BIOANTHROPOLOGICAL ANALYSIS OF A SEVENTEENTH-CENTURY NATIVE AMERICAN SPANISH MISSION POPULATION: BIOCULTURAL IMPACTS ON THE NORTHERN UTINA

By

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They have endured it all with me--from the initial stages when there was no light at the end of the tunnel, through the difficult times when the realization of all goals and aspirations appeared unattainable, through the stress-filled and tedious process of data collection and analysis, and on to the satisfaction of conquering the seemingly unsurmountable. Their interest, encouragement, love, and unwavering support have made this work possible. For all they have done, and for all that I can never begin to repay--I dedicate this work to my parents.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Dissertation Presented to the Graduate School of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

BIOANTHROPOLOGICAL ANALYSIS OF A SEVENTEENTH-CENTURY NATIVE AMERICAN SPANISH MISSION POPULATION: BIOCULTURAL IMPACTS ON THE NORTHERN UTINA

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Bioanthropological analysis is employed to evaluate the impact of the Spanish mission system upon the northern Utina, a Western Timucuan-speaking group that inhabited the present-day Florida counties of Columbia, Suwannee, Union, and Hamilton. A post-Columbian northern Utinan skeletal collection, excavated from the Fig Springs site (8CO1), in Ichetucknee State Park, Columbia County, Florida, was observed. The site is the location of the seventeenth-century Spanish mission of San Martín. Pre-Columbian skeletal remains from northern and north-central Florida that display cultural continuity with the historic northern Utina were also analyzed. Comparison of these data has provided an interpretation of the biological consequences of European contact upon Florida's original inhabitants.

Although evidence exists for infectious diseases in local pre-Columbian aboriginal populations, it is commonly accepted that the introduction of Old World pathogens, such as measles, devastated New World populations. Numerous Spanish and French documents describe epidemic outbreaks that affected Timucuan mission populations during the years 1613-1617, 1649-1659, and 1672-1674, and that contributed to Timucuan population decline.

Despite ethnohistoric documentation suggesting the introduction of Old World diseases into native Florida populations, analysis of the San Martín skeletal remains does not provide direct evidence for epidemic death. Rather, this population demonstrates a lifetime of chronic stress and generally compromised health. Peak mortality occurs between 26-30 years of age. A high prevalence (74.7%) of enamel hypoplasias and retarded long bone growth in juveniles implies that childhood stressors, including parasite loads, nutritional deficiencies, and diseases, were common. The rates and distribution of adult bone pathologies, such as porotic hyperostosis and periosteal lesions, support an interpretation of a chronically stressed mission life-style.

In contrast, typical skeletal indicators of chronic stress, dietary inadequacies, and acute crowd infections are absent in the pre-Columbian collection. These data indicate a relatively healthy and stress-free population. Observed trends in disease prevalence and expression in the northern Utinan transition to mission life demonstrate that the Spanish mission system provided the primary stimuli for increased physiological and systemic stress and morbidity. Indeed, European-introduced pathogens upon such a chronically stressed population must have contributed significantly to the ultimate decline of the northern Utina.

CHAPTER I
INTRODUCTION

> When civilized nations come into contact with barbarians the struggle is short, except where a deadly climate gives its aid to the native race. New diseases and vices have in some cases proved destructive; and it appears that a new disease often causes much death until those who are most susceptible to its destructive influence are gradually weeded out. (Charles Darwin 1859 in 1936:543)

The profound impact of the Spanish mission system upon contact-period aboriginal cultures is well documented through the archaeological record. To date a through investigation of the biological impact on the native peoples of La Florida has been limited to coastal populations. Previous archaeological research in the American Southeast has, however, provided the foundation for explorations concerning the biological consequences of the Spanish mission system upon Florida's aboriginal populations. Current studies of sixteenth- and seventeenth-century Spanish documents, archaeological excavations, and biological analyses of mission-period human skeletal remains are expanding this data base and bringing new insight into the reconstruction of the lifeways of extinct populations. The research presented here, through incorporation of ethnohistorical and archaeological data with biological analysis of human skeletal remains, utilizes a multidisciplinary approach to establish the biological and cultural consequences of the Spanish mission system upon the native northern Utina, a Timucuan-speaking group from north Florida, geographically located north of the Santa Fe River. The osteological data were obtained from excavations conducted in the burial area and a church at the seventeenth-century Spanish mission site of San Martín. San Martín, archaeological site 8CO1, is located adjacent to Fig Springs, a small tributary spring about 1.5 km below the head spring of the Ichetucknee River, in Ichetucknee Springs State Park, Columbia County, Florida. The San Martín site is situated at the southern-most boundary of north Florida and thus rests on the border of north-central Florida.

This research represents the first interpretation of the biological effects of European contact upon the northern Utina and will help to clarify the complex set of interactive forces that affected post-contact aboriginal populations. Such interactions, viewed as a variety of stress agents, include, but are not limited to: increased sedentariness and population aggregation, disease processes, systemic stresses, ethnic conflict, forced labor, and diet.

Three different analyses are integrated in the reconstruction of the demographic and cultural collapse of the northern Utina following European contact. First, the San Martín mission-period skeletal remains are analyzed and hypotheses are generated to explain the observed patterns of demography and pathology. Second, six pre-Columbian skeletal collections from northern and north-central Florida that demonstrate cultural continuity with the historic-period Timucua, are studied to detail changing disease patterns over time. Third, the findings from the mission period inland northern Utina are compared to the physical anthropological data on the culturally distinct Georgia coast mission Guale Indians to provide a more complete cross-regional reconstruction of the consequences of European contact on the native populations of La Florida. These data will permit a more complete and comprehensive understanding of Florida's Spanish colonial period and will be especially critical for the interpretation of the impact of the Spanish mission system upon Florida's original inhabitants.

Although numerous Spanish and French documents describe epidemic episodes that affected the aboriginal populations of La Florida, definitive evidence for their presence among the San Martín mission population has not been observed. Analysis of the San Martín skeletal series does, however, indicate that population-level health was generally compromised by a lifetime of chronic and cumulative systemic stress. Forced changes in the lifeways of the northern Utina, including nucleation of aboriginal groups into mission confines and alterations in native adaptive and cultural systems, greatly influenced the patterning and frequency of disease by providing the ideal environment for the transmission and rapid spread of acutely infectious diseases. The dynamic relationship between decreased general health levels and disease resistance has been expressed archaeologically as non-specific stress-induced bone lesions, morbidity, and high mortality in the San Martín skeletal collection. Such a population, demonstrating evidence of a life dominated by prolonged and severe stress, would be particularly vulnerable to the introduction of new pathogens. Outbreaks of epidemics among the northern Utina would have prompted sudden death and precluded skeletal involvement. The effect of these infectious diseases, exacerbated by mission conditions, can be considered to have contributed significantly to the ultimate decline of the northern Utina.

Chapter II provides the historical background on the interactions between the Spaniards and Native American Indians in north Florida. Ethnohistoric portrayals of the western Timucan-speaking populations, with specific attention focused on the northern Utina, are reviewed. The rise and decline of the

Spanish mission system in La Florida, particularly among the northern Utina, is discussed.

Chapter III presents the archaeological data on the pre-Columbian ancestors of the western Timucua. Five sites, representing the McKeithen Weeden Island culture, the Cades Pond culture, and the Alachua tradition, in north Florida, are reviewed. These sites demonstrate temporal cultural continuity with the western Timucua. Data on the six human skeletal collections from these sites establish an important pre-Columbian baseline against which the data from the Spanish mission period can be compared.

Chapter IV presents information on the archaeology of Spanish missions in La Florida. General mission patterns, architectural plans, construction methods, and structural layouts are discussed. The history of archaeological research at the Fig Springs site (8CO1), from which the mission skeletal collection was drawn, is reviewed. Excavations, in conjunction with historical research, have demonstrated the site to be the location of the San Martín Franciscan Spanish mission established in 1608.

Chapter V provides basic information on the biological and cultural environments of the northern Utina. Ethnohistoric verification of the presence of epidemic episodes among La Florida's native inhabitants, as well as the epidemiology of infectious diseases, is presented. Mission life is discussed and population estimates for the early colonial-period Timucua are provided. The debilitating effects of endemic stress on mission populations are presented along with the devastating consequences of Old World pathogens. A discussion of the etiology and differential diagnoses of the specific skeletal lesions indicative of systemic stress are provided.

Chapter VI explains the sample composition utilized in the bioanthropological interpretation of the San Martín mission population. An interpretation of the mission burial program is presented. As reconstruction of the biocultural environment of the northern Utina is dependent upon reliable skeletal demography techniques, the methods used to achieve the demographic profile are discussed. The technique employed in the determination of age-at-death from the seriation of occlusal dental wear patterns and its application to the San Martín series is presented.

Chapter VII describes the demographic data for the San Martín mission population. Mortality profiles and life tables have been constructed. As taphonomic forces and differential burial practices do not appear to have contributed significantly to the patterns observed here, alternate hypotheses, which seek to explain a chain of causation among the multiple etiological factors of disease, are suggested.

Chapter VIII presents data on dental pathologies. The etiology of and anthropological research on dental caries is provided to facilitate understanding of the patterns observed in this population. The population-specific occurrences of carries, enamel hypoplasias, dental crowding, attrition, abscesses, periodontal disease, mottled teeth, and temporomandibular joint disease are each discussed separately. The relationship between carious lesions, periodontal disease, attrition, and calculus are examined and a hypothesis offered to explain observed patterning.

Chapter IX presents the results derived from analysis of bone pathologies observed in the mission-period skeletal remains. Periostitis, hematogenous osteomyelitis, porotic hyperostosis, cribra orbitalia, Harris lines, platycnemia, osteoarthritis, and trauma-induced injury are considered. The incompletely understood etiologies of stature and sexual dimorphism are reviewed.

Chapter X summarizes the bioanthropological findings for the San Martín mission-period population. Gender and temporal patterns are discussed. Conclusions, which implicate ethnohistorically documented European-introduced epidemics, are presented in conjunction with the San Martín mortality profile, archaeological data, the biological and cultural environments, and the pattern of population-specific pathology.

Chapter XI reports the results of the biological analysis on six pre-Columbian skeletal populations from five sites in north and north-central Florida. The collections represent a temporal cross-section of the pre-Columbian period and demonstrate cultural affinity and continuity with the colonial-period northern Utina and other western Timucuans. This data set establishes a pre-Columbian baseline against which the biological consequences of the Spanish mission period can be evaluated. Published data on the Georgia coast mission-period Guale were utilized to provide a cross regional analysis of the biological consequences of the Spanish mission system upon two culturally distinct populations from within La Florida. General trends of skeletal response to infectious disease processes and mission life are presented. The physiologically stressful effects of life transitions, as observed in archaeologically derived skeletal populations, are discussed.

The absence of the infectious diseases tuberculosis and treponematosis in the San Martín mission population is addressed in Chapter XII. These diseases are frequently reported in both pre- and post-Columbian archaeological skeletal series from across the continental United States. A review of the literature and examination of the skeletal collections housed at the

Florida Museum of Natural History indicates that tuberculosis was not present among northern Florida's native inhabitants. The presence of treponematosis has, however, been recorded in pre-Columbian Florida human skeletal remains. Models and hypotheses are offered to explain the puzzling absence of these diseases, particularly treponematosis, in this mission population.

Chapter XIII offers conclusions. The Spanish mission system produced profound alterations in the mechanisms of northern Utinan social and cultural integration and as such dramatically affected the health of these peoples.

CHAPTER II
SPANIARDS AND INDIANS IN NORTH FLORIDA

The first representation of peninsular Florida is depicted apparently on the Cantino map of 1502 (H. Smith 1956:1). Albert Cantino, the Italian agent who reported the return of the Corte Real ships to Lisbon in 1501, copied a Portuguese map (1502) which is now known as the Cantino map. This map, the earliest known representation of Florida and the Florida strait, shows a body of peninsular land in about the proper location for Florida, and a northern mainland (Sauer 1969:189, 1971:25). Although the Council of the Indies claimed that Spanish fleets and ships had traveled to La Florida since 1510, the 1513 voyage of Juan Ponce de Leon is the first recorded Spanish venture into what is now the state of Florida. Juan Ponce, who sighted land during the Easter season, Pasqua florida, designated the peninsula La Florida (Davis 1935:18; Gannon 1965:1). In the following one hundred years the territory of La Florida came to encompass not only present-day Florida, but lands north to Newfoundland and those extending westward indefinitely from the Atlantic Coast (Gannon 1965:1) (Figure 2.1). It is believed that after sailing the east coast of Florida, Juan Ponce's initial expedition disembarked among the Calusa Indians along the southwest Gulf Coast of Florida (Davis 1935:18; Gannon 1965:3; Milanich and Fairbanks 1980:213; Smith and Gottlob 1978:2). That the Calusa were openly hostile, and that at least one of the Indians displayed a knowledge of Spanish, suggests that this was not the first

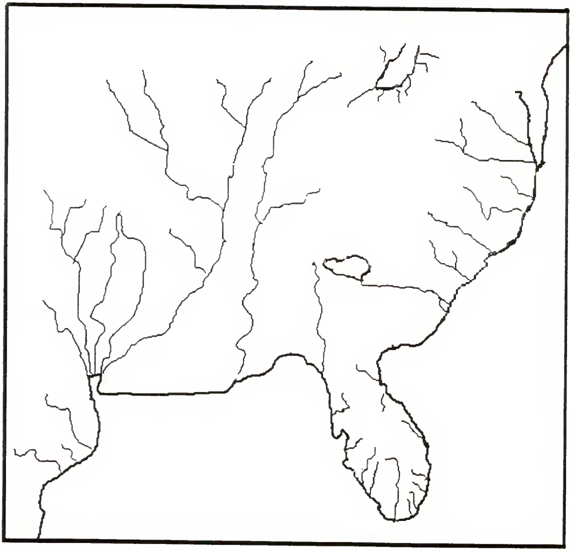

Figure 2.1
La Florida circa 1539

encounter between Florida's native inhabitants and Spanish explorers (Smith and Gottlob 1978:2).

Between 1513 and 1528 Spanish expeditions and explorations, largely unsuccessful, sought to establish a presence in La Florida (Davis 1935; Gannon 1965). In 1521 Juan Ponce, on his second expedition, landed along the Gulf Coast, possibly in the vicinity of Charlotte Harbor. The party, attacked by natives, retreated and suffered casualties, including the death of Juan Ponce (Davis 1935:63; Smith and Gottlob 1978:2; Swanton 1952:27). In 1526 Lucas Vázquez de Ayllón's attempt to colonize the Atlantic Coast resulted in the demise of most settlers, Ayllón included. Pánfilo de Naváez, who probably landed near Johns Pass, just north of Tampa Bay, conducted the first major overland exploration of Florida in 1528 (H. Smith 1956:3). His expedition was plagued by one adversity after another, from disease to Indian attacks. Finally, a handful of survivors landed on the Texas' coast and were taken captive by aboriginal peoples (Cabeza de Vaca 1904:15-54). The most industrious and perhaps the most renowned of the sixteenth-century Spanish explorers was Hernando de Soto, whose 1539 expedition encountered various Timucuan-speaking peoples in the vicinity of the present-day towns of Bradenton, Dade City, Ocala, Gainesville, Lake City, and Live Oak, Florida (Milanich 1978a:70).

Prompted by a depleted state treasury and a costly, failed settlement by Tristán de Luna y Arellano near Pensacola, King Philip II of Spain proclaimed Florida closed to Spanish exploration in 1559 (Lyon 1976:22). The French Huguenots' establishment of Fort Caroline at the mouth of the St. Johns River in 1564 prompted Philip to recant his proclamation. In 1565 Pedro Menéndez de Avilés, an emissary of Spain, landed in Florida, overcame the French, and established St. Augustine as a permanent Spanish garrison and mission (Lyon

1976:111-116). St. Augustine and its sister city Santa Elena, a Spanish settlement on Parris Island, in present-day South Carolina, became focal points for shipping defense and coordinating centers for several satellite garrisons and Spanish-Indian missions.

The Timucua

At the time of European contact Timucuan-speaking groups occupied most, if not all, of north peninsular Florida. These groups are represented by four material cultural assemblages. The Alachua tradition was indigenous to north-central Florida; the Suwannee Valley complex was found in north Florida; the St. Johns complex was located in eastern Florida and the St. Johns River drainage; and a Wilmington Savannah-derived complex was common on Cumberland Island, Georgia, north of the mouth of the St. Marys River (Milanich 1976, 1978b) (Figure 2.2).

The first known European contact with Timucuan peoples was the 1513 landing of Ponce de Leon either near St. Augustine or elsewhere on the northeast Florida coast. The narrative of that voyage, however, provides almost no information on the native populations (Davis 1935). The 1528 travel account of Alvar Núñez Cabeza de Vaca, who traveled into the interior of west Florida with the ill-fated Narváez expedition, likewise provides little description of Timucuan populations. The narratives from the 1539 Hernando de Soto expedition provide the first European accounts of the Timucuan people living in Florida (Swanton 1939; Milanich and Hudson in press). Much information on the northeast Florida and the St. Johns River Timucuans is furnished by the French, particularly René de Laudonnière, a soldier who was commander of the

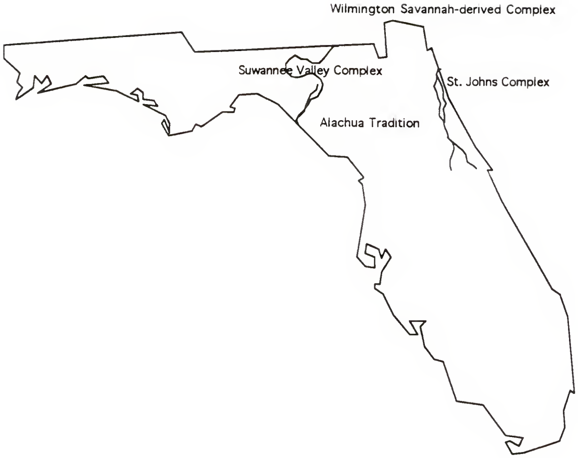

Figure 2.2
The Pre-Columbian Timucua: Cultural assemblages
Adapted from Milanicb and Fairbanks 1980:168

French colony in 1564, and Jacques Le Moyne, the artist and mapmaker who accompanied the Huguenots into Florida in 1564. Le Moyne escaped the 1565 Spanish capture of Fort Caroline and returned to Europe. In 1586 publication of Laudonnière's narratives drew attention to Le Moyne's artistic renderings of the Huguenot colony and the Florida natives. In 1588 Flemish engraver Theodore de Bry purchased Le Moyne's paintings and narratives from his widow. In 1591 he published a volume of engravings based on the Le Moyne originals. Only one of Le Moyne's original paintings has survived. The engraved copies are all that exist today (Lorant 1946:30-31).

Le Moyne's artistic renderings, the first of native North American Indians, contain information on many aspects of Timucuan life. That Le Moyne produced his paintings only after his return to Europe and because de Bry drew liberally from other New World sources, has led scholars to question the ethnographic authenticity of some of the details in the engravings (Milanich and Sturtevant 1972; Sturtevant 1968). Additional ethnohistoric documentation has, however, facilitated a rather comprehensive reconstruction of many of the Timucuan groups at the time of European contact and into the mission period (e.g., Deagan 1978; Milanich 1978a; Milanich and Hudson in press; Swanton 1922).

Timucuan-speaking groups inhabited that portion of northern Florida bounded on the west by the Aucilla River, eastward to the Atlantic Ocean, and north into southern Georgia (including a portion of southeastern Georgia). The southern boundary is more uncertain, but some of the Tampa Bay aboriginal groups were Timucuan, as were people in the vicinity of Lake George in the St. Johns River drainage (R. Bullen 1969; Ehrmann 1940; Milanich 1978a).

Traditionally the Timucuan-speaking populations have been divided into eastern and western groups based upon geographic location, archaeological complexes, and ceremonial, political, and techno-enviromental factors (Deagan 1978; Johnson 1991; Milanich 1978a; Milanich and Hudson in press) (Figure 2.3). The eastern groups were numerous and included the Saturiwa, Agua Dulce, and the Cascange, Ibi (Yui), Icafui, Oconi, Tacatacuru, Tucururu, and Yufera in southeast Georgia. The western groups included the Acuera possibly on the Oklawaha River, Ocale in southwestern Marion county, Potano in Alachua County, northern Utina in Suwannee and Columbia counties, and Yustega between the Suwannee and Aucilla rivers (Johnson 1991:70). The eastern Utina lived just west of the St. Johns River near present Lake Grandier. Following Johnson (1991), the terms "northern Utina" and "eastern Utina" are adopted to distinguish the groups in north Florida whom scholars refer to as "Utina" (see next section). The "generic" term "Timucua" is used for all the sixteen or more groups who spoke the same language.

Milanich and Fairbanks (1980) estimate the population of the Timucuans at the time of first contact to have been at least 40,000, a figure today recognized as much too low. Ramenofsky (1987:13) provides a concise summary of various authors' population estimates for the Timucuan-speaking peoples. These estimates, which range from 5,000 to 722,000 individuals, demonstrate that demography remains a matter of controversy.

The Timucua are best described as a group of cognate groups recognized collectively from their language, which appears to be a language isolate, unrelated to any of the Muskogean languages widespread in the Southeast at the time of contact. Julian Granberry (1987) posits that the primary Timucuan lexical source had multiple origins. The morphemic and syntactic structure

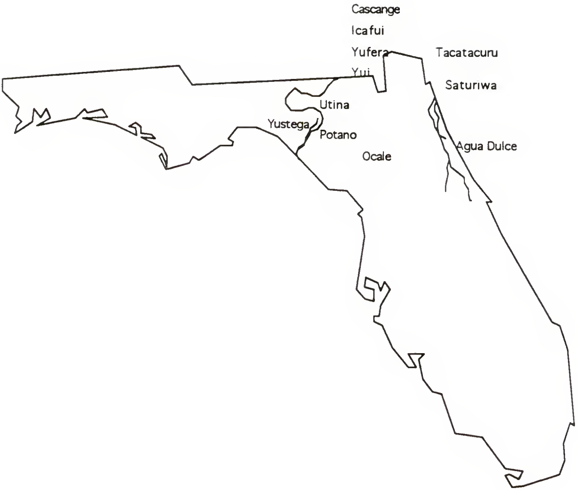

Figure 2.3
Eastern and western Timucuan-speaking peoples
at time of European contact
Adapted from Milanich and Fairbanks 1980:212

appears similar to the Marco-Chibchan languages with lexical borrowings from Waroid, Northern Maipuran Arawakan, and North American Muskogean sources.

Although the Timucuan groups spoke various dialects of a common language and shared some cultural similarities, they were discrete political units (Ehrmann 1940; Milanich 1978a; Milanich and Fairbanks 1980; Willey 1949). Basic technologies, social, political, and religious traits were strikingly analogous as a consequence of years of intergroup contact (Ehrmann 1940; Milanich 1978a; Milanich and Fairbanks 1980; Willey 1949). Dialectic variations among the Timucua have been attributed to differences in political and ethnic formation, social endogamy, and/or territoriality (Milanich 1978a:61).

Several hypotheses exist as to the origin of the name "Timucua." The derivation may be traced either to a particular village or to a chief name, or possibly to both. Laudonnière, commander of the French 1564 expedition, wrote that:

the Timuquanan tribes had their most populous settlements on the St. Johns River, along whose banks, and those of its tributaries lay scattered many villages, each with its petty chief. On one of these was situated the village of Thimogoa, from which their name Timuqua is derived. (Lowery 1905:59)

Ehrmann (1940) and Swanton (1946) posit that the name "Timucua" was derived from the word for lord, ruler, or chief. The most recent research suggests that native allies of the French in 1564 referred to their enemies as "Thimogona" and the term soon began to be used by the French as a geographic reference.

"Thimogona" was the word from which the Spanish derived "Timucua," the name they assigned to north Florida and the mission province established there. Modern scholars use "Timucua" as the name of a language as well as the people who spoke that language. It is highly unlikely that any of the Timucua speakers ever referred to themselves as Timucua. (Milanich and Hudson in press)

Numerous variations of Timucua exist, among them Thimogoa, Thimogona, Timoqua, Timuqua, Tymangana, and Tymangaua (Conner 1925; Lowery 1905).

The Northern Utina

Available data demonstrate that by A.D. 300 northern Florida was occupied by a Weeden Island culture closely affiliated with that of northwest Florida. Excavations suggest that the complex burial ceremonialism associated with Weeden Island groups is closely related to the McKeithen Weeden Island culture represented by pre-Columbian burial mounds in northern Columbia and Suwannee counties. In the colonial period this region was inhabited by the northern Utina, a group of western Timucuans (Milanich and Fairbanks 1980).

Recently it has been demonstrated that many of the late Weeden Island period sites in Columbia, Suwannee, Union, and Hamilton counties are associated with the Suwannee Valley ceramic series. The people who occupied these sites were the pre-Columbian ancestors of the northern Utina (Johnson 1991:95 ; Johnson and Nelson 1990:61). The heartland of the northern Utina is in central Columbia and Suwannee counties. Sites are located on high ground near ponds or lakes a good distance from river valleys. Soil is more than adequate for agriculture and an abundance of diverse terrestrial and aquatic resources exists (Johnson 1991:95) (Figure 2.4).

Figure 2.4
Geographic orientation of the Utina in present-day Florida
Adapted from Johnson 1991:74

Current research indicates that the traditional ceramic seriation for north-central Florida is not applicable to north Florida, northern Utinan territory. Recognition of a distinctive late pre-Columbian and early contact-period ceramic assemblage, the Indian Pond complex, as a part of the Suwannee Valley ceramic series in north Florida has done much to clarify both the archaeological record and geographic boundaries of the northern Utina who "have been strangely 'invisible' archaeologically" (Johnson 1991:72 ; Johnson and Nelson 1990:48). Through ceramic seriation it is now possible to distinguish archaeologically the inhabitants of this region, the northern Utina, a people clearly distinct from their more southerly Timucuan neighbors. It is now also possible to trace the Indian Pond complex and the Suwannee Valley series back through time, correlating the northern Utina with the pre-Columbian occupation of the region.

The Indian Pond complex is equated with the sixteenth-century northern Utina who battled the Hernando de Soto expedition and possibly with the early seventeenth-century northern Utina who submitted to the Spanish missionaries (Johnson 1991:96). During the mission period, the seventeenth-century Indian Pond complex was replaced by a new ceramic complex. However, as Johnson (1991) has noted, based on ceramic seriation

> the sixteenth century [northern] Utina were direct ancestors of the seventeenth century [northern] Utina. They occupied the same territory and there is no evidence to suggest that they were displaced by any other group during this period. The region was not depopulated and abandoned following de Soto.
> (Johnson 1991:118)

Thus, the Indian Pond ceramic complex, which originated in the pre-Columbian period, can be traced into the colonial period and correlated with the northern Utina and their descendants who occupied the San Martín mission.

Analysis of the aboriginal ceramic complex from a single-component pre-Columbian occupation at the southern portion of the San Martín mission native village site, in Columbia County, Florida, now recognized as northern Utinan territory, has further refined the Suwannee Valley ceramic series and its distinctiveness from the Alachua tradition. These aboriginal ceramics appear to represent a separate regional late pre-Columbian ceramic assemblage for north Florida. The Suwannee Valley series definition was based on recognition of the uniqueness of the Indian Pond complex and its distinctiveness from the Alachua tradition ceramic complex (Worth 1992:191-192). Included in the Suwannee Valley ceramic series is the complex associated with the seventeenth-century northern Utinan missions. That assemblage, according to Worth, includes the division of the original Jefferson Series into the Lamar and the Jefferson series. The grog-tempered Jefferson series is apparently quite restricted, appearing only during the mission period and even then with limited distribution within the Spanish mission system (Worth 1992:190). An additional regionally distinct type, Fig Springs Roughened, constitutes a major portion of the Suwannee Valley Series in north Florida and represents the major departure of the Suwannee Valley Series from the Alachua tradition ceramic assemblage to the south (Worth 1992:194).

Scholars misinterpreting French and Spanish documents have created a great deal of confusion over the name "Utina." The same name, as noted above, has been used to refer to quite distinct Timucuan groups. Recent research has helped clarify the problem of who were and who were not the Utina. Johnson (1991) has convincingly argued that the Utina near the St. Johns River, who were in contact with the French in the mid-1560s, were a group distinct from those peoples inhabiting north Florida north of the Santa Fe River in Union, Columbia, Hamilton, and Suwannee counties. This latter group, who were associated with the de Soto-period towns of Cholupaha, Aguacaleyquen, Uriutina, and Napituca, are the people Johnson refers to as northern Utina, as opposed to the St. Johns eastern Timucua. The region of the north Utina, the area north of the Santa Fe River and east of the Aucilla River, appears to have been united at the time of the Hernando de Soto expedition through a political alliance of chiefs, with village names perhaps reflecting chiefly status. Uzachile seems to have been the most powerful chief of the alliance. Aguacaleyquen also appears to have been an important chief (Johnson 1991:76; Milanich and Hudson in press). Aguacaleyquen was the first town encountered by de Soto when he crossed the Santa Fe River to the north (Johnson 1991:98; Swanton 1922:150).

The northern Utina of the seventeenth-century Spanish missions are the descendants of the various sixteenth-century groups encountered by de Soto in 1539. The main village of one of those groups, Aguacaleyquen, probably was near the later San Martín mission. The inhabitants of the villages served by that mission were the descendants of the Aguacaleyquen, one of the northern Utinan groups of the sixteenth century.

Granberry (1987) posits that the speakers of the Timucuan Utinan dialect were synonymous with the tribal-political division Utina. The name "Utina," which translates as powerful, probably referred to the tribal chief and originated from the Timucua word "uti" meaning earth or land/country (Granberry 1987:125). Historically the northern Utina were one of the largest, if not the largest, and most powerful Indian populations in Florida (Milanich 1978a; Swanton 1922).

It appears that the earliest European contact with the northern Utina may have been made by the 1528 Narváez expedition, which may have traveled through the western end of northern Utinan territory (Milanich 1978a:70; B. Smith 1871). The 1539 de Soto explorations traveled across the center of the region and were involved in several conflicts and one full-scale battle with northern Utinan groups. After that time, the northern Utina remained isolated from European contacts until the 1560s when the first French and Spanish may have traveled to that region. Later, after Franciscan missionary activities commenced in La Florida, at the end of the seventeenth century, more contact took place.

