina coast may in fact represent one, evolving group, with extensive gene flow in evidence between the samples. Further, comparing the North Carolina coastal samples to other skeletal populations from the Southeast substantiates previous results (Griffin 1993, Griffin et al. 2001, Killgrove 2002) that the North Carolina coastal groups represent distinct populations with regard to contemporaneous and later groups from Georgia, western North Carolina and colonial Florida.

Additionally, the results of this study have bearing on, and for the most part articulate with, a recent cranial nonmetric biodistance analysis conducted by Killgrove (2002) on the same samples. Cranial and dental discrete data are complementary lines of investigation,

though the genetic origins and patterning of the traits are often significantly different (Griffin 1993:94-95). Killgrove also found no statistically significant differences between the North Carolina samples, distinctions between the North Carolina and other Southeastern groups using the same comparative data (Griffin et al. 2001), and she further identified sample size problems with some of the smaller ossuaries. Killgrove, however, encountered different sample size issues with the cranial data than those evident in the dental samples. Though the dental data from this study were checked for population representativeness--i.e., traits were removed that could not be observed in most of the individuals (see Chapter 5)--the cranial data as Killgrove collected it was already barely above the threshold for inclusion in her biodistance comparison (Killgrove 2002:114-115). Thus, while the some of the dental data from this project suffers from small sample sizes, it appears that Killgrove's cranial data is somewhat biased because of the inclusion of rare, or nonrepresentative traits.

Further, Killgrove grouped the Late Woodland cranial data by historic language affiliation, concluding that "Iroquoian" sites (Jordan's Landing, Sans Souci, and the Abbyville and Hand sites in southern Virginia) are more closely related to "Siouan" sites (Cold Morning and McFayden Mound) than both are to "Algonquian" sites (Killgrove 2002:67, 102). Through this grouping technique, she also linked the Hollowell site (31Co5) to the "Iroquoian" variable. Hollowell, an inner coastal ossuary that archaeologists have characterized as showing a mixture of Algonquian and Iroquoian traits (Phelps 1983), was

actually found to be more closely related to the outer coastal sites in the dental analysis, such as Baum (31Ck9), West #2 (31Ck22) and even southern coastal sites, notably Piggot (31Cr14), Flynt (31On305) and McFayden Mound (31Bw67).

The dental data directly contradicts Killgrove's grouped distance estimations, as well as shows that pooling by cultural group is methodologically suspect. Since both the dental and cranial analyses found no statistically significant differences between the ossuary samples, there is no skeletal basis for grouping ossuaries by cultural or linguistic group. Killgrove's single site cluster analysis, where no cultural groups were constructed, actually shows similar patterns as the dental configuration (2002:104).

Thus, despite the existence of different material cultures (Phelps 1983, Ward and Davis 1999) and varied pathological patterns between inner and outer coastal groups (Hutchinson 2002), Late Woodland Native peoples on the North Carolina coast were found to be too genetically similar to be considered separate, or isolated, populations. Whether the material cultural differences apparent in the archaeological record were maintained through political, environmental or linguistic factors--or through complex interactions between all of these variables--the dental biodistance, and I would argue the cranial biodistance analysis as well, show that no biological differences can be teased out for these groups in the Late Woodland period.

Similar to the biodistance analyses, in the realm of archaeology, Herbert's recent dissertation (2002, see Chapter 2) takes a significant step in decoupling material culture from historic linguistic or ethnic boundaries, as well as represents an important re-evaluation of the Woodland coastal ceramic sequence. One of his main contentions is that ceramic technology in this region remains stable across time, and similar between different cultural groups. Further, his reclassification of the outer North Carolina coastal ceramics as Virginia Townsend series will no doubt provoke further discussion of the Woodland and Late Woodland North Carolina coast as a single regional context. Herbert's findings synch well with the tenor of those from this dissertation, in opening the possibility--where it had not existed before-- that culture and material technology did not move along the same trajectories on the North Carolina coast in the Late Woodland period.

Thus, this study was not focused on measuring differences between skeletal samples which then point to underlying differences in cultural identity, a problematic association archaeologists and bioarchaeologists should avoid (see Chapters 3 and 4). The goal of this dissertation was estimating the possible interactions between Late Woodland peoples based on the fragmentary skeletal samples available. That the North Carolina coastal groups may represent a single evolving population does not imply that they must correspond culturally or linguistically to the biological data; rather, all these variables can move and change on different trajectories (Terrell 2001). While biological distance may be a

useful tool for discriminating between populations, it can only accomplish this result in relative terms.

The amount of gene flow suggested by the biodistance analysis, however, could be seen as material support for patterns of Southeastern Native American kinship, economic, and political organization recently documented by ethnohistorians (e.g. Fischer 2002, Kupperman 2000). Across the Southeast, many Native groups organized themselves into matrilineal kinship systems, where descent was reckoned through the mother's family and powerful matrilines held influential positions in a town or polity (Perdue and Green 2001). For example, leaders of coastal Virginia groups, namely Powhatan, his brother Itoyatan and cousin Opechancanough, gained their influence in part through their positions as members of the same powerful matriline (Gleach 1997:142-143). Marriage was often restricted to people from different matrilines, and during the colonial period marriage was also frequently employed to include both Europeans and African people into Native matrilines, thus bringing new levels of trust to economic and political relationships (Perdue 1979, 2002). Further, though the exact pattern of kinship is unknown for the outer North Carolina coastal groups, the colonial Tuscarora were organized patrilineally, which worked similarly in terms of increasing diversity among patrilines. These kinship and political configurations imply significant gene flow between Native groups, cultural patterns which may have existed during the Late Woodland period.

Another ethnohistoric example germane to the conclusions of this dissertation is Kristen Fischer's (2002) recent study of Native-European-African relationships on the North Carolina coast in the early colonial period. She argues that Native people, until the devastation of the Tuscarora War (1710-1713), had significant influence over political and economic relationships with colonists because they were able to maintain many of their precontact cultural traditions (Fischer 2002:70-74). Using John Lawson's account and unpublished court records, she identifies culturally specific ways that Native people dictated the terms of trade, and increased diversity in their communities: adoption of captives and traders, marriage, and brief encounters where women exchanged sex for trade goods (see also Rountree 1990, 1993). In effect, Native groups were able to impose these practices on the new arrivals until the colonies began to gain in population, land pressure increased, and violent conflict between Native groups and the English became more frequent. These patterns as well may have existed in the period before European contact, also pointing to significant gene flow between different Native cultural and linguistic groups.

It is possible then, that the dental trait similarity between the Late Woodland North Carolina coastal groups is a biological marker of these kinds of cultural practices. Although projecting these ethnohistoric patterns eight hundred years into the past would be as problematic as relying on a link between language and skeletal morphology, shifting our focus away from stable identities--for which biological evidence cannot be marshalled--and

re-emphasizing interaction, can help both archaeologists and bioarchaeologists ask other questions of their data. It may never be possible to tease out whether material traces of culture or material traces of biology make a “different people” on the Late Woodland North Carolina coast. We may be able to illuminate material flows and barriers, however, that suggest distinctions as well as similarities in the Late Woodland period which persisted or changed through time or in response to European contact and colonization.

### **Conclusions: Classification and bioarchaeological re-evaluation**

Archaeologists have used historic linguistic categories to link North Carolina coastal Native people from the colonial period to those in burials from the long Late Woodland (AD 800-1650) period which preceded it. In this project, I have argued that these categories are drawn from a typological physical anthropology which is not part of current bioarchaeological practice. I also proposed and constructed a different framework, one which tested skeletal remains directly for biological relationships and that effectively decoupled the biological from the linguistic classifications. After identifying the reasons for re-evaluating the ethnolinguistic categories, Chapter 2 reviewed current archaeological literature and showed how interpretations based on linking skeletal biology and language contradicted material culture evidence, and further had the interpretive consequence of imagining the Late Woodland North Carolina coast as a static region, biologically, materially and culturally.

Chapter 3 further examined the history of the ethnolinguistic categories, as articulated in studies and the bases of the theory on which the linkages with skeletal size and language were constructed. The cranial metric methods used to classify North Carolina Late Woodland ossuaries (Hrdlička 1916, Neumann 1952) could produce no other result than a simple typology, as the racial classifications on which they were based envisioned biological distinctions to be the sole product of immutable and unchanging physical differences between human groups.

In the last two chapters, I designed and completed a dental biological distance analysis on skeletal samples from thirteen Late Woodland coastal ossuaries. While no statistical differences were found between the biological samples, this result does not suggest that the Late Woodland period was marked by little political, cultural or linguistic change. Rather, the amount of gene flow evident between the ossuary samples denotes that Late Woodland people maintained a consistent level of biological diversity within their groups at least through the 16th century. In the early contact and colonial period, the inner coastal Tuscarora (Iroquoian speakers) outer coastal Algonquian speakers, and southern coastal Siouan speakers clearly considered themselves different from one another (Lawson 1967 [1709]). However, I argue that these cultural and linguistic differences, even if they existed during the Late Woodland period, do not translate into biological distinctions that can be projected into the distant past and used to classify archaeological sites.

Archaeologists, bioarchaeologists and biodistance researchers (see especially Greenberg et al. 1986) often use historic period cultural and linguistic classifications to categorize ancient burial populations. This project challenged the basis of applying historic ethnolinguistic labels to archaeological populations in the North Carolina coastal region. This kind of labeling is appropriate only when material culture evidence and clear historical continuity can be documented between earlier and later temporal groups. Certainly both archaeological and historical continuity exists in many places in Native North America, from the Cherokee in western North Carolina, to Iroquoians in the Northeast (Snow 1995), and to many groups in the midwestern and western part of the country. However, such a smooth line of descent is not apparent for the peoples of the North Carolina coast, who were some of the first groups impacted by European contact and colonization, diseases and many of the first groups to be pushed onto reservations (Perdue and Green 2001).