The Spanish Mission System in La Florida

In 1566 the Spaniards erected the first mission in La Florida in St. Augustine. In that year Menéndez petitioned the Society of Jesus (i.e., Jesuits) for missionaries and directed construction of a chain of forts "to see that the Indians became Christians" (Gannon 1965:30). These initial efforts, hampered both by the seasonal movements of the coastal aboriginal populations and their resistance to Jesuit doctrines, were unsuccessful (Gannon 1951; Lyon 1981). By 1572 the Jesuits had abandoned their attempts to missionize and Menéndez requested of the Spanish crown that Franciscan missionaries be sent to administer to the native peoples of La Florida (Gannon 1965:34).

In 1573 the first Franciscans landed at Santa Elena. By 1578 a member of the order was assigned to the St. Augustine garrison (Milanich and Hudson in press). Mission contact with aboriginal groups was sporadic until twelve Franciscans reached St Augustine in September of 1595. By the close of 1596 nine missions were established among the Timucuan-speaking native peoples, who inhabited the coast between St. Augustine and present-day Cumberland Island, Georgia, and the Guale, whose territory encompassed the present-day Georgian sea islands from St. Simon Island to St. Catherines Island (Gannon 1965:435; Milanich in press ; Milanich and Sturtevant 1972:10). However, a revolt by the Guale Indians in 1597 destroyed the Guale missions and killed all but one of the missionaries (Gannon 1965:40-42; Milanich in press; Smith and Gottlob 1978:6).

During the seventeenth century the mission system of La Florida was greatly expanded. By the close of 1603 the Guale missions were once again thriving (Gannon 1965:43), and in 1606 mission work was begun among the Potano, a Timucuan group in present-day Alachua County (Geiger 1937). By 1620 the Franciscans had established two mission chains in La Florida: one stretched along the Atlantic Coast from St. Augustine northward along the Georgia coast; and the other extended westward from St. Augustine across northern Florida to the Aucilla River. "By 1633, many of the Timucua Indians had been brought under mission control, and the Spanish began to extend the mission chain into Apalachee territory in northwest Florida" (Smith and Gotlobb 1978:6-7). By the end of the 1630s the Franciscan mission system in La Florida was well established and embodied more than forty churches and some fifty missionaries (Milanich and Johnson 1989:1) (Figure 2.5).

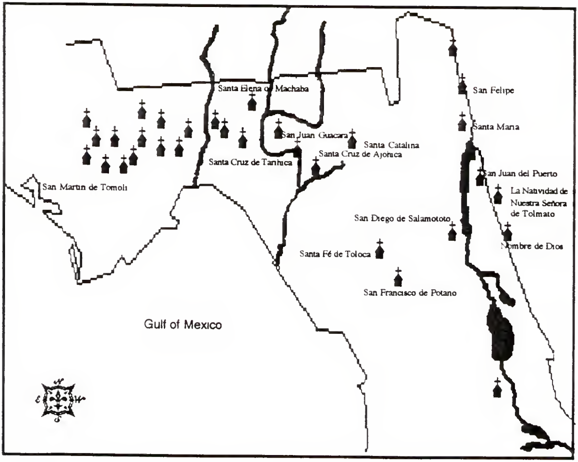

Figure 2.5
Spanish missions among the Timucua
Adapted from Gannon 1965

The Spanish mission system, beleaguered by Indian rebellions and other problems, was neither static nor peaceful. A 1647 Apalachee rebellion ended in the death of three priests and the destruction of seven mission churches (Smith and Gottlob 1978:7). After an eight-month Timucuan rebellion in 1656, provincial Governor Rebolledo ordered the capture and hanging of eleven Timucuan chiefs. Many of the Timucuan missions were either abandoned or moved (Hann 1986:373; Spellman 1965:363; Swanton 1922:338). Late in the seventeenth century the British, or British-abetted privateers, carried out raids on some of the inland Timucuan missions and the missions of Guale.

The 1675 northern Utinan missions and villages included Santa Fe (the principle mission in Timucua), Santa Catalina Ajohica, Santa Cruz de Tarichica, and San Juan de Guacara, with a combined population of only 230 individuals (Deagan 1972:25; Johnson 1991:107; Milanich 1978a:72). A 1689 census of the San Juan and Santa Cruz missions counted fifty families for a total of approximately 250 persons. Two missions north of the Santa Fe River, San Juan and Santa Cruz, were destroyed by a British raid in 1690, and the mission inhabitants were removed to the mission of Santa Fe and to St. Augustine (Milanich in press). Santa Catalina, listed in the 1675 enumeration of Spanish missions compiled by Bishop Calderón of Cuba (Boyd 1948:181; Geiger 1940:129; Wenhold 1936:18), is last mentioned in 1685 by Juan Cabera who reported that the mission had been destroyed by a band of Yamassee Indians, a branch of the Creek nation driven southward from their native Georgia by the British (Boyd et al. 1951:38; Deagan 1972:25).

By 1686 Guale was completely abandoned and after 1689 Santa Fe is the only documented northern Utinan mission (Gannon 1965; Milanich in press). British armies from the Carolina colony, aided by Indian allies, continued their raids into the early eighteenth century. During the 1702 War of Spanish Succession, forays into Apalachee destroyed several missions. By 1704 Carolinean Governor James Moore's army had burned or depopulated most of the remaining nine Timucuan and fourteen Apalachee missions (Spellman 1965:371), effectively ending the mission system among the Apalachee and Timucua. Continued British and Yamassee Indian raids against Timucuan missions in 1706 and 1707 resulted in the complete destruction of the Florida mission system by 1708 (Gannon 1965:76; Milanich in press). By 1710 the Timucua were virtually devastated with only a few survivors clustered around St. Augustine (C. Hudson 1976:436); in 1728 only a single surviving Timucuan Indian could be documented (Deagan 1978:115).

Spanish Missions Among the Northern Utina

The interior missions among the northern Utina were frontier settlements established deliberately to modify Native American culture to suit Spanish ethnocentric values (Thomas 1987:75). Virtually all members of the mission society were native Florida Indians. In the interior most missions, Spanish priests probably outnumbered Indians by about 200 to 1 (Weisman 1992a:8). Missions included religious edifices and the surrounding settlement of aboriginal groups (Thomas 1987:75).

Spanish missionaries resided in the doctrina, a principal mission in which the Catholic doctrine was taught to native villagers. Priests periodically traveled to visitas, nonresidential satellite missions, in outlying villages. Most mission priests lived at a more or less centralized primary village and administered to affiliated outlying villages. Soldiers occasionally were stationed at doctrinas as representatives of the Spanish garrison (Sturtevant 1962:62). Rarely, however, did they number more than one or two.

In 1597 contact between the Spanish and the northern Utina became increasingly frequent. In that same year Father Balthasar Lopéz first visited the main aboriginal town in northern Utina (Johnson 1991:100-101). Later, the Franciscan priest, Martin Prieto, who first passed through the region in 1607 on frequent visits to the Potano Indians to the south (Deagan 1972; Geiger 1940; Milanich 1978a; Swanton 1946), established the first northern Utinan mission at that town, naming it San Martín. San Martín has alternately been referred to as San Martín de Timucua, San Martín de Tomloe, and San Martín de Ayaocuto (Geiger 1940:123-126; Oré 1936:110). Prieto baptized one hundred children in residence, suggesting a total population of 250-400 (Johnson 1991:104). Apparently the mission had four near-by satellite villages. By 1616 other northern Utinan missions had been established, including Santa Fe de Teleo, Santa Cruz de Tarichica (Tari), San Juan de Guacara, and perhaps others (Johnson 1991:104).

CHAPTER III
THE ARCHAEOLOGICAL BACKGROUND OF PRE-COLUMBIAN ANCESTORS OF THE TIMUCUAN PEOPLES

Human skeletal remains excavated from six pre-Columbian-period burial mounds from five sites in north and north-central Florida aided the analysis and interpretation of the biological and cultural effects of the Spanish mission system upon the northern Utina. The skeletal collections are presently stored at the Florida Museum of Natural History, University of Florida, Gainesville, Florida.

The collections analyzed here represent a temporal cross section beginning with the Weeden Island-period cultures in north and north-central Florida and ending with the colonial-period native peoples; they span the temporal range of the early Weeden Island and Alachua tradition periods. These collections, from the region of the later Timucuan mission province, establish an important pre-Columbian baseline to facilitate interpretations of changing biocultural patterns over time and to evaluate the impact of the Spanish mission system upon the native northern Utina.

The Cross Creek (8AL2), Melton Mound 1 (8AL7), and Wacahoota (8AL58) sites, located in north-central Florida, are representative of the Weeden Island-related Cades Pond culture in Alachua County. The Henderson site (8AL463) is a later Alachua tradition burial mound also in Alachua County. Contemporary with the Cades Pond sites is the McKeithen site (8CO17) in north Florida. The site is an early Weeden Island-period mound and village complex in Columbia County (Figure 3.1). The following sections will first discuss in

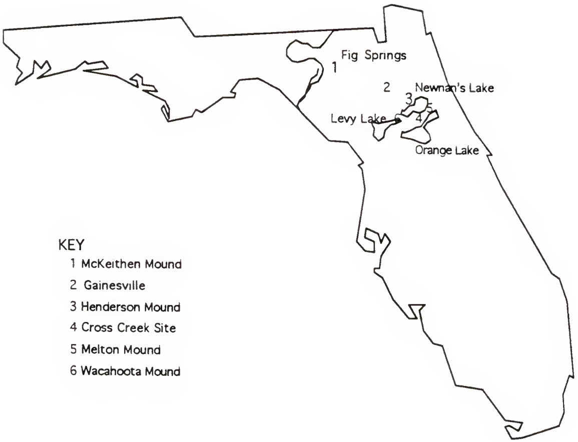

Figure 3.1
Pre-Columbian northern Utinan sites

general the cultures involved and then focus on the specific sites chosen for the analysis.

The Weeden Island Culture

The geographic heartland of the Weeden Island culture, A.D. 200 to A.D. 900, was northern Florida, southwestern Georgia, and southeastern Alabama (Milanich et al. 1984:16). Gordon Willey (1949), using ceramic seriation, was the first to recognize that the Weeden Island period consisted of two distinct temporal units. He designated these periods as early Weeden Island I (now dated A.D. 250-700), and later Weeden Island II (A.D. 700-900). More recently it has been recognized that distinct ceramic complexes existed within Weeden Island villages and their associated burial mounds (Milanich et al. 1984:16). Thus the Weeden Island culture has both a secular ceramic complex and a sacred/ceremonial complex (Milanich et al. 1984:12).

During the Weeden Island I period, the number of sites is more limited than during the Weeden Island II period. The later period is marked by an overall increase in site numbers and movement into new locales, suggesting larger population densities and an increased reliance on cultigens (Milanich et al. 1984:11). Although no direct evidence exists for maize agriculture among these cultures, early Weeden Island peoples may have cultivated local plants. Indirect evidence in the form of corn-cob impressed pottery and ceramic gourd effigies suggests, while not intensive, partial reliance on cultigens by late Weeden Island peoples (Milanich and Fairbanks 1980:116, 118, 127). The Weeden Island II period might best be viewed as a transition from the settlement, subsistence, and social systems of Weeden Island I people into the life-style of the farming cultures of the Mississippian period (Milanich et al. 1984:12).

The location of inland Weeden Island villages in northern Florida, adjacent to freshwater sources in deciduous or mixed pine and deciduous forests, facilitated harvesting a wide variety of wild plant and animal species from diverse habitats. Although the subsistence strategies of the various Weeden Island cultures differed by environmental zone, such as inland versus coastal, the cultures shared similar ceremonial activities and participated in extensive trade (Milanich and Fairbanks 1980:92). It appears that Weeden Island ceremonialism and socio-political organization shared some aspects of ideology with Lower Mississippi Valley cultures, particularly those cultures that adhered to Hopwellian-affiliated belief and behavior patterns (Milanich and Fairbanks 1980:131; Milanich et al. 1984:22). One model that attempts to explain the social and cultural organization of the Weeden Island peoples is based upon excavations at the McKeithen site; it emphasizes the presence of small villages composed of households that together formed an interacting community of related families (Milanich et al. 1984:41). Lineages were basically egalitarian with status based upon age and gender. Social differentiation between villages and/or lineages was a product of environmental production advantages. New villages developed as branches of existing villages. Villages with mounds represented a focus of intra-lineage social interaction (Milanich et al. 1984:42).

In 1958 Sears identified two types of Weeden Island burial mounds. Patterned mounds of the pottery deposit variety were identified by a large quantity of pottery on the east side of the mound and a central burial in a special tomb. Continuous-use mounds contained large numbers of scattered burials with no distinct evidence for layering or internal structure. Additional research on Weeden Island continuous-use burial mounds in north Florida has demonstrated that they may not always be associated with an adjacent village; that mound complexes (two or more mounds) may accompany a single village; or that several villages utilized the same mound or mound complex (Milanich et al. 1984:39).

It appears that mound burial was guaranteed all lineage members and that lineage members were interred together, reflecting an intra-lineage egalitarian status structure. Each village or lineage had a religious practitioner whose special status was reflected in burial practices (Milanich et al. 1984:42-43). Bundle burials and single-skull interments were the most common burial modes. Flexed burials were rather common, but actual cremations were rare. Although the mounds typically included funerary goods--including polished stone celts, sheet mica, galena lumps, and large quantities of broken killed vessels--grave goods associated with individual burials were rare (S. Smith 1971:34-37, 53, 89).

The McKeithen Site: A Weeden Island Culture

Much of the research on the Weeden Island culture was conducted at the McKeithen site, 8C017. The site, located adjacent to Orange Creek in Columbia County, Florida, was excavated between 1976 and 1979 by the Florida Museum of Natural History, Jerald Milanich project director. Detailed description of site excavations and interpretations are available in McKeithen Weeden Island: The culture of northern Florida, A.D. 200-900 (Milanich et al.

1984) and only a brief review of the burial mound excavations will be mentioned here.

Three sand mounds arranged in an isosceles triangle, and encircled by horse-shoe shaped village midden, were excavated. Radiocarbon dates indicate that mound construction was initiated around A.D. 350 and terminated at approximately A.D. 475.

Mound A, a rectangular platform mound, was the largest of the three mounds. Three types of fires were evident on the platform, a central hearth, small circular hearths, and a series of at least fifty small pits. The authors suggest that many of these archaeological features, including circular burial and maceration pits, indicate that this platform mound was utilized as a charnel structure for initial preparation of the dead with final interment within Mound C. Vessels within Mound A were basically utilitarian, similar to those types found in village middens.

Mound B was a circular platform sand mound with a rectangular structure erected on it. The artifact assemblage encountered in the framework suggests that the artifacts were associated with the structure's inhabitant. A grave pit containing the extended burial of one individual was excavated from a tomb constructed in the floor of the structure. Rodent gnawing on the left clavicle and humerus, the tibiae, and fibulae suggests that the individual was exposed for a period of time before final interment. Milanich and co-workers suggest that the Mound B burial is indicative of an individual with elevated status, possibly a religious specialist. This hypothesis is supported by the types of ceramic vessels found in the structure.

Mound C, the repository for the human remains prepared on Mound A, began as a circular platform mound. Evidence for a burned structure, possibly a charnel house, was found on the platform. No central tomb existed. After burning the structure and before capping the mound, a ceremony was preformed in which human remains were interred and ceramic effigies and vessels were deposited. The remains of thirty six individuals--three flexed, three single, and seventeen bundle burials--were also placed around the edge of the platform mound and deposited on its southeastern edge. Bundle burials were mostly comprised of a single skull with long bones, and several contained the remains of more than one individual.

Cades Pond Culture

After about A.D. 200 the Sante Fe River served as a geographical and cultural boundary between the Cades Pond culture in north-central Florida and the Weeden Island cultures in north Florida (Milanich et al. 1984:27). Cades Pond is recognized as the principal aboriginal culture occupying what is now Alachua County area from ca. A.D. 200-800, or from the late Deptford period until the intrusion of the Alachua tradition peoples (Milanich 1978c:151). As such, Cades Pond sites occupy a very restricted physiographic region in north-central Florida. Although the Cades Pond culture overlaps temporally with early Weeden Island, it is quite distinct from Weeden Island developments to the north. Cades Pond is described as a Weeden Island-related period culture because Weeden Island village traits are not found in Cades Pond sites in north-central Florida, although Weeden Island pottery is common in mounds (Milanich and Fairbanks 1980:91, 96).

The name "Cades Pond" was assigned in 1949 by John Goggin, who borrowed the term from early publications describing a burial mound near Lake

Sante Fe (Hemmings 1978:141). All Cades Pond sites are located south of the Sante Fe River in hardwood hammocks adjacent to streams, ponds, lakes, and other extensive water sources and wetlands (Loucks 1976:10; S. Smith 1971:115) and are especially prevalent around Lake Lochloosa, Orange Lake, Newnan's Lake, and Paynes Prairie (Milanich 1978b:134).

Although it appears that the Cades Pond culture was initially influenced by St. Johns and later Weeden Island mortuary practices, it lost these affinities over time. Developing Cades Pond culture can thus be identified as a distinctive sociocultural system based on adaptations to the environmental conditions of north-central Florida (S. Smith 1971:119). Subsistence depended upon extensive exploitation of a wide variety of aquatic and forest fauna in addition to intensive harvesting of plant resources, especially hickory nut (Hemmings 1978:144; Loucks 1976:11).

That the Cades Pond people were at least partially sedentary has been inferred from subsistence patterns (Loucks 1976:11), temporal changes in burial practices (Milanich and Fairbanks 1980:106), and settlement patterning (Hemmings 1978:148; Milanich 1978c:167).

An initial typology of Cades Pond settlements might include the following: (1) ceremonial centers consisting of some combination of mounds, cemeteries, earthworks, ponds, and village areas. (2) ceremonial centers consisting of two or more burial mounds and a village area. (3) single mounds associated with hamlets. (4) outlying hamlets. (Hemmings 1978:146)

Milanich (1978c) has refined Hemming's (1978) typology and identified five types of Cades Pond archaeological sites: (1) mound with a semicircular earthwork and adjacent village containing evidence of long-term and sedentary occupation; (2) mounds (s) with an adjacent village within one-half km; (3) mound (s) with an associated village within one-half to one and one-half km; (4) specialized sites; and (5) camp sites (Milanich 1978c:166). By evaluating relative age, site type, subsistence activities, and geographical location of known sites, Milanich (1978a) developed an occupational nexus model to explain Cades Ponds settlement patterning.

Cades Ponds sites appear to occur geographically in clusters with each cluster/nexus containing at least one major mound-village complex. The placement of connected sites, each occupying a restricted geography zone, was relative to both the social and natural environment (Milanich 1978c:167).

> One hypothesis present in the model is that each nexus functioned as a separate political unit, bound together by social organization, shared beliefs, and economic ties. One major mound-village complex served as a "center" at any one time with a large portion of the nexus population residing at the village adjacent to or associated with the mound (s). (Milanich 1978c:170)

As Cades Pond cultures became increasingly sedentary, interments at these mound centers shifted from continuous-use mounds to mass burial type mounds. Charnel structures appear to have been used to prepare the bodies for burial (Loucks 1976; Milanich and Fairbanks 1980). Small earthworks were common and mass secondary burial was the norm with primary burials and cremations occurring less frequently (Hemmings 1978:147).

The Melton Site

Much of our knowledge of Cades Pond village life is based upon the 1971 re-excavation of the Melton site (8AL169), Alachua County, Florida, by the University of Florida. The site was originally excavated by John Goggin in 1951. The Melton site, along with Melton mounds 1 (8AL5), 2 (8AL6), and 3 (8AL7), is included in the mound-village complex designated the North Paynes Prairie nexus (Milanich 1978a:169). This nexus originally contained as many as five ceremonial mounds and ten villages and camps (Milanich and Fairbanks

1980:109).

Melton Mound 1 was a conical sand-burial mound containing seventeen human burials, the majority of which were secondary interments (Hemmings 1978:148; Loucks 1976:14) Two primary flexed burials, one female and one male, interred in intrusive pits in the center of the mound, indicate that the mound continued to be used after initial construction (Milanich and Fairbanks 1980:109). Melton Mound 3 was also a conical sand-burial mound and exhibited evidence for a primary core mound and a secondary mound (Loucks 1976:14). More than twenty two burials, including one primary flexed interment and two cremations, were excavated from within the mound by William Sears (Sears 1956). The remaining burials were secondary mass interments and bundle burials (Loucks 1976:15). Evidence suggests that this mound was constructed in two distinct stages. Initially the primary mound contained a deposit of pottery sherds and several burials in the central core. Later, previous to the second-stage construction, seven or eight bundle burials were placed on the center of the mound surface. At the same time as many as twenty more bundle burials were placed upon the mound's surface (Milanich and Fairbanks 1980:110).

The Cross Creek Site

The Cross Creek nexus includes both the River Styx and the Cross Creek site complexes (Milanich 1978c:169). The Cross Creek site was located in a line parallel to both Orange Lake and Lochloosa Lake in Alachua County. The Cross Creek village-mound complex was composed of a large flat-topped mound, a smaller burial mound, a village between these two ceremonial mounds, an embankment trench, and a large borrow trench (S. Smith 1971:64). Mound 1, a conical sand-burial mound, contained at least seven burials, interment method unknown, and was surrounded by a semicircular earthwork (S. Smith 1971:88). Mound 2, a level structure containing no intentionally deposited artifacts, may have functioned as a platform for a temple or a charnel house. Three historically heavily looted mounds with small village areas in close association are also part of the Cross Creek nexus (Milanich and Fairbanks 1980:108).

Wacahoota

The Wacahoota mound (8AL58) was located on the west side of Paynes Prairie, Alachua County, Florida, near Levy Lake. This mound-village complex is composed of a conical sand-burial mound with an adjacent village within one-half km. Thirty two secondary burials were excavated from within the mound by John Goggin. The Wacahoota site, together with the Ramsey Pasture mound and village, forms the Levy Lake nexus (Milanich 1978c:169).

The Alachua Tradition

The Cades Pond culture in north-central Florida was replaced around A.D. 700 by an intrusive culture, the Alachua tradition (A.D. 700-1600). The Alachua tradition peoples were the direct ancestors of the western Timucuan group, the Potano. The Alachua tradition appears to have originated as a gradual population expansion from inland sites in southeastern and South-central Georgia into the north-central Florida region (Milanich 1968; Milanich and Fairbanks 1980; H. Smith 1956). Large clusters of sites are found around

Orange Lake, on the north side of Paynes Prairie, and in the Moon Lake region of Alachua County (Milanich 1978b:134). Sites are also known to exist in Marion, Levy, and Dixie counties (Loucks 1976).

John Goggin was the first to recognize that the Alachua tradition was distinct from the Cades Pond culture. Because a large number of sites have been excavated it has been possible to define four temporal Alachua tradition periods. These periods are designated as Hickory Pond, A.D. 700 (or later) to A.D. 250; Alachua A.D. 1250 to A.D. 1600, Potano I, A.D. 1600 to A.D. 1630, and Potano II A.D. 1630-1700 (Milanich and Fairbanks 1980:70). This temporal sequence is based upon seriation of changing ceramic techniques through time, specifically the ratio of cord-marked sherds to cob-marked sherds (Johnson 1991:110). The final period, Potano II, is designated by the appearance of Spanish artifacts in aboriginal village sites (Milanich and Fairbanks 1980).

It has recently been demonstrated that the Alachua tradition ceramic seriation assigned to north-central Florida, Potano territory, is not applicable to north Florida, the home of the northern Utina (Johnson and Nelson 1990:49; Johnson 1991:72). Recognition of a regionally distinct ceramic assemblage, the Indian Pond complex, has clarified the archaeological record and defined the geographic boundaries of the Utina (Johnson 1991). Re-examination of recorded Alachua tradition and Weeden Island II sites in Columbia, Suwannee, Union, and Hamilton counties, has determined that these sites are associated with the Indian Pond complex (Johnson 1991:139).

The Alachua tradition was basically a sedentary agricultural complex with rather extensive village sites on high ground near agricultural lands and next to a freshwater source (Goggin 1964; Milanich 1978b:134; H. Smith

1956:318). A large variety of aquatic and terrestrial species and wild plants contributed to a varied diet. Strong evidence for maize horticulture comes from cob-marked sherds, descriptions by the early sixteenth-century Spanish explorers of maize granaries, and charred kernels and cobs recovered from Potano sites (Milanich and Fairbanks 1980:172).

Only two Alachua tradition mounds have been excavated, the Woodward Mound (R. Bullen 1949) and the Henderson Mound (Loucks 1976). The Woodward mound was a continuous-use annular sand-burial mound. Three adult burials were placed on a prepared mound base, which was then capped. Later, over a period of time, twenty six extended burials were interred on the eastern slope of the mound and then each was covered with at least one m of fill. Subsequent interments were bundle burials (R. Bullen 1949; Milanich and Fairbanks 1980)

The Henderson Mound (8AL463) contained a mound base about sixty cm deep with several single-skull interments, one flexed burial, and five extended burials placed on its surface and then capped with sand. Additional burials were interred on the mound's surface, the majority placed on the eastern slope of the mound. Grave goods were scarce, but red ochre deposits were common. A total of thirty nine burials were excavated, including single-skulls (eight), semi-flexed (one), flexed (five), and primary extended burials (twenty five). Fifteen of sixteen individuals observable for the trait were identified as male. Age distribution--five preadults, five individuals aged 2-6 years, three individuals aged 12-18 years, and three individuals aged 18-22 years--appears to favor a young cohort. Mean adult stature is reported as 154.25 cm. Pathologies are limited to one expanded cortex of a left tibia and thirteen individuals with dental caries (Loucks 1976).

Summary

The pre-Columbian human skeletal remains from the Cross Creek, Melton Mound 1, Wacahoota, Henderson, and McKeithen sites constitute the data base for Chapter XI. Demography and pathology will be interpreted for these pre-Columbian populations as a unit, with the results compared to those obtained from the Spanish mission-period northern Utina. Comparison of the data derived from the pre- and post-Columbian Timucuan remains will facilitate an interpretation of the biocultural consequences of the Spanish mission system upon the native northern Utina.

CHAPTER IV
ARCHAEOLOGY OF SPANISH MISSIONS

The bulk of information concerning architectural and construction details of sixteenth-century Spanish mission complexes in La Florida comes from excavations conducted in two Spanish mission provinces; Apalachee in northwest Florida, and Guale on the Georgia coast. Until recently (Weisman 1992a, 1992b), the archaeological record of Spanish missions in north-central Florida had not been explored. The following section will discuss Spanish mission architectural features and site configurations in La Florida. The relevance of these findings to the Fig Springs/San Martín Spanish mission site will then be discussed.

Spanish Mission Architecture

A review of the available data indicates that a combination of formal plans and informal building techniques were used in construction of the La Florida Franciscan missions of the seventeenth-century. Mission buildings were generally arranged along a variant of the quadrangle plan, which incorporated a church, a convento (priests house), and a kitchen positioned around a central courtyard or large plaza (Saunders 1990:531). Cemeteries, located to one side of the church or beneath the church floor, and aboriginal council houses are also documented for Spanish mission sites. Missions tend to be oriented along an axis that ranges between 45 and 81 degrees east or west of north (Jones and Shapiro 1990:505). Although attempts have been made to define a mission structure standard and the quadrangle layout may be used as a basic departure for interpretation, investigations indicate that variability between original mission plan and actual structural layout is the norm rather than the exception. Regional deviations can be attributed to influences of local economies, politics, environment, and date of construction (Saunders 1990:531).

The one consistent and typically the most imposing and predominate structure among all excavated Spanish mission sites is the church, which is commonly associated with human burials and a churchyard or plaza (Jones and Shapiro 1990:504). Churches, with the sanctuary often located at the eastern end of the structure, appear to be rectangular in plan and oriented along a northwest to southeast axis. In this respect, orientation of the church, as well as the majority of mission structures, follows the same orientation of the mission complex. Church walls were either constructed largely of wattle-and-daub or churches may have been open-air structures with thatched roofs supported by wooden posts. Prepared clay floors were typical. Church dimensions vary in size from 17.8 to 26 meters in length and 11 to 12.6 meters in width (Jones and Shapiro 1990:504). Saunders (1990:533) posits that these proportions suggest that the actual size of the church had little connection to the size of the congregation.

The convento, or friary, is usually separated from and positioned near the church (Jones and Shapiro 1990:504). It was normally constructed along a simple plan of a single row of rooms, and may have housed the friars' cells and some specialized rooms, such as a kitchen, offices, and workshops (Saunders 1992:131; Thomas 1987:77-78). Wattle-and-daub construction is typical and, in some instances, a convento could include more than one structure. Convento sizes varied widely, ranging between 30 to 92 square meters (Jones and Shapiro 1990:504).

The kitchen, or cocina, may have also served as a storage facility. This building, typically the third structure in the church complex, was usually square and smaller than the convento (Marrinan 1992). The kitchen was commonly located to one side of the church, but at a greater distance from the church than the convento. In these instances the church, convento, and kitchen formed a right triangle (Jones and Shapiro 1990:504). The long axis of the building was generally easterly-westerly (Marrinan 1992:246).

> Aside from the church and convento complex, the most striking feature of the La Florida mission was the council house (or buhîo), a traditional Southeastern architectural construction without parallel elsewhere in the borderlands. (Thomas 1990:382)

Documentary and archaeological evidence indicates that the council house would have typically been located on the plaza opposite and facing the church (Saunders 1992:129). These aboriginal council houses appear to have functioned year-round as the native seat of government and general meeting place. Excavations at San Luis de Talimali show that construction consisted of two concentric rings of benches around a central hearth. This plan is strikingly similar to the documented portrayals of council houses in Spanish Florida (Shapiro and Hann 1990:516-517).

Typically human burials are closely associated with the churches and may be located outside church walls in a campo santo or in cemeteries with bodies interred parallel to one side of the church (Jones and Shapiro 1990:505; Larsen 1990:20). The pattern, however, varies from mission to mission. At some sites burials are placed beneath the floor of the church itself, rather than in a separate cemetery (Larsen et al. 1990; Hoshower and Milanich 1992;

Thomas 1990:383). There is some indication that light, open pavilion-like structures may have covered some outdoor cemeteries (Jones and Shapiro 1990:506). The mortuary program followed at all Spanish missions is similar in that the arms of the deceased were crossed with hands clasped or folded on the chest or abdomen and bodies were supine and extended. Burials may be placed in coffins, wrapped in shrouds, or completely lacking covering (Larsen 1990:20). Bodies are typically aligned parallel to the long axis of the church with heads oriented to the east and feet to the west.

The Fig Springs/San Martín Mission Site

The Fig Springs Site (8CO1) is located adjacent to Fig Springs, a small tributary spring about 1.5 km west of the head of the Ichetucknee River in Columbia County, Florida. The site is located in that portion of north Florida historically inhabited by the northern Utina Indians (Figure 4.1). This site is probably at or near the main village of Aguacaleyquen where de Soto's army stayed in 1539. Over a three-year period, beginning in 1949, John Goggin, a University of Florida archaeologist, and his students collected an extensive assemblage of artifacts from the Spanish-contact period in the spring itself. Although Goggin was convinced that the spring was utilized as a refuse area for a nearby Spanish mission, he was never able to locate the original mission site.