Further, the application of cultural labels to past archaeological and biological populations often has direct bearing on how scholars view the colonial period, as well as the modern descendants of such ancestral groups. In the case of the North Carolina coast archaeologists and bioarchaeologists have imagined the Late Woodland period as a time when three discrete peoples in terms of language, culture, and biology coexisted with little exchange or significant effect on each other for 800 years. In this interpretive context, it is not surprising then to see such a system quickly break down during the cultural and political

tumult of the colonial period. The strategies coastal people used during the colonial period however, such as migration to different cultural areas after the Powhatan uprisings in 1622 and 1644 (see Chapter 3), and coalitioning across linguistic lines in conflicts like the Tuscarora War (Crane 1929, Rights 1947), perhaps represent deeper connections across time and space than we have previously assumed (Fischer 2002, Perdue and Green 2001). Especially in light of the biodistance results, it may actually be more accurate to envision the Late Woodland North Carolina coast as a complex and perhaps contentious multi-lingual and multi-ethnic region, similar to what Hariot and Lawson found and chronicled in 1585 and 1709 respectively (Fischer 2002, Gray 1999).

### **Directions for further bioarchaeological research**

In light of the biodistance results and discussion, there are a number of directions imaginable for new bioarchaeological research on the coast of North Carolina. First, archaeologists have argued that the larger Late Woodland ossuaries represent community burials, while the smaller burials represent kin groups (Phelps 1983, and see Chapter 4). As previously discussed, the Hollowell site (31Co5), as a large ossuary with distinct skeletal bundles within it, straddles this theoretical line. One speculation the discussion in this study raises is if North Carolina coastal peoples used a lineage system similar to their neighbors to the north and west, it is possible that all ossuary burials represent kin groups, whether they

are organized in discrete bundles or large masses of remains. A way to approach this question would be to combine detailed mortuary analyses with biological distance statistics such as Fisher's Exact test or binomial probabilities (Howell and Kintigh 1996), which can determine if dental trait frequencies occur randomly or in patterns that suggest relatedness within a single burial context.

Additionally, dental nonmetric data can be collected on deciduous (juvenile or subadult) maxillary and mandibular molar teeth as well (Griffin 1998). Comparisons between subadult and adult male and female dental patterns with the above statistics, optimized for smaller sample sizes, may be able to detect patterns of genetic difference both between and within ossuary sites. These types of patterns could track people's movements across the region, or they might detect the introduction of new people from different areas into the coastal groups.

Furthermore, with or without a biological distance component, a mortuary variability study, including consideration of possible cultural modifications of the skeletal remains (e.g., cut marks signaling defleshing practices), is needed for these ossuary groups. Hutchinson's (2002) recent paleopathological and lifeway study of the northern coast certainly represents a positive step toward a more comprehensive understanding of precontact North Carolina coastal life. Because most detailed bioarchaeological studies on the southern coast, however, have only considered single ossuaries (e.g. Driscoll 1995, Kakaliouras 1997,

Truesdell 1995), as yet we do not have a clear understanding of how regional burial practices and lifeways may have changed through time across the entire coast.

The kind of re-evaluation undertaken in this dissertation represents a critical direction for biological anthropologists and bioarchaeologists. As researchers who specialize in using human skeletons from archaeological populations to reconstruct past patterns of behavior, it is crucial that the way we categorize past peoples be as specific and accurate as possible. Skeletal remains are an important source of evidence for examining the past, but they are not artifacts of material culture, nor are they direct proxies for linguistic or ethnic affiliations. Along those lines, the principal findings of this dissertation are, first, that for the Late Woodland North Carolina Coast, ethnolinguistic classification is not a valid or productive way to envision Late Woodland coastal Native American people. Secondly, those coastal people represented skeletally in ossuary populations are, biologically, too alike to have lines drawn between them that demarcate some essential difference in identity.

## Appendix A: Data recording forms

### INVENTORY and NONMETRIC DENTAL TRAITS (ASU SYSTEM - after Griffin 1998)

site	_____
burial	_____
individual	_____
collection	_____
sex	_____
criteria	_____
age	_____
criteria	_____
age category	_____
preservation	_____
comments	_____
	_____
	_____

### PERMANENT DENTITION

### INVENTORY

#### MAXILLARY LEFT

M3	M2	M1	P4	P3	C	I2	I1

#### MAXILLARY RIGHT

I1	I2	C	P3	P4	M1	M2	M3

#### MANDIBULAR LEFT

M3	M2	M1	P4	P3	C	I2	I1

#### MANDIBULAR RIGHT

I1	I2	C	P3	P4	M1	M2	M3

### DECIDUOUS DENTITION INVENTORY

#### MAXILLARY LEFT

DM2	DM1	DC	DI2	DI1

#### MAXILLARY RIGHT

DI1	DI2	DC	DM1	DM2

#### MANDIBULAR LEFT

DM2	DM1	DC	DI2	DI1

#### MANDIBULAR RIGHT

DI1	DI2	DC	DM1	DM2



## **Appendix B: Source code for “Biodistance” program, © 2001 Jan Kujawa**

The arcsine trait transformations and Mean Measures of Divergence (MMDs) for the skeletal samples analyzed in this study were calculated using a portable Java application called “Biodistance”. The input for the program is a comma delimited text file, the first line of which contains arbitrary site name variables (e.g. BAUM, JORD, HATT, etc.). Each line thereafter is comprised of the dental trait frequencies of a single site in the format “number observed, frequency” (e.g., 12, 0.05, 15, 0.8 ...) corresponding exactly in number and order to the site names and dental traits observed.

The following are the files making up the source code of the “Biodistance” program. They are separated by page breaks for consistency. A disk image of the program with directions for use can be obtained by contacting Ann M. Kakalioras at this permanent email address: akakalio@piper.hamline.edu. Use of this code without acknowledging the programmer (Jan Kujawa) is prohibited.

### **File Turkey.java**

```
//  
// Turkey.java  
//  
package biodistance;  
  
import java.util.*;  
import java.io.*;  
import java.lang.*;  
  
public class Turkey {  
    private int populations;  
    private int numtraits;  
    private double[][] a;  
    private double[][] b;  
    private String[] names;  
  
    public Turkey(String Filename) throws FileNotFoundException, IOException{  
        FileReader fr= new FileReader(Filename);  
        LineNumberReader lnr = new LineNumberReader(fr);  
  
        //read headings, get number of populations  
        if(lnr.ready()){  
            String headings=lnr.readLine();  
            StringTokenizer st=new StringTokenizer(headings, " ,");  
            populations=st.countTokens();  
            if(populations<1)  
                throw(new IllegalArgumentException("Not enough headings in "+Filename));  
            names=new String[populations+1];  
            for(int i=1;i<=populations;i++)
```

```

        names[i]=st.nextToken();
    } else
        throw(new IllegalArgumentException("Couldn't read names from "+Filename));

//System.out.println("Populations: "+Integer.toString(populations));

//read first population, which sets numtraits and the sizes of a and b
int linenum=1;
if(lnr.ready()){
    String line=lnr.readLine();
    StringTokenizer st=new StringTokenizer(line, " ,");
    int count=st.countTokens();
    if(!isEven(count))
        throw(new IllegalArgumentException("odd number of entries on line
"+Integer.toString(lnr.getLineNumber())+" in "+Filename));
    numtraits=count/2;
    a=new double[populations+1][numtraits+1];
    b=new double[populations+1][numtraits+1];
    int offset;
    for(int i=0;i<count;i+=2){
        offset=(i/2)+1;
        a[linenum][offset]=Double.valueOf(st.nextToken()).doubleValue();
        b[linenum][offset]=Double.valueOf(st.nextToken()).doubleValue();
    }
} else
    throw(new IllegalArgumentException(Filename+" didn't have enough lines. Expect-
ing "+Integer.toString(populations)));

//System.out.println("Numtraits: "+Integer.toString(numtraits));

while(lnr.ready()){
    linenum++;
    String line=lnr.readLine();
    StringTokenizer st=new StringTokenizer(line, " ,");
    int count=st.countTokens();
    if(!isEven(count))
        throw(new IllegalArgumentException("odd number of entries on line
"+Integer.toString(lnr.getLineNumber())+" in "+Filename));
    if( (count/2)!=numtraits )
        throw(new IllegalArgumentException("line
"+Integer.toString(lnr.getLineNumber())+" has the wrong number of entries in "+Filename));
    int offset;
    for(int i=0;i<count;i+=2){
        offset=(i/2)+1;
        a[linenum][offset]=Double.valueOf(st.nextToken()).doubleValue();
        b[linenum][offset]=Double.valueOf(st.nextToken()).doubleValue();
    }
}

```

```

fr.close();

//System.out.println("Linenum: "+Integer.toString(linenum));

if(linenum!=populations)
    throw(new IllegalArgumentException(Filename+" had a different number of headings
and data lines."));

}

private boolean isEven(int n){
    int m=n/2;
    return( (m*2)==n);
}

//public static void main (String args[]) throws FileNotFoundException, IOException {
//    Turkey T = new Turkey("/Users/kujawa/Projects/Turkey/data.txt");
//    System.out.println("");
//    T.printSineTrans();
//    System.out.println("");
//    T.printDistances();
//}

public void printDistances(PrintStream out){
    int numcomps=getNumcomps(populations);
    int x1, x2;
    int compnum=0;
    out.println("Population1, Population2, MMD, StdDeviation,StdMMD");
    for(x1=1;x1<=populations;x1++){
        for(x2=1;x2<=populations;x2++){
            if(x1==x2) continue;
            if(x1>x2) continue;
            double[] theta1 = new double[numtraits+1];
            double[] theta2 = new double[numtraits+1];
            for(int y=1;y<=numtraits;y++){
                theta1[y]=sineTrans(b[x1][y],a[x1][y]);
                theta2[y]=sineTrans(b[x2][y],a[x2][y]);
            }
            double mmd=getMMD(numtraits,theta1,theta2,x1,x2);
            double variance=getVariance(numtraits,x1,x2);
            double sd=Math.sqrt(variance);
            double StMMD=mmd/sd;
            out.println(names[x1]+", "+names[x2]+", "+Double.toString(mmd)+",
"+Double.toString(sd)+
", "+Double.toString(StMMD));
        } //x2
    } //x1
}

```

```

}

public void printSineTrans(PrintStream out){
    out.println("Population, NumObserved, Frequency, Theta");
    for(int x=1; x<=populations; x++){
        for(int y=1; y<=numtraits;y++){
            double k=b[x][y];
            double n=a[x][y];
            double theta=sineTrans(k,n);
            out.println(names[x]+", "+Double.toString(n)+", "+Double.toString(k)+",
"+Double.toString(theta));
        }
    }
}

private double getMMD(int r, double[] theta1, double[] theta2, int x1, int x2){
    double sum=0;
    for(int i=1;i<=r;i++){
        double t= theta1[i]-theta2[i];
        double n1i=a[x1][i];
        double n2i=a[x2][i];
        sum+= t*t - (1.0/(n1i+.5)+1.0/(n2i+.5));
    }
    return(sum/r);
}

private double getVariance(int r, int x1, int x2){
    double sum=0;
    //System.out.println("r, t, sum");
    for(int i=1;i<=r;i++){
        double n1i=a[x1][i];
        double n2i=a[x2][i];
        double t=1.0/(n1i+.5)+1.0/(n2i+.5);
        sum+=t*t;
        //System.out.println(Integer.toString(r)+", "+Double.toString(t)+",
"+Double.toString(sum));
    }
    double divisor=r*r;
    double mult=2.0/divisor;
    double result=mult*sum;
    //System.out.println("2/r*r= "+Double.toString(mult)+" , result="+Double.toString(result));
    return(result);
}

private int getNumcomps(int populations){
    //find odd number <= populations
    int q=populations/2;
    q*=2;
}

```



### File Interface.java

```
package biodistance;

import javax.swing.UIManager;
import java.awt.*;

public class Interface {
    boolean packFrame = false;

    /**Construct the application*/
    public Interface() {
        MainFrame frame = new MainFrame();
        //Validate frames that have preset sizes
        //Pack frames that have useful preferred size info, e.g. from their layout
        if (packFrame) {
            frame.pack();
        }
        else {
            frame.validate();
        }
        //Center the window
        Dimension screenSize = Toolkit.getDefaultToolkit().getScreenSize();
        Dimension frameSize = frame.getSize();
        if (frameSize.height > screenSize.height) {
            frameSize.height = screenSize.height;
        }
        if (frameSize.width > screenSize.width) {
            frameSize.width = screenSize.width;
        }
        frame.setLocation((screenSize.width - frameSize.width) / 2, (screenSize.height -
        frameSize.height) / 2);
        frame.setVisible(true);
    }
    /**Main method*/
    public static void main(String[] args) {
        try {
            UIManager.setLookAndFeel(UIManager.getSystemLookAndFeelClassName());
        }
        catch(Exception e) {
            e.printStackTrace();
        }
        new Interface();
    }
}
```

### File MainFrame.java

```
package biodistance;

import java.awt.*;
import java.awt.event.*;
import javax.swing.*;
import javax.swing.border.*;
import java.io.*;

public class MainFrame extends JFrame {
    JPanel contentPane;
    JMenuBar jMenuBar1 = new JMenuBar();
    JMenu jMenuFile = new JMenu();
    JMenuItem jMenuItemExit = new JMenuItem();
    JMenu jMenuHelp = new JMenu();
    JMenuItem jMenuItemHelpAbout = new JMenuItem();
    GridLayout gridLayout1 = new GridLayout();
    JPanel jPanel1 = new JPanel();
    JPanel jPanel2 = new JPanel();
    JPanel jPanel3 = new JPanel();
    Border border1;
    GridLayout gridLayout2 = new GridLayout();
    JPanel jPanel4 = new JPanel();
    Box box2;
    JButton MMDButton = new JButton();
    JTextField MMDField = new JTextField();
    JLabel jLabel1 = new JLabel();
    JLabel jLabel2 = new JLabel();
    GridLayout gridLayout3 = new GridLayout();
    JPanel jPanel5 = new JPanel();
    Box box1;
    JLabel jLabel3 = new JLabel();
    JLabel jLabel4 = new JLabel();
    JButton DataButton = new JButton();
    JTextField DataField = new JTextField();
    GridLayout gridLayout4 = new GridLayout();
    JPanel jPanel6 = new JPanel();
    Box box3;
    JLabel Label5 = new JLabel();
    JButton ThetaButton = new JButton();
    JTextField ThetaField = new JTextField();
    JLabel jLabel6 = new JLabel();

    //paths
    private String DataPath;
    private String ThetaPath;
```

```

private String MMDPath;
private String cwd;

JPanel jPanel7 = new JPanel();
BorderLayout borderLayout1 = new BorderLayout();
Box box4;
JButton GoButton = new JButton();

/**Construct the frame*/
public MainFrame() {
    enableEvents(AWTEvent.WINDOW_EVENT_MASK);
    try {
        jbInit();
    }
    catch(Exception e) {
        e.printStackTrace();
    }
}
/**Component initialization*/
private void jbInit() throws Exception {
    //
setIconImage(Toolkit.getDefaultToolkit().createImage(MainFrame.class.getResource("[Your
Icon]")));
    contentPane = (JPanel) this.getContentPane();
    border1 = new EtchedBorder(EtchedBorder.RAISED,Color.white,new Color(142, 142,
142));
    box2 = Box.createHorizontalBox();
    box1 = Box.createHorizontalBox();
    box3 = Box.createHorizontalBox();
    box4 = Box.createHorizontalBox();
    contentPane.setLayout(gridLayout1);
    this.setSize(new Dimension(460, 331));
    this.setTitle("Biodistance");
    jMenuFile.setText("File");
    jMenuFileExit.setText("Exit");
    jMenuFileExit.addActionListener(new ActionListener() {
        public void actionPerformed(ActionEvent e) {
            jMenuFileExit_actionPerformed(e);
        }
    });
    jMenuHelp.setText("Help");
    jMenuHelpAbout.setText("About");
    jMenuHelpAbout.addActionListener(new ActionListener() {
        public void actionPerformed(ActionEvent e) {
            jMenuHelpAbout_actionPerformed(e);
        }
    });
}

```

```

gridLayout1.setRows(4);
jPanel1.setBorder(border1);
jPanel1.setLayout(gridLayout3);
jPanel2.setBorder(BorderFactory.createEtchedBorder());
jPanel2.setLayout(gridLayout2);
jPanel3.setBorder(BorderFactory.createEtchedBorder());
jPanel3.setLayout(gridLayout4);
gridLayout2.setRows(3);
MMDButton.setText("Set... ");
MMDButton.addActionListener(new java.awt.event.ActionListener() {
    public void actionPerformed(ActionEvent e) {
        MMDButtonActionPerformed(e);
    }
});
jLabel1.setText("This sets where to save MMD output.");
jLabel2.setText("MMD");
gridLayout3.setRows(3);
jLabel3.setText("Data Set");
jLabel4.setText("Use this to load a data set");
DataButton.setToolTipText("");
DataButton.setText("Set... ");
DataButton.addActionListener(new java.awt.event.ActionListener() {
    public void actionPerformed(ActionEvent e) {
        DataButtonActionPerformed(e);
    }
});
DataField.setToolTipText("");
DataField.setEditable(false);
gridLayout4.setRows(3);
Label5.setText("Theta");
ThetaButton.setText("Set... ");
ThetaButton.addActionListener(new java.awt.event.ActionListener() {
    public void actionPerformed(ActionEvent e) {
        ThetaButtonActionPerformed(e);
    }
});
jLabel6.setText("This sets where to save Theta output.");
MMDField.setEditable(false);
ThetaField.setEditable(false);
jPanel7.setLayout(borderLayout1);
GoButton.setText("Calculate");
GoButton.addActionListener(new java.awt.event.ActionListener() {
    public void actionPerformed(ActionEvent e) {
        GoButtonActionPerformed(e);
    }
});
jMenuFile.add(jMenuFileExit);
jMenuHelp.add(jMenuHelpAbout);

```

```

jMenuBar1.add(jMenuFile);
jMenuBar1.add(jMenuHelp);
this.setJMenuBar(jMenuBar1);
contentPane.add(jPanel1, null);
jPanel1.add(jPanel5, null);
jPanel5.add(jLabel3, null);
jPanel1.add(box1, null);
box1.add(DataButton, null);
box1.add(DataField, null);
jPanel1.add(jLabel4, null);
contentPane.add(jPanel2, null);
jPanel2.add(jPanel4, null);
jPanel4.add(jLabel2, null);
jPanel2.add(box2, null);
box2.add(MMDButton, null);
box2.add(MMDField, null);
jPanel2.add(jLabel1, null);
contentPane.add(jPanel3, null);
jPanel3.add(jPanel6, null);
jPanel6.add(Label5, null);
jPanel3.add(box3, null);
box3.add(ThetaButton, null);
box3.add(ThetaField, null);
jPanel3.add(jLabel6, null);
contentPane.add(jPanel7, null);
jPanel7.add(box4, BorderLayout.EAST);
box4.add(GoButton, null);
DataPath = new String("");
MMDPath = new String("");
ThetaPath = new String("");
cwd = new String("");
}

public void error(String Message){
    ErrorBox errorBox=new ErrorBox(Message);
    Dimension dlgSize = errorBox.getPreferredSize();
    Dimension frmSize = getSize();
    Point loc = getLocation();
    errorBox.setLocation((frmSize.width - dlgSize.width) / 2 + loc.x, (frmSize.height -
dlgSize.height) / 2 + loc.y);
    errorBox.setModal(true);
    errorBox.setResizable(false);
    //errorBox.setVisible(true);
    errorBox.show();
}

private String getFile(boolean Save, String Title){
    JFileChooser chooser = new JFileChooser(cwd);

```

```

chooser.setDialogTitle>Title);
int returnVal;
if(Save)
    returnVal = chooser.showSaveDialog(this.getParent());
else
    returnVal = chooser.showOpenDialog(this.getParent());
if(returnVal == JFileChooser.APPROVE_OPTION){
    File f=chooser.getSelectedFile();
    cwd=f.getParent();
    if(cwd==null)
        cwd=new String("");
    return f.getAbsolutePath();
} else
    return("");
}

/**File | Exit action performed*/
public void jMenuFileExitActionPerformed(ActionEvent e) {
    System.exit(0);
}
/**Help | About action performed*/
public void jMenuHelpAboutActionPerformed(ActionEvent e) {
    MainFrame_AboutBox dlg = new MainFrame_AboutBox(this);
    Dimension dlgSize = dlg.getPreferredSize();
    Dimension frmSize = getSize();
    Point loc = getLocation();
    dlg.setLocation((frmSize.width - dlgSize.width) / 2 + loc.x, (frmSize.height -
    dlgSize.height) / 2 + loc.y);
    dlg.setModal(true);
    dlg.show();
}
/**Overridden so we can exit when window is closed*/
protected void processWindowEvent(WindowEvent e) {
    super.processWindowEvent(e);
    if (e.getID() == WindowEvent.WINDOW_CLOSING) {
        jMenuFileExitActionPerformed(null);
    }
}

void DataButtonActionPerformed(ActionEvent e) {
    DataPath = getFile(false,"Load Data Set from... ");
    DataField.setText(DataPath);
}

void MMDButtonActionPerformed(ActionEvent e) {
    MMDPath = getFile(true,"Save MMD ouput as... ");
    MMDField.setText(MMDPath);
}