Based on native pottery and Spanish ceramics, Goggin (1953) dated the site from the middle of the seventeenth century and posited that the assemblage was from a Timucuan mission that was destroyed in 1657. Kathleen Deagan (1972) assigned the Fig Springs artifact assemblage to the Florida historic period known as Leon-Jefferson, A.D. 1650-1725, and suggested that the

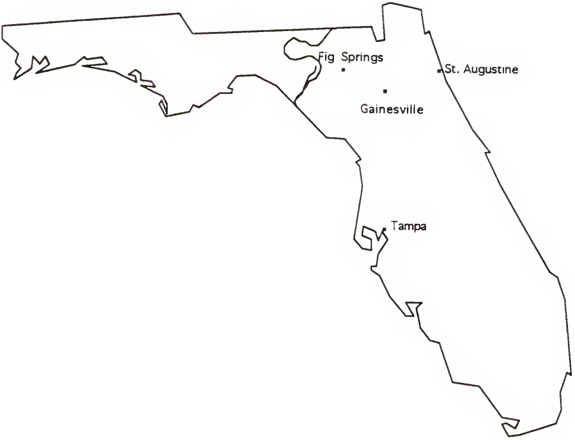

Figure 4.1
Location of the Fig Springs Site

assemblage was associated with the Santa Catalina de Afuerica (Afoica) mission, documented to at least A.D. 1675-1685. Interpretations of historical documents had placed Santa Catalina at about the head of the Ichetucknee River (Boyd 1939:262, 1948:182; Deagan 1972:25; Goggin 1953:6).

In December 1986 Kenneth Johnson of the Florida Museum of Natural History located the mission complex itself by making test excavations on the high ground above Fig Springs. His tests located mission-period artifacts, a possible clay floor, and human burials like those found in other mission burial areas (Johnson 1987, 1990). Auger surveys were implemented in February 1988 under the direction of Brent Weisman with subsequent excavations conducted over a sixteen-month period (Weisman 1992a). The 1988 auger survey further determined the extent of the mission complex and located two or possibly three structures located along the south and west sides of the possible cemetery as well as the plaza and an associated aboriginal village. These findings suggested that the Fig Springs mission layout generally resembled known mission plans from other sites. Analysis of the artifact assemblage indicated it predated 1650 and could not be the later mission of Santa Catalina (Weisman 1992a:36-38).

Subsequent documentary research has suggested that the Fig Springs Site is actually the location of the Franciscan mission of San Martín de Timucua established by Father Martin Prieto in 1608 (Weismann 1988, 1992a, 1992b). The San Martín mission was founded at a distance of 34 leagues (88.4 miles) from St. Augustine, a range quite comparable to the actual Fig Springs distance of 82 air miles (Weisman 1992a:35). The mission, which had four satellite villages, was established in the principle village of the region, possibly near the site of Aguacaleyquen (Milanich and Hudson in press). The San Martín mission site is located almost directly upon a southern mission trail that did not see extensive use early in the mission period. A 1597 Spanish document describes the location of the future site of the San Martín mission as off the beaten path (desviado) from St. Augustine (Milanich and Johnson 1989:10).

San Martín de Timucua was probably identical with the San Martín de Ayaocuto of later mission lists (Swanton 1922). The chief of Ayaocuto led the 1656 Timucuan insurrection. Although it appears that the San Martín mission was destroyed as a result of this rebellion--its name was henceforth dropped from mission lists (Swanton 1939)--a later letter tells of the need to re-populate the town of San Martín in the year 1659 (Hann 1986:376). Thus, the mission may have been reoccupied after that time, although this is not certain and is not supported by the seriation of Spanish ceramics.

Unfortunately the fragmentary and incomplete nature of Spanish mission documentation makes it difficult to establish with absolute certainty the precise location of many mission sites. In addition

> it must be borne in mind that it was possible for a mission to move its location yet retain its name, which complicates the problem by introducing the probability that two archaeological sites may actually be the same mission at different periods of time. (Boyd et al. 1951:112)

Thus, although the certainty of Fig Springs as the San Martín mission may never be made, archaeological and documentary evidence strongly supports that the site was the mission of San Martín (Weisman 1992a:36).

The 1988 and 1989 Archaeological Investigations at the San Martín Site

The following discussion is based upon Weisman's (1992a) interpretation of the architecture at San Martín as it relates to general similarities in mission site plan noted by archaeologists active in mission excavations across La Florida. Although each is unique,

> all share the concept of sacred and secular districts, with the religious buildings and cemetery in one area of the site and the mission village in another. Thus the San Martín church, convento, cemetery, plaza, and aboriginal areas . . . are so named because of their general resemblance to the architecture and site plans of known sites. (Weisman 1992a:22)

Identification of the church or chapel by Weisman was based upon the lack of domestic artifacts within the structure, special preparation of the building surface, orientation of the building axis relative to associated burials, and the general architectural similarity to other excavated mission-period churches. No evidence for wattle-and-daub wall construction was encountered. Features included packed sand and clay floors, and clay for chinking between the east wall boards. Pine posts, beams, and boards were also found. Wesiman (1992a) suggests that this structure resembled a chapel-like church which was open on three sides and enclosed three rooms or activity areas.

Construction of the structure was as follows. The original ground surface was stripped and graded, including depositing fill, and a prepared clay floor placed on top of the construction fill in the western portion of the building. The clay floor was repaired at least once during the life of the building. Roof support posts were placed near the edge of the floor, and pine boards were used as wall or room partitions. The church is interpreted to have functioned primarily as a roofed, open shelter for the altar, sacristy, and pulpit.

Weisman's excavations led him to believe the convento was located east of the presumed cemetery and northeast of the chapel (Figure 4.2). A concentration of Spanish artifacts, lack of a special construction sequence, relative location of this structure in the general mission plan, and its clear association with the church and cemetery, suggested to Weisman that this building was the remains of the mission's convento. Within the building evidence for wood-frame construction was clear. Wattle-and-daub apparently was not used in construction and clear indications of a prepared clay floor were lacking.

An area of low artifact density separating the complex of the church or chapel, the convento, and the presumed cemetery from the aboriginal mission village has been identified as the mission plaza or church yard. The aboriginal village was located approximately 200 m south of the plaza and mission complex. A kitchen may have been located in the village area at the southwestern end of the plaza. Unlike other structures, the kitchen appears to have been constructed of wattle-and-daub.

A 9 by 14 m rectangular aboriginal structure is located south of the plaza, itself south of the church-cemetery-convento complex. The long axis of the building is oriented approximately 45 degrees west of north. A large number of aboriginal artifacts and features, including hearths and/or fire pits, burnt wood-filled/smudge pits, and a dog burial, were uncovered within the structure. There was no direct evidence for wattle-and-daub architecture. Placement of postholes or charred-post features indicates

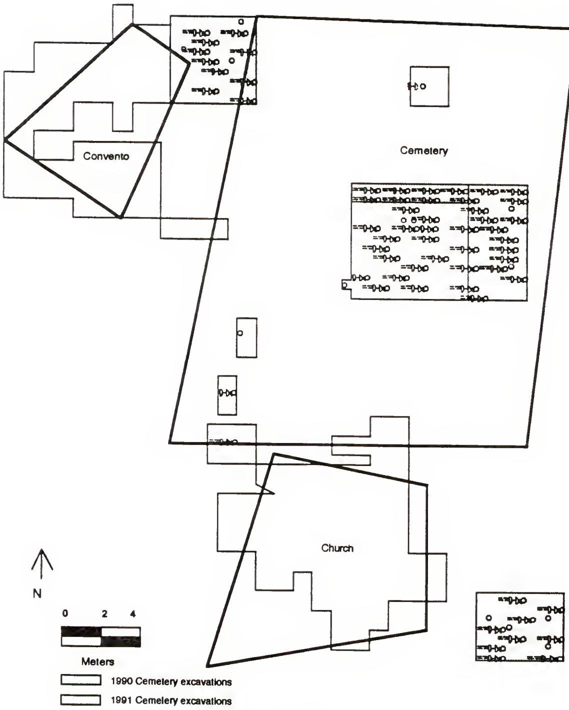

Figure 4.2
Architectural features at the Fig Springs site

Bold outlines indicate the location of the church, cemetery, and convento based on Weisman(1992a, 1992b). The 1990 and 1991 excavations indicate that Weisman's cemetery is actually the location of the larger church (which extends in a more easterly to westerly direction) and includes the sub-floor burials. Weisman's church is probably an earlier and smaller chapel. Adapted from Hoshower and Milanich 1992:215.

that major wall posts were placed approximately 1.7 m apart. Evidence of smaller interior posts and the placement of smudge pits, suggests that benches lined the inner wall of the building, which may have been some type of community structure, perhaps the aboriginal council house.

Based on human burials excavated in Johnson's and Weisman's tests and on misidentified bone recovered from the auger survey, Weisman believed that the mission cemetery was located north of the chapel and extended a considerable distance to the north. The misidentified bone fragments have been re-analyzed and identified as animal bone. These new data, and especially the excavations carried out in the northern area of the site during the 1991 field season, demonstrate that the hypothesized location of the cemetery is incorrect. What was thought to be a large cemetery has instead been shown to be a more spatially restricted distribution of human burials within the confines of a second, much larger church. The human burials excavated in Weisman's tests were encountered along what proved to be the north wall of the church. A total of eleven burials were excavated by Weisman, but analyses of demography and pathology were not conducted. The relative spacing of the burials suggested that interments occurred in orderly rows. Although the area of the interments was not completely free of artifacts, the eleven individual burials were not accompanied by grave goods.

The 1990 and 1991 Archaeological Investigations at the San Martín Site

In 1990 excavations were conducted in the presumed burial area located by Weisman as part of a six-week pilot project to determine the feasibility of on-site osteological analysis followed by immediate reburial and to gather bioanthropological data on this northern Utinan mission population. The archaeology of the burial area was found to be much more complex than anticipated and a third goal emerged, interpretation of architectural features. The excavations located a number of interments which were placed closely together and which resembled more closely the sub-floor interments reported for the mission church of Santa Catalina de Guale on the Georgia coast than they did the cemetery burials documented at the Santa Catalina mission on Amelia Island, Florida (Hoshower and Milanich 1992).

Excavations revealed portions of a prepared clay floor on the seventeenth-century ground surface 10 to 15 cm below the present ground surface. This clay floor was either part of a disturbed continuous floor or it was the remains of several small floors of small structures (chapels?) erected in the cemetery. At the end of the short field season either hypothesis seemed viable (Hoshower and Milanich 1992).

In 1991 additional excavations conducted within the burial area indicated that a single large clay floor had been present and that it overlay an earlier dirt floor. Both floors were within a large structure measuring approximately 15 by 25 m. Subsequent testing indicated that the extent of burials was much more confined than proposed by Weisman. Indeed, all the burials in that locale were restricted to the structure. At this time it seems certain that the burials were placed in graves dug into the floors of a large church building, a church associated with mission San Martín. A separate cemetery or campo santo is not evident at the mission. The long axis of the church is oriented east-west and is aligned approximately 5 degrees off cardinal north. An estimated 400-500 interments were made through the two floors.

The location of the church and its relation to Weisman's (1992a) "convento" strongly suggest that the "convento" is not a separate structure but architectural features and debris from the western end of the church. Burials extend well into the "convento" locale. Weisman's church or chapel to the south may well be an earlier structure, the first church built at the mission. Later, the larger church, with its two floors, was erected to the north.

Excavations in 1990 and 1991 indicated that interments also were placed around Weisman's chapel, at least on the north, east, and south sides. On the north and east sides the burials abutted the wall of the structure. Excavations have shown with certainty that the large two-floored church is a separate structure from the smaller chapel with its associated burials (Hoshower and Milanich 1992).

Stratigraphy within the larger two-floored church provides evidence for two distinct burial episodes, an early one in which burials were placed in graves dug through an earth floor and a later episode when graves were dug through the clay floor. Under the two floors two types of burial pits are clearly visible. The later pits are characterized by fill which contains an orange-brown to tan sand with clay. The earlier pits are characterized by fill composed of a medium gray sand without clay. The medium gray clay-less pit fill indicates that these earlier interments were made prior to the super-positioning of the earthen floor with the clay floor. Later burials, those with orange pit fill, were interred after the clay floor was placed over the dirt floor. This dichotomy in grave fills allowed the sub-floor church burials to be separated into two distinct and sequential episodes within the seventeenth-century.

The other group of burials, those associated with the smaller, earlier chapel, were in graves that had an orange sand fill on top, changing to gray sand at the bottom of the graves. All these graves were dug down to the top of a naturally occurring clay deposit that underlay that portion of the site. In a few instances, graves were dug into this clay stratum.

Summary

Artifact assemblages, archaeologically determined architectural plans, site location, and ethnohistoric documentation all strongly suggest that the Fig Springs site is the location of the San Martín mission, a Franciscan mission founded in 1608 and functioning until at least 1656. A small church or chapel, a larger church, plaza, aboriginal village, and possible mission kitchen have been identified.

Burials are more restricted in area and extent than suggested by Weisman (1992a). Evidence indicates that a minimum of three sequential and distinct burial episodes occurred. The earliest interments are located south of the large church, around the small church or chapel excavated by Weisman. This structure was probably the first church erected at the mission. Later interments were placed beneath the floors of the larger (and later) church. Within the later structure two temporally distinct burial episodes are documented. Early interments were placed through a dirt floor, later interments were made through a clay floor which was built atop the earth floor. These temporal distinctions will be utilized in the interpretation of the biocultural consequences of the Spanish mission period upon the San Martín northern Utina mission population.

CHAPTER V
THE BIOLOGICAL AND CULTURAL ENVIRONMENTS

Epidemiological inquiry requires that disease be viewed as a dynamic relationship among the agent of infection, the host, and the environment. The environment itself is comprised of many interacting forces, including biological, cultural, and natural agents. A change in any of these components will alter the equilibrium and affect disease expression.

The Spanish mission system disrupted the native equilibrium, established the stimuli for profound changes in aboriginal lifeways, and provided the ideal environment for stressful living conditions and the spread of infectious diseases characterized by high morbidity and mortality. Thus, the study of epidemic disease and the synergistic relationship between culture, biology, and environment will promote an understanding of the process of northern Utinan population and culture change.

This chapter will consider the biological, cultural, and natural agents in the environment which affected the San Martín mission population. The appropriate skeletal Indicators for measuring the impact of the Spanish mission system upon the northern Utina will be addressed.

Documentation of Epidemics Among Spanish Mission Populations

Although ample evidence exists for the presence of pre-Columbian infectious diseases in New World aboriginal populations (Baker and Armelagos 1988; Buikstra 1981a; Larsen 1982; M. Newman 1976), it was the post-contact introduction of Old World pathogens that devastated the native populations of North and South America. Documentation from the sixteenth century is rare, but numerous seventeenth-century Spanish and French records describe epidemics that affected the aboriginal populations of La Florida. So convincing is the available evidence that today it is readily accepted that epidemics, such as measles, smallpox, and influenza, were repeatedly introduced by Europeans to the Southeastern region (Milner 1980:47).

Historic records that document the types and numbers of epidemics that affected the native populations of present-day Florida between 1512 and 1562 are scarce. Based largely upon indirect and often tenuous sources, Dobyns (1983) posits that eight separate epidemics passed among the protohistoric-period Native Americans of Florida. Dobyns believes that the first Old World epidemic may have swept through the native peoples of Florida between 1513 and 1514. Support of this hypothesis comes from the contention that the ruling elite of Florida's aboriginal populations joined with the Spaniards in their search for the miraculous curative powers of the "River Jordan," commonly known today as the Fountain of Youth. As aboriginal populations

> had no need for miraculous cures until Old World diseases began to decimate them . . . the obvious explanation for the behavior of the Cubans and the Florida ruling elite is that all suffered from a serious, lethal, contagious epidemic of an Old World disease to which neither Native American populations possessed any immunity. (Dobyns 1983:255-256)

Absent in this narrative is acknowledgement of the atrocities inflicted upon the natives by the Spaniards. Dobyns himself notes that Spanish leaders frequently broke peace pledges to the natives and in one massacre alone killed 3,000 men, women, and children. It is possible and perhaps more plausible, given the lack of direct documented evidence for pathogens of epidemic proportions, that the native Florida rulers acquiesced to Spaniards in an attempt to mitigate further violence upon their native subjects.

Similar lines of documentary inference are employed by Dobyns (1983) to support Spanish-to-Indian transmission of seven additional epidemics--the first a smallpox epidemic brought to Florida from Cuba in 1519. An outbreak of either measles or typhoid fever among aboriginal populations is suggested in 1528. An unknown disease was transmitted tribe-to-tribe from Central Mexico into Florida between 1535 and 1538. Dobyns posits that between 1545 and 1548 the bubonic plague was carried to Florida by Mesoamerican canoe traders. Typhus in 1549, mumps in 1550, and influenza in 1559, all reached native Floridians by canoe traders.

As promising as Dobyns hypotheses may appear, his speculations actually employ broad historical license. Loose interpretations of scant documentary evidence, combined with much conjecture, have produced interesting, but unrealistic scenarios of the biological environment of Native Americans during this early-contact period. This skepticism is well stated by Henige in his review of Dobyns' most recent volume Their Number Become Thinned (1983).

> Confusion between the possible and the probable and between the probable and the real mars virtually every page of Number. Serious consideration of possibleness for its own sake remains largely the domain of philosophers, who willing suspend the rules linking serious discourse to reality in much of their work. (Henige 1986:306)

Sir Francis Drake, during his 1586 raid on St. Augustine, introduced what may have actually been the first documented major epidemic, possibly typhus, which quickly killed many Native Americans in the vicinity of St. Augustine (Crosby 1972:40; Milner 1980:42). The first reported epidemic among mission Indians in La Florida occurred in 1570 and was followed by a second incidence in 1591 (Bushnell 1981:13). Epidemics among the Timucuan missions during 1613-1617, 1649-1659, and 1672-1674 were major contributors to aboriginal population decline and, in some instances, complete village depopulation (Bushnell 1981; Dobyns 1983; Geiger 1937; Hann 1986; Swanton 1922, 1946, 1952). To the friars' knowledge, more than half of the missionized Indians succumbed to the 1613-1617 epidemic (Bushnell 1981:13). "A letter from the missionaries dated Jan. 17, 1617 informs us that in the preceding four years more than half of the Indians had died of pestilence" (Swanton 1922:338).

Between 1649 and 1659 three epidemics devastated the Apalachee, Guale, and Timucuan missions. The 1649 epidemic killed both Spaniards and Indians. Reports indicate that the contagion was directly transmitted to Florida by ship from Havana and may have been either typhus or yellow fever. In 1655 Governor Rebolledo specifically elucidated the devastating effects of smallpox upon the aboriginal populations (Hann 1986). In 1657 Rebolledo wrote that although the Apalachee, Guale, and Timucuan missions had all been affected by recent epidemics, the Guale and Timucua were more severely stricken, such that "very few Indians were left because so many had died off in recent years with the illness of the plague and of smallpox" (Hann 1986:381). In 1659 measles descended upon aboriginal populations. The visitation document of Governor Rebolledo identifies San Martín as one of the missions in need of repopulation at the end of 1659 (Hann 1986:376). In this record the San Martín and Chamile missions share a joint listing; the inhabitants of Chamile had been moved approximately a hundred miles east to occupy the decimated San Martín settlement (Hann 1986:376-377). Seven months after taking office in February 1659, the provincial Governor

Aranguiz y Cotes reported that 10,000 Indians had died from this highly contagious disease. A letter from Captain Juan Francisco de Florencia to the governor of Florida dated mid-1675 states that, in November of 1659,

> he had been ordered to go to the provinces of Ustaqua and Timucua to people and rebuild the towns of San Francisco, Santa Fe, San Martín, and San Juan de Guacara, which had been depopulated because some natives had died in the pestilences they had had and others had gone to the forests. (Swanton 1922:388)

After an unidentified epidemic between 1672 and 1674 there were so few Indians in central Florida that the Spanish gave land in Timucuan Province to anyone who would introduce cattle (Bushnell 1981:13). By 1680 mission lists document a distinct population decrease among the Timucuan and Guale missions. Indigenous populations from the north were brought to repopulate the nearly depopulated missions and it appears evident that some former Timucuan missions were largely inhabited by non-Timucuan populations (Swanton 1922:329).

The Cultural Environment

Cultural change and population nucleation have often been cited as primary stimuli for the increase of stress-induced skeletal lesions and morbidity among archaeological populations (Larsen 1990; Milner 1980; Rose et al. 1984). The Spanish mission itself disrupted Timucuan life-styles at all levels. The economy of the Spanish mission system, founded upon Indian labor and mission success, depended on the aggregation and control of native peoples.

Interpretation of the available data suggests that aboriginal Timucuan culture changed rapidly as a result of contact with the Europeans. The

Franciscan mission system, which dramatically altered native cultural, social, political, technological, and religious systems, seems to have provided the greatest stimulus for change (Milanich and Strutevant 1972). Over the course of conversion, aboriginal populations were removed from their native surroundings and concentrated within the confines of the missions. Distinctive native cultural practices, such as dispersal of the population into small groups in the fall, were discouraged by the mission priests as detrimental to mission success. Native burial practices and rituals were replaced with Catholic funerary rites. Burial mounds were no longer constructed and natives were interred beneath the floors of the mission churches (Hoshower and Milanich 1992; Jones and Shapiro 1990; Larsen 1990; Thomas 1987, 1990). Increasing control of the Indians by the missionaries finally lessened inter-village organization, and altered native social and political organizations, cultural traits and values, and subsistence technologies (Milanich and Sturtevant 1972:3-4). This increased sedentariness and aggregation of indigenous populations then provided the ideal environment for stressful living events and the spread of infectious diseases characterized by high morbidity and mortality. Acculturation of the natives appears to have progressed rapidly. Indeed, "the younger generation which has been nourished on the milk of the gospel makes fun of and laughs at some of the old men and women who carelessly have recourse to these abuses (the aboriginal customs)" (Ore 1936:106). Later, as the Spanish influence became more pressing, the physical, social, and religious aspects of aboriginal culture were changed through missionary work and the amount of acculturation occurring between the two groups (H. Smith 1948:318). Alterations of native customs, including the breakdown of the tribal political organization, appear to have reached a peak by 1700 with the decimation of much of the Timucuan population and assimilation of many Spanish traits (Milanich and Sturtevant 1972:3-4).

The mission system economy required the recruited labor of native populations. Tribute was extracted from the Timucua by the Spanish in the form of "paid" compulsory service in the repartimiento, (labor force), which consisted of shifts of work parties laboring for a limited period of time as mandated by law (Kirkpatrick 1939:374). Indians, living at the missions, represented a readily available labor service for mission crop cultivation, building and quarry projects, cargo bearing, and numerous other additional services (Hann 1988; Larsen 1990). During the mid-seventeenth century the cost of labor was low and Indian quarrymen, loggers, and carpenters were paid in set amounts of trade goods (Bushnell 1981:19).

Over time the focus of the repartimiento appears to have shifted from mandated low-wage labor to long-term labor at more attractive wages (Hann 1986:380). Finally, the labor system evolved until it resembled more a forced-labor program. [The overt enslavement of Florida Indians was, however, categorically denied by the Spanish crown (Bushnell 1981:21).] In response to a rebellion in 1638 the provincial governor condemned the Timucua and Apalachee residing in villages near St. Augustine to forced labor on the fortifications of the presidio under harsh and unjust conditions (Gannon 1990:450; Spellman 1965:361). As part of their "tribute" service, Timucuan males were required to transport seventy five pounds of maize on their backs fifteen to thirty leagues to to supply the main Spanish garrison at St. Augustine (Hann 1986:376). Natives also maintained transportation and communication systems with St. Augustine and supplied provincial garrisons (Bushnell 1981:98). From forced labor on public works to forced cultivation of mission and soldiers' private gardens, manipulations of the Timucua by the Spanish steadily increased (Gannon 1990). The burden of serving and feeding the Spaniards and performing unskilled labor in St. Augustine fell more and more heavily on the Indians (Bushnell 1981:99, 110).

Conditions were harsh and the effects of this heavy labor on the natives were devastating. Of two hundred Indians who carried burdens to St. Augustine in 1655 only ten returned to their homes, the rest had died of hunger on the way (Spellman 1965: 362). Finally in 1656, after Governor Rebolledo had subjected the Timucuan nobles to forced labor, an armed rebellion organized by the cacique of the San Martín mission broke out among the mission Indians (Spellman 1965:363; Swanton 1922: 324). Governor Rebolledo and the missionaries, each seeking to assign blame for the rebellion on the other, heatedly disputed the topic of mistreatment and enslavement of the Indians. In Spain the Council of the Indies decided that Rebolledo had exceeded Spanish law in his treatment of the natives and ordered his arrest. Rebolledo died before the orders could be implemented (Gannon 1990:450). During the 1680-1687 tenure of Governor Juan Márquez Cabrera the internal correspondences of Florida were filled with charges and countercharges on the subjects of whipping and exploitation of Indian labor (Gannon 1983). As late as the 1690s field soldiers complained of mistreatment and enforced labor of the Indians by the missionaries (Spellman 1965:370).

The final devastation to the Florida Indians was the invasion of the Creek and Yamassee Indians from the north at the close of the seventeenth century. The 1704 British raids led by James Moore and the resultant break-up of the Apalachee missions further devastated the Timucuan peoples who then gathered around missions near St. Augustine. Later pestilences further decimated these remaining Timucua and their ruin was completed by attacks of the British and their Indian allies, so that by 1710 the Timucua were virtually destroyed with only a few survivors clustered near St. Augustine (C. Hudson 1976:436). By 1725 the Timucua were reduced to fifteen men and eight women (Deagan 1978:115), apparently living in a single village. Between September 1 and October 5 of 1728 a pestilence struck the village killing all but three Indians, one a cacique (Milanich 1978a:73). The cacique and forty newly converted Indians of unknown tribal affiliation merged with a village of Apalachee living near St. Augustine (Deagan 1978:115). These few survivors appear to have moved to a stream called Tomoka, which still bears this name today. Later they either took up residence with other Indian populations or were incorporated by the invading Seminole (Swanton 1952:151). After 1730 the Timucua were no longer mentioned in Spanish records (Deagan 1978; Milanich 1978a). Today there are no living descendants of the Timucua.

Population Estimates for the Timucua

Almost every major investigation of pre-Columbian cultural evolution and European conquest must ultimately raise the question of Indian demography (Denevan 1972:1). The question is not one of if native population declined after European contact, but to what magnitude or extent they did decline. The answer to this question requires the estimation of pre-Columbian native population numbers and has been attempted for a variety of pre-Columbian Native American groups (Borah 1976; S. Cook 1943a, 1943b; Dobyns 1983; Goggin 1952; Kroeber 1934; Mooney 1928; Ramenofsky 1987; Rosenblat

1976; Ubelaker 1976--to mention but a few). Although a plethora of methods, including settlement patterning, social structure, food production, carrying capacity, environmental settings, archaeology, skeletal counts, and analysis of historic records and documents, have been utilized to derive population estimates, the questions remain far from resolved.

Very little work has been conducted on this question as it relates to the contact-period Timucua (Dobyns 1983 is the exception). Until additional representative pre-Columbian skeletal series are recovered, the data base for post-Columbian populations is expanded, and historic documentation becomes more readily available, most inquiries into Timucuan demography will remain unanswered.

The twentieth-century estimates of population size for the precontact Timucua are summarized in Ramenofsky (1987:13). These figures, which range from 5,000 to 722,000, demonstrate the controversy encountered in the estimation of pre-Columbian population size. The most recent, and perhaps the most controversial, work on Timucuan population dimensions has been conducted by Dobyns (1983). Dobyns' figure, which far exceeds that of other paleodemographers, was achieved through estimations of carrying capacity, settlement variables, army size, and mortality from assumed epidemics. The figures themselves were derived from secondary and translated ethnographic sources. Dobyns' estimate of 722,000 precontact Timucua is primarily founded on his belief, unsupported by documentary evidence, that twelve epidemics struck Florida between 1513 and 1596. Circular reasoning ensues in which Dobyns assumes that

> had Native American numbers in North America not been originally on the order of magnitude estimated in this essay, the aborigines collectively could not have survived the numerous epidemic episodes that I have outlined. (Dobyns 1983:43)

This high figure is difficult to accept because of Dobyns' biases and methods of reconstruction that derive from incomplete data (Ramenofsky 1987:13).

Recent research indicates that the regions north of the Santa Fe River possessed greater agricultural potential and political complexity than those in southern Florida. It is not surprising, therefore, that the de Soto expedition encountered denser aboriginal populations in northern Florida than they had in more southerly parts of the state (Milanich and Hudson in press). Thus, population estimates for the pre-Contact Timucua remain a matter of much conjecture. Incomplete historical records and a paucity of available archeological demographic data contribute to this controversy.

Epidemiology

Epidemics, such as measles, influenza, and smallpox, reported to have affected the Timucuan populations, all share a similar etiology. These epidemics are characterized by the following common features: the necessity of a host population for disease maintenance; restriction to one viral species; lack of host/pathogen commensal states; lack of extended vitality outside the host; and developed immunity by the host to subsequent infection (Milner 1980; Whitlock 1981).

The types of epidemic diseases that affected the Timucua are rapid killers. These diseases do not incubate within virgin-soil populations, ones in which the particular infectious agent has never been present, but strike quickly and fatally, and are often over within one month. The brief period between disease contraction and death does not allow time for skeletal involvement and hinders the study of epidemics among both historical and archaeological skeletal populations.

Epidemiology, as defined by its Greek root words Epi (upon), Demos (people), and Logos (thought/study), is a method of reasoning about disease as a population-based phenomenon in an environmental context (Duncan 1988:3). It is possible, therefore, despite the lack of skeletal lesions from epidemic diseases, to analyze an archaeologically derived skeletal population for death by epidemic. The foundation of such an analysis must draw upon a representative demographic profile with support provided by archaeological data.

Epidemiological inquiry views disease as the product of forces within a dynamic system consisting of the agent of infection, the host, and the environment--the epidemiological triad (Duncan 1988:3). Each component must be analyzed and understood for comprehension and prediction of patterns of disease. A change in any of the components will alter the equilibrium and either increase or decrease disease expression (Mausner and Bahn 1974:32).