```

```

void ThetaButton_actionPerformed(ActionEvent e) {
    ThetaPath = getFile(true,"Set Theta output as...");
    ThetaField.setText(ThetaPath);
}

void GoButton_actionPerformed(ActionEvent e) {
    if(DataPath.equals("") ||
       ThetaPath.equals("") ||
       MMDPath.equals("") ) {
        error("You must set paths for input and output.");
        return;
    }

    if( DataPath.equals(ThetaPath) ||
        DataPath.equals(MMDPath) ||
        MMDPath.equals(ThetaPath) ) {
        error("File paths must be unique.");
        return;
    }

    try {
        File Theta = new File(ThetaPath);
        File MMD = new File(MMDPath);

        FileOutputStream ThetaStream = new FileOutputStream(Theta);
        FileOutputStream MMDStream = new FileOutputStream(MMD);

        Turkey T = new Turkey(DataPath);
        T.printDistances(new PrintStream(MMDStream));
        T.printSineTrans(new PrintStream(ThetaStream));
    } catch (Exception ex) {
        error("An error occurred while calculating: "+ex.toString());
        return;
    }

    error("Done.");
}

```

### File MainFrame\_AboutBox.java

```
package biodistance;

import java.awt.*;
import java.awt.event.*;
import javax.swing.*;
import javax.swing.border.*;

public class MainFrame_AboutBox extends JDialog implements ActionListener {

    JPanel panel1 = new JPanel();
    JPanel panel2 = new JPanel();
    JPanel insetsPanel1 = new JPanel();
    JPanel insetsPanel2 = new JPanel();
    JPanel insetsPanel3 = new JPanel();
    JButton button1 = new JButton();
    JLabel imageLabel = new JLabel();
    JLabel label1 = new JLabel();
    JLabel label2 = new JLabel();
    JLabel label3 = new JLabel();
    JLabel label4 = new JLabel();
    BorderLayout borderLayout1 = new BorderLayout();
    BorderLayout borderLayout2 = new BorderLayout();
    FlowLayout flowLayout1 = new FlowLayout();
    GridLayout gridLayout1 = new GridLayout();
    String product = "";
    String version = "1.0";
    String copyright = "Copyright (c) 2001";
    String comments = "";
    public MainFrame_AboutBox(Frame parent) {
        super(parent);
        enableEvents(AWTEvent.WINDOW_EVENT_MASK);
        try {
            jblInit();
        }
        catch(Exception e) {
            e.printStackTrace();
        }
        pack();
    }
    /**Component initialization*/
    private void jblInit() throws Exception {
        //imageLabel.setIcon(new ImageIcon(MainFrame_AboutBox.class.getResource("[Your
        Image]")));
        this.setTitle("About");
        setResizable(false);
```

```

panel1.setLayout(borderLayout1);
panel2.setLayout(borderLayout2);
insetsPanel1.setLayout(flowLayout1);
insetsPanel2.setLayout(flowLayout1);
insetsPanel2.setBorder(BorderFactory.createEmptyBorder(10, 10, 10, 10));
gridLayout1.setRows(4);
gridLayout1.setColumns(1);
label1.setText(product);
label2.setText("Biodistance 1.0");
label3.setText("Copyright (c) 2001 Jan M. Kujawa");
label4.setText(comments);
insetsPanel3.setLayout(gridLayout1);
insetsPanel3.setBorder(BorderFactory.createEmptyBorder(10, 60, 10, 10));
button1.setText("Ok");
button1.addActionListener(this);
insetsPanel2.add(imageLabel, null);
panel2.add(insetsPanel2, BorderLayout.WEST);
this.getContentPane().add(panel1, null);
insetsPanel3.add(label1, null);
insetsPanel3.add(label2, null);
insetsPanel3.add(label3, null);
insetsPanel3.add(label4, null);
panel2.add(insetsPanel3, BorderLayout.CENTER);
insetsPanel1.add(button1, null);
panel1.add(insetsPanel1, BorderLayout.SOUTH);
panel1.add(panel2, BorderLayout.NORTH);
}
/**Overridden so we can exit when window is closed*/
protected void processWindowEvent(WindowEvent e) {
    if (e.getID() == WindowEvent.WINDOW_CLOSING) {
        cancel();
    }
    super.processWindowEvent(e);
}
/**Close the dialog*/
void cancel() {
    dispose();
}
/**Close the dialog on a button event*/
public void actionPerformed(ActionEvent e) {
    if (e.getSource() == button1) {
        cancel();
    }
}
}

```

### File ErrorBox.java

```
//  
// ErrorBox.java  
// Biodistance  
//  
// Created by kujawa on Fri Oct 26 2001.  
// Copyright (c) 2001 __MyCompanyName__. All rights reserved.  
//  
package biodistance;  
  
import java.awt.*;  
import java.awt.event.*;  
import javax.swing.*;  
  
public class ErrorBox extends JDialog  
    implements ActionListener  
{  
    protected JButton okButton;  
    protected JLabel aboutText;  
  
    public ErrorBox(String Message) {  
        super();  
        this.getContentPane().setLayout(new BorderLayout(15, 15));  
        this.setFont(new Font ("SansSerif", Font.BOLD, 14));  
  
        aboutText = new JLabel (Message);  
        JPanel textPanel = new JPanel(new FlowLayout(FlowLayout.CENTER, 15, 15));  
        textPanel.add(aboutText);  
        this.getContentPane().add (textPanel, BorderLayout.NORTH);  
  
        okButton = new JButton("OK");  
        JPanel buttonPanel = new JPanel(new FlowLayout(FlowLayout.CENTER, 15, 15));  
        buttonPanel.add (okButton);  
        okButton.addActionListener(this);  
        this.getContentPane().add(buttonPanel, BorderLayout.SOUTH);  
        this.pack();  
    }  
  
    public void actionPerformed(ActionEvent newEvent) {  
        setVisible(false);  
    }  
}
```

**Appendix C: Dental trait frequencies, Late Woodland Coastal North Carolina ossuary sites**

Dental Trait	Grade	Frequency (%)				
		Baum Burial 1	Baum Burial 5	Baum Burial 7	Broad Reach	Camp Lejeune
Winging	1A	1(10.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1B	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	1(33.3)	0(0.0)
	3	7(70.0)	0(0.0)	1(100.0)	1(33.3)	1(100.0)
	4	2(20.0)	0(0.0)	0(0.0)	1(33.3)	0(0.0)
Shoveling I1	0	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	1(16.7)	0(0.0)	0(0.0)	3(42.9)	0(0.0)
	3	3(50.0)	0(0.0)	0(0.0)	2(28.6)	0(0.0)
	4	0(0.0)	2(66.7)	0(0.0)	2(28.6)	0(0.0)
	5	2(33.3)	1(33.3)	0(0.0)	0(0.0)	1(50.0)
	6	0(0.0)	0(0.0)	1(100.0)	0(0.0)	1(50.0)
178	Shoveling I2	0	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1	0(0.0)	0(0.0)	0(0.0)	2(13.3)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	4(26.7)	0(0.0)
	3	1(25.0)	0(0.0)	0(0.0)	0(0.0)	2(50.0)
	4	1(25.0)	0(0.0)	1(50.0)	5(33.3)	2(50.0)
	5	2(50.0)	0(0.0)	1(50.0)	4(26.7)	0(0.0)
	6	0(0.0)	2(66.7)	0(0.0)	0(0.0)	0(0.0)
	7	0(0.0)	1(33.3)	0(0.0)	0(0.0)	0(0.0)
	8	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Double shoveling	0	6(54.5)	0(0.0)	0(0.0)	0(0.0)	1(50.0)
	1	0(0.0)	0(0.0)	0(0.0)	4(50.0)	0(0.0)
	2	3(27.3)	1(25.0)	2(100.0)	0(0.0)	0(0.0)
	3	2(18.2)	2(50.0)	0(0.0)	0(0.0)	1(50.0)
	4	0(0.0)	0(0.0)	0(0.0)	3(37.5)	0(0.0)
	5	0(0.0)	1(25.0)	0(0.0)	1(12.5)	0(0.0)
	6	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Interruption groove	0	8(53.3)	0(0.0)	3(100.0)	7(43.8)	0(0.0)
	1	3(20.0)	0(0.0)	0(0.0)	1(6.3)	0(0.0)

Dental Trait	Grade	Baum Burial 1	Baum Burial 5	Baum Burial 7	Broad Reach	Camp Lejeune
Tuberculum dentale	2	3(20.0)	4(100.0)	0(0.0)	4(25.0)	2(100.0)
	3	1(6.7)	0(0.0)	0(0.0)	2(12.5)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	4(25.0)	0(0.0)
	0	9(90.0)	0(0.0)	1(100.0)	11(91.7)	2(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	1(10.0)	1(100.0)	0(0.0)	1(8.3)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	6	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Canine mesial ridge	0	3(60.0)	2(100.0)	1(100.0)	4(33.3)	2(100.0)
	1	2(40.0)	0(0.0)	0(0.0)	6(50.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	2(16.7)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Canine distal accessory ridge	0	8(100.0)	2(100.0)	1(100.0)	11(100.0)	2(66.7)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(33.3)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Metacone M3	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	3(25.0)	3(60.0)	3(37.5)	1(7.1)	0(0.0)
	1	0(0.0)	0(0.0)	1(12.5)	1(7.1)	0(0.0)
	2	1(8.3)	0(0.0)	0(0.0)	1(7.1)	0(0.0)
	3	2(16.7)	1(20.0)	2(25.5)	7(50.0)	2(66.7)
	3.5	4(33.3)	1(20.0)	0(0.0)	2(14.3)	0(0.0)
Hypocone M1	4	1(8.3)	0(0.0)	2(25.5)	2(14.3)	1(33.3)
	5	1(8.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Hypocone M2	3.5	11(47.8)	1(14.3)	4(28.6)	4(33.3)	4(66.7)
	4	11(47.8)	3(42.9)	10(71.4)	4(33.3)	1(16.7)
	5	1(4.3)	3(42.9)	0(0.0)	4(33.3)	1(16.7)
Hypocone M2	0	2(9.5)	0(0.0)	2(28.6)	0(0.0)	0(0.0)

Dental Trait	Grade	Baum Burial 1	Baum Burial 5	Baum Burial 7	Broad Reach	Camp Lejeune
Metaconule M1	1	3(14.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	5(23.8)	0(0.0)	0(0.0)	2(15.4)	0(0.0)
	3	2(9.5)	2(33.3)	4(57.1)	3(23.1)	5(71.4)
	3.5	7(33.3)	4(66.7)	1(14.3)	7(53.8)	1(14.3)
	4	2(9.5)	0(0.0)	0(0.0)	0(0.0)	1(14.3)
	5	0(0.0)	0(0.0)	0(0.0)	1(7.7)	0(0.0)
	0	14(93.3)	2(40.0)	1(25.0)	4(80.0)	4(100.0)
	1	0(0.0)	2(40.0)	2(50.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	1(25.0)	0(0.0)	0(0.0)
	3	1(6.7)	1(20.0)	0(0.0)	1(20.0)	0(0.0)
Metaconule M2	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	12(92.3)	3(100.0)	5(83.3)	3(50.0)	3(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	1(7.7)	0(0.0)	0(0.0)	1(16.7)	0(0.0)
	3	0(0.0)	0(0.0)	1(16.7)	2(33.3)	0(0.0)
Carabelli's trait M1	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	11(73.3)	2(40.0)	5(55.6)	8(100.0)	4(100.0)
	1	0(0.0)	1(20.0)	2(22.2)	0(0.0)	0(0.0)
	2	1(6.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	2(13.3)	0(0.0)	2(22.2)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	1(6.7)	2(40.0)	0(0.0)	0(0.0)	0(0.0)
Carabelli's trait M2	6	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	7	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	9(100.0)	3(75.0)	8(88.9)	7(100.0)	5(100.0)
	1	0(0.0)	1(25.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	1(11.1)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Parastyle	0	8(100.0)	6(100.0)	4(100.0)	10(90.9)	4(100.0)

Dental Trait	Grade	Baum Burial 1	Baum Burial 5	Baum Burial 7	Broad Reach	Camp Lejeune
Enamel extensions	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	1(9.1)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	20(95.2)	7(100.0)	12(100.0)	16(76.2)	2(100.0)
Premolar root number	1	0(0.0)	0(0.0)	0(0.0)	2(9.5)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	2(9.5)	0(0.0)
	3	1(4.8)	0(0.0)	0(0.0)	1(4.8)	0(0.0)
Molar root number	1	15(88.2)	2(100.0)	10(100.0)	7(63.6)	4(100.0)
	2	2(11.8)	0(0.0)	0(0.0)	4(36.4)	0(0.0)
Peg-shaped incisor	1	0(0.0)	0(0.0)	1(11.1)	1(10.0)	0(0.0)
	2	4(21.1)	1(33.3)	1(11.1)	1(10.0)	0(0.0)
	3	15(78.9)	2(66.7)	7(77.8)	8(80.0)	4(100.0)
	0	31(96.9)	6(100.0)	16(100.0)	14(100.0)	4(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	1(3.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Peg-shaped molar	0	27(90.0)	7(100.0)	14(100.0)	12(100.0)	4(100.0)
	1	1(3.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	2(6.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Odontome – upper	0	27(100.0)	4(100.0)	3(100.0)	13(100.0)	2(66.7)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(33.3)
Odontome – lower	0	35(100.0)	6(100.0)	6(100.0)	11(100.0)	0(0.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Lower P3 variation	A	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	10(66.7)	0(0.0)	2(100.0)	7(50.0)	2(66.7)
	1	2(13.3)	0(0.0)	0(0.0)	3(21.4)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	2(14.3)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	1(6.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	2(13.3)	1(50.0)	0(0.0)	2(14.3)	1(33.3)
	6	0(0.0)	1(50.0)	0(0.0)	0(0.0)	0(0.0)

Dental Trait	Grade	Baum Burial 1	Baum Burial 5	Baum Burial 7	Broad Reach	Camp Lejeune
Lower P4 variation	7	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	8	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	9	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	A	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	21(100.0)	1(33.3)	6(75.0)	2(33.3)	3(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	1(16.7)	0(0.0)
	2	0(0.0)	0(0.0)	1(12.5)	2(33.3)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	0(0.0)	2(66.7)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	1(16.7)	0(0.0)
Anterior fovea	6	0(0.0)	0(0.0)	1(12.5)	0(0.0)	0(0.0)
	7	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	8	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	9	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1	2(33.3)	0(0.0)	2(100.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	3(50.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	1(16.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1	12(85.7)	4(66.7)	6(75.0)	5(83.3)	7(87.5)
Groove pattern M1	2	1(7.1)	0(0.0)	0(0.0)	0(0.0)	1(12.5)
	3	1(7.1)	2(33.3)	2(25.0)	1(16.7)	0(0.0)
	1	1(4.0)	3(50.0)	2(16.7)	2(22.2)	0(0.0)
Groove pattern M2	2	16(64.0)	3(50.0)	10(83.3)	6(66.7)	8(80.0)
	3	8(32.0)	0(0.0)	0(0.0)	1(11.1)	2(20.0)
	1	5(23.8)	4(66.7)	3(33.3)	0(0.0)	2(20.0)
Cusp number M1	4	9(42.9)	2(33.3)	6(66.7)	4(80.0)	6(60.0)
	5	7(33.3)	0(0.0)	0(0.0)	1(20.0)	2(20.0)
	6	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	7	21(87.5)	6(100.0)	10(71.4)	6(66.7)	2(18.2)
	4	2(8.3)	0(0.0)	2(14.3)	3(33.3)	8(72.7)
Cusp number M2	5	1(4.2)	0(0.0)	2(14.3)	0(0.0)	1(9.1)
	6					

Dental Trait	Grade	Baum Burial 1	Baum Burial 5	Baum Burial 7	Broad Reach	Camp Lejeune
Deflecting wrinkle	0	3(50.0)	1(100.0)	0(0.0)	0(0.0)	0(0.0)
	1	1(16.7)	0(0.0)	0(0.0)	0(0.0)	2(100.0)
	2	0(0.0)	0(0.0)	1(100.0)	0(0.0)	0(0.0)
	3	2(33.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Distal trigonid crest	0	7(100.0)	0(0.0)	4(100.0)	0(0.0)	1(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Protostyloid M1	0	27(79.4)	3(50.0)	5(55.6)	4(57.1)	2(28.6)
	1	7(20.6)	0(0.0)	2(22.2)	3(42.9)	4(57.1)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(14.3)
	4	0(0.0)	3(50.0)	1(11.1)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	1(11.1)	0(0.0)	0(0.0)
18	Protostyloid M2	0	15(78.9)	0(0.0)	6(85.7)	5(71.4)
		1	4(21.1)	0(0.0)	1(14.3)	2(28.6)
		2	0(0.0)	0(0.0)	0(0.0)	0(0.0)
		3	0(0.0)	2(100.0)	0(0.0)	0(0.0)
		4	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Cusp 5 M1	0	3(20.0)	2(50.0)	3(33.3)	0(0.0)	2(20.0)
	1	2(13.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	3(20.0)	2(50.0)	2(22.2)	4(57.1)	2(20.0)
	3	6(40.0)	0(0.0)	0(0.0)	3(42.9)	4(40.0)
	4	0(0.0)	0(0.0)	2(22.2)	0(0.0)	2(20.0)
	5	1(6.7)	0(0.0)	2(22.2)	0(0.0)	0(0.0)
Cusp 5 M2	0	19(86.4)	6(100.0)	10(71.4)	7(63.6)	2(15.4)
	1	2(9.1)	0(0.0)	2(14.3)	0(0.0)	0(0.0)
	2	1(4.5)	0(0.0)	0(0.0)	2(18.2)	6(46.2)
	3	0(0.0)	0(0.0)	2(14.3)	2(18.2)	2(15.4)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(23.1)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Cusp 6 M1	0	14(77.8)	4(100.0)	9(100.0)	8(100.0)	9(90.0)
	1	2(11.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)

Dental Trait	Grade	Baum Burial 1	Baum Burial 5	Baum Burial 7	Broad Reach	Camp Lejeune
Cusp 6 M2	3	2(11.1)	0(0.0)	0(0.0)	0(0.0)	1(10.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	19(90.5)	5(100.0)	14(87.5)	11(100.0)	11(84.6)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	2(12.5)	0(0.0)	0(0.0)
Cusp 7 M1	3	2(9.5)	0(0.0)	0(0.0)	0(0.0)	2(15.4)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	14(100.0)	5(100.0)	7(100.0)	7(87.5)	9(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Cusp 7 M2	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	1(12.5)	0(0.0)
	0	17(100.0)	5(100.0)	13(100.0)	12(100.0)	12(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Canine root number	1	31(100.0)	9(100.0)	17(100.0)	17(100.0)	3(100.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Tome's root	0	10(100.0)	7(70.0)	10(76.9)	12(75.0)	2(66.7)
	1	0(0.0)	2(20.0)	3(23.1)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(33.3)
	3	0(0.0)	0(0.0)	0(0.0)	4(25.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	1(10.0)	0(0.0)	0(0.0)	0(0.0)
1 <sup>st</sup> molar root number	1	2(7.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	24(92.3)	6(100.0)	17(100.0)	11(100.0)	7(100.0)
2 <sup>nd</sup> molar root number	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1	6(28.6)	0(0.0)	0(0.0)	1(9.1)	1(20.0)
	2	15(71.4)	8(100.0)	13(100.0)	9(81.8)	4(80.0)
	3	0(0.0)	0(0.0)	0(0.0)	1(9.1)	0(0.0)