Three epidemic types have been identified--physical, biological, and social (Fox et al. 1970:34-35). It may be argued that the Timucua were affected by a social epidemic, the key variables of which include population density, age distribution, culture, and cultural norms. The success of the epidemic depends upon these factors to provide an environment conducive to disease transmission between the infectious agent and a susceptible host. Environmental factors affecting both the agent and host tend to operate concurrently and in an interrelated manner. Missionization efforts provided the ideal environment for the rapid spread of Old World pathogens among susceptible peoples. Aggregation of native peoples provided the human reservoir necessary for the rapid transmission of disease.

The level of individual and population immunity is a critical variable as evidenced by the severe disease expression and high fatality rate when an epidemic, such as measles, is introduced into a virgin-soil population (see Panum 1940). In such instances no natural active immunity exists among the host population. Passive immunity is acquired and maintained for life by individuals who survive the disease. For example, measles infection results first in the disease and then lifelong immunity (Jolly and Levene 1985). In addition, mothers who survive a measles outbreak will confer passive immunity onto their children transplacentally.

A typical feature of any virgin-soil population epidemic is the undue susceptibility of the two extremes of life, infants and older adults, to infectious disease. Typically older adults have acquired life-long immunities to all communicable infections. Introduction of a new disease, however, confers a special vulnerability which is reflected in a sharp increase in mortality with age. Children, although easily infected, tend to cope with the infection and acquire passive immunity which will last throughout life. Young adults, lacking pre-existing immunity to the newly-introduced disease, may frequently demonstrate high mortality. Thus, although a newly introduced infection will severely impact upon all ages, mortality is likely to show peaks in infancy and old age, with often a conspicuously high death rate among young adults. When the disease persists, the only susceptible non-immune individuals are the newborns. Both the incidence of symptoms and mortality will then be highest in infancy and young adulthood (Burnet 1962).

The Concept of Stress

Along with the devastating effects of Old World epidemic pathogens, the potentially debilitating consequences of endemic disease stress must also be considered in an analysis of the biological environment of archaeologically derived populations. Endemic disease is a low-level frequency of disease maintained at moderately regular intervals within a geographic area. Unlike epidemic diseases, which kill quickly, many of these chronic and often life-long stressors leave behind skeletal lesions that can be macroscopically detected and analyzed.

Basically stress is a nonspecific, fundamentally physiologic response/change caused either by functional activity or damage that increases the vulnerability of the host. A stress reaction's primary objective is the maintenance of life and the re-establishment of normalcy during and after damage (Selye 1956:37). It is the failure of the stress response that leads to the development of disease. Seyle has identified two forms of stress, systemic and local. Systemic stress, or General Adaptation Syndrome (G-A-S), is a three-stage process involving: (1) the alarm reaction, (2) resistance, and (3) exhaustion or adaptation. Local Adaptation Syndrome (L-A-S), is a three stage, nonspecific process of local adaptive reaction comprising topical regressive (degeneration, necrosis) and/or progressive (inflammation, hyperplasia) changes (Seyle 1956:22). The Selyean concept of stress most significant in the reconstruction of the disruptive biological consequences on archaeological populations states that under the influence of systemic stress (G-A-S) a certain region in the body may selectively come to be the focus of intense topical stress (L-A-S). In such an instance a specific local focus of disease may selectively arise in a circumscribed region. These focal points of disease are frequently expressed as readily observable skeletal lesions.

Analyses of skeletal demography and pathology view stress as central to the reconstruction of adaptation in past populations (Goodman et al. 1988: 170). The concept of stress is typically employed in a variety of areas of anthropological research, including response to subsistence change, cultural disruption, environmental and social change, dietary inadequacies, and biological factors such as infectious disease processes. Thus interpretations of the effects of stress go beyond the mere presence or absence of the skeletal lesions manifest in archaeological populations. Factors such as age of onset, peak frequency of involvement, and degree and state of the lesions also provide insight into the etiology and dynamics of pathology (Palkovich 1987).

Thus, stressors do not operate in isolation, but function as interactive components in which

> adaptation to one stressor may transfer benefit (cross-adaptation) or interfere with adaptation to other stressors. While more complicated, consideration of adaptation to multistressor conditions provides a clearer picture of the adaptive "decisions," with attendant costs and benefits faced by individuals and groups. (Goodman et al. 1988: 172)

Typically the skeletal indicators of stress must be relatively severe or of a sufficient duration (chronic) to be observable. In the skeletal hierarchy of stress response, bones are less buffered than teeth, with more subtle skeletal and dental metabolic disruptions revealed at a microstructural level (Goodman et al. 1988:177). In the human skeleton, osteons, the building blocks of bone, are either laid down or resorbed, or it is possible for both processes to alternately occur. One of the primary functions of the skeletal system is to maintain the body's normal chemical balance. Disruption of this objective results in skeletal lesions indicative of stress. These abnormal conditions of the bone can be placed into four general categories: (1) abnormal bone loss, (2) abnormal bone gain, (3) a combination of abnormal bone loss and abnormal bone gain, and (4) normal quality of bone but abnormal shape or contour (Ortner and Putschar 1985:36). The following discussion considers the localized macroscopically visible skeletal markers/lesions of systemic stress, with the exception of Harris lines.

Skeletal Indicators of Systemic Stress

Enamel Hypoplasias

Enamel, the hard, calcified substance that covers the crown of the tooth, is formed by ameloblasts (enamel-producing cells) and built up through sequential secretions of a cementing substance (calco-globulin). In the development of the tooth, the deposition of dentine preceeds that of the enamel, so that the first layer of enamel is laid down next to a layer of immature dentine. The first deposits begin in the tips of the cusps and deposition proceeds uniformly from the tip of the crown downward to the tooth base. Enamel hypoplasias result from ameloblast death and failure to form enamel matrix during the initial stages of enamel development.

Hypoplasias are transverse linear depressions which form in the enamel during dental development as a response to a variety of systemic stressors, including nutrition, infectious disease, localized trauma, or metabolic stress. Enamel hypoplasias can thus be used to infer the nutritional adequacy of populations and aid in the analysis of systemic disturbances upon those populations. Typically hypoplastic banding has been associated with decreased longevity and nutritional status with peaks near the weaning period

(Goodman et al. 1988; Rose et al. 1985). Because the growth of dental tissue is cumulative and once formed remains unaltered, except through occlusal-surface attrition, which can obscure patterning, these disrupted growth patterns may be used to estimate an individual's developmental age at time of hypoplastic formation (Rose et al. 1985:282).

Dental Crowding

Dental crowding, which should not be confused with the genetic predisposition for mesially rotated maxillary central incisors (Enoki and Dalhberg 1958), is defined as the displacement of teeth from their anatomically correct position in the dental arcade. Although dental crowding may be an indication of nutritional or chronic stress in archaeological populations (Goodman et al. 1984), genetic, environmental, and even evolutionary factors appear to be more common causes. Goodman et al. (1984) note that some studies have demonstrated increased dental crowding and impacted molars in severely malnourished children. Guagliardo (1982) suggests that interference from exogenous chronic stressors, such as malnutrition or disease, may prevent teeth from developing to their full genetic-size potential. He hypothesizes that in any given population relatively smaller tooth crowns in juveniles would be one indicator of stressful living conditions.

Ortner and Putschar (1985) point out that the development of teeth are primarily under the control of genetic and environmental conditions that act independently of the factors that affect development of the jaws. This relationship most often results in inadequate jaw size and is expressed as dental crowding. Although crowding of teeth is inheritable, neither environmental causes nor the etiological factor of diet should be ignored (Corruccini 1991).

Mesial drift/migration is one of the functional responses of alveolar bone that has often been cited as a cause for dental crowding. Most frequently the distal teeth tend to drift mesially and fill in the space formerly occupied by a lost or missing tooth (Wheeler 1974:408). Without previous tooth loss, mesial migration of posterior teeth leads to pressures that cause the anterior teeth to overlap or block later-erupting teeth from full eruption (Lombardi 1982:40). Mesial drift may be an evolutionary response to differential wear on anterior and posterior teeth. As the anterior teeth are worn down or lost, horizontal replacement is achieved by the mesial migration of posterior teeth. This sequential replacement of worn teeth allows jaw size to be adapted to the environment without loss of chewing surface through wear. Mesial drift may be a survival adaptation favored by natural selection to maintain adequate masticatory function (Lombardi 1982).

As has been demonstrated, there are no clear and definitive etiologies that adequately explain dental crowding and associated tooth rotation and displacement. Etiologies such as disuse, nutrition, genetics, oral breathing, attrition, caries, decidious tooth exfoliation, muscle recruitment, temporomandibular function, habits, bruxism, and tongue dynamics have been studied for archaeological populations (Corruccini 1991). The belief in genetic predeposition appears, however, to be quite pervasive (Corruccini and Potter 1980; Corruccini and Whitley 1981). It seems evident however, that the full potential of the crucial role of environment upon this phenomena has yet to be fully understood.

Porotic Hyperostosis or Cribra Orbitalia

Porotic hyperostosis is characterized by thickened neurocranial diploë in conjunction with thinning of the outer dense cortical bone resulting in surface porosity. This hypertrophy of the cranial vault is the product of increased red blood cell production in the diploë, the spongy center layer of cranial bone. The diploë expands and places pressure on the outer table of bone. Macroscopically, porotic hyperostosis is easily distinguished by bone that is thickened, porous and sieve-like in appearance. Radiographs of affected diploë demonstrate striations radiating from the inner to the outer tables, the recognized hair-on-end effect of the trabecular bone.

An array of processes have been implicated in porotic hyperostosis of the skull, including genetic predisposition toward anemia, parasitic infections, dietary deficiencies, and infectious and metabolic disease (Ortner and Putschar 1985). Typically both porotic hyperostosis--lesions on the frontal, parietal, and occipital bones--and cribra orbitalia--lesions on the frontal bone along the superior border of the orbits--have been associated with the anemias, specifically iron-deficiency anemia, and tend to occur more frequently in populations ingesting a considerable amount of maize.

Differential diagnosis of the specific anemia involved, whether hereditary or nutritional, is often difficult. Lesion location, severity, and age/gender distribution are important diagnostic features. The association of other morbidity conditions, the interaction of cultural, environmental, and/or biological factors, and the role of infectious disease in increasing the frequency and severity of porotic hyperostosis must also be considered in the interpretation of porotic hyperostosis (Goodman et al. 1984; Lallo et al. 1977;

Mensforth et al. 1978; Ortner and Putschar 1985). Recent investigations, however, are increasing appreciation of the adaptability and flexibility of iron metabolism and affecting the commonly held notions of porotic hyperostosis as a pathologic condition. It has become apparent that diet plays a minor role in the development of iron-deficiency anemia and that iron deficiency (hypoferremia) is actually an adaptation to disease and parasite load. Thus, porotic hyperostosis is viewed not as a nutritional indicator, but as an indication that a population is attempting to adapt to the pathogen load in its environment (Stuart-Macadam 1992:39).

Harris Lines

Indicative of acute and/or recurring systemic stress, Harris lines are visible only by radiographs of the diaphyses of long bones, primarily the tibiae. Harris lines are the thin layers of horizontally oriented trabeculae formed by osteoblastic activity after a growth suspension followed by a growth spurt. Harris lines record compensatory acceleration of growth more than the cessation of growth. These opaque, transverse growth-arrest lines have typically been associated with episodic periods of stress in which growth is arrested and then followed by a period of recovery.

Although it is generally accepted that line formation appears to record a period of recovery from stress, there is little agreement over the precise cause of Harris lines. Harris lines, unlike other indicators of stress, do not correlate well with either higher mortality rates or additional specific stressors, such as enamel hypoplasias. Goodman et al. (1984) posit that if Harris lines are a valid indicator of stress, then they are more likely to indicate acute and episodic stress, such as famines, and/or epidemic episodes, than provide a record of cumulative stress. Other researchers posit that Harris lines may develop from slight subclinical infections with no accompanying history of severe illness, indicating that a trivial condition may produce a Harris line (Kent 1986:626). It is not possible to specify the precise interaction of gender and cultural factors in the etiology of line formation (Martin et al. 1985). Adding to interpretation difficulties is the fact that once formed, Harris lines may actually be resorbed and disappear. Older individuals tend to show fewer lines probably because they have had more time for resorption (Buikstra and Cook 1980). It appears that the record of stress exhibited by Harris lines is clearest and relatively unaltered by resorption in the earlier preadult years (Larsen 1987).

Periostitis

Periosteal reactions on the outer bone surfaces are indicators of non-specific infectious disease. These lesions may be caused by a variety of infectious agents and represent a reaction to pathologic changes in the endosteal and cancellous parts of the bone.

Periostitis can be part of a specific disease syndrome or a specific disease itself. Periosteal lesions are the most predominate forms of pathological skeletal involvement in archaeological populations. The most common example of periostitis in archaeological skeletons is fusiform bone hypertrophy along the diaphyses of long bones. The fusiform lesions may either be a solid mass of new bone or they may be layers of dense bone with intermediate, less dense or spongy layers in between, creating an onion-skin effect in cross or longitudinal section (Ortner and Putschar 1985:40). Lesions are of irregular thickness and elevation, tend to be unevenly distributed along the long bone surfaces, and are often accompanied by the fusiform expansion of the long bone shaft. The frequent reporting of non-specific periostitis in archaeological skeletal series is based upon the fact that, without clinical manifestations of many diseases, it is often impossible to diagnosis the specific disease process responsible for the expression of periosteal reactions. This undifferentiated and non-specific designation does not, however, eliminate the possibility that the periosteal reaction is secondary to a specific disease (Ortner and Putschar 1985:131-132).

Less frequently encountered in skeletal series is the more severe form of periostitis, osteomyelitis. Osteomyelitis is an infection of the bone involving the marrow. The introduction of pyogenic, i.e., pus forming, bacteria into the bone by direct infection, by direct extension from adjacent soft tissue infections, or by hematogenous distribution from a septic focus (Ortner and Putschar 1985:105) is expressed skeletally as osteomyelitis. Osteomyelitis is recognized by marked alterations of bone cortices, filling in of the medullary cavities with coarse, disorganized trabeculae, and exuberant proliferation of new periosteal bone (Milner 1991). Osteomyelitis is distinguishable from periostitis by severity of expression and the presence of cloaca, drainage sinuses, and sequestrum, dead bone, within a cavity.

While it is not possible to diagnosis the specific disease process responsible for periosteal lesions, it is accepted that these reactions are expressions of disease affecting the general health of an individual. The lesions are a bony generalized reaction to a low-grade or chronic disease condition. Because periostitis is so prevalent among archaeological populations, interpretations of periosteal reactions must incorporate the cultural milieu, differential expression by age and gender, additional indicators of stress, and the severity and timing of the expression.

Additional Indicators of Stress

In addition to those stressors which leave specific macroscopic lesions on bone, there are several population-level skeletal indicators of stress. The compilation of life tables and mortality schedules, which require a large and complete population or at least a representative sample, enhance the diagnosis of both chronic and severe stress indicators in all population subgroups.

Reduced stature in preadults relative to dental age may be indicative of chronic undernutrition. Depressed growth rates in adults, expressed as smaller body size and a decline in stature, are frequently attributed to reduced dietary resources and nutritional stress (Larsen 1987).

Within a population degree of sexual dimorphism may indicate differential access to essential nutrients and increased levels of stress during the preadult years. Although a number of environmental stressors, including nutritional inadequacies, effect the expression of human sexual dimorphism, it is not always possible to distinguish among such stressors (Stini 1985). When nutritional stress is involved the difference in body size between females and males decreases. In times of improved, or adequate, dietary resources these differences increase. Some evidence appears to indicate that males may be more susceptible to decline in nutritional quality during growth and development (Stini 1985). Thus, a decrease in sexual dimorphism, the result of reduced body size between the sexes, is actually the result of the greater impact of nutritional deficiencies upon the male skeleton. Genetics, age, activity, and survivorship differences have also been implicated (D. Cook 1984). Larsen (1987) hypothesizes that subsistence-related gender role differentiation would be expressed as developmental effects on skeletal and dental tissues and should, therefore, be reflected in skeletal differences between the sexes.

Summary

This chapter has discussed the importance of the biological and cultural environments in the analyses of archaeological collections. Skeletal lesions are not isolated phenomena, but represent the archaeological record of a lifetime of stresses imposed upon once-living peoples. A population-level analysis of skeletal pathology, which reports the incidence rates of disease by gender and age distribution, seeks a synergistic relationship between different disease processes, recognizes the contributions made by the host, pathogen, and environment to disease expression, and provides the foundation for interpretation of the etiology of disease as it once affected these groups. Thus, the biocultural perspective is essential to provide the most complete examination of such dynamic relationships.

It would be difficult, if not impossible, to isolate any one of the phenomena of cultural disruption, endemic stress, and/or disease imports as the sole contributor to the demise of the northern Utina. Unquestionably Spanish military action, forced labor of aboriginal populations, raids, rebellions, and disruption of settlement patterns and life-styles all acted in tandem with the introduction of Old World diseases to promote an atmosphere which fostered population decline and the ultimate destruction of the northern Utina. The consequences of the Spanish mission system, which drastically altered aboriginal lifestyles and promoted increased sedentariness and aggregation of indigenous populations, provided the ideal environment for spread of infectious diseases characterized by high morbidity and mortality. Although the study of epidemic disease is clearly relevant to our understanding of the process of native population and culture change in the Southeast (Milner 1980: 40), the dynamic relationship between culture, biology, and environment must be not be ignored.

The data obtained from demography and pathology, combined with a knowledge of the causes and consequences of disease and biological stressors, will allow inferences about the synergistic relationships at work among the mission-period northern Utina. Such relationships can only be revealed when multiple-disease profiles are evaluated as an interacting and dynamic unit. In this manner the sum of the whole is actually greater than that of its parts, as it reveals otherwise unobtainable insights into the lifeways of extinct populations.

CHAPTER VI
BIOANTHROPOLOGICAL INTERPRETATION OF THE SAN MARTÍN POPULATION: SAMPLE COMPOSITION

Burial Interpretation

Excavations of the San Martín sub-floor burials indicate that the extent of the burials corresponded closely to the size of the church, approximately 15 x 25 m. No physical evidence for coffins or shrouds was recognized. Interments parallel the east-west alignment of the church with the heads of the deceased to the east and the feet to the west. The majority of individuals were interred fully articulated (extended) and supine with hands clasped beneath the mandible or across the chest, a characteristic "Christian" posture recognized at all the known mission cemeteries throughout La Florida (Thomas 1990:383). In this respect the San Martín mortuary program is similar to other archaeologically documented burial programs across La Florida (Jones and Shapiro 1990; Larsen 1990; Thomas 1987, 1990). Although the location of burials inside the church walls and under the floor is unusual among mission burial episodes, it is strikingly similar to the mortuary program followed at the Santa Catalina de Guale mission where 431 individuals were recovered from beneath the church floor (Larsen 1990).

The majority of the San Martín burials represent interments of single individuals. Mass burial episodes are rare, but intrusive burials are relatively common. Of the eighty eight total burials, twenty six individuals were disturbed by intrusive burials, including five early interments (gray pit fill), which were disrupted by the placement of two architectural support posts. In the central portion of the church some burials were interred three deep in places, separated by only a fine lens of sand. All burials peripheral to this area were more ordered, probably aligned in rows. In the southern portion of the burial area, associated with the earlier church structure, all interments were undisturbed, primary, single burial episodes (Figure 6.1).

Although there is some evidence for location of burial in relation to age in other excavated La Florida cemeteries (Larsen 1990:22), excavations at San Martín did not reveal any evidence for preferential burial treatment by age, gender, or status. Although juvenile remains were recovered from all portions of the San Martín burial area, there appears to be a somewhat higher concentration of preadults from within the northeastern area of the excavation.

Grave goods are virtually absent from Spanish mission cemeteries, but do appear to become more common at late seventeenth-century missions (Jones and Shapiro 1990:506). Typical grave goods, although scarce, among Apalachee mission burials include glass or rolled copper beads. Contemporary Spanish burials in St. Augustine are likewise without grave goods, a mortuary pattern that is reminiscent of prevalent sixteenth- and seventeenth-century Hispanic Catholic custom (Thomas 1990:384). An unusually rich artifact assemblage was, however, recovered from the Santa Catalina de Guale mission cemetery. Spanish items, including beads, estimated to number in excess of 100,000, medallions, mirrors, rings, copper bells, crucifixes, majolica vessels and plates, rosaries, shroud pins and cloth, and a variety of aboriginal artifacts were all recovered during excavations (Larsen 1990:22). At the Santa Catalina de Guale mission cemetery, low burial density associated with a high

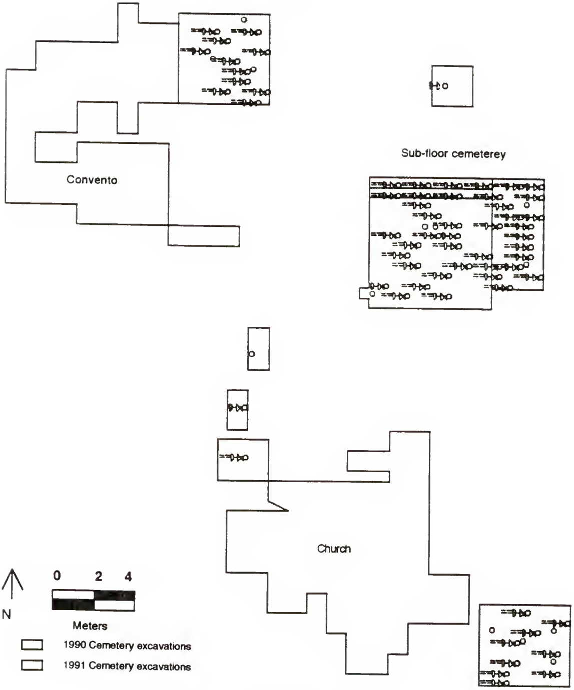

Figure 6.1
The San Martín burial area

The excavated portion of the San Martín burial area in relationship to the architectural features indicated by Weisman (1992a). The southeastern block is now believed to have existed by the earlier chapel and the central block directly beneath the later church. Also refer to Figure 4.2, page 51.

density of quality artifacts in close proximity to the altar, suggests variability related to social/status distinctions (Larsen 1990; Thomas 1990).

No such pattern was discovered at the San Martín mission. Rather, the almost complete lack of grave goods from within the San Martín cemetery corresponds with the reported norm for the majority of mission burial areas across La Florida. Four individuals (4.5%) were interred with heat-altered blue Spanish glass beads. A chert knife point was discovered resting directly upon the right scapula of a 45+ year-old female, who displayed no osteological trauma. The only exception to the seemingly impoverished burial program is a cut silver-alloy metal cross with Burial 91-59, a 25-30 year-old female, excavated from the southern portion of the burial area.

Demography: Materials and Methods

Archaeological skeletal collections offer unique opportunities to reconstruct the biocultural environment of past populations. Reliable demographic representation of human skeletal remains is essential for accurate portrayal of the record of events impacting once-living populations. The reconstruction of a representative demographic profile begins with an accurate estimation of age at the individual level. It is essential that each individual set of human remains be subjected to as many independent indicators of age (and sex) as possible. A systematic, consistent, and accurate age determination will establish the demographic profile as an invaluable tool for the reconstruction of the impact of cultural, social, biological, and environmental consequences at a population level. Adult age may be determined by evaluating several indicators, including age-accumulative modifications to the pubic symphyseal surface and auricular surface, occlusal wear patterns of the dentition, metamorphic changes in the sternal extremity of the fourth rib, age-related changes in the vertebral bodies, endocranial suture closure, and ossification of the thyroid cartilage. Skeletal age in the preadult may be determined by tooth eruption and calcification standards, epiphyseal union of long bones, linear growth of long bones, developmental sequence of the tympanic plate of the temporal bone, and union sequence of the four parts of the occipital bone (see review in Krogman and Işcan 1986).

Common to all biological anthropological analyses of skeletal populations is the basic and necessary assumption that the skeletal collection is a mortality sample of the living population from which it is derived (D. Cook 1981). This assumption mandates that all members of the living group who die during the period of time the burial area was in use will be interred within that burial area. It has been aptly demonstrated that inclusion of individuals in the burial area implies inclusion of those individuals in the corporate group (Binford 1971; Charles and Buikstra 1983; O'Shea 1981, 1984). Analysis of the San Martín skeletal series has been conducted with this fundamental assumption.

Several rather consistent trends have been noted among temporally and spatially distinct archaeological skeletal populations. First, many skeletal samples demonstrate a higher female than male mortality rate in the 20-30 year age interval. This relative increase in mortality has typically been explained as the result of birth-related trauma (see S. Clarke 1977). Second, there commonly tends to be a higher representation of males in archaeological skeletal collections (Weiss 1972, 1973). It has been suggested that the more gracile female skeleton and osteoporosis among postmenopausal women are in part responsible for the accelerated post-depositional destruction of female skeletal remains and thus their under-representation in the archaeological record (Walker et al. 1988). Third, infants and young children are typically under-represented. This trend has been attributed to rapid disintegration of incompletely calcified bones by taphonomic forces (Gordon and Buikstra 1981). Fourth, individuals over fifty years of age are likewise under-enumerated. Older adults are particularly vulnerable to bone loss with advancing age (osteoporosis), suggesting that these fragile remains would be increasingly susceptible to disintegration after burial (Walker et al. 1988).

The potential biases affecting demographic reconstruction of archaeological populations have long been recognized by the anthropological community. Despite attempts by Bocquet-Appel and Masset (1982, 1985) to sound the death knell for paleodemographic analysis, such studies continue to be the foundation of bioanthropological inquiries. Demographic data provide more than mere mortality profiles. This information contributes to a broader comprehension of health, disease, and growth and development from birth through adulthood in earlier societies (Larsen 1987:345). Van Gerven and Armelagos (1983), Buikstra and Konigsberg (1985), and Greene et al. (1986) have clearly demonstrated that paleodemographic analyses provide meaningful demographic reconstructions. These data, incorporated with environmental and cultural processes, provide insight into and understanding of otherwise unattainable dimensions that in turn facilitates reconstruction of the lifeways of extinct populations.

Aggregation of the native Timucuan population into the San Martín mission, which dates from at least 1608 to 1656, permits this skeletal series to be treated as a stationary population. It has been shown that, when dealing with skeletal samples spanning several generations, the assumption of a stationary population is justifiable (Weiss 1973). Important to skeletal series of limited size, such as those represented by mission populations, is Weiss' (1973) demonstration, based on observations of living groups and simulation studies, that even relatively small populations will effectively stabilize after significant demographic disruption. Thus, a burial area that has functioned over a period of years should provide a reasonably accurate means of characterizing the vital rates of a population (Buikstra and Mielke 1985:364).

Although overall preservation at the San Martín cemetery is good, the majority of the pubic symphyseal faces, articular surfaces of the long bones, and vertebral bodies, were subject to taphonomic forces that often precluded complete and intact retrieval from the soil matrix. Determination of adult age has, therefore, been largely based upon the auricular surface of the ilium (Lovejoy et al. 1985a), endocranial suture closure (Acsádi and Nemeskéri 1970), and dental wear patterns (Miles 1962, 1963, 1978). Immature individuals have been aged through tooth eruption and calcification standards, diaphyseal length of long bones (Ubelaker 1978), and epiphyseal closure of long bones (Bass 1987 ; Flecker 1942). Determination of adult gender has been based upon accepted features of cranial and mandibular morphology, postcranial general robusticity, sexual dimorphism (Bass 1987; Krogman and Işcan 1986) and pelvic morphology (Phenice 1969). Two years of excavation have demonstrated that the San Martín population is distinctly sexually dimorphic. Increased overall size and robusticity, clearly more pronounced among the male subset, is supported by traditional pelvic morphology (Phenice 1969).

The age profile of the San Martín skeletal population is similar to many archaeological series in that infants less than one year of age and adults over forty years of age are under-enumerated. Age estimations have been made through the application of multiple criterion and seriation of dental wear patterns. Seriation techniques ensure that groups of individuals are assembled with similar degrees of expression of a particular indicator. In this manner subtle age-related differences within categories permit maximization of informational content of the age determination system (Lovejoy et al. 1985a:3). Seriation techniques also reduce observer error, with the seriation of dental wear providing the most accurate and unbiased determination of age-at-death (Lovejoy et al. 1985a:12). It has been demonstrated that employing multiple aging criterion on both individual and population levels will improve accuracy and reduce the bias of final age estimates, thereby providing the most accurate estimates of age-at-death available (Lovejoy et al. 1985a). Thus, the estimation of age-at-death in an archaeologically derived skeletal series, when achieved by composite methods such as those described here, may actually provide more accurate mortality profiles than those derived from living "primitive" populations (Lovejoy et al. 1985a:12).

Application of these techniques to the San Martín skeletal series appears to indicate that taphonomy, in particular the acidic sandy soil matrix, is partially responsible for the age distribution observed here. Developmental dental ages assigned to twenty preadults shows that virtually all ages, save infants less than one year, are present. The majority of these remains are typically represented by cranial bones and dentition with post-cranial remains often poorly preserved. It has been demonstrated that with increasing soil acidity preservation of immature and incompletely calcified remains decreases. In fact, all or most of the infants and children may be systematically eliminated from the mortality sample by preservational bias (Gordon and

Buikstra 1981:569). These same taphonomic forces may also be partially responsible for the low representation of the older and more fragile skeletal remains in this series. The theory that the remains of infants and older adults are more susceptible to rapid disintegration after burial, may help explain the San Martín demographic profile. This concept alone, however, is not sufficient and alternative explanations may be more applicable. Although infants less than one are conspicuously absent from this sample, high mortality in preadults, over one year and less than twenty years of age, indicates that these individuals were recovered in relatively significant numbers. Taphonomy alone cannot explain this mortality profile. An optional hypothesis, for the biased age distribution of both children and adults, would incorporate the biological consequences of introduced New World pathogens (epidemics), endemic (chronic) stress, and cultural disruption. These issues will be addressed in following chapters.

Dental Wear and the Determination of Age-at-Death

At San Martín the teeth are better preserved and more abundant than most post-cranial skeletal elements typically used by archaeologists and biological and forensic anthropologists for aging. Chronological age stages have been developed for the San Martín northern Utina through a seriation of occlusal dental wear patterns based upon the method pioneered by Miles (1962, 1963, 1978). Not only does the Miles method develop a population-specific age profile, but numerous researchers have demonstrated it to be a reliable indicator of age-at-death (Keiser et al. 1983; Lovejoy 1985; Lovejoy et al. 1985a; Nowell 1978; B. H. Smith 1984; Wolpoff 1979). Of special importance for the San Martín population is the fact that Russell and co-workers (1990) have shown that modifications to the Miles system are both highly accurate and reliable for the Spanish mission period Guale, a contemporary La Florida population from the Georgia coastal region.