Dental Trait	Grade	Baum Burial 1	Baum Burial 5	Baum Burial 7	Broad Reach	Camp Lejeune
Palatine torus	0	12(75.0)	1(33.3)	6(66.7)	5(71.4)	0(0.0)
	1	4(25.0)	2(66.7)	3(33.3)	1(14.3)	2(100.0)
	2	0(0.0)	0(0.0)	0(0.0)	1(14.3)	0(0.0)
Mandibular torus	0	15(83.3)	5(71.4)	6(66.7)	5(71.4)	0(0.0)
	1	2(11.1)	1(14.3)	2(22.2)	2(28.6)	0(0.0)
	2	1(5.6)	1(14.3)	1(11.1)	0(0.0)	0(0.0)
Torsomolar angle	0	16(66.7)	5(55.6)	9(75.0)	9(56.3)	0(0.0)
	1	7(29.2)	2(22.2)	0(0.0)	2(12.5)	1(100.0)
	2	1(4.2)	2(22.2)	3(25.0)	5(31.3)	0(0.0)

Dental Trait	Grade	Cold Morning	Flynt	Garbacon Crk	Hatteras	Hollowell
Winging	1A	0(0.0)	0(0.0)	1(50.0)	0(0.0)	1(100.0)
	1B	0(0.0)	1(100.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	1(50.0)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Shoveling I1	0	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1	0(0.0)	0(0.0)	1(14.3)	0(0.0)	0(0.0)
	2	0(0.0)	2(14.3)	2(28.6)	1(100.0)	1(10.0)
	3	2(40.0)	4(28.6)	0(0.0)	0(0.0)	2(20.0)
	4	0(0.0)	2(14.3)	2(28.6)	0(0.0)	3(30.0)
	5	3(60.0)	5(35.7)	2(28.6)	0(0.0)	2(20.0)
	6	0(0.0)	1(7.1)	0(0.0)	0(0.0)	2(20.0)
Shoveling I2	0	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1	0(0.0)	0(0.0)	0(0.0)	2(100.0)	1(14.2)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(14.2)
	3	2(33.3)	0(0.0)	3(100.0)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(14.2)
	5	4(66.7)	1(33.3)	0(0.0)	0(0.0)	2(28.6)
	6	0(0.0)	1(33.3)	0(0.0)	0(0.0)	2(28.6)
	7	0(0.0)	1(33.3)	0(0.0)	0(0.0)	0(0.0)
	8	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Double shoveling	0	2(25.0)	1(7.1)	0(0.0)	0(0.0)	4(33.3)
	1	0(0.0)	4(28.6)	0(0.0)	0(0.0)	1(8.3)
	2	2(25.0)	1(7.1)	3(100.0)	3(100.0)	1(8.3)
	3	0(0.0)	3(21.4)	0(0.0)	0(0.0)	5(41.6)
	4	2(25.0)	5(35.7)	0(0.0)	0(0.0)	1(8.3)
	5	2(25.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	6	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Interruption groove	0	2(33.3)	6(75.0)	4(100.0)	3(100.0)	7(63.6)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(9.1)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(27.3)

Dental Trait	Grade	Cold Morning	Flynt	Garbacon Crk	Hatteras	Hollowell
Tuberculum dentale	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	4(66.7)	2(25.0)	0(0.0)	0(0.0)	0(0.0)
	0	2(100.0)	7(58.3)	3(100.0)	0(0.0)	10(90.9)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	2(16.7)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	2(16.7)	0(0.0)	0(0.0)	0(0.0)
	4	0(0.0)	1(8.3)	0(0.0)	0(0.0)	1(9.1)
Canine mesial ridge	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	6	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	5(71.4)	2(50.0)	6(100.0)	5(100.0)	6(66.7)
	1	0(0.0)	1(25.0)	0(0.0)	0(0.0)	3(33.3)
	2	2(28.6)	1(25.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	5(83.3)	3(75.0)	7(100.0)	4(80.0)	9(75.0)
Canine distal accessory ridge	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(8.3)
	2	0(0.0)	1(25.0)	0(0.0)	0(0.0)	0(0.0)
	3	1(16.7)	0(0.0)	0(0.0)	0(0.0)	2(16.7)
	4	0(0.0)	0(0.0)	0(0.0)	1(20.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	1(20.0)	1(14.3)	0(0.0)	1(25.0)	0(0.0)
	1	2(40.0)	1(14.3)	3(50.0)	0(0.0)	0(0.0)
Metacone M3	2	0(0.0)	1(14.3)	0(0.0)	0(0.0)	0(0.0)
	3	2(40.0)	0(0.0)	1(16.7)	1(25.0)	4(80.0)
	3.5	0(0.0)	3(42.9)	1(16.7)	2(50.0)	0(0.0)
	4	0(0.0)	1(14.3)	1(16.7)	0(0.0)	1(20.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	1(9.1)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Hypocone M1	3.5	0(0.0)	5(29.4)	4(50.0)	4(36.4)	5(41.7)
	4	5(83.3)	10(58.8)	4(50.0)	5(45.5)	3(25.0)
	5	1(16.7)	2(11.8)	0(0.0)	1(9.1)	4(33.3)
	0	0(0.0)	1(11.1)	0(0.0)	1(10.0)	1(11.1)

Dental Trait	Grade	Cold Morning	Flynt	Garbacon Crk	Hatteras	Hollowell
Metaconule M1	1	0(0.0)	0(0.0)	2(20.0)	1(10.0)	1(11.1)
	2	4(50.0)	2(22.2)	1(10.0)	1(10.0)	1(11.1)
	3	0(0.0)	1(11.1)	3(30.0)	1(10.0)	1(11.1)
	3.5	4(50.0)	3(33.3)	0(0.0)	3(30.0)	1(11.1)
	4	0(0.0)	2(22.2)	2(20.0)	3(30.0)	4(44.4)
	5	0(0.0)	0(0.0)	2(20.0)	0(0.0)	0(0.0)
	0	0(0.0)	3(27.3)	3(75.0)	7(87.5)	11(73.3)
	1	0(0.0)	3(27.3)	0(0.0)	0(0.0)	3(20.0)
	2	2(33.3)	4(36.4)	1(25.0)	1(12.5)	1(6.7)
	3	4(66.7)	1(9.1)	0(0.0)	0(0.0)	0(0.0)
→ Metaconule M2	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	1(100.0)	2(40.0)	3(75.0)	5(100.0)	9(90.0)
	1	0(0.0)	0(0.0)	1(25.0)	0(0.0)	1(10.0)
	2	0(0.0)	2(40.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	1(20.0)	0(0.0)	0(0.0)	0(0.0)
Carabelli's trait M1	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	1(16.7)	5(38.5)	4(50.0)	8(100.0)	8(53.3)
	1	0(0.0)	0(0.0)	2(25.0)	0(0.0)	2(13.3)
	2	0(0.0)	2(15.4)	0(0.0)	0(0.0)	2(13.3)
	3	3(50.0)	6(46.2)	0(0.0)	0(0.0)	0(0.0)
	4	1(16.7)	0(0.0)	0(0.0)	0(0.0)	1(6.7)
	5	1(16.7)	0(0.0)	2(25.0)	0(0.0)	0(0.0)
Carabelli's trait M2	6	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(13.3)
	7	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	6(100.0)	5(83.3)	5(71.4)	10(100.0)	7(77.8)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(11.1)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	2(28.6)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(11.1)
	5	0(0.0)	1(16.7)	0(0.0)	0(0.0)	0(0.0)

Dental Trait	Grade	Cold Morning	Flynt	Garbacon Crk	Hatteras	Hollowell
Parastyle	0	6(100.0)	4(57.1)	5(83.3)	3(100.0)	13(92.9)
	1	0(0.0)	3(42.9)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	1(16.7)	0(0.0)	1(7.1)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Enamel extensions	0	6(100.0)	8(61.5)	9(81.8)	9(75.0)	0(0.0)
	1	0(0.0)	2(15.4)	1(9.1)	0(0.0)	0(0.0)
	2	0(0.0)	1(7.7)	1(9.1)	3(25.0)	0(0.0)
	3	0(0.0)	2(15.4)	0(0.0)	0(0.0)	0(0.0)
Premolar root number	1	2(100.0)	8(72.7)	5(83.3)	7(100.0)	12(100.0)
	2	0(0.0)	3(27.3)	1(16.7)	0(0.0)	0(0.0)
Molar root number	1	0(0.0)	0(0.0)	0(0.0)	1(10.0)	1(14.3)
	2	0(0.0)	2(22.2)	1(16.7)	0(0.0)	1(14.3)
	3	1(100.0)	7(77.8)	5(83.3)	9(90.0)	5(71.4)
Peg-shaped incisor	0	4(80.0)	7(100.0)	9(100.0)	12(100.0)	2(50.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(25.0)
	2	1(20.0)	0(0.0)	0(0.0)	0(0.0)	1(25.0)
Peg-shaped molar	0	8(100.0)	6(100.0)	10(100.0)	13(100.0)	7(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Odontome – upper	0	10(100.0)	10(90.9)	7(100.0)	8(100.0)	12(100.0)
	1	0(0.0)	1(9.1)	0(0.0)	0(0.0)	0(0.0)
Odontome – lower	0	0(0.0)	7(100.0)	6(100.0)	11(100.0)	12(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Lower P3 variation	A	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	2(50.0)	1(14.3)	7(87.5)	3(30.0)	6(54.5)
	1	0(0.0)	0(0.0)	0(0.0)	1(10.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	3(30.0)	2(18.2)
	3	2(50.0)	1(14.3)	1(12.5)	1(10.0)	2(18.2)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	5(71.4)	0(0.0)	1(10.0)	1(9.1)

Dental Trait	Grade	Cold Morning	Flynt	Garbacon Crk	Hatteras	Hollowell
Lower P4 variation	6	0(0.0)	0(0.0)	0(0.0)	1(10.0)	0(0.0)
	7	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	8	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	9	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	A	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	5(100.0)	4(50.0)	6(75.0)	4(44.4)	8(66.7)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	3(33.3)	1(8.3)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(8.3)
	4	0(0.0)	2(25.0)	0(0.0)	0(0.0)	1(8.3)
Anterior fovea	5	0(0.0)	0(0.0)	2(25.0)	1(11.1)	1(8.3)
	6	0(0.0)	1(12.5)	0(0.0)	1(11.1)	0(0.0)
	7	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	8	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	9	0(0.0)	1(12.5)	0(0.0)	0(0.0)	0(0.0)
	0	0(0.0)	0(0.0)	0(0.0)	3(100.0)	0(0.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	1(33.3)	3(37.5)	0(0.0)	0(0.0)	0(0.0)
	3	2(66.7)	3(37.5)	0(0.0)	0(0.0)	3(60.0)
Groove pattern M1	4	0(0.0)	2(25.0)	0(0.0)	0(0.0)	2(40.0)
	1	4(50.0)	5(50.0)	6(54.5)	9(69.2)	6(60.0)
	2	3(37.5)	3(30.0)	2(18.2)	1(7.7)	0(0.0)
	3	1(12.5)	2(20.0)	3(27.3)	3(23.1)	4(40.0)
Groove pattern M2	1	1(14.3)	3(27.3)	0(0.0)	2(11.1)	2(13.3)
	2	4(57.1)	2(18.2)	3(50.0)	7(38.9)	10(66.7)
	3	2(28.6)	6(54.5)	3(50.0)	9(50.0)	3(20.0)
Cusp number M1	4	0(0.0)	0(0.0)	1(14.3)	1(10.0)	4(30.8)
	5	9(81.8)	4(36.4)	6(85.7)	7(70.0)	8(61.5)
	6	2(18.2)	7(63.6)	0(0.0)	2(20.0)	1(7.7)
	7	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Cusp number M2	4	5(41.7)	4(36.4)	1(12.5)	14(66.7)	8(66.7)
	5	6(50.0)	4(36.4)	7(87.5)	4(19.0)	4(33.3)

Dental Trait	Grade	Cold Morning	Flynt	Garbacon Crk	Hatteras	Hollowell
Deflecting wrinkle	6	1(8.3)	3(27.3)	0(0.0)	3(14.3)	0(0.0)
	0	1(33.3)	2(33.3)	0(0.0)	2(100.0)	2(50.0)
	1	0(0.0)	2(33.3)	0(0.0)	0(0.0)	0(0.0)
	2	1(33.3)	1(16.7)	0(0.0)	0(0.0)	1(25.0)
Distal trigonid crest	3	1(33.3)	1(16.7)	0(0.0)	0(0.0)	1(25.0)
	0	2(66.7)	8(88.9)	2(100.0)	6(100.0)	5(100.0)
	1	1(33.3)	1(11.1)	0(0.0)	0(0.0)	0(0.0)
Protostyloid M1	0	2(20.0)	8(50.0)	3(37.5)	10(58.8)	6(35.3)
	1	8(80.0)	5(31.3)	4(50.0)	7(41.2)	9(52.9)
	2	0(0.0)	1(6.2)	1(12.5)	0(0.0)	2(11.8)
	3	0(0.0)	2(12.5)	0(0.0)	0(0.0)	0(0.0)
Protostyloid M2	4	0(0.0)	0(0.0)	0(0.0)	1(5.9)	0(0.0)
	0	3(37.5)	2(22.2)	5(62.5)	11(68.8)	3(33.3)
	1	5(62.5)	5(55.6)	3(37.5)	4(25.0)	6(66.7)
	2	0(0.0)	2(22.2)	0(0.0)	1(6.3)	0(0.0)
Cusp 5 M1	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	1(7.7)	0(0.0)	1(14.3)	2(14.3)	5(31.3)
	1	0(0.0)	1(8.3)	0(0.0)	0(0.0)	4(25.0)
Cusp 5 M2	2	7(53.8)	8(66.7)	4(57.1)	5(35.7)	4(25.0)
	3	5(38.5)	3(25.0)	2(28.6)	5(35.7)	2(12.5)
	4	0(0.0)	0(0.0)	0(0.0)	2(14.3)	1(6.3)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Cusp 6 M1	0	5(41.7)	4(33.3)	1(14.3)	13(65.0)	12(70.6)
	1	0(0.0)	0(0.0)	0(0.0)	1(5.0)	2(11.8)
	2	1(8.3)	5(41.7)	5(71.4)	5(25.0)	2(11.8)
	3	6(50.0)	3(25.0)	1(14.3)	1(5.0)	0(0.0)
Cusp 6 M2	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(5.9)
	0	11(84.6)	4(33.3)	7(100.0)	10(76.9)	12(92.3)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(7.7)
	2	1(7.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)

Dental Trait	Grade	Cold Morning	Flynt	Garbacon Crk	Hatteras	Hollowell
Cusp 6 M2	3	1(7.7)	5(41.7)	0(0.0)	3(23.1)	0(0.0)
	4	0(0.0)	3(25.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	10(90.9)	7(70.0)	8(100.0)	19(90.5)	12(92.3)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	1(10.0)	0(0.0)	1(0.0)	0(0.0)
Cusp 7 M1	3	1(9.1)	2(20.0)	0(0.0)	2(9.5)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(7.7)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	11(100.0)	14(100.0)	7(100.0)	14(100.0)	17(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Cusp 7 M2	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	11(100.0)	9(100.0)	8(100.0)	18(94.7)	12(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	1(5.3)	0(0.0)
	1	7(100.0)	10(100.0)	11(100.0)	21(100.0)	6(100.0)
Canine root number	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	1(25.0)	9(100.0)	6(66.7)	12(80.0)	11(100.0)
	1	0(0.0)	0(0.0)	3(33.3)	2(13.3)	0(0.0)
	2	3(75.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	1(6.7)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Tome's root	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(8.3)
	2	8(88.9)	9(90.0)	11(100.0)	21(100.0)	11(91.7)
	3	1(11.1)	1(10.0)	0(0.0)	0(0.0)	0(0.0)
	1	2(33.3)	0(0.0)	1(10.0)	3(18.8)	6(40.0)
	2	4(66.7)	9(100.0)	9(90.0)	13(81.3)	9(60.0)
Palatine torus	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	0(0.0)	2(50.0)	3(75.0)	1(100.0)	3(60.0)

Dental Trait	Grade	Cold Morning	Flynt	Garbacon Crk	Hatteras	Hollowell
Mandibular torus	1	0(0.0)	2(50.0)	0(0.0)	0(0.0)	2(40.0)
	2	0(0.0)	0(0.0)	1(25.0)	0(0.0)	0(0.0)
	0	3(42.9)	5(71.4)	2(40.0)	12(75.0)	2(100.0)
	1	4(57.1)	1(14.3)	3(60.0)	1(6.3)	0(0.0)
Torsomolar angle	2	0(0.0)	1(14.3)	0(0.0)	3(18.8)	0(0.0)
	0	12(100.0)	2(66.7)	9(100.0)	10(71.4)	2(66.7)
	1	0(0.0)	1(33.3)	0(0.0)	3(21.4)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	1(7.1)	1(33.3)

Dental Trait	Grade	Jordan's Lng	McFayden	Piggot	Sans Souci	West #2
Winging	1A	0(0.0)	0(0.0)	0(0.0)	1(100.0)	0(0.0)
	1B	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	1(100.0)	0(0.0)	0(0.0)
	3	1(100.0)	1(100.0)	0(0.0)	0(0.0)	3(100.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5					
Shoveling I1	0	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1	1(33.3)	0(0.0)	3(30.0)	0(0.0)	2(25.0)
	2	0(0.0)	3(60.0)	2(20.0)	0(0.0)	0(0.0)
	3	1(33.3)	1(20.0)	0(0.0)	0(0.0)	2(25.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	1(33.3)	0(0.0)	5(50.0)	0(0.0)	2(25.0)
Shoveling I2	6	0(0.0)	1(20.0)	0(0.0)	0(0.0)	2(25.0)
	0	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1	0(0.0)	0(0.0)	3(60.0)	0(0.0)	2(20.0)
	2	0(0.0)	2(50.0)	1(20.0)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	1(20.0)	0(0.0)	2(20.0)
	4	1(50.0)	1(25.0)	0(0.0)	3(100.0)	1(10.0)
Double shoveling	5	1(50.0)	1(25.0)	0(0.0)	0(0.0)	2(20.0)
	6	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(30.0)
	7	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	8	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	9					
	0	1(33.3)	2(40.0)	4(50.0)	0(0.0)	4(40.0)
Interruption groove	1	1(33.3)	0(0.0)	2(25.0)	2(100.0)	0(0.0)
	2	1(33.3)	0(0.0)	1(12.5)	0(0.0)	0(0.0)
	3	0(0.0)	1(20.0)	1(12.5)	0(0.0)	1(10.0)
	4	0(0.0)	1(20.0)	0(0.0)	0(0.0)	2(20.0)
	5	0(0.0)	1(20.0)	0(0.0)	0(0.0)	3(30.0)
	6	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	2(50.0)	3(100.0)	1(20.0)	0(0.0)	5(50.0)
	1	0(0.0)	0(0.0)	1(20.0)	2(66.7)	0(0.0)
	2	2(50.0)	0(0.0)	2(40.0)	1(33.3)	5(50.0)

Dental Trait	Grade	Jordan's Lng	McFayden	Piggot	Sans Souci	West #2
Tuberculum dentale	3	0(0.0)	0(0.0)	1(20.0)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	2(100.0)	2(50.0)	3(60.0)	0(0.0)	6(66.7)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	2(50.0)	0(0.0)	0(0.0)	3(33.3)
	3	0(0.0)	0(0.0)	2(40.0)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Canine mesial ridge	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	6	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	4(100.0)	3(33.3)	8(88.9)	2(100.0)	9(90.0)
	1	0(0.0)	4(44.4)	0(0.0)	0(0.0)	1(10.0)
	2	0(0.0)	2(22.3)	1(11.1)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Canine distal accessory ridge	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	4(80.0)	8(100.0)	4(50.0)	2(100.0)	7(70.0)
	1	1(20.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	2(25.0)	0(0.0)	3(30.0)
	3	0(0.0)	0(0.0)	2(25.0)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Metacone M3	0	0(0.0)	1(10.0)	0(0.0)	0(0.0)	2(22.2)
	1	0(0.0)	2(20.0)	0(0.0)	0(0.0)	1(11.1)
	2	1(16.7)	2(20.0)	0(0.0)	0(0.0)	1(22.2)
	3	2(33.3)	1(10.0)	3(75.0)	0(0.0)	1(11.1)
	3.5	3(50.0)	4(40.0)	1(25.0)	3(100.0)	1(11.1)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(22.2)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(11.1)
Hypocone M1	3	1(14.3)	1(7.1)	2(15.4)	0(0.0)	0(0.0)
	3.5	2(28.5)	3(21.4)	4(30.8)	2(33.3)	8(38.1)
	4	3(42.9)	9(64.3)	4(30.8)	4(66.7)	10(47.6)
	5	1(14.3)	1(7.1)	3(23.1)	0(0.0)	3(14.3)
Hypocone M2	0	1(14.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1	0(0.0)	3(14.3)	1(14.3)	0(0.0)	1(7.1)