The Miles method compares degrees of functional wear (loss of occlusal surfaces through attrition) within a population to estimate age. A three-staged approach is necessary to develop the data set for this population-specific age structure (Walker et al. 1991). At least twenty immature individuals, aged by standard methods independent of tooth wear, are established as a baseline. Degrees of tooth wear are then recorded for the total population. Lastly a seriation is developed between the baseline and incrementally increasing degrees of wear observed across the sample. This premise is founded upon eruption patterns of the permanent molars. The first permanent molar (M1) erupts at age 6, the second permanent molar (M2) erupts at age 12, and the third permanent molar (M3) erupts at age 18. M1 will be in occlusion an average of 6 years longer than M2 and will thus average six more years of wear. M2 will average six more years of wear than M3 and M1 will average twelve more years of wear than M3. The time that the molars are in active occlusal wear is defined as the functional age of the tooth. Adding functional age to age of eruption determines chronological age. Thus, individual age can be assigned solely on the basis of the severity of dental wear (Walker et al. 1991).

Application of aging through dental wear is dependent upon two basic assumptions. First, it must be assumed that uniform eruption times are applicable for all immature individuals (Wolpoff 1979). As Russell et al. (1990:38) note, the dental calcification and eruption scheme developed by Ubelaker (1978) for Amerindian populations can be used with confidence to age preadults. Although rate and time of dental eruption may vary slightly with sex, race, and nutrition, these variations present virtually no bias when preadults are grouped into five-year age classes (Russel et al. 1990:38).

Second, it must be assumed that the pattern of wear is fairly consistent for all individuals and that the wear pattern for each tooth is independent of age and consistent in each tooth class (Walker 1978). Russell and co-workers (1990), through a literature review and independent testing on the Santa Catalina de Guale population, have demonstrated that although wear may not be consistent through life and may not be completely independent of age, an assumption of a linear relationship between occlusal wear and chronological age is valid as in population-specific analyses only limited directional error can exist.

Individuals included in the San Martín dental aging scheme had to have at least two molars present. Maxillary and mandibular dentition were independently seriated from youngest to oldest based upon dental development of the baseline sample (n=20) and incremental stages of wear. Baseline ages were developed through calcification and eruption patterns and supported, when possible, by stages of long bone epiphyseal closure. Independent aging of the adult remains was achieved through analysis of metamorphic changes in the auricular surface (Lovejoy et al. 1985b) and endocranial suture closure (Acsádi and Nemeskéri 1970).

Unfortunately there were no individuals in the 36-40, 41-45, and 46+ age categories with at least two molars available for seriation. Thus stages 7, 8, and 9 have been estimated based on the steadily increasing rates of occlusal attrition observed in Stages 1 through 6 and supported by the auricular surface and endocranial suture closure aging methods. Table 6.1 and Figure 6.2 report these results.

Analysis of demography and pathology has been conducted on a total of eighty eight skeletons on two basic levels. First, age and gender were assigned and calculated for the series as a whole unit. Then, because stratigraphic evidence indicates two distinct church burial episodes, the data were divided into relatively early and late population subsets. This internal microchronology, in which burial pit fill color is correlated with temporally distinct interment episodes, has allowed a primary analysis of changing disease patterning over time. These results are reported in Chapters 7, 8, 9, 10, and 11.

TABLE 6.1
Functional age and stages of dental wear

Stage 1:

M1: Slight polish of all cusps. Initial faceting occasionally appearing on maxillary lingual cusps and mandibular buccal cusps.

Age: 8-9 years.

Stage 2:

M1: Virtually all cusps display distinct facets. If polished cusps still exist they tend to do so bucally in the maxillary dentition and lingually in the mandibular dentition.

M2: Polish of all cusps.

Age: 11-15 years.

Stage 3:

M1: Majority of cusps are distinctly faceted (completely flattened). Initial stage of dentine exposure, occurring lingually on the maxillary cusps and bucally on the mandibular cusps.

M2: All cusps display distinct faceting, but are not totally flattened.

M3: Unerupted. Crypt open.

Age: 15-17 years.

Stage 4:

M1: Dentine exposure of all maxillary and mandibular cusps. Maxillary wear is more pronounced lingually. Mandibular wear is more pronounced buccally--cusps are beginning to cup.

M2: Distinct faceting of all cusps.

M3: Polish of all cusps. Initial faceting occasionally appearing on all cusps.

Age: 21-25 years.

TABLE 6.1--continued

Stage 5:

M1: Dentine exposure of all maxillary and mandibular cusps. Dental cupping and coalescing are prominent on maxillary lingual cusps and on mandibular buccal cusps.

M2: Distinct faceting of all cusps. Dentine exposure on maxillary lingual and mandibular buccal cusps.

M3: Distinct faceting of all cusps.

Age: 26-30 years.

Stage 6:

M1: All cusps are coalescing. Coalescing of the maxillary lingual and mandibular buccal cusps is more pronounced. The coalescence is approaching the lingual-buccal boundary.

M2: Maxillary buccal cusps and mandibular lingual cusps all display dentine exposure and a strong tendency for cupping. Maxillary lingual and mandibular buccal cusps are coalesced.

M3: Dentine exposure on all cusps with tendency for maxillary lingual and mandibular buccal cusps to cup.

Age: 31-35 years

Stage 7:

M1: All cusps are now coalesced, the lingual-buccal boarder has been crossed.

M2: All cusps are coalesced. The coalescing of the maxillary lingual and mandibular buccal is more pronounced and approaching buccal and lingual boarders respectively.

M3: Dental cupping of all cusps with a tendency for maxillary lingual and mandibular buccal cusps to coalesce.

Age: 36-40 years

TABLE 6.1--continued

Stage 8:

M1: All cusps coalesced with a relatively small ring of enamel maintained along the outer margins.

M2: All cusps are now coalesced, the lingual-buccal boarder has been crossed.

M3: All cusps are coalesced. Coalescence is more pronounced on maxillary lingual and mandibular buccal cusps which are approaching buccal and lingual boarders respectively.

Age: 41-45 years

Stage 9:

M1: Relative increase in coalescence, with little or no remaining enamel ring.

M2: All cusps completely coalesced. A ring of outer enamel is maintained.

M3: All cusps are coalesced.

Age: 46+ years

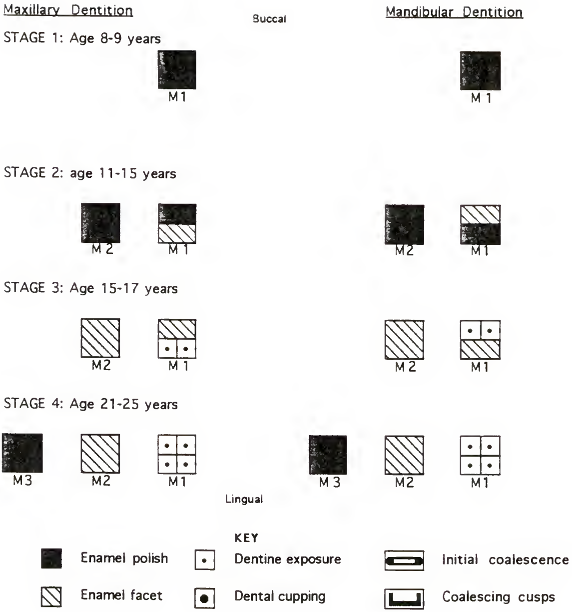

Figure 6.2
Dental wear stages and chronological age

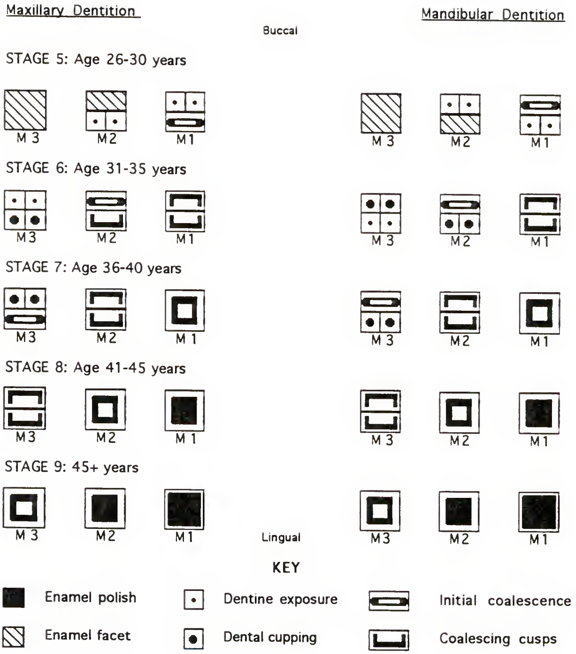

Figure 6.2--continued

CHAPTER VII
DEMOGRAPHIC ANALYSES

Based upon ethnohistoric documentation and the hypotheses of Henry Dobyns (1983) outlined in Chapter V, it was expected that the San Martín skeletal series would provide evidence of a population impacted by the introduction of Old World diseases. If this population had no previous contact with European pathogens, then it would exhibit a high mortality profile for life's two extremes, infants and older adults. A conspicuously high death rate in the young adult age group might also be expected (Burnet 1962). Analysis of the San Martín mortality profile does not, however, support death by epidemic(s) for this particular mission population.

Taphonomy (see Chapter VI) has been discussed as one factor responsible for the absence of infant (0-1 year of age) and older adult (over thirty years of age) premains in this sample. Alternatively, it may be suggested that infants were not interred in the church. It might be expected that infants dying before the age of one year would not have been baptized and would therefore have been excluded from burial in consecrated grounds. Excavations within the San Martín burial area proper and across the remainder of the site have, however, yielded no evidence for additional or separate burial areas. In addition, historic records do not indicate preferential burial treatment for a specific segment of mission society--all individuals were afforded equal burial treatment. Until further excavations demonstrate otherwise, it must be assumed that all individuals who lived at the San Martín mission were interred beneath the church floor or around the smaller chapel. It has also been demonstrated that, although infants are conspicuously absentfrom the sample, the uncalcified remains of preadults represent 26% of the sample recovered from the San Martín cemetery. The small proportion of infants in this mission sample does, however, indicate that some sampling error may be related to preservation. Although it seems unlikely, it may be possible that actual infant mortality among the San Martín population was not high. Transplacentally acquired immunities may have ensured that a significant proportion of infants survived their first year. After age one, the effects of prolonged weaning and nutritional deficiencies would be reflected in a relative increase in mortality among young children. This hypothesis will be discussed further in Chapter VIII under the heading Enamel Hypoplasias.

The Demographic Profile

The actual number of deaths (D_X) and percent of deaths (d_X) at each age interval are presented in Table 7.1 and Figure 7.1. These data indicate that the percentages of deaths occurring between 1-5 years of age (10.2%) and 6 to 15 years of age (15.9%) are low. The low mortality rates among young children and preadults does not appear to support evidence for death by epidemic.

The proportion of individuals dying between 21 and 25 years of age is also low--15.9%. However, a significant percentage of the population has died between 26-30 years of age and this period is followed by a relatively suppressed mortality in the remainder of adults. Although the combined mortality rate for individuals between the ages of 21-30 years, 46.6%, is relatively high, it is impractical to hypothesize, on this figure alone, for death by

TABLE 7.1
Mortality profile:
Number of individuals (D_x) and percentage of deaths (d_x)

AGE (x)	D_x	d_x
0-1 years	0	0
1-5 years	10	11.4
6-10 years	8	9.1
11-15 years	6	6.8
16-20 years	1	1.1
21-25 years	14	15.9
26-30 years	27	30.7
31-35 years	10	11.4
36-40 years	2	2.3
41-45 years	1	1.1
45+ years	3	3.4
Adult	6	6.8
Total aged	88	99.9

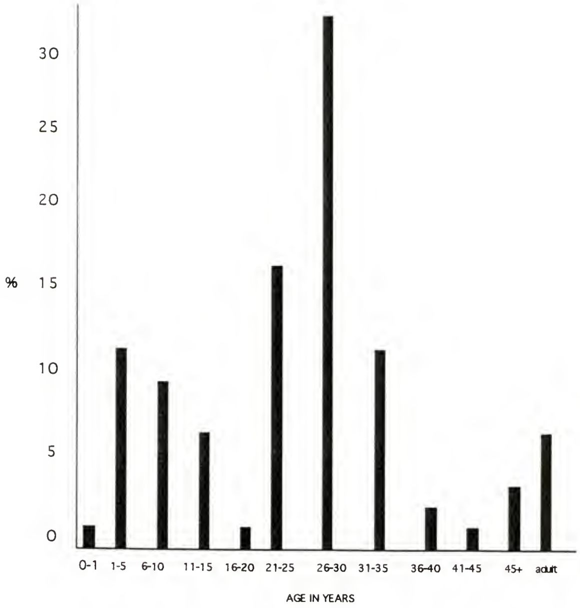

Figure 7.1
Mortality profile

epidemic. It is not likely that if the San Martín population lacked previous encounters with Old World pathogens that only this segment of the community would have been affected and the remaining susceptible individuals would have gone unscathed.

Older adults represent only 18.2 % of the mortality profile. In death by epidemic, it would be expected that this population subset should also be well represented. It has been suggested that differential preservation of the older and more fragile adult remains is partially responsible for this trend. It is also possible that random differential preservation across the site could have affected the demographic profile. Recovery of preadult remains and lack of evidence for preferential burial treatment argues against the hypothesis that taphonomy alone is responsible for the under-representation of older adult remains.

Life tables have been constructed to better utilize the assigned age estimates in the assessment of the impact of European contact on this northern Utinan mission population. Life tables permit the computation of mortality rates in extinct populations and facilitate interpretations of population-level health. Life tables computed from cemetery data are composite life tables as they represent mortality patterns summed across several generations (Buikstra and Mielke 1985:395).

In virtually any analysis of skeletal populations, some remains do not easily fit into the assigned age intervals. To maximize the data derived from life tables, it is more reasonable to distribute these remains across age intervals than to omit ambiguous skeletons (Buikstra and Mielke 1985:397). Assuming that these adult individuals follow the age ranges identified in Table 7.1 allows adults of unknown age to be distributed among the adult age intervals. The distribution of adults of unknown age at death was accomplished following a procedure explained by Larsen (1982:197). A collection-specific weight factor is derived by dividing the total number of adults by the number of adults of known age. For the San Martín collection, a weight factor of 1.1 was calculated by dividing the total number of adults (n=65) by the number of adults of known age (n=59). The weight factor was multiplied by the actual number of individuals in each age interval. This corrected age distribution (Table 7.2) represents a more realistic reconstruction of age profiles and was, therefore, the one used in construction of the San Martín life table (Table 7.3).

Although the potential under-enumeration of preadult remains has been discussed, it has been demonstrated that missing age sets, such as infants, do not affect all statistical values for other age groups (J. Moore et al. 1975). The probability of dying (q_x) and life expectancy at birth (e_x) are little affected by under-enumeration in previous cohorts and thus remain viable in the face of under-enumeration error. Life tables, therefore, provide the foundation for interpretation of the cultural, biological, and environmental processes affecting extinct populations.

Weiss (1973) indicates that between 30% and 70% of the preadults in any archaeological population will die before age fifteen. An archaeological collection that demonstrates a lower percentage of preadult remains would indicate that a portion of this cohort was either absent from the mortuary site or not recovered. San Martín individuals less than fifteen years of age comprise 27.2% of the population, indicating that preadult under-enumeration is not a serious problem.

Examination of the San Martín life table (Table 7.3) reveals low infant mortality and a life expectancy at birth of 23.5 years. Individuals surviving to

TABLE 7.2

Redistribution of mortality profile:
Number of individuals (D_x) and mortality (d_x) in age classes

AGE (x)	D_x	d_x
0-1 years	0	0
1 year	1	1.1
2 years	3	3.4
3 years	3	3.4
4 years	2	2.3
4.9 years	1	1.1
5-9.9 years	8	9.1
10-14.9 years	6	6.8
15-19.9 years	1	1.1
20-24.9 years	16	18.1
25-29.9 years	30	34.1
30-34.9 years	11	12.5
35-39.9 years	2	2.3
40-44.9 years	1	1.1
45+ years	3	3.4
Total aged	88	99.8

Table 7.3
Life table

x	D_x	d_x	l_x	q_x	L_x	T_x	e_x
0-1	0	0	1000	0	1000	23484	23.5
1	1	11	1000	11	994	22484	22.4
2	3	34	989	34	972	21490	21.7
3	3	34	955	36	938	20518	21.5
4	2	23	921	25	909	19580	21.2
4.9	1	11	898	12	892	18671	20.8
5-9.9	8	91	887	102	4207	17779	20.0
10-14.9	6	69	796	86	3807	13572	17.0
15-19.9	1	11	727	15	3607	9765	13.4
20-24.9	16	182	716	254	3125	6158	8.6
25-29.9	30	341	534	638	1817	3033	5.7
30-34.9	11	125	193	647	652	1216	6.3
35-39.9	2	23	68	338	282	564	8.3
40-44.9	1	11	45	244	197	282	6.3
45+	3	34	34	1000	85	85	2.5

x = age interval
D_x = actual number in sample dying
d_x = cohort based on 1000
l_x = number of individuals living at age x
q_x = probability of dying at age x (d_x / l_x multiplied by 1000)
L_x = life years lived by the initial cohort of 1000 during interval x
T_x = cumulative sum of L_x beginning at bottom of column
e = life expectancy at birth (T_x / l_x)

age five, would be expected to live an additional twenty years. An individual living to age ten, would live another seventeen years, and so forth. Mortality remains relatively depressed through age ten, after which a slight increase is observed. The probability of dying increases significantly at age twenty five, also marking a significant decrease in survivorship rates. Mortality increases dramatically between 25-35 years of age and is followed by a relative increased chance of survivorship until age 45+ (Figure 7.2). Suppressed mortality rates after thirty five years may, however, reflect a lower percentage of these individuals in the living cohort.

Although biological and cultural factors, as outlined in Chapter V, would have provided an ideal environment for the transmission of Old World pathogens, demographic evidence for death by epidemic is not present in either the San Martín mortality profile or the archaeological record. Epidemics, such as measles and smallpox, do not have long incubation periods, but kill significant portions of a population quickly. These fatal virgin soil epidemics are frequently over within one month. In a population decimated by epidemics, it would be expected that large numbers of individuals would have had to have been buried quickly. The burial pattern at the San Martín mission is largely one of single interments with individuals placed in orderly rows. Although one multiple burial (n=2) and one mass burial instance (n=3) have been discovered, they scarcely represent evidence for the type of burial pattern expected in times of epidemics. Lack of grave markers on the church floor or loss of such markers over time may explain the relatively common intrusive burials, comprised primarily of earlier interments disturbed by later interments.

Ethnohistoric reports provide strong documention for three devastating epidemic episodes among the Apalachee, Guale and Timucuan mission

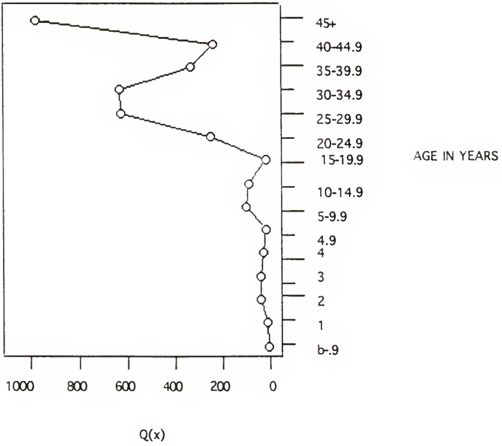

Figure 7.2
Probability of dying at a certain age

populations between 1649 and 1659. It is reported that the Timucuan were particularly hard-struck by smallpox and measles during this interval. Between 1672 and 1674, an unidentified pathogen further decimated Timucua populations. These epidemics may have occurred late enough in the history of the San Martín mission (1608-1656) that evidence for such events would be absent in the archaeological record.

Spanish documents record the location of the San Martín mission as off the beaten path (desviado) from St. Augustine and, thus, upon a southern mission trail that did not see extensive use early in the mission period (Milanich and Johnson 1989:10). The isolation of this settlement may have saved the mission population somewhat from the devastating effects of the earlier epidemics.

> Rebolledo's use of the more remote northern Utinan villages as a population reservoir from which to replenish the depopulated mission centers on the royal road suggests that their location may have protected them to some degree from the worst ravages of the plagues of the 1649-1656 and the 1613-1617 periods . . . . (Hann 1986:378)

Atypical of mortality profiles reported for the majority of archaeological skeletal series, the San Martín sample does not demonstrate a generally higher female mortality rate, particularly between the ages of 21 to 25 years. Between 26 to 30 years of age the genders are equally represented (Tables 7.4 and 7.5 and Figures 7.3 and 7.4). The female mortality profile is, however, basically bimodal with peak mortality occurring between 26 to 30 years of age. This pattern suggests that death at this age may be partially attributable to birth-related trauma. In contrast, the male mortality profile is unimodal, but like the female sample appears to be young.

TABLE 7.4
Demography: Gender ratio

SEX	NUMBER	%
Female	22	25.0
Male	30	34.1
Adult	13	14.8
Preadult	23	26.1
Total Number of Individuals	88	100

TABLE 7.5
Demography: Combined gender and age data

AGE	SEX		
	Female	Male	Adult
11-15 years	1	0	0
16-20 years	0	1	0
21-25 years	5	8	1
26-30 years	11	11	5
31-35 years	2	6	2
36-40 years	0	2	0
41-45 years	0	1	0
45+	1	1	1
Adult	2	0	4
MNI	22	30	13

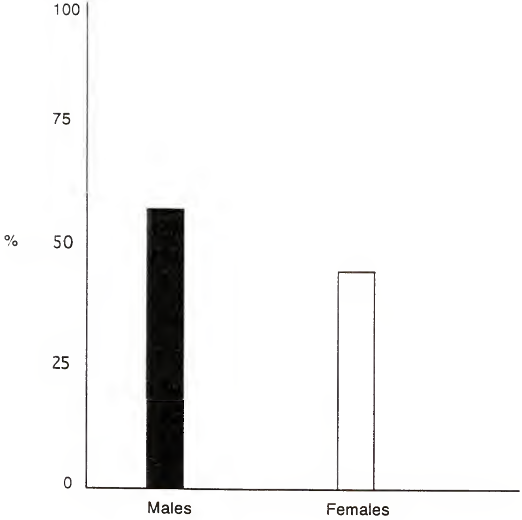

Figure 7.3
Mortality based on 52 individuals of identified gender

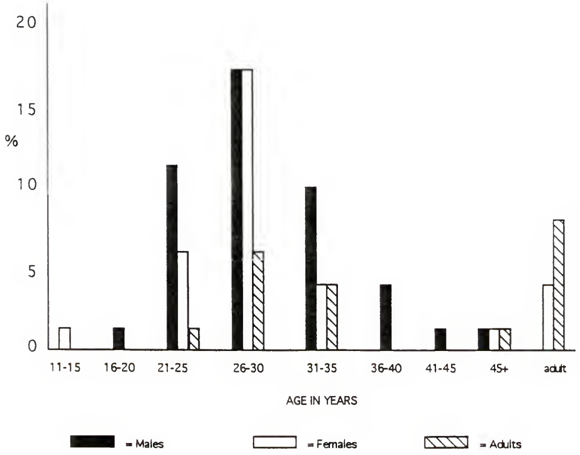

Figure 7.4
Demography: Age to gender ratio

TABLE 7.6
Demography: Early versus late populations

EARLY (MNI=31)

AGE	?	Female	Male
0-1	1	0	0
1-5 years	4	0	0
6-10 years	3	0	0
11-15 years	2	1	0
16-20 years	0	0	1
21-25 years	0	2	2
26-30 years	0	1	6
31-35 years	1	2	1
36-40 years	0	0	0
41-45 years	0	0	1
45+ years	0	0	0
Adult	1	2	0
	12	8	11

LATE (MNI=16)

AGE	?	Female	Male
0-1	0	0	0
1-5 years	0	0	0
6-10 years	2	0	0
11-15 years	2	0	0
16-20 years	0	0	0
21-25 years	0	0	4
26-30 years	2	1	2
31-35 years	0	0	2
36-40 years	0	0	0
41-45 years	0	0	0
45+	0	0	1
Adult	0	0	0
	6	1	9

Although small sample size makes speculation about sex ratio differences between the early and late populations impractical, there is a noticeable lack of female representation in the late population (Table 7.6). Typically in archaeological skeletal collections there is a regular and systematic sexing bias which tends to favor males (Weiss 1972). This bias is most frequently encountered, however, among collections represented by older skeletons, which themselves tend to display more masculine traits, e.g., areas of muscle attachment. The young age profile of the San Martín skeletal collection does not indicate that such a bias should have affected demographic analysis. It is difficult to speculate upon this occurrence other than to report that a late seventeenth-century visitation record documents the presence of significant numbers of Apalachee men, unaccompanied by women, in Timucuan province working as contract laborers (Hann 1986:379).

Johansson and Horowitz (1986) have suggested that mortality based on closed and stationary populations is unrealistic. They argue that mortality can only be estimated independently of estimations of growth rate. Fertility can, however, be estimated directly from mean age-at-death. Therefore, age-at-death has an inverse relationship to fertility. Milner et al. (1989) also argue that fertility has more of an effect than mortality on age-at-death distributions. Sattenspiel and Harpending (1983) advocate that because mean skeletal age is reciprocal to birth rate and not correlated with the death rate, it is not possible to infer changes in life span and death rate from changes in mean age-at-death. In light of these theories, it appears that the decrease in the adult mean age-at-death among the San Martín population may actually represent an increase in fertility and thus population growth. This is puzzling, given the readily accepted hypothesis that European contact, and especially the missionization of aboriginal populations, depressed both mean age-at-death and population growth. If the San Martín population was buffered from the ravages of Old World pathogens and continued to thrive, then it is possible that fertility rates increased at this particular mission. It may also help to explain the tendency for the ability of certain villages in this area to "hold their own, or even to grow, despite the province's general secular trend toward sharp demographic decline" (Hann 1986:379).

Horowitz et al. (1988) argue, however, that the inverse of the birth rate as a substitute for the average age of death is actually an artifact of high mortality at an early age. The authors advocate that archaeological populations with relatively larger proportions in the younger age groups will bias demographic patterning.

> The result is a lower value for the mean age of death in that population. This is reversed when births are decreasing in the population. Therefore, it is obvious that the mean age of death is age structure dependent. (Horowitz et al. 1988:184)

Thus, rather than interpret mean age at death as a measure of population fertility, alternative models and techniques which provide insights into population-specific demographics must be sought. Therefore, an optional explanation for the San Martín demographic pattern would point to the continued amalgamation of dispersed northern Utinan groups into the mission cohort. Alternatively, mission life was hard and short.

Summary

It has been suggested that taphonomy and differential burial practices are not sufficient to explain what may be infant and older adult under-enumeration in this mission cemetery population. Alternative hypotheses, which seek to establish a chain of causation and identify the etiological factors of disease, must be utilized to explain the impact of biocultural stressors upon this population. Neither the San Martín mortality profile nor the burial program support a hypothesis of death by epidemic. Rather, mortality peaks between 26-30 years of age and suggests that mission life was relatively difficult and short. These topics will be addressed in the following chapters.

CHAPTER VIII
DENTAL PATHOLOGIES

The Etiology of Dental Caries

The word "caries" is derived from the Latin caries, which means rottenness. Dental caries is a disease process characterized by the focal demineralization of dental hard tissues by organic acids produced by the bacterial fermentation of dietary carbohydrates, especially sugars (Larsen 1987:375). Highly cariogenic foods, such as maize, are known to promote tooth decay as they contain a relatively large amount of the simple sugar sucrose, which acts as a pathway for oral bacteria, including Lactobacillus acidophilus and Steptococcus mutans (Keyes 1968). The bacteria produce an acid that destroys the enamel and eventually the underlying dentine. Thus, dental caries is a pathological process that affects either the occlusal, buccal, cervical, and/or interproximal tooth surfaces or the tooth root after destruction of the enamel or recession of the gingiva. This pathological condition is a common contributor to the high rate of antemortem tooth loss observed in many archaeological populations, populations typically lacking appropriate measures and medical intervention to prevent the decalcifying effects of acids upon dental enamel.

To understand the etiology of dental caries it is essential that the condition be viewed as a complex interactive process. The major factors that influence and contribute to the development of caries are environmental components, such as the mineral content of soil and water and dietary abrasives; pathogenic agents, such as the oral bacteria lactobacilli and stretococci; exogenous factors, including the chemical composition and texture of diet; and endogenous factors, including tooth-crown morphology, enamel integrity, and salivary ions and flow rate (Powell 1985). Larsen et al. (1990) have divided the components involved in the development of dental caries into essential factors, including occlusal surface exposure, oral bacteria, and diet, and modifying variables, such as occlusal attrition, enamel defects, age, heredity, and certain systemic diseases. Basically, the three components that affect caries epidemiology are the pathological agents responsible for lesions, an oral environmental conducive to the development of lesions, and host susceptibility, including both physiological and morphological characteristics (Powell 1985).

Biological Anthropological Dental Caries Research

The study of human dentition has provided anthropologists with a wealth of information on the interaction between diet, food preparation techniques, and dental health in archaeological populations. Powell (1985) notes that the relationship between diet and dental disease was first recognized by Aristotle who remarked that the adherence of figs to the teeth was associated with dental caries. Mummery (1869), who examined dental caries in archaeological and contemporary dentitions, may be credited with the first controlled study of the relationship between diet and dental health in archaeological populations. Research by Corbett and Moore (1976) Moore and Corbett (1971, 1973, 1975) has confirmed Mummery's (1869) conclusion that the incidence rate of caries among pre-Columbian British populations increased over time. Moore and Corbett concluded that caries rate was a direct correlate of reduced attrition and increased carogenic plaque as a result of a simultaneous increase in refined foods and dietary sugars.

For more than a century studies hypothesizing the relationship between the frequency of dental caries, diet, and dental health in both archaeological samples and among contemporary populations, have been conducted in virtually every area of the globe. Australian aborigines (Cran 1959), Neolithic agriculturists of Jarmo, Iraq (Dalhberg 1960), Mesolithic Nubians (Armelagos and Rose 1972), the Masi (Schwartz 1946), Aleutian Island Eskimos (Moorrees 1957), and North American Indian populations (Leigh 1925) have all been the focus of dental caries research.

Leigh's (1925) classic comparison of four pre-Columbian North American Indian groups demonstrated that a higher incidence rate of caries existed among those populations with an agricultural lifeway than among those with a nonagricultural or mixed economy subsistence pattern. More recently this trend has been confirmed by Turner (1979) who reviewed the literature on reported caries rates among distinct groups practicing different subsistence economies and then calculated population percentages of teeth affected by carious lesions.

> The variability of caries as assessed by the range of frequencies of carious teeth increases from hunting and gathering economies (0.0-5.3%), through the mixed economies (0.44-10.3%), to the agricultural ones (2.3-26.9%). (Turner 1979:624)

The average population frequencies of carious lesions among hunter-gatherers (1.3%), mixed economists (4.8%), and agriculturalists (10.4%) indicate that nonagriculturalists had fewer carious teeth than did agriculturalists (Turner 1979). Archaeological populations from eastern North America exhibit a frequency of 0.4 to 7.8% carious teeth for hunter-gatherers and a frequency of 4.5 to 43.4% for agriculturists (Milner 1984). Larsen et al. (1991) have analyzed the published data discussing the frequencies of carious lesions from an additional seventy five eastern North American sites and have found that populations known to have incorporated maize into their diets generally had higher caries rates (in excess of 7%) than populations without dietary maize (less than 7%). Rose and co-workers' (1984, 1991) analyses of archaeological populations from the central and lower portions of the Mississippi Valley demonstrate that the dividing line between high and low carbohydrate diets occurs at a rate of two carious lesions per individual. Studies such as these have produced general agreement among the physical anthropological community that the incidence of dental caries increased as populations shifted from a hunter-gatherer lifeway to agricultural subsistence patterns (Cohen and Armelagos 1984).

Materials and Methods

A total of 1,489 teeth from 75 individuals were macroscopically examined on all visible surfaces for dental caries with a dental explorer. Loose teeth not associated with individual burials were not included in this analysis. Information was recorded for size, location, and prevalence of carious lesions. Observations on caries size and location is consistent with that reported by Larsen (1982), Corbett and Moore (1976), and Moore and Corbett (1971, 1973, 1975).

Caries observations for the present study included size and location of carious lesions on each permanent and decidious tooth. Lesion size was divided into three categories: (1) incipient (small pit); (2) medium (pit not extending to the pulp chamber); and (3) gross (pit involving the pulp chamber at minimum and total crown destruction at maximum). Four types of lesion locations were observed for each carious tooth: (1) occlusal (grooves and/or cusps); (2) buccal (pit and/or groove); (3) interproximal (tooth contact area); and (4) cervical (enamel-root junction). If cariogensis had produced nearly total crown destruction, its location on the tooth was recorded as unknown because the place of origin of the lesion on the tooth had long since been obliterated by the decalcification process. (Larsen 1982:189)

Caries prevalence/percentage rates were calculated in three different ways. First, the average population frequency of carious lesions was obtained by dividing the total number of lesions by the total number of teeth observed. Second, the number of carious individuals was derived by dividing the number of individuals with at least one dental cavity by the total number of individuals observed. A true prevalence rate is not, however, achieved by merely calculating the percentage of individuals with dental caries, as the number of antemortem or postmortem teeth absent in any given individual will affect these rates. A more significant and representative comparison of percentage of teeth affected by dental caries is derived by calculating the prevalence of caries for each tooth type. This third level of analysis was achieved by dividing the number of carious lesions in a specific tooth type by total number of that tooth observed. The sample was then subdivided by age, by age and gender, and further subdivided into early and late populations.

Individuals in the age categories of birth-to-20 years and 40+ years displayed no carious lesions of the permanent dentition. The birth to 20 age sub-sample is composed of twenty five individuals with all tooth types, both decidious and permanent, represented. The 40+ age category is made up of only three individuals.

Results and Discussion

Four general population trends were discovered. First, that the posterior teeth (premolars and molars) demonstrated a higher frequency of dental caries than did the anterior teeth (incisors and canines). Second, mandibular molars were three times as likely to have been affected by dental caries than maxillary molars. Third, dental caries were an age-accumulative process. Fourth, males were somewhat more prone to carious involvement than were females.

The average population frequency of carious lesions is 4.7% (72 carious teeth of 1,489 observed). Nineteen of seventy five individuals were affected by dental caries (25.3%) (Table 8.1, Figure 8 .1). Observations for carious lesion size in the permanent dentition demonstrate that lesions were either incipient or gross. Occlusal caries predominate (59 of 72 observable caries or 82.9%), followed by interproximal (7 of 72 for 9.7%), and cervical (6 of 72 or 8.3%). This pattern is expected given the complex morphology of the posterior dentition, particularly the molars. Incipient (51%) and gross (49%) dental caries are virtually equal for occlusal foci. Interproximal and cervical caries were incipient only and there were no buccal-labial smooth surface carious lesions.

Although both anterior and posterior teeth are virtually equally represented in the sample, the posterior mandibular dentition show a marked predilection for carious involvement. The molars, and specifically the mandibular molars, are the tooth type most affected by carious lesions (Table 8.2 and Figures 8.2 and 8.3).

The trend of a higher carious frequency rate among the posterior dentition has been noted by numerous researchers of both pre-Columbian and historic populations practicing a wide variety of subsistence modes (see Powell 1988 for discussion). Tooth crown size and tooth morphology are significant contributing factors and perhaps the most influential of the endogenous factors (Powell 1985:317).

The shape and size of teeth is intimately associated with susceptibility to pit and fissure caries. The presence of pits on a tooth surface may be the single most

TABLE 8.1
Caries rates for total number of teeth and individuals

Teeth	Individuals
4.7%	25.3%

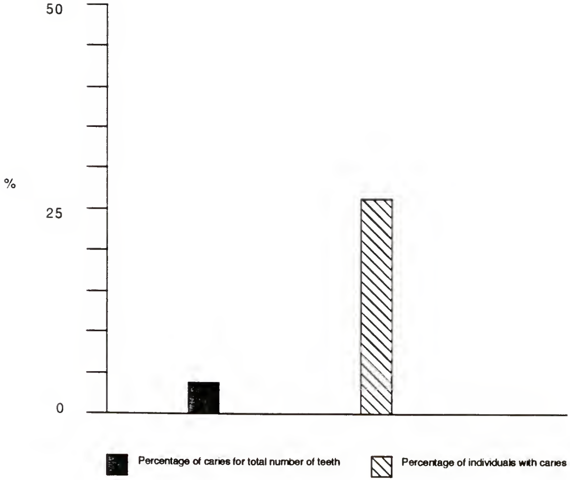

Figure 8.1
Dental caries rate

TABLE 8.2
Dental caries by tooth

Maxilla

Tooth	Number observable	Number with caries	%
I1	82	0	0
I2	84	0	0
C	96	1	1.0
P3	105	4	3.8
P4	108	3	2.8
M1	100	4	4.0
M2	94	3	3.2
M3	76	4	5.3
TOTAL	745	19	2.5

Mandible

Tooth	Number observable	Number with caries	%
I1	95	0	0
I2	93	0	0
C	103	1	1.0
P3	106	4	3.8
P4	104	6	5.8
M1	91	14	15.4
M2	87	16	18.4
M3	65	13	20.6
TOTAL	744	54	7.3

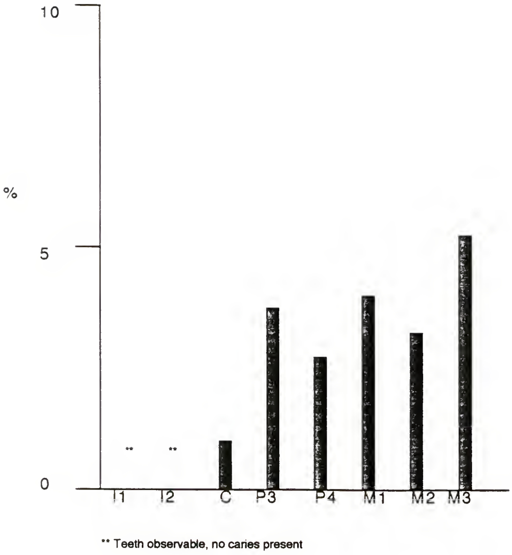

Figure 8.2
Maxillary dental caries by tooth

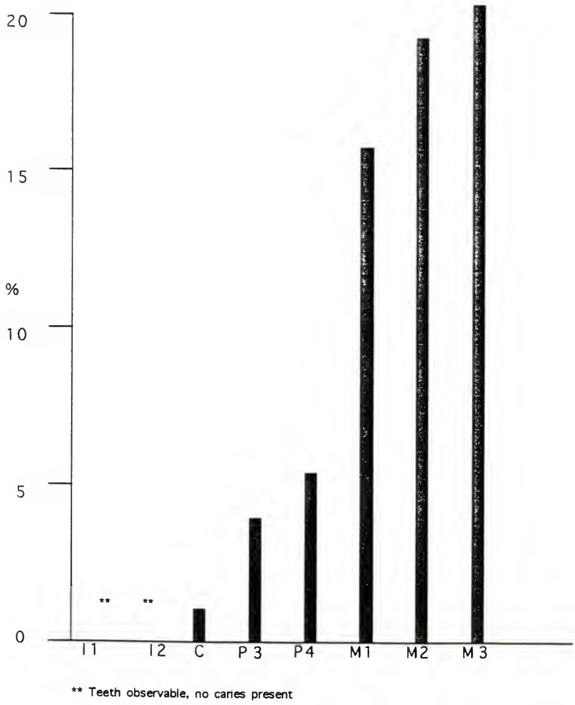

Figure 8.3
Mandibular dental caries by tooth

important factor in determining whether caries occurs at that site or not. (Paynter and Grainger 1962:156)

The larger, more complex, and more convoluted occlusal surfaces of the posterior dentition are more prone to the retention of food particles and plaques than are the smoother and somewhat sloping occlusal surfaces of the anterior teeth. Although pits and fissures on the posterior dentition act as food traps that serve as reservoirs for caries, salivary flow and tongue and cheek movements are natural oral mechanisms that aid in cleansing the anterior dental arcade (Paynter and Grainger 1962). The higher frequency of dental caries found in the mandibular molars may be attributed to a relatively more complex occlusal morphology, an increased number of pits and fissures as a function of an additional cusp, and the laws of gravity, whereby food particles naturally pool in the mandible during and following mastication.

Table 8.3 and Figures 8.4 and 8.5 suggest that among the San Martín population dental caries appears to be an age-progressive process. Adults are markedly more affected than preadults, who display no carious lesions. Older adults (30-40 years of age) are more affected than younger adults (20-30 years of age) and demonstrate a slight increase in carious involvement of the more anterior dentition. In the older adults, canines are affected for the first time, the premolars show a slight increase in carious involvement, and mandibular molars are the tooth-type most affected. The average frequency of maxillary carious involvement is 2.8% for individuals 20-30 years of age and 4.5% for individuals 30-40 years of age. Mandibular frequencies range from 8.8% in the younger adults to 9.5% in the older adults.

Although the frequency of dental caries in the molars of the older individuals is more pronounced, the data demonstrate that this pattern is most

TABLE 8.3

Dental caries by tooth and age

Maxilla

Tooth	20-30 years N[a]	N[b]	%	30-40 years N[a]	N[b]	%
I1	49	0	0	15	0	0
I2	47	0	0	16	0	0
C	54	0	0	18	1	5.5
P3	66	3	4.5	18	1	5.5
P4	68	3	4.4	20	0	0
M1	64	3	4.7	15	1	6.7
M2	64	2	3.1	17	1	5.8
M3	57	2	3.5	13	2	15.4
TOTAL	469	13	2.8	132	6	4.5

Mandible

Tooth	20-30 years N[a]	N[b]	%	30-40 years N[a]	N[b]	%
I1	55	0	0	20	0	0
I2	53	0	0	20	0	0
C	56	0	0	17	1	5.8
P3	62	2	3.2	21	2	9.5
P4	66	5	7.6	18	1	5.5
M1	51	10	19.6	12	4	33.3
M2	56	12	21.4	15	4	26.7
M3	42	10	23.8	14	2	14.3
TOTAL	441	39	8.8	137	14	10.2

a Number of teeth observable
b Number of teeth with caries

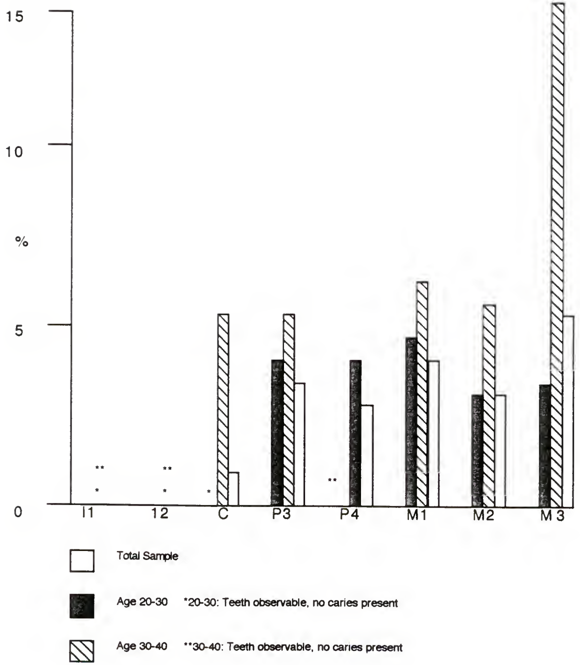

Figure 8.4
Maxillary dental caries by age

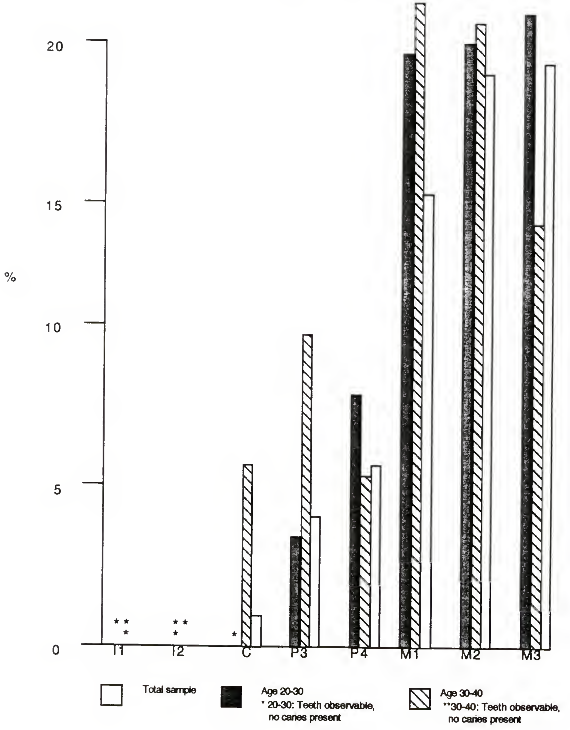

Figure 8.5
Mandibular dental caries by age

evident among the upper third molars and the lower first molars. As the first molar erupts approximately six years earlier than the second molar and approximately twelve years earlier than the third molar, the first molar should display a higher incidence rate of caries with age than either the second or third molars. Only one subset meets this age-accumulative pattern, the mandibular molars of those individuals aged 30-40 years. A decreased sample size of the mandibular M1, as a function of antemortem tooth loss, may have contributed to this phenomenon.

Tables 8.4 and 8.5 and Figures 8.6-8.9 show that, unlike frequencies typically reported for archaeological series (see review in Larsen 1987), the incidence of female caries is generally not higher than that for males. Analysis of the total sample reveals that on the average only the maxillary dentition of the females is slightly more prone to carious involvement (5.2%) than the maxillary dentition of the males (2.1%). This relatively higher frequency of involvement becomes insignificant when the maxillary dentition of the females (2.8%) and males (2.6%) of the 20-30 year age category are compared. A lack of a sufficient sample size of females over thirty years of age has prevented further analysis along these lines. Analysis of all mandibular dentition demonstrates that males (10.2%) are at a significantly greater risk for carious lesions than are females (5.7%). Between the ages of 20-30 years males (9.6%) maintain a higher predilection for mandibular caries than do females (5.2%).

When the San Martín population is divided into early (n=34) and late (n=16) segments, the subsamples become too small for meaningful interpretation. Preliminary analysis seems to indicate, however, an unexpected trend. There appears to be a temporal (early to late) decrease (from 63% to 36%) in the frequency of individuals affected with carious lesions. The

TABLE 8.4

Dental caries by tooth: Gender comparison

Maxilla

	Females			Males		
Tooth	N[a]	N[b]	%	N[a]	N[b]	%
I1	19	0	0	44	0	0
I2	16	0	0	45	0	0
C	23	0	0	49	1	2.0
P3	26	1	3.8	54	2	3.7
P4	26	0	0	57	3	5.3
M1	28	2	7.2	47	2	4.3
M2	28	3	10.7	48	0	0
M3	26	4	15.4	41	0	0
TOTAL	192	10	5.2	385	8	2.1

Mandible

Tooth	N[a]	N[b]	%	N[a]	N[b]	%
I1	24	0	0	49	0	0
I2	24	0	0	48	0	0
C	25	0	0	45	0	0
P3	29	0	0	57	4	7.0
P4	26	1	3.8	56	4	7.1
M1	16	2	12.5	44	12	27.3
M2	19	6	31.6	47	10	21.3
M3	12	1	8.3	45	10	22.2
TOTAL	175	10	5.7	391	40	10.2

a Number of teeth observable
b Number of teeth with caries

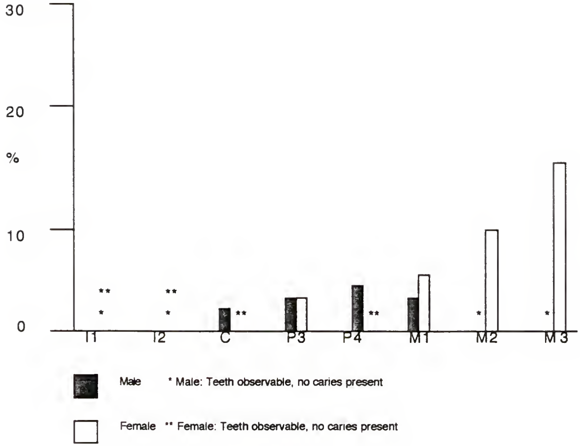

Figure 8.6
Gender ratio of maxillary dental caries by tooth

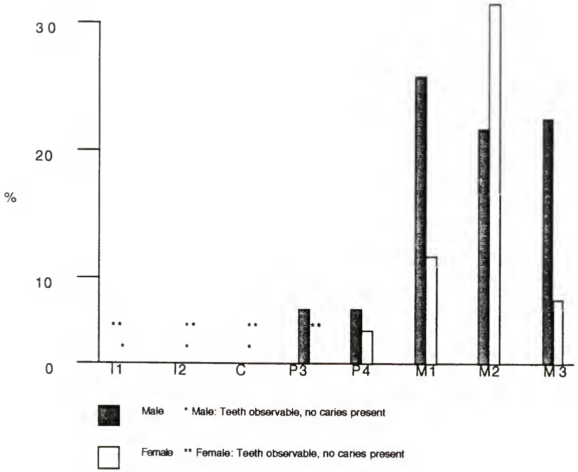

Figure 8.7
Gender ratio of mandibular caries by tooth

TABLE 8.5
Dental caries by tooth: 20-30 age category:
Gender comparison

Maxilla

	Females			Males		
Tooth	N[a]	N[b]	%	N[a]	N[b]	%
I1	20	0	0	26	0	0
I2	14	0	0	26	0	0
C	20	0	0	27	0	0
P3	23	0	0	32	1	3.1
P4	23	0	0	34	3	8.8
M1	26	1	3.8	32	2	6.2
M2	26	2	7.7	30	0	0
M3	24	2	8.3	27	0	0
TOTAL	176	5	2.8	234	6	2.6

Mandible

Tooth	N[a]	N[b]	%	N[a]	N[b]	%
I1	21	0	0	28	0	0
I2	21	0	0	26	0	0
C	22	0	0	30	0	0
P3	23	0	0	30	1	3.3
P4	24	1	4.2	32	3	9.4
M1	15	2	13.3	27	6	22.2
M2	17	4	23.5	29	5	17.2
M3	12	1	8.3	26	7	26.9
TOTAL	155	8	5.2	228	22	9.6

a Number of teeth observable
b Number of teeth with caries

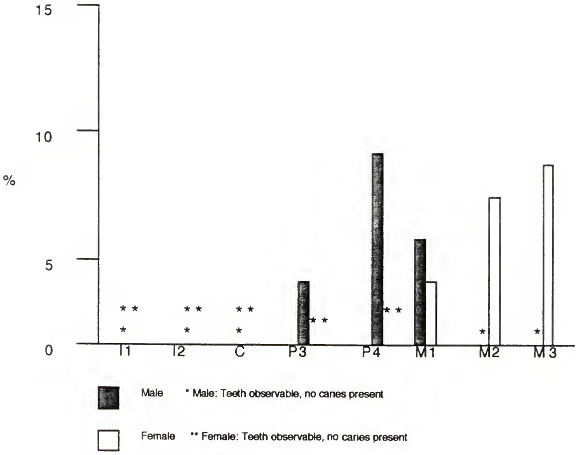

Figure 8.8
Gender ratio of maxillary dental caries by tooth: 20-30 years of age

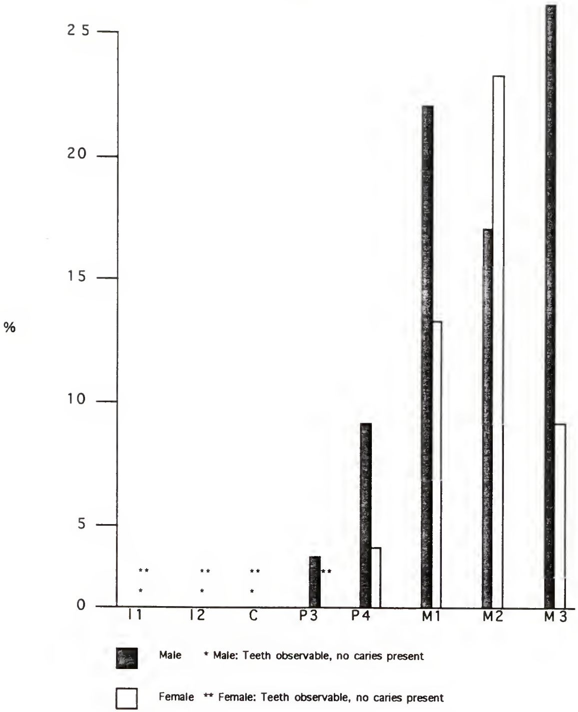

Figure 8.9
Gender ratio of mandibular denta caries by tooth: 20-30 years of age

mandibular dentition remains more affected, especially the mandibular molars. Obviously an increased skeletal sample and additional research is needed to verify this trend.

It seems likely that the absence of carious lesions in preadult individuals, ranging in age from 2-17 years, is related to both the general population trend of absence of dental caries in the anterior dentition as well as insufficient temporal exposure of the posterior dentition to the various carious-causing agents. Although the lack of carious lesions in the age category of 40+ years may be a function of small sample size, it may be suggested that at least some antemortem tooth loss in adults has occurred from destruction of the dental alveolus through carious involvement. Eleven individuals display alveolar bone abscesses, in eight of these individuals (72.7%) abscessing was also associated with dental caries. Seventy-three percent of this sample is composed of 20-30 year old individuals and in all cases abscessing was associated with a grossly carious molar. Three individuals, 30-40 years of age, displayed extensive antemortem tooth loss with associated remodeling of the alveolus, but no dental caries. Grossly carious lesions associated with abscessing of the alveolus may precede antemortem tooth loss, thus reducing the number of carious teeth in older individuals. In addition, nine individuals 20-30 years of age and three individuals 30-40 years of age exhibited combinations of gross dental caries, antemortem tooth loss, and active-at-death remodeling of the alveolus.

The general pattern of carious involvement in the decidious dentition follows the basic trend established by the permanent dentition. Decidious molars are the only tooth type affected, with involvement limited to the occlusal surface. Carious lesions are either incipient (40%) or gross (60%). With the exception of one 2.0-2.5 year-old individual, dental caries tend to affect older preadults (over nine years and less than fourteen years).

In summary, among the San Martín population, the mandibular posterior dentition, and specifically the mandibular molars, were most prone to carious invasion. Turner (1979) has also commented upon the tendency of the lower teeth to demonstrate more carious involvement. Dental caries is, in part, an age-accumulative process. Males were more likely to be affected by carious lesions, with mandibular involvement most likely.

The rate reported here for population caries frequency, 4.7%, is consistent with that reported for populations practicing mixed-economic subsistence patterns (Turner 1979) and those with a high carbohydrate diet (Rose et al. 1984, 1991). In addition, Larsen et al.'s (1991) summary of North American Indian populations, known to have incorporated maize into their diets, demonstrates a caries rate in excess of 7%, compared to a rate of less than 7% for populations without dietary maize. It is known that the mission Timucua cultivated maize to supply the Spanish garrisons and that males comprised the labor force which transported the maize to the Spanish settlements. Pre-mission French ethnographic accounts mention Timucuan cultivation, harvesting, and warehousing of maize as well as a porridge, guachuela, made from maize (Covington 1963, 1978; Ehrmann 1940). Caries incidence rates suggest, however, that although maize was incorporated into the northern Utinan diet, it was not a major component of the diet.

Enamel Hypoplasias

All dental remains were examined for hypoplastic banding with a dental probe and a hand held magnifier. The distance of each hypoplasia from the cementoenamel junction (CEJ) was recorded to the nearest tenth of a millimeter using Helios dial calipers. The distance was translated into age-of-occurrence using the conversion table from Rose et al. (1985:294). In other analyses of population-level hypoplastic age-at-occurrence, it has been demonstrated that maximum data recovery is still obtained if only canines and incisors are used (Goodman et al. 1980). Although all teeth of all tooth types were observed for enamel hypoplasias, only data for these "best teeth," the maxillary central incisor and mandibular canine, are reported here (Goodman et al.1984).

Analysis of this subset indicates that the majority of age-at-occurrence for hypoplasias among this population occurs between the ages of twenty four to sixty months. It is generally accepted that enamel hypoplasias function as indicators of systemic or nutritional stress asqociated with weaning (Goodman and Rose 1991; Rose et al. 1985), and that a cleap tendency of weaning-associated hypoplasias occurs most frequently between the ages of 18 to 36 months (Goodman and Rose 1991). Therefore, it appears that weaning-related stress is at least partially responsible for enamel hypoplasias in the San Martín population. As Table 8.6 demonstrates, a large percentage of the population--56 of 75 individuals observable for the trait (74.7%)--was affected by hypoplastic formation. In 48 of the affected individuals (85.7%) hypoplastic expression took the form of multiple, narrow, shallow bands. The remaining eight individuals (14.3%) displayed deep, wide hypoplastic banding. The width of enamel hypoplasias, from the superior to inferior margins, provides a rough estimate of duration of metabolic stress whereby narrow bands reflect short-term stress and wider bands reflect long-term stress (Blakey and Armelagos 1985). It appears, from the degree and range of enamel hypoplasias present,

TABLE 8.6

Enamel hypoplasias: Percentage of population affected

	N	N^a	N^b	N^c	N^d
# observable	75	17	34	31	16
# with hypoplasias	56	11	25	24	13
%	74.7	64.7	73.5	77.4	81.3

N Individuals from total sample

N^a Females from total sample

N^b Males from total sample

N^c Individuals from early population

N^d Individuals from late population

that the vast majority of the San Martín population demonstrates a predilection for a childhood and adolescence accentuated by chronic, short-term stress.

Females (64.7%) and males (73.5%) are almost equally involved. Within the earlier population 24 of 31 individuals (77.4%) observable for the trait demonstrate evidence for enamel hypoplasias. In the later population 13 of 16 individuals (81.3%) are affected by hypoplastic occurrence. Although there is no appreciable increase in band width over time, incidence rate has increased from 77.4% to 81.3%. Females and males in both subsamples are equally affected.

Even thought the sample size is small, it is interesting to note that the incidence rate of enamel hypoplasias increased slightly over time. It is difficult, however, to assign this trend to any one factor. Enamel hypoplasias are related to a wide variety of non-specific disturbances, including hereditary anomalies, localized trauma, systemic metabolic stress, infectious disease, and/or nutrition. Although it appears clear that enamel hypoplasias are relatively sensitive to undernutrition, the relative importance of the roles of nutrition, critical nutrients, and diet interaction have yet to be clarified.

Although the range of age-at-occurrence for hypoplastic formation among the San Martín population falls within the accepted norms for weaning-associated stress, the twenty-four month extension beyond the upper limit of the norm, suggests that either a prolonged weaning period was practiced or that chronic exogenous stressors were prevalent during the childhood years. In undernourished populations weaning may be delayed up to three to four years, during which time protein inadequacies, frequently aggravated by a protein-poor weaning diet of maize gruel, are bound to develop. Prolonged weaning with protein insufficiencies and a protein-poor diet would promote protracted undernourishment or even malnutrition and negatively affect an individual's ability to develop immunity to disease. Under metabolic stress, amino acids that would otherwise be used for skeletal growth are mobilized in the response to stress (Acheson 1960). Resultant nutritional deficiencies would be recorded in the skeletal system as enamel hypoplasias.

In addition, a dynamic relationship may exist between hypoplastic formation, weaning, nutritional stress, and epidemic-induced stress. Investigators of archaeological populations repeatedly remark on the commonality of high morbidity at approximately age two, a critical period in postnatal human life (Wood 1983). At San Martín infants under one year of age are absent from the archaeological record. Measles epidemics have been recorded for the mission-period populations occupying this region. In a measles epidemic no active immunity exists. Passive immunity is acquired by individuals who have survived measles and transplacentally by children from mothers who have survived the disease. The majority of the measles antibody is passed through the mother's bloodstream to the child during the last month of pregnancy. The antibody has a half-life of twenty one days. This means that one-eight of the antibody will still be present in the child's bloodstream three months after birth--one-sixteenth after four months--one-thirty-second after five months and so on. Therefore, the amount of measles antibody present in an infant between six months to one year of age is dependent upon the amount conferred at birth. A sufficient amount of the antibody may protect the infant from the worst ravages of measles during the first year of life. The under-representation of infants, the high prevalence of enamel hypoplasias, the extended age-of-occurrence, and the increase in prevalence over time may reflect the synergistic effects of introduced pathogens upon an already chronically stressed population.

Individuals with enamel defects are more susceptible to stress and therefore more likely to enter the skeletal sample at an earlier age (D. Cook 1981). Infants and children with enamel hypoplasias during the first two years of life have experienced metabolic stresses that affect their ability to cope with pathogens and increase their rate of mortality (Cook and Buikstra 1979). Analyses of adult enamel hypoplasias are measurements of an individual's ability to survive childhood stressors, and thus reflect survivorship.