Dental Trait	Grade	Jordan's Lng	McFayden	Piggot	Sans Souci	West #2
Metaconule M1	2	2(28.5)	8(38.1)	3(42.9)	3(60.0)	0(0.0)
	3	1(14.3)	4(19.0)	0(0.0)	0(0.0)	7(50.0)
	3.5	2(28.5)	3(14.3)	2(28.6)	2(40.0)	5(35.7)
	4	1(14.3)	3(14.3)	1(14.3)	0(0.0)	1(7.1)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	5(100.0)	4(50.0)	1(11.1)	6(85.7)	6(42.9)
	1	0(0.0)	2(25.0)	0(0.0)	0(0.0)	4(28.6)
	2	0(0.0)	0(0.0)	3(33.3)	1(14.3)	1(7.1)
	3	0(0.0)	2(25.0)	5(55.6)	0(0.0)	3(21.4)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Metaconule M2	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	2(100.0)	10(100.0)	2(33.3)	7(100.0)	5(83.3)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	2(33.3)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	2(33.3)	0(0.0)	1(16.7)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Carabelli's trait M1	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	5(100.0)	17(94.4)	3(21.4)	2(66.7)	15(78.9)
	1	0(0.0)	0(0.0)	4(28.6)	0(0.0)	1(5.3)
	2	0(0.0)	0(0.0)	2(14.3)	0(0.0)	1(5.3)
	3	0(0.0)	1(5.6)	2(14.3)	1(33.3)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	2(14.3)	0(0.0)	2(10.5)
	6	0(0.0)	0(0.0)	1(7.1)	0(0.0)	0(0.0)
Carabelli's trait M2	7	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	4(100.0)	19(95.0)	3(75.0)	2(100.0)	12(100.0)
	1	0(0.0)	0(0.0)	1(25.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Parastyle	4	0(0.0)	1(5.0)	0(0.0)	0(0.0)	0(0.0)
	0	5(100.0)	8(80.0)	2(100.0)	3(100.0)	7(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)

Dental Trait	Grade	Jordan's Lng	McFayden	Piggot	Sans Souci	West #2
Enamel extensions	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	1(10.0)	0(0.0)	0(0.0)	0(0.0)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	1(10.0)	0(0.0)	0(0.0)	0(0.0)
	0	0(0.0)	20(100.0)	12(100.0)	11(91.7)	18(94.7)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	1(8.3)	1(5.3)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Premolar root number	1	4(100.0)	4(80.0)	1(33.3)	7(100.0)	10(100.0)
	2	0(0.0)	1(20.0)	2(66.7)	0(0.0)	0(0.0)
Molar root number	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	2(33.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	4(66.7)	7(100.0)	3(100.0)	5(100.0)	6(100.0)
Peg-shaped incisor	0	5(100.0)	7(100.0)	6(100.0)	8(100.0)	12(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Peg-shaped molar	0	5(100.0)	9(100.0)	6(100.0)	8(100.0)	11(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Odontome – upper	0	0(0.0)	12(100.0)	8(80.0)	9(100.0)	15(100.0)
	1	0(0.0)	0(0.0)	2(20.0)	0(0.0)	0(0.0)
Odontome – lower	0	0(0.0)	12(100.0)	12(100.0)	5(100.0)	12(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Lower P3 variation	A	0(0.0)	1(12.5)	0(0.0)	0(0.0)	0(0.0)
	0	4(100.0)	5(62.5)	0(0.0)	0(0.0)	14(82.4)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(5.9)
	3	0(0.0)	1(12.5)	0(0.0)	0(0.0)	1(5.9)
	4	0(0.0)	0(0.0)	3(60.0)	0(0.0)	0(0.0)
	5	0(0.0)	1(12.5)	0(0.0)	3(100.0)	1(5.9)
	6	0(0.0)	0(0.0)	2(40.0)	0(0.0)	0(0.0)
	7	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)

Dental Trait	Grade	Jordan's Lng	McFayden	Piggot	Sans Souci	West #2
Lower P4 variation	8	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	9	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	A	0(0.0)	1(8.3)	0(0.0)	0(0.0)	0(0.0)
	0	4(100.0)	8(66.7)	5(83.3)	0(0.0)	13(76.5)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(11.8)
	3	0(0.0)	1(8.3)	0(0.0)	0(0.0)	2(11.8)
	4	0(0.0)	1(8.3)	1(16.7)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	1(100.0)	0(0.0)
	6	0(0.0)	1(8.3)	0(0.0)	0(0.0)	0(0.0)
Anterior fovea	7	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	8	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	9	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	0(0.0)	2(20.0)	0(0.0)	0(0.0)	0(0.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	2(20.0)	0(0.0)	0(0.0)	0(0.0)
	3	1(100.0)	3(30.0)	3(100.0)	0(0.0)	0(0.0)
	4	0(0.0)	3(30.0)	0(0.0)	0(0.0)	0(0.0)
	1	1(16.7)	13(65.0)	6(46.2)	0(0.0)	11(91.7)
	2	2(33.3)	6(30.0)	2(15.4)	3(100.0)	1(8.3)
Groove pattern M1	3	3(50.0)	1(5.0)	5(38.5)	0(0.0)	0(0.0)
	1	0(0.0)	2(10.5)	1(14.3)	0(0.0)	2(12.5)
	2	6(100.0)	9(47.4)	6(85.7)	5(100.0)	10(62.5)
Groove pattern M2	3	0(0.0)	8(42.1)	0(0.0)	0(0.0)	4(25.0)
	4	2(33.3)	2(10.5)	0(0.0)	4(100.0)	2(20.0)
	5	3(50.0)	12(63.2)	10(76.9)	0(0.0)	8(80.0)
Cusp number M1	6	1(16.7)	5(26.3)	3(23.1)	0(0.0)	0(0.0)
	7	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	5(83.3)	3(20.0)	2(25.0)	6(100.0)	12(70.6)
	5	1(16.7)	8(53.3)	6(75.0)	0(0.0)	2(11.8)
Cusp number M2	6	0(0.0)	4(26.7)	0(0.0)	0(0.0)	3(17.6)
	0	1(50.0)	6(50.0)	1(25.0)	0(0.0)	0(0.0)

Dental Trait	Grade	Jordan's Lng	McFayden	Piggot	Sans Souci	West #2
Distal trigonid crest	0	2(100.0)	8(100.0)	6(100.0)	0(0.0)	1(100.0)
Protostyloid M1	0	3(75.0)	6(35.3)	1(7.1)	4(66.7)	7(53.8)
Protostyloid M2	0	1(100.0)	8(47.1)	1(16.7)	2(50.0)	6(46.2)
Cusp 5 M1	0	1(20.0)	1(5.9)	0(0.0)	7(100.0)	2(18.2)
Cusp 5 M2	0	3(60.0)	6(37.5)	2(22.2)	6(100.0)	11(68.8)
Cusp 6 M1	0	4(80.0)	12(70.6)	10(83.3)	7(100.0)	11(100.0)

Dental Trait	Grade	Jordan's Lng	McFayden	Piggot	Sans Souci	West #2
Cusp 6 M2	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	5(100.0)	12(80.0)	9(100.0)	6(100.0)	13(81.3)
	1	0(0.0)	3(20.0)	0(0.0)	0(0.0)	1(6.3)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(6.3)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(6.3)
Cusp 7 M1	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	5(100.0)	16(94.1)	11(91.7)	7(100.0)	13(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	1(8.3)	0(0.0)	0(0.0)
	3	0(0.0)	1(5.9)	0(0.0)	0(0.0)	0(0.0)
Cusp 7 M2	0	5(100.0)	13(86.7)	9(100.0)	6(100.0)	16(100.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	0(0.0)	2(13.3)	0(0.0)	0(0.0)	0(0.0)
	1	6(100.0)	8(100.0)	7(100.0)	9(100.0)	20(100.0)
Canine root number	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	0(0.0)	3(75.0)	7(100.0)	7(100.0)	17(89.5)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(10.5)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	4	0(0.0)	1(25.0)	0(0.0)	0(0.0)	0(0.0)
1 <sup>st</sup> molar root number	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	2	8(100.0)	10(100.0)	9(100.0)	7(70.0)	15(100.0)
	3	0(0.0)	0(0.0)	0(0.0)	3(30.0)	0(0.0)
	1	3(37.5)	2(20.0)	1(20.0)	0(0.0)	2(16.7)
	2	5(62.5)	8(80.0)	4(80.0)	8(100.0)	10(83.3)
2 <sup>nd</sup> molar root number	3	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	3(75.0)	2(66.7)	2(66.7)	2(66.7)	4(80.0)
Palatine torus						

Dental Trait	Grade	Jordan's Lng	McFayden	Piggot	Sans Souci	West #2
Mandibular torus	1	1(25.0)	1(33.3)	1(33.3)	1(33.3)	1(20.0)
	2	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Torsomolar angle	0	4(80.0)	1(100.0)	5(83.3)	3(60.0)	5(71.4)
	1	0(0.0)	0(0.0)	1(16.7)	2(40.0)	2(28.6)
Torsomolar angle	2	1(20.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	0	2(66.7)	3(75.0)	6(100.0)	2(40.0)	10(90.9)
	1	1(33.3)	0(0.0)	0(0.0)	3(60.0)	0(0.0)
	2	0(0.0)	1(25.0)	0(0.0)	0(0.0)	1(9.1)

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