As taphonomic forces appear partially responsible for the under-representation of children less than one year of age in the San Martín skeletal collection, it is possible that a greater number of individuals have entered the mortality profile than have been reported. These individuals did not live long enough to be represented in the archaeological database that records enamel hypoplasias in adult canines and incisors. In infants under one year of age the enamel of the permanent dentition has barely begun to form. The enamel of the adult canines and incisors is complete between five and seven years of age. This reasoning implies that an even greater percentage of the San Martín population has been affected by childhood stressors, such as weaning, nutritional deficiencies, and epidemic-induced stress, than is actually recorded here.

Dental Crowding

Twenty-one of 75 individuals (28.0%) observable for the trait displayed evidence for dental crowding. Males (n=10) and females (n=8) are equally affected as are the maxillary and mandibular arcades. The most common expressions of crowding are mesial and distal rotation of the premolars, mesial rotation of the third molars, reduced and microdont third molars, and congenital absence of the third molars. The genetic trait of maxillary incisor rotation (Enoki and Dalhberg 1958) was not included in this analysis. Following Turner et al. (1991) congenital absence was considered only in adults 17-20 years, aged independently of dental methods. The distal surfaces of the second molars were examined for wear facets and radiographs were taken to ensure that the teeth were not impacted.

It has been demonstrated that, in general, populations with heavy masticatory demands tend to develop more robust cranial-facial features (Larsen 1987; Martin et al. 1984). Those populations with less mechanical demand exhibit less robust features of the face and jaw. Recent biocultural models implicate diet with the development of cranial-facial structure (Martin et al. 1984). Populations with soft diets and low-demand mastication tend to develop less bony architecture. The reduction in level of bone growth and development in the facial structure of agriculturalists has had marked consequences for dental occlusion (Larsen 1987). A softer and processed diet, lack of interproximal attrition, and decreased masticatory demand is reflected in an increase in malocclusion, dental crowding, and impaction of the third molars (Lombardi 1982).

The marked level of occlusal attrition observed in the San Martín series (see following section for discussion) does not provide evidence for a consistently soft diet. Diet alone cannot explain the prevalence of dental crowding observed in the San Martín population. Exogenous factors, such as less-than-optimal health, nutritional inadequacies, and/or environmental disturbances, such as cultural change, seem to have contributed to the expression of dental crowding and congenitally absent third molars. Attrition may, however, play a role in the expression of dental crowding. Rapid tooth wear can affect the eruptive movement of the teeth. Tension in the periodontal ligament is transmitted to bone and may result in a combined movement of tooth and bone (Clarke and Hirsch 1991). Dental crowding may be one result of such movement in the dental arcades.

Dental Attrition

Attrition, the wearing away of the occlusal tooth surface from direct tooth-to-tooth contact during mastication, can be attributed to abrasion by dietary components or the role of the teeth as tools. Among the San Martín population there are no wear patterns or wear facets indicative of teeth functioning as tools. Marked occlusal attrition is present, however, and increases with rapid regularity. Differential patterns of wear are not observed between the sexes.

Diet is heavily implicated in the analysis of dental wear in archaeological populations. The fibrous nature of food, its abrasive content, and the preparation or lack of preparation are all considered major sources of tooth destruction (Molnar 1971, 1972; T. Murphy 1959). In relating food and food-borne abrasives to attrition those food items which are important dietary supplements, but still place a considerable burden on the dentition, are often neglected (Molnar 1972). The significant amount of occlusal attrition present among the San Martín population suggests a diet high in fibrous food or one in which abrasive substances, such as grit, were introduced into the food during preparation. Stone grinding implements are absent from the Florida Spanish mission-period archaeological record. Historically corn was processed using a wooden mortar and pestle (C. Hudson 1976:304).

Although certain types of carbohydrates, such as those found in maize, may cause increased levels of attrition, maize alone was not responsible for the relatively rapid attrition rate demonstrated here. The French colonist René de Laudonnière remarked on a Timucuan diet saying that "in necessity they eat a thousand rifraffs, even to the swallowing down of coal, and putting sand into the pottage that they make with the meal" (Swanton 1922:362). Although this behavior may be symptomatic of pica, a rare nutritional disorder in which individuals display a desire for strange foods, such dietary additives may have facilitated dental wear among the San Martín population. The Spanish reported that one Utinan staple, corn cakes, was baked in hot sand and that another staple, gacha, was a bread loaf made from acorn hulls. Ingested in sufficient quantities, the abrasive content of these staples would contribute significantly to the marked dental wear observed in the San Martín sample.

In addition to Utninan food preparation techniques and the natural abrasive content of the diet, mechanical influences should also be considered. Masticatory function, the timing and sequence of eruption, tooth position, and/or enamel composition (thickness and hardness) may have also contributed to the rapid rate of occlusal surface attrition observed in this population.

Abscesses

Eleven (14.7%) of 75 individuals observable for the trait were affected with apical abscesses. Abscessing is typically associated with pulp chamber exposure, the chief cause of which is dental caries. Abscesses may also form in association with general periodontal disease. In the San Martín population abscessing demonstrates a predilection for the maxillary and mandibular molars. There are neither gender nor age biases, but abscessing is overwhelmingly associated with grossly carious teeth. Sequentially the second molar is the most preferred sight of abscess involvement, followed by the first and then the third molar. This order loosely follows that for the most frequent carious tooth type, the molars. Of 18 abscessed teeth, 12 or 66.7%, occur with gross dental caries. Early and late populations were equally affected.

Calculus

Calculus is the calcified remains of dental plaque. Plaque is a highly organized ecological unit consisting of relatively characteristic collections of bacteria (Ash and Ward 1986:140). The bacteria mass on the surfaces of the teeth and form plaque, which becomes calcified through the absorption of minerals.

Although carbohydrate residues have been recognized as essential components for carious involvement, not all carbohydrate residues are equally conducive to plaque formation. Streptococcus mutans, a strain of streptocci implicated in the initiation and progression of carious lesions, also demonstrates the ability to adhere to teeth and form plaque (Ash and Ward 1986). S. mutans is an opportunistic bacteria, which ferments the simple dietary sugar sucrose, adheres to the teeth (plaque), and facilitates formation and accumulation of acids which in turn cause decalcification of enamel (dental caries). Although the complete etiology of plaque formation has yet to be clarified, it is evident that dental plaque is highly dependent on the ability of various bacteria to adhere to one another. A large body of information suggests that S. mutans is a plaque-forming bacterium capable of producing dental caries (Ash and Ward 1986) and indicates that a close relationship exists between dental plaque and caries.

Thirty seven (49.3%) of 75 observable individuals displayed evidence for calculus. Calculus is present on the buccal, labial, and lingual surfaces of the dentition. The heavy amount of dental wear in this population has not allowed calculus to form on the occlusal surfaces. The degree of expression in the majority of individuals (29 of 37 for 78.3%) is slight. These individuals are either 21-30 years of age or are preadults. Moderate expression of calculus was observed in seven individuals aged 30+ years. In one individual, 41-45 years, calculus was heavy. This age-accumulative pattern should be expected in populations lacking mechanical dental intervention and treatment.

No relationship between calculus and caries was observed. Individuals with no evidence for calculus were as prone to dental caries as those individuals with calculus. Males (n=20) were twice as likely to develop calculus as females (n=8). The incidence of calculus appears to have risen over time. Although the sample is small, 32% of the early individuals developed calculus, while 62.5% of the late individuals were affected. As only one female is present in the late sample, this figure actually represents an increase in calculus in males over time. Although it is difficult to assign this trend to any one factor, in general the San Martín males were also more prone to caries. Preliminary evidence indicates that the rates of both dental caries and calculus increased over time. This trend may be related to an increase in the percentage of cariogenic foods. Highly cariogenic foods, high in carbohydrates and the simple sugars, promote both dental caries and calculus formation.

Periodontal Disease

Periodontal disease involves an inflammatory response to one or more morbid conditions (irritants) and generally arises from irritation and low grade infection associated with plaque deposits. Resorption of alveolar bone, in response to the inflammation, results in increased distance between the bone and the cementoenamel junction (Ortner and Putschar 1985). The supporting tissues of the teeth, the gingiva, cementum, periodontal ligaments, and alveolar bone, degenerate. Ultimately the periodontal structure can no longer support the teeth because there is inadequate bony surface attachment for the ligaments (Hildebolt and Molnar 1991).

The etiology of periodontal disease is a complex and incompletely understood phenomenon that includes the interaction of oral factors with systemic and environmental conditions (Hildebolt and Molnar 1991). Although a number of studies have demonstrated that a close relationship between plaque and periodontal disease may exist, no single strain or combination of bacteria has yet been found to enhance susceptibility to periodontitis. Elimination of bacterial plaque may, however, hinder the development of periodontitis (Ash and Ward 1986).

As it is possible that periodontal disease and alveolar recession are highly correlated with occlusal forces and degree of attrition (Watson 1986), it is essential to relate age and degree of tooth wear when reporting the incidence of periodontal disease among archaeological populations. Severe attrition and resultant tooth movement may account for alveolar recession (increased distance between cementoenamel junction and alveolar crest). This condition should not, however, be confused with periodontitis. In periodontitis the crestal margin of bone undergoes loss of the surface cortical bone, exposing the porous cancellous bone, usually with an accompanying change of the contour of the crest (Clarke and Hirsch 1991:241).

In archaeological specimens care must be taken to distinguish between local alveolar resorption associated with periapical abscesses and tooth loss due to general alveolar resorption from periodontal disease. Clarke and Hirsch (1991) report that physical anthropologists tend to overestimate the prevalence and severity of periodontal disease. Clearly if there is alveolar resorption but little or no evidence of caries or tooth loss, a diagnosis of periodontal disease is appropriate (Ortner and Putschar 1985:443). The localized nature of bony lesions, such as apical abscesses, must be distinguished from true periodontal disease which demonstrates a consistent horizontal distribution of alveolar-crest bone loss around the arch (Clarke and Hirsch 1991). Two common bone modifications that may be mistaken for periodontal disease are dehiscence and fenestration. Dehiscence is a common developmental anomaly in which bone over all or part of the root surface is thin or missing and most frequently occurs over the maxillary incisors and canines. Fenestration is a developmental inadequacy of the alveolar plate that leaves the alveolar margin intact. Perforation of the bone occurs and the tooth roots are visible on the buccal or lingual surface (Clarke and Hirsch 1991; Hildebolt and Molnar 1991).

Seven (9.3%) cases of periodontal disease were observed. The cases are evenly distributed between the sexes, five instances were found within the 31-35 year age category and two individuals were between 26-30 years. All cases are classified as generalized slight or generalized medium (Turner et al. 1991). In all individuals periodontal disease appears to be age-accumulative and closely associated with calculus and caries but does not lead to extensive tooth loss. Nine cases of dehiscence and two cases of fenestration were observed.

Mottled Enamel

Mottled enamel, fluorosis, is a yellowish or light brown discoloration of the enamel affecting any or all teeth, but is most common on the labial surfaces of the upper and lower central incisors (McKay 1916). This type of hypoplasia develops during enamel formation of the permanent dentition when water containing more than two parts per million of fluoride is ingested (Ash and Ward 1986). Mottled teeth are not only more susceptible to enamel fracture, but attrition as well (Ash and Ward 1986). In that only eight individuals (10.6%) demonstrate evidence for mottled enamel, it appears that the mission water source was not sufficiently fluoride-rich to have affected the majority of the population. Monitoring of Fig Springs, the spring by which the San Martín mission was erected, by the Suwannee River Authority between October 1991 and January 1992, has revealed an average of 0.16 parts per million of fluoride (Janis Sellers, Florida Game and Fresh Water Fish Commission, personal communication, April 1992). It appears evident that these modern levels are significantly below the fluoride levels that produce mottled teeth. It is possible that fluorapatite-producing minerals were in greater abundance 300 years ago than evidenced today (Joe Seary, Florida Game and Fresh Water Fish Commission, personal communication, April 1992). If fluoride was present in the water, then the levels were less than adequate to have inhibited the development of caries, as 50% of those individuals with mottled dentition also display evidence for caries.

Alternatively it may be suggested that the individuals affected with mottled enamel were not indigenous to the San Martín mission. It is possible that these eight individuals were raised in a different geographic region, one where flouride levels were high enough to produce this dental discoloration. If this scenario is correct, then it presents some evidence for population movement during the mission period.

Temporomandibular Joint Disease

The temporomandibular joint is the articulation of the mandibular condyle with the mandibular fossa of the temporal bone. Its normal joint function depends on balanced mandibular motion by a pair of freely movable, synovial joints, each with two synovial spaces. Although the organic and functional elements responsible for temporomandibular joint disease are not clearly understood, it appears that both processes act simultaneously in the disorder (Murphy and Adams 1981). Classifications of temporomandibular joint disorders include those initiated by traumatic, dental, infectious, congenital, arthritic, functional, and neoplastic factors.

Temporomandibular joint disease (TMJ) was observed in two males and one female. In one male, 21-25 years, TMJ disorder was the result of what appears to have been a rather severe trauma. The left mandibular body displays evidence for a slightly misaligned, healed, and completely remodeled fracture. The left mandibular condyle is distally displaced, shortened, and flattened. The articular surface is significantly remodeled with a marked crenulated appearance. The left mandibular fossa of the temporal bone is a mirror image of the condyle. The remaining two cases appear to have had functional origins and are classified as slight with one fourth of the TMJ surface pitted (Turner et al. 1991:28).

The Association Between Dental Caries, Periodontal Disease, Attrition, and Calculus

Analysis of the San Martín dental pathology has demonstrated (1) a low incidence (4.7%) of dental caries, (2) a low incidence (9.3%) of periodontal disease, and (3) a high incidence (49.3%) of plaque/calculus (Table 8.7). These relative rates of occurrence point to a dynamic relationship among dental pathologies that has been noted by other researchers of archaeological populations. H. Newman (1974) notes that in a "natural diet," one in which masticatory activity is a direct function of a generally tough diet containing fiber and grit, the incidence of both caries and periodontal disease is low.
The significant amount of dental attrition demonstrated in the San Martín series combined with the low rates of both caries and periodontal disease, strongly suggests either a diet high in fiber or one with introduced dietary abrasives, such as grit or sand. Corn cakes baked in hot sand, bread made from acorn hulls, and the addition of sand to corn gruel, have been cited as ethnographically documented sources of dietary abrasives.

Although maize was a dietary item, the 4.7% incidence rate for caries in this population is noticeably less than the 7% caries rate cited for populations known to have significantly incorporated maize into their diets (Larsen et al. 1991). This rate suggests that although maize was a dietary component, it did not constitute a major portion of the diet.

TABLE 8.7
Individual rates for dental pathologies
based on 75 observable individuals

	Number of individuals	Percentage affected
Abscessing	18	24.0
Calculus	37	49.3
Periodontal disease	7	9.3
Dental crowding	21	28.0
Tempromandibular joint disease	3	4.0
Mottled Enamel	10	13.3

The high incidence of calculus (49.3%) and marked occlusal attrition indicates, however, that some form of dietary carbohydrates were present. Rose et al. (1991) have noticed that very rapid attrition in the Coles Creek skeletal series, A.D. 1000, from the lower Mississippi valley is accompanied by a significant increase in dental caries. No evidence for maize is apparent, but the remains of numerous starchy seeds, maygrass, knotweed, and goosefoot, are documented. The authors posit that the small size of the seeds and their hard seed coats would require extensive masticatory grinding. Thus, the grit in the seed coat particles would explain tooth wear and the carbohydrate content of the seeds would also explain the high caries rate. Archaeological analysis from the San Martín site demonstrates that maize and potentially abrasive foods, such as acorn and hickory nuts, were are present in the archaeological record (Newsom and Quitmyer 1992).

It appears that a symbiotic relationship exists between plaque and saliva, through which salivary ions, particularly calcium and phosphate, can enter or adhere to the tooth surface (H. Newman 1974). Higher than average calcium and phosphate levels in the diet arrest carious invasion, and thus carious lesions, and also promote plaque and calculus formation. Hence the association noted by researchers between high prevalence of calculus and low prevalence of dental caries (Powell 1985:315).

Moderate and consistent dental wear over a lifetime can be beneficial as it will aid in cleansing tooth surfaces and the removal of prime caries loci (Powell 1985). Dental wear can, however, enlarge interproximal spaces between alveolar bone and the cementoenamel junction of the teeth allowing food particles to accumulate. Bacteria induce inflammatory responses in the gingiva which will subsequently lead to gingival recession and exposure of the cementoenamel junction. Although dental wear is rapid in this population, it does not appear to have promoted periodontal disease. It seems likely that, as periodontal disease appears to be age-accumulative, a high incidence would not be expected for this relatively young population.

Not all the factors affecting the relationship between caries, periodontal disease, plaque, and attrition are clear. It does seem apparent, however, that in the San Martín population a co-dependent relationship existed between the low percentages of carious lesions and periodontal disease and the high percentage of calculus and rapid and marked occlusal wear. A summary of dental pathologies will be addressed in Chapter X as part of an overview of the biological health of the San Martín population.

CHAPTER IX
BONE PATHOLOGIES

Eighty individuals, 91% of the collection, included bone elements observable for pathology. Eight individuals are represented by dentition only. All skeletal elements are not equally represented in all individuals. The various forms of skeletal completeness are as follows: twenty one individuals--complete; thirty two individuals represented by cranium and long bones only; five individuals, missing feet only; one individual, missing hands and feet; eighteen individuals missing various combinations of hands, feet, ribs, and/or vertebrae; and three individuals with cranium only. Thirty nine (49%) individuals were unaffected by any bone pathology. Differential preservation, reflected in various degrees of skeletal completeness, has introduced an uncontrollable bias into this analysis which is tempered by the variation in numbers of observable osteological elements. The inherent nature of this bias predisposes a conservative profile, because it is a virtual certainty that additional pathologies would be revealed by more complete skeletal representation.

Bone pathologies are summarized in Table 9.1. Incidence rates for all pathologies are provided for the total number of individuals affected, for gender distribution, and for the early and late populations.

Periostitis

Periostitis, the non-specific infectious involvement of the long bones, is especially common to archaeological populations (Ortner and Putschar 1985).

TABLE 9.1
Bone pathology

Pathology	N	%	N^a	%	N^b	%	N^c	%	N^d	%
Periostitis	32	40	17	53	10	31	10	32	4	25
Porotic hyperostosis cribra orbitalia	24	30	15	63	4	17	4	13	5	31
Osteoarthritis	25	31	15	60	10	40	7	23	3	19
Platycnemia	13	16	7	54	4	31	4	13	5	31
Trauma	14	17	9	64	4	29	3	10	1	6

N = total number of affected individuals of 80 observable
N^a = number of males represented in total number of individuals affected
N^b = number of females represented in total number of individuals affected
N^c = number of early individuals affected in early population (n=31)
N^d = number of late individuals affected in late population (n=16)

Periosteal lesions of the long bones, and most specifically the tibiae and fibulae, are the single most prevalent skeletal indicator of systemic stress observed in the San Martín population. Thirty-two of eighty (40%) individuals were affected. For the majority of individuals (n=21) lesions were healed at time of death and degree of expression was slight (n=27). Males (n=17) represent 53% of the thirty two individuals affected by periosteal involvement, whereas females (n=10) represent 31%. The majority of cases are distributed within the 26-30 year age category, with only four preadults displaying evidence for this non-specific stressor. Thirty-two percent of the early and 25% of the late population demonstrate periosteal reactions.

Consistently, the major focal area of periosteal inflammation occurred symmetrically along the lateral borders of the tibial shafts adjacent to, but not involving, the anterior crests. The second most frequent site of involvement is the combined foci of the lateral borders of the tibial shafts and the medial aspects of the fibular shafts. The medial margins of the fibular shafts are the third most infected site. In this population, it appears that the tibia was the primary and initial focus of infection, which then traveled along and across the interosseous membrane to infect the fibula.

This pattern of involvement is unlike that reported by Powell (1988, 1990, 1991) in a diagnosis of endemic treponematosis among the pre-Columbian Irene Mound (Georgia) skeletal collection. In the Irene population the major focus of periosteal inflammation was localized along the lateral aspect of the anterior crests of the tibiae. Frequent observations of periostitis in the long bones, more extensive pathological involvement (of the tibiae) approaching the classic deformity known as "saber shins," remodeling indicative of extensive healing and quiescence of the disease prior to death, and gummatous ulcers which affect the cranial vault as osteolytic lesions known as "caries sicca," all support a diagnosis of endemic treponematosis (Powell 1990:28). Although 40% of the San Martín population was affected by periostitis, the slight degree of individual involvement, absence of saber-shin tibiae, lack of any cranial involvement, and especially the complete absence of caries sicca does not support a diagnosis of treponemal infection for the San Martín skeletal series.

Abundant evidence clearly indicates that treponemal infections were present in pre-Columbian populations (see review in Baker and Armelagos 1988). Treponematosis has also been documented in numerous pre-Columbian skeletal series from Florida (A. Bullen 1972, 1973; Hrdlicka 1922; Işcan 1983; Işcan and Miller-Shavitz 1985; C. Moore 1922; Snow 1962). Hutchinson (1991) has described a disease process, active among skeletal populations from five central Gulf Coast Florida sites, which mirrors the pattern of infectious involvement found among the Irene Mound population. Evidence indicates that treponemal infections were present in Florida populations prior to contact and probably as long ago as the Late Archaic period (Hutchinson 1991:135; also see discussion in A. Bullen 1972). It appears that skeletal responses demonstrate not only the presence of, but also the continuity of treponemal infection among some of Florida's aboriginal populations through time.

Ethnographic documentation from the sixteenth century also records the presence of treponemal infections among the Timucua, specifically the eastern Utina in the area of the St. Johns River.

> The priests . . . carry always about them a bagge full of herbs and drugs to cure the sicke diseased which for the most part are sicke of the Pox, for they love women and maydens exceedingly which they call the daughters of the Sunn. (Laudonnière 1587 in Basinier 1964:3)

"Venereal disease is common among them, and they have several natural remedies for it" (Le Moyne 1564 in Lorant 1946:75).

Despite bioanthropological evidence of treponemal lesions among Florida pre-Columbian skeletal collections and ethnohistoric documentation for a treponemal syndrome among post-Columbian eastern Utina peoples, the nature of periosteal involvement expressed in the San Martín northern Utina collection does not support a specific treponemal etiology. Rather, the degree of periostitis observed here resembles periosteal reactions stimulated by localized infectious foci.

> Periostitis of long bones is often seen in the tibiae of archeological skeletons. The reasons for this localization remain obscure. . . . It is, however, instructive to note that . . . bones near the skin are more exposed to direct trauma than bones protected by overlying muscle. (Ortner and Putschar 1985:132)

Hematogenous Osteomyelitis

A male, 21-25 years of age excavated from within the early sub-floor cemetery, suffered from osteomyelitis. The disease process, observable on the tibiae, fibulae, and the left ulna, was long-standing, sclerotic, and healed at time of death. The isolated nature of this case, the presence of cloaca, and the absence of carries sicca does not warrant a diagnosis of treponematosis. It is more likely that these skeletal lesions developed as a response to the introduction and dissemination of pyogenic (pus forming) bacteria into bone by a hematogenous route from a remote septic focus (Ortner and Putschar 1985:105-106).

The cranium and pelvis of a 15-17 year old male exhibit areas of periosteal remodeling that are not consistent with a non-specific diagnosis of periostitis. A cavitation of the frontal bone approximating glabella is present. The borders of this lesion have been remodeled. The periosteum of the right half of the frontal bone is elevated and displays areas of both healed and active infection. The outer table resembles a shell of raised porous hypervascular bone. There are no sequestra nor stellate patterns indicative of carries sicca. The process has crossed the coronal suture to infect the right parietal bone, where healing is evidenced. The diploë has been involved, but the infectious process has not reached the inner table of the parietal bone. The dorsal aspects of the ilia are covered by elevated periosteal bone along the borders of the iliac crests. Although the iliac crests have begun to unite, they are not completely fused. Irregular deposition of periosteal bone intermittently obliterates portions of the suture lines. The disease process is most pronounced along the lateral border of the left dorsal iliac crest.

While the primary focus of hematogenous osteomyelitis is typically found in the long bones of the extremities, cancellous bones can be affected, albeit rarely. When cancellous bones are affected, the process locates in the area with the most cancellous bone, such as the spine of the scapula, the lateral wing of the sacrum, and the iliac crest of the pelvis. Although osteomyelitis of the skull is rare, the most frequent site of involvement is the frontal bone (Ortner and Putschar 1985:116-117). Skeletal lesions develop from the extension of an empyema, the accumulation of pus in a bony cavity, of the frontal sinus into the frontal bone.

The structure of the diploë with its interconnecting large vascular channels permits spreading of the infection through the cranial vault. Sutures may act as a temporary barrier, but extension into the parietal bone is not uncommon. (Ortner and Putschar 1985:117)

This etiology appears to indicate that this young male was affected with an infrequently occurring form of hematogenous osteomyelitis. The remainder of the well preserved and complete skeleton of this individual was free of pathology. The cloaca-like lesion near glabella suggests a pyogenic infection of the frontal sinus, an extension of an empynema through the foramen cecum and along the superior sagittal sinus and sagittal sulcus to exit the outer table near glabella. The pattern of involvement observed in the ilia appears to be related to growth rate and epiphyseal union of the anterior iliac crests. In males, the anterior iliac crests can display partial union as early as fourteen years of age and demonstrate complete union by age seventeen, with the range of variation falling between fourteen to twenty three years (Suchey in Bass 1987:199). Ortner and Putschar (1985:110-111) report that hematogenous osteomyelitic infection in childhood and adolescence always starts in the metaphysis near an actively growing plate. Foci of pyogenic bacteria in a metaphysis will spread and discharge pus through the marrow cavity and lead to vascular compression and destruction of the newly formed spongiosa. In the metaphysis, near the growth plate, the thin remodeling cortex facilitates easy extension of the sepsis under the periosteum (Ortner and Putschar 1985:112).

Porotic Hyperostosis and Cribra Orbitalia

Porotic hyperostosis and/or cribra orbitalia is evidenced in twenty four (30%) crania. Sixteen individuals were affected by porotic hyperostosis only, three by cribra orbitalia only, and five by both disease processes. The degree of expression in sixteen cases was slight and moderate in eight cases. In fifteen individuals all lesions were healed at time of death, with active lesions observed in nine individuals. Males (63%) overwhelmingly represent the majority of cases. Females (17%) and preadults (17%) are equally affected. Thirteen percent of the early population displays evidence for either porotic hyperostosis and/or cribra orbitalia, compared to 31% of the late population.

It appears that within the San Martín population porotic hyperostosis and/or cribra orbitalia demonstrates a predilection for adult males. While age of onset could not be established, the fact that the lesions were healed at time of death clearly implies an earlier time of onset than that suggested by age at death, indicating that the majority of individuals survived at least one stress episode.

It seems that the incidence rate of porotic hyperostosis/cribra orbitalia has increased over time. Traditionally, an increased reliance on dietary maize has been cited as a major contributor in promoting iron-deficiency anemia and thus the increased expression of porotic hyperostosis and cribra orbitalia in archaeological populations (Cohen and Armelagos 1984). Hutchinson (1991) reports a low prevalence of porotic hyperostosis, cribra orbitalia, and carious lesions in three contact-period populations from the Florida Central Gulf Coast. He posits that these low levels of disease expression indicate a population that may have utilized maize in the diet, but at relatively insignificant levels. Analysis of stable nitrogen and carbon isotopes also suggest that maize was not a major dietary component (Hutchinson 1991:125).

At San Martín all cases of porotic hyperostosis occurred in conjunction with additional indicators of systemic stress (periosteal reactions and/or enamel hypoplasias). For example, 34% (17 of 50 individuals observable for both traits) displayed both enamel hypoplasias and porotic hyperostosis and/or cribra orbitalia. It has been suggested that the synergistic relationship between iron-deficiency anemia and infectious disease will appear skeletally as an associated pattern of porotic hyperostosis and periosteal responses (Palkovich 1987). The multiple-stressor pattern observed in the San Martín population indicates that such a dynamic relationship may be partially responsible for these disease expressions. The low incidence rates of porotic hyperostosis, cribra orbitalia, and carious lesions are comparable to those reported by Hutchinson (1991). These findings suggest that dietary maize was not the lone factor responsible for the expression of porotic hyperostosis and cribra orbitalia in the San Martín population. Thus, non-dietary factors, population aggregation and the subsequent effects of parasitic disease load, and/or infectious diseases, may also have contributed to low-blood iron levels in the San Martín skeletal series.

Harris Lines

The tibiae of twenty preadults and adults, selected for a representative age and gender sample, were radiographed for the presence of Harris lines. No lines were observed. In adults resorption may be responsible for the absence of lines. Preadults may have died before an episode of growth arrest and subsequent recovery. However, the absence of lines never means that individuals did not suffer from any disease or hunger periods in their past histories (Vyhnanek and Stloukal 1991:92). It is also possible that the San Martín population was unaffected by the stressor responsible for line formation or that the unradiographed tibiae contain Harris lines. It has been hypothesized that Harris lines form in response to acute and episodic stresses, such as food inadequacies, severe illness, and/or epidemic episodes, rather than extended and cumulative stress (Goodman et al. 1984). Recent research has suggested that the chronically ill do not develop Harris lines, only those who suffer a transient illness with prompt recovery will develop the lines (Vyhnanek and Stloukal 1991:94). This research implies that the San Martín population did not suffer from punctuated periods of food deprivation or acute episodic stress.

The emerging pattern of general health among the San Martín population appears to indicate that acute stress was not a major contributor to the skeletal expression of disease. Instead, evidence appears to indicate that health levels were generally compromised. If this population was affected by European-introduced epidemics, then it does not seem likely that individuals would have survived long enough for Harris line formation.

Platycnemia

Platycnemia is a pronounced mediolateral flattening of the diaphysis of the tibia determined by a cnemic index of 64.9 or less. The tibia is measured in a mediolateral and dorsovental direction at the level of the nutrient foramen. The cnemic index is reached by the transverse diameter of the diaphysis (mediolateral) x 100/dorsoventral diameter (Bass 1987:233).

Platycnemia is present in thirteen San Martín individuals. Although the sample size is small, it appears that males (54%) were more likely to have been affected than females (31%). No age bias was observed. Late population individuals (31%) were more than twice as likely as the early population sample (13%) to display the trait.

Platycnemia has been attributed to pathological stressors, nutritional deficiencies, and muscle stress, particularly hyperactivity of the tibialis posticus muscle among populations inhabiting mountainous and rough terrain and flexion stress from the soleus muscle and the deep plantar-flexors of the feet (Kennedy 1989:150). Lovejoy et al. (1976:505) have demonstrated that the soleus, gastrocnemius, and other posterior shank muscles responsible for locomotion and the acute torsional strains likely to occur in active locomotion on uneven substrates play a paramount role in the development of platycnemia. The flat terrain of north Florida would not implicate muscle stress/hypertrophy of the muscles of locomotion as the causative factor in the expression of platycnemia among the San Martín skeletal series. Repeated postural influences, such as squatting, or activity-related patterns such as those involved in the transportation of maize, may be responsible for the platycnemia observed here. A lifetime of less than adequate general health and/or dietary stress is, however, more likely to have promoted platycnemia in this population.

Osteoarthritis

Osteoarthritis is a disease of the joints in which there is hypertrophy of bone along joint margins (lipping) in addition to breakdown of the margins of hard tissue on joint surfaces (rarefaction) (Larsen 1987:388). Thus, in skeletal populations, osteoarthritis can be observed on both the joint surfaces as destruction, eburnation (polish), or pitting of the articular surfaces, and as the formation of new bone (lipping) along the articular margins of the bone (s). Osteoarthritis is not an inflammatory disease but rather an age-related disease based on the degeneration of the articular cartilage of the synovial (shoulder, elbow, wrist, hand, hip, knee, ankle, and feet) and intervertebral joints (Ortner and Putschar 1985).

The majority of bioanthropological studies of osteoarthritis have focused on habitual behavior patterns to reconstruct the physical activities of extinct populations (see Bridges 1991; Jurmain 1977; Kennedy 1989; Larsen 1982; Merbs 1983, to mention but a few). Although mechanical stress appears to be the major factor in the development of osteoarthritis, metabolism, nutritional impairment of a joint, heredity, obesity, vascular disruptions or deficiencies, and infection can all contribute to the development of osteoarthritis (Ortner and Putschar 1985).

Twenty five (31%) cases of osteoarthritis were observed in the San Martín skeletal series. Males (60%) are somewhat more affected than females (40%). Early (23%) and late (19%) individuals are virtually equally represented. In twenty four individuals the degree of expression is slight, with involvement limited to marginal lipping--no destruction, eburnation, or pitting of joint surfaces was observed.

There is no evidence to suggest activity-related osteoarthritic behaviors. Fourteen of the total number of cases (56%) were observed within the 26-30 year age category and represent 51% of their age cohort. Affected individuals aged 31-35 comprise 70% of their age group. These relative incidence rates indicate that among the San Martín population, osteoarthritis is an age-accumulative process.

The bias of differential preservation is perhaps most evident for this particular pathology, as the articular bone surfaces were the least well preserved osseous tissue. It seems evident that, with increased preservation of the long bone epiphyses, additional cases of osteoarthritis would have been observed and activity-related patterns may have been ascertained.

Trauma

Fourteen individuals, 17% of the observable population, displayed some evidence for trauma-related injury. Males (64%) are almost three times as likely as females (23%) to have been affected. Rates of involvement are similar between early (10%) and late (6%) individuals. The one case of trauma-induced temporomandibular joint disease discussed in dental pathologies is included in these figures.

Skeletal traumas present among females include a completely healed fracture of the left foot. The navicular has completely fused to the left talus and the surrounding foot joints show moderate arthritic lipping. One individual exhibits a healed depression fracture on the frontal bone at approximately glabella. Another individual demonstrates a healed compression fracture of the fifth and sixth cervical vertebrae with osteophytic remodeling but no union of the bodies themselves. Compression fractures are the result of sudden excessive impaction and true compression fractures are best illustrated in the vertebral column (Ortner and Putschar 1985:57).

Two males, both 31-35 years of age, display evidence for healed depression fractures of the frontal bone--one approximately at glabella and one just anterior to bregma. These skull fractures, which appear as cranial concavities, are the result of inward displacement of the bone from a trauma. Two individuals, one male and one unsexed adult, both 31-35 years of age, display compression fractures of the cervical vertebrae. In the adult the third and fourth cervical vertebrae are collapsed. The fourth and fifth cervical vertebrae of the male were collapsed and fused. The fifth lumbar vertebrae of this individual also displays evidence for a compression fracture. The collapsed fourth and fifth lumbar vertebrae of a 26-30 year old male also suggest a trauma-induced compression fracture. Schmorl's nodes are present on the first, second, and third lumbar vertebrae of a 31-35 year old male. Schmorl's nodes are the skeletal response to the herniation of the nucleus pulposus of the intervertebral disk into the end plate of an adjacent vertebral body. Pronounced arthritic lipping of the superior and inferior body margins is present in all three vertebrae. The right fourth metacarpal of this individual was also fractured and healed before death.

The pattern of fracture and healing observed in the left distal radius and ulna of a 31-35 year old male indicates a pseudoarthrosis, a condition in which the healing process of a fracture is delayed or incomplete. The forearm is perhaps the most common site for pseudoarthrosis, often referred to by the term "non-union" (Ortner and Putschar 1985:82). The condition is almost always the result of inadequate immobilization of the fracture during the healing phase. This event is followed by complications in which there is inadequate mineralization of the callus due to a lack of osteoid, allowing the union to remain flexible. Over time, the broken bone will be closed off by new bone formation which is then connected by fibrocartilage. This process may ultimately result in a joint capsule approximating the anatomy of a normal joint (Ortner and Putschar 1985:66-67).

The mid-shaft of the above-described radius was fractured. Misalignment of the bone during the healing process and subsequent callus formation has resulted in angulation of the shaft. The ulna was also fractured resulting in a non-union of the distal epiphysis and shaft. The medullary cavity of the ulnar shaft is closed. The distal epiphysis was not recovered. The radius and ulna exhibit evidence of both endosteal and periosteal remodeling. It appears that remodeling of the ulna was the direct response to infection introduced either directly during the fracture or secondarily from surrounding soft-tissue infection, by hematogenous dissemination, or extension across the interosseous membrane after fracture. The patterns of fracture and bone remodeling observed here indicate the introduction of infectious organisms and suggests a mid-shaft compound fracture of both the radius and ulna.

One preadult demonstrated a skeletal pathology that may have been trauma related. Both occipital condyles and the superior articular facets of the first cervical vertebrae were moderately lipped. Eburnation of the articular surfaces was observed.

The right humerus of a 21-25 year old male displays evidence for localized trauma. A small round lytic cloaca-like opening, approximately three mm in diameter, is located on the anterior proximal shaft. The edges are remodeled and encircled by healed periosteal bone. The lesion suggests a focus of septic infection subsequent to a localized injury.

Additional Bone Pathologies and Anomalies

Osteoblastic Tumors

Osteoblastic tumors, or osteomas, were observed in two females. Osteoblastic tumors are a benign condition consisting of mostly dense lamellar bone and occur almost exclusively in the skull. These lesions, commonly referred to as button osteomas, are usually located on the outer table of the cranial vault and appear as an ivory-hard smooth lump of less than two cm in maximum diameter (Ortner and Putschar 1985:368).

The cranial vault of a 26-30 year old female contained a total of six button osteomas, three on each parietal bone. The left tibia of an adult female had one button osteoma on the medial shaft.

Retarded Long Bone Growth

The preadults tend to demonstrate inconsistencies between age estimations derived from long bone lengths and tooth eruption and calcification standards developed by Ubelaker (1978). For example, one individual was assigned a dental age of 12-14 years, while diaphyseal long bone length indicated an age of 8.0-8.5 years. This particular difference in skeletal age is the most extreme for the series. At the opposite end of the range, one preadult, with a dentally-derived age of 3-4 years, was aged between 2.5-3.0 years from long bone length standards. Most preadults fall between these two extremes.

Research has indicated that a relationship exists between long bone growth and general health (D. Cook 1984; Goodman et al. 1984; Huss-Ashmore 1981; Merchant and Ubelaker 1977; Stewart 1968; Sundick 1978; Walker 1969). Depressed growth rates are the by-product of increased levels of stress. Stressors, such as parasite load, less than adequate nutritional resources, and disease can all adversely affect growth and development.

It has been suggested that in protohistoric populations tooth formation standards are the most reliable indicator of juvenile age-at-death (Merchant and Ubelaker 1977). These methods must, however, be used with caution when applied to populations other than those for which the standards were developed. In analyses of archaeological skeletal series it appears that standards based upon a White sample may overage the skeletons and thus underestimate the growth of Indian populations (Merchant and Ubelaker 1977:71).

A study comparing the variability of age estimations based on diaphyseal bone lengths to dental eruption standards, demonstrates that the range of variability for diaphyseal lengths is either about the same or actually less than the variability for tooth eruption ages (Hoffman 1979:463). Ubelaker (1974) suggests that dental calcification and long-bone lengths are more reliable age estimators than dental eruption, and that femoral diaphyseal lengths are the most reliable of all the long bones. Thus, when complete skeletal material is available for estimation of age in the preadult, dental calcification standards are most reliable. When dental and epiphyseal data are missing, diaphyseal lengths can be used and may even be more reliable than dental eruption standards (Hoffman 1979; Ubelaker 1974).

These studies demonstrate that dental calcification standards provide the most reliable age-at-death estimates for preadults. Although aging the San Martín preadult remains by these standards may have produced consistent over-aging, this hypothesis has yet to be firmly established. Until that time it must be assumed that growth retardation of the long bones, not acceleration of dental calcification, is responsible for differential age estimates in this population. This assumption implies that the San Martín preadults were subjected to life stressors that retarded growth rates. Depressed growth and development in juveniles also supports the theory that general mission population health was less than adequate.

Cradle Boarding

Three individuals, two males and one female, display flattening of the occipital bone. This form of cranial deformity is consistent with the pattern produced by the prolonged and consistent positioning of an individual on a hard surface during infancy and childhood, and is commonly referred to as cradle boarding.

One individual, a 15-17 year old male, demonstrates evidence for a more involved form of artificial cranial deformation. In this individual deforming devices appear to have been placed on both the frontal and occipital bones, producing the classic fronto-occipital deformation pattern. The frontal and occipital bones are flattened and the skull appears ovoid in shape with a greater transverse diameter. This isolated case of intentional artificial cranial deformation suggests that this individual was not native to north Florida and/or that he enjoyed some form of status differentiation. This deformed cranium is from the one individual displaying evidence for hematogenous osteomyletic involvement of cancellous bone.

Unidentified Pathologies

Meningeal Reaction

In one 9-10 year old juvenile the inner tables of the left and right parietal bones have been affected with what appears to be areas of periosteal inflammation. The endocranial surfaces are slightly porous with pin-point pitting transversing the meningeal vessel grooves. The outer tables and diploë are not involved. There is no evidence of healing and degree of expression is slight. Post-cranial remains were not recovered. D. Cook (1976) has described a similar pathologic process among pre-Columbian Woodland populations from the lower Illinois River Valley. In these populations endocranial lesions are also associated with post-cranial periosteal reactions. The disease process is most prevalent among juveniles and declines in frequency with age. Females and males were equally affected. D. Cook (1976) has posited that the endocranial periosteal-like inflammatory areas are suggestive of a meningeal reaction.

Ante-mortem Cranial Modification

The left parietal bone of a 25-30 year old female excavated from within the earlier chapel, demonstrates evidence for circular holes, each about five mm in diameter, drilled through the cranium during life. All openings perforate both the inner and outer tables. No evidence for trauma-induced fracture is present. Microscopic examination revealed that the inner edges of the holes are striate, as if made with a stone drill-like implement. The altered edges are not sharp, but demonstrate evidence for remodeling associated with healing. Two holes are in direct alignment posterior to the left parietal eminence, the third is located almost on the lambdoid suture.

Carr et al. (1984) report a similar pattern in the cranium of an Archaic individual from the Santa Maria site in south Florida.

> This individual contained six incomplete tunnels on the left parietal bone. The tunnels . . . appeared to have been made by "drilling." A survey of the literature did not yield archaeological or ethnographic examples to suggest a cultural origin for the drilled "tunnels." (Carr et al. 1984:186)

Stature

Adult stature was calculated from the Trotter and Gleser (1952a, 1952b, 1958) regression equation formula for the Mongoloid race and from the relationship of long bone lengths to stature (Genovés 1967). Figure 9.1 presents the range and mean statures for females and males. Basic anthropological tenets concerning height dictate that within a population considerable variation in stature will be found and the average stature for females is less than that for males (Brothwell 1967:100).

Although a substantial variation in ranges and mean heights was obtained, both formulae dictate that mean female stature is two inches less than mean male stature. It is difficult to attribute this difference to any one variable. Differential stature may reflect little more than basic gender distinctions in growth and development.

> As a result of the timing and duration of the male pubertal growth spurt, males tend to grow to a larger size, on the average, than females. Two factors intrinsic to the growth curve itself contribute to this size difference. One is simply the greater length of time males are permitted to grow before the process is terminated. The other factor is the greater intensity if growth at the time of peak growth velocity. Combined, these factors yield the sexual dimorphism in stature that characterizes our species. (Stini 1985:214)

Alternatively, adult stature differences may be a product of nutritional status, population-specific genetic factors, heterosis, or disease load (D. Cook 1984:237). The depressed growth rates and development in the San Martín juveniles, as indicated by retarded diaphyseal long bone lengths relative to age derived from dental standards, implicates environmental stress and/or nutritional deficits. A dependence on limited food resources will have a profound impact on growth and development suggesting that smaller body size

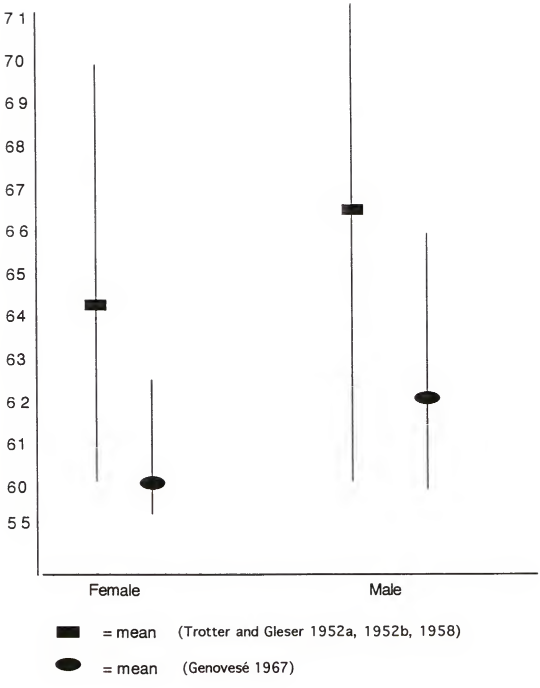

Figure 9.1
Adult stature in inches

is the result of poor nutrition (Larsen 1987:349). Differential attainment of stature in a population may also be the product of preferential access by certain segments of society to nutritional resources, such as higher quality foods. This reasoning implies that San Martín males were afforded differential access to preferred nutritional resources.

Because no other Timucuan mission cemeteries have been excavated, it is difficult to present adequate interpretation of the stature differences observed here. As such, the San Martín stature data remains a temporal and spatial isolate and little more than gender-based differences should be noted at this time.

Sexual Dimorphism

Noticeable gender-based size variations between similar skeletal elements have been observed and are most pronounced in long-bone morphology. In the larger male skeleton differences go beyond mere rugosity of muscle attachment areas and are consistently expressed in the general size of the bones. Although it is accepted that sexual dimorphism in skeletal populations is typically the result of the smaller relative size of the female, the degree of sexual dimorphism observed in the San Martín skeletal series is quite pronounced. The differential degree of robusticity in this skeletal series is supported by traditional pelvic morphology (Phenice 1969). Robusticity in this discussion refers to general morphology expressed in size, length, and circumference of the long bones.

Although common, analyses of sexual dimorphism in archaeological populations are difficult to interpret. The volume Paleopathology at the origins of agriculture, (M. Cohen and G. Armelagos editors 1984), has demonstrated that consensus does not exist to explain the observed trends in sexual dimorphism across populations. In fact different scenarios have been used to explain the expression of sexual dimorphism in the same population. The impact of dietary deficiencies, genetic factors, age, activity patterns, and differential survivorship have been implicated to explain body size differences between the sexes (D. Cook 1984). Hence, the meaning of dimorphism itself as an indicator of health trends appears to be ambiguous (Cohen and Armelagos 1984:588).

As with stature, the expression of sexual dimorphism among the San Martín skeletal series must be tempered by the temporal and spatial isolation of the sample. When culturally continuous skeletal collections become available, it will be possible to evaluate the degree of sexual dimorphism of this population in terms of human adaptation. Studies with dietary and technical controls within specific cultural settings have suggested that sexual dimorphism may be related to gender-based behavioral differences that are both economic (food procurement and preparation) and noneconomic (warfare) (Larsen 1987:353).

Explanatory models for bone and tooth pathologies are further discusses in Chapter X. Prevalence rates and population distributions are discussed and hypotheses generated for the general patterns of involvement observed.

CHAPTER X
SUMMARY OF BIOANTHROPOLOGICAL FINDINGS FOR THE MISSION-PERIOD NORTHERN UTINA

Data have been gathered on pre-Columbian and mission-period northern Florida skeletal collections to evaluate the biological consequences of the Spanish mission system on a Native American population. Material derived from this research, the first of its type conducted on Florida's aboriginal peoples, will add to the expanding knowledge concerning adaptation of Native American populations to changes in their environment.

Although European-introduced pathogens have typically been implicated in the decline of Native American populations, analysis of the San Martín skeletal remains does not demonstrate direct evidence for epidemic death. However, the virulence and mortality of such epidemics dictate that death frequently occurs prior to skeletal involvement. Biological interpretation indicates that northern Utinian mission life was dominated by a disease load that produced a pattern of life-long chronic stress. General health levels were compromised and peak mortality for both genders falls between 26-30 years of age (see Tables 7.1-7.3). Simply stated, mission life was difficult and short.

It is commonly accepted, however, that the repeated introduction of Old Worlds pathogens, specifically acute crowd infections like measles, smallpox, and influenza, into La Florida devastated the colonial-period Native Americans. A plethora of Spanish documents have recorded the presence of various epidemic episodes which besieged the Timucuan mission populations during the years 1613-1617, 1649-1659, and 1672-1674. The authenticity of these historic records is not in question. Direct evidence for the transmission of these outbreaks to the San Martín mission is, however, absent from the skeletal and archaeological record.

The mortality data and life tables derived from the San Martín skeletal collection do not suggest a population impacted by the introduction of Old World diseases. Such a mortality profile would demonstrate peak morbidity among infants and older adults. As disease is typically hardest on the very young and very old, these age groups should be disproportionately represented in any epidemic mortality collection. Adolescents and young adults might also be differentially affected (Burnet 1969; Milner 1980:49).

It has been demonstrated that neither taphonomy nor preferential burial treatment (Chapters 6 and 7) have contributed significantly to the archaeological absence of infants and older adults. Individuals less than fifteen years represent 27% of the mortuary population, a figure comparable to the expected norm (Weiss 1973). Table 7.1 shows a unimodal mortality profile in which mortality steadily increases from age one through age twenty five, peaks between 26-30 years, and then steadily declines. It is improbable that acute crowd infections would have selected against only this segment of society. Alternatively, it may be suggested that the northern Utinan elders maintained stronger ethnic ties and did not take up residence at the mission.

The burial program observed at San Martín does not support epidemic-proportion interment patterns. Epidemics that affect populations with no previous disease experience strike quickly and fatally and are frequently over within one month. Although these rapid killers leave no time for skeletal involvement, one would expect the burial program to reflect the interment of a large portion of the population within a short time. The majority of burials are single interments and mass burials are rare. Although intrusive burials are relatively common, they appear to be a function of the extended temporal use of the cemetery. Burials are typically ordered in rows. Alternate factors, such as lack of archaeological evidence for grave markers and the fact that all burials are located within the relatively restricted confines of the church, may also be responsible for this pattern. While the presence of multiple and mass burials in archaeological series have been used as evidence for European epidemic disease affecting Native Americans (Milner 1980:48), these interpretations must be treated with caution. Although the apparent lack of mass burials indicates that these individuals did not die as a result of local epidemics, their absence should not be interpreted as lack of evidence for regional epidemics as the ethnohistoric record dictates otherwise. These data underscore the La Florida landscape as a mosaic of disease experiences, with emphasis on heterogeneity based on the cultural and natural environments.

Archaeological evidence gathered on northern Utinan settlement patterning offers some support for this hypothesis. It has been suggested that, despite the regional trend toward decline in native population numbers and density, the opposite pattern may have been true for certain individual clusters of sites (Johnson 1991). The archaeological record indicates an increased number of northern Utinan habitation sites from the late pre-Columbian and early-contact period into the mission period (Johnson 1991:452). Community patterns were changing across the region, suggesting that the more northerly Utina may have been shifted southward during the mission period (Johnson 1991:453). Although population density was declining regionally, population numbers may have remained stable at some missions. At some sites, increases in size throughout the mission period may either indicate an increase in local populations or possibly amalgamation and reduction (Johnson 1991:454).

Spanish documentation places the mission of San Martín along a mission trail that did not see extensive use early in the mission period. It is also known that Governor Rebolledo utilized the more remote northern Utinan villages as a population reservoir to replenish depopulated mission centers on the more intensely traveled royal road. These findings suggest that the relative isolation of San Martín may have, to some degree, shielded its inhabitants from the most profound and detrimental effects of the epidemics.

The 4.7% population level caries incidence suggests a mixed-economic subsistence pattern (Turner 1979) and one in which maize was present, but did not constitute a large portion of the diet. Archaeobotanical analysis of plant remains excavated from the seventeenth-century aboriginal structure associated with the San Martín mission complex proper, is consistent with assemblages from pre-Columbian sites in Florida, particularly in regard to the wild species like maypop and persimmon (Newsom and Quitmyer 1991:230). The presence of introduced and native domesticated and wild taxa, suggests a combined subsistence strategy of gathering wild fruits and nuts along with limited emphasis on cultivated species (Newsom and Quitmyer 1991; Ruhl 1990). The San Martín archaeobotanical and faunal data, which demonstrate the diversity of the Utinan subsistence behavior, support the dental data for a mixed-economic subsistence pattern. "This diversity shows a well-developed hunting, fishing, and gathering, economy integrated with the horticultural system" (Newsom and Quitmyer 1992:233).

The marked and rapid rate of occlusal wear and the high prevalence (49%) of calculus indicates an abrasive diet relatively high in carbohydrates. The association between dental caries, attrition, and calculus, combined with archaeobotanical data, indicates a carbohydrate-rich diet, but not one to which maize contributed significantly. Low rates of periodontal disease and abscesses are also present. Abscessing has been highly associated with gross carious lesions and may precede ante-mortem tooth loss. Although periodontal disease was an age-accumulative process, it has not been associated with extensive tooth loss.

In this population a twenty-four month extension beyond the mean range of enamel hypoplastic age-at-occurrence suggests post-weaning stress. This period may have been epidemic-induced, the product of nutritional deficiencies aggravated by a prolonged protein-poor weaning diet, and/or the by-product of increased susceptibility to infectious diseases. That 74.7% of the population demonstrated enamel hypoplasias and that hypoplastic banding typically took the form of multiple, narrow, shallow bands, suggests that the childhood period was characterized by repeated (chronic) short-term bouts with metabolic stress. Retarded long bone growth and development also implies that childhood stressors, such as parasite loads, nutritional deficiencies, and disease, were prevalent among this mission population.

Exogenous chronic stressors, such as impaired health, nutritional inadequacies, genetic factors, and/or environmental disturbances have been implicated in the etiology of dental crowding. The prevalence of dental crowding in this population suggests, however, a genetic predisposition for the trait.

The biological profile derived from analysis of bone pathologies supports the dental evidence in an interpretation of a chronically stressed mission lifestyle. The most prevalent skeletal indicator of systemic stress is periostitis, observed in 40% of the population. The nature of periosteal involvement indicates an infectious process with a predilection for the tibiae and suggests a localized bacterial etiology. Such a distribution would be expected among a sedentary, nucleated mission population in an environment conducive to the spread of crowd infections. Alternatively, the distribution and morphology of the lesions may indicate the presence of a low-grade, endemic, treponemal infection.

Porotic hyperostosis and cribra orbitalia are present in 30% of the collection. As with periosteal lesions, most of cases were healed at time of death suggesting that many individuals typically survived at least one stress episode. The synergistic relationship between periostitis and porotic hyperostosis implicates an etiology of both diet and disease. In addition, 34% of the individuals observable for both enamel hypoplasias and porotic hyperostosis were affected by both conditions. It has been suggested that the platycnemia observed here is an expression of a lifetime of less-than-adequate general health to which dietary stress and the physical demands of the repartimiento may have contributed. Harris lines, which do not develop in the chronically ill, are absent. Combined, these data strongly suggest that acute and transitory illness was not the norm among this mission population.

Osteoarthritic patterns show no evidence for activity-related behavior. Trauma-related pathologies are present in only 17% of the population. Differential stature and sexual dimorphism have been posited to reflect the skeletal expressions of preferential access to dietary resources. Degrees of expression are also believed to be influenced by anatomy, genetic factors, diet, physiology, and culture.

Gender and Temporal Patterns

Adult males were clearly more affected by systemic and specific diseases than were females. Males demonstrate a markedly higher incidence of dental caries, calculus, periostitis, porotic hyperostosis, platycnemia, osteoarthritis, and trauma-related injuries. Males were almost twice as likely to have been affected with periostitis, were twice as likely to have been affected by trauma, and were almost four times as likely to have been affected with porotic hyperostosis and cribra orbitalia than females. This very apparent gender-biased distribution suggests that the detrimental effects of the Spanish mission system impacted more heavily upon the male cohort. Because the biological data indicate that both female and male preadults were equally subjected to the adverse effects of the environment, an alternative explanation must be sought for the observed dichotomy in adult disease involvement. It has been suggested that this pattern is a correlate of the repartimiento, the native labor force organized by the Spanish and comprised of the male members of the mission population. Spanish records tell us that conditions were harsh and demanding and that treatment of the natives was certainly less than optimal, and often cruel.

All the natives of those provinces suffer great servitude, injuries, and vexations from the fact that the governors, lieutenants, and soldiers oblige them to carry loads on their shoulders . . . to the fort of St. Augustine. . . . And in addition to this, in order to employ them further, they detain them in St. Augustine for as long as they wish . . . with very short rations, such as giving them only two pounds of corn a day,one real for each day of work, which sum is usually given them in the form of old rubbish of little or no value or utility to them. Add to this the further vexation or injury of being snatched by force from their homes or villages, not only for tasks at the fort but also for work for private citizens, and this in the rigor of winter (when they come naked) or in the middle of summer, which is when they are most occupied in the labor of their crops on which solely depends not only their sustenance and that of their wives and children but also the victuals necessary for the relief of the garrison. (Moral 1676 in Hann 1988:140-141)

As Table 10.1 clearly demonstrates, the biological and physiological consequences of Spanish exploitation of northern Utinan males is reflected in the pathology profile of this mission skeletal collection. The male cohort demonstrates greater pathology and increased morbidity. Rates of dental caries and calculus are twice as high among males and may be attributed to the fact that males themselves carried maize to St. Augustine to supply the garrison and not only relied on corn as a staple during the trip, but were also paid "wages" in corn and "rubbish" while indefinitely detained at the garrison. They also lived a significant portion of the year in St. Augustine laboring for the Spaniards.

Traditionally, an increased reliance on dietary maize has been cited as a major contributor in promoting iron-deficiency anemia and thus the skeletal expression of porotic hyperostosis. It has been argued here that maize alone cannot be cited as the sole factor responsible for the development of porotic hyperostosis in the San Martín population. Non-dietary factors, such as population aggregation and the subsequent effects of disease load and the introduction of infectious diseases, have contributed to the observed population-level distribution of porotic hyperostosis. Environmental stressors, correlated with the repartimiento, compounded with an increased reliance on maize by males, could explain the fact that the San Martín males were four times as likely to have been affected with porotic hyperostosis.

The San Martín males were also at a greater risk for periosteal involvement, osteoarthritis, platycnemia, and trauma-related injuries. A higher incidence of periostitis among the males appears to be an artifact of the

TABLE 10.1
Rates of pathologies at San Martín: Male versus female

Pathology	Percentage of Females Affected	Percentage of Males Affected
Dental caries	24	56
Calculus	16	33
Enamel Hypoplasias	65	74
Porotic Hyperostosis	17	63
Platycnemia	31	54
Periostitis	31	53
Osteoarthritis	40	60
Trauma-induced injury	23	64

generally more stressful living conditions visited upon the males by the repartimiento. Platycnemia, the skeletal response to muscular stress, suggests extended periods of long distance travel and the repetition of postural influences associated with maize cultivation or another activity. Nutritional deficiencies have also been implicated in the etiology of platycnemia. It is possible that a combination of muscle stress and an over-reliance on dietary maize is responsible for the fact that the San Martín males are over one and a half times as likely to have been affected by platycnemia. Although males were more than three times as likely to have been affected by trauma-related pathologies, the low population prevalence of 17% and the types of injuries observed do not indicate aggression-related activities. It is more likely that the traumas suffered by the males were a factor of the harsh and exploitative conditions of the repartimiento.

Although the sample sizes are small, the data indicate a trend for increased skeletal pathologies between the early and late mission populations (Table 10.2). The rise in disease prevalence and percentage of individuals affected by physiological stressors between the early and late mission populations suggests an increase in stressful living conditions at the mission over time. It appears that although individuals survived more than one stress episode, continued exposure to the mission system ultimately produced a stress load so deleterious that these people could not rebound and resulted ultimately in population extinction.

It appears that the percentage of individuals affected with carious lesions may have actually decreased over time. This trend suggests either a reorientation of native subsistence patterns or that the majority of maize cultivated at the mission was transported to St. Augustine for Spanish

TABLE 10.2

Rates of pathologies at San Martín: The late versus the early population

Pathology	Percentage of Early Individuals Affected	Percentage of Late Individuals Affected
Dental caries	63	36
Calculus	32	62
Enamel Hypoplasias	77	81
Porotic Hyperostosis	13	31
Platycnemia	13	31
Periostitis	32	25
Osteoarthritis	23	19
Trauma-induced injury	10	6

consumption. However, the percentage of individuals affected with calculus doubled over time. This trend suggests a temporal increase in dietary carbohydrates and may indicate evidence for a shift toward greater reliance on carbohydrate-rich cultivated plants other than maize. Archaeobotanical data from the San Martín site seem to indicate a continuity with the basic aboriginal pattern of reliance on wild plants, with at least limited emphasis on cultivated species and perhaps also the first indication of a shift toward greater emphasis in cultivated species and introduced taxa. (Newsom and Quitmyer 1992:230)

The incidence of trauma-related injury remained consistent over time. The prevalence of periostitis declined slightly from 32% to 25%, while the rate of porotic hyperostosis and cribra orbitalia rose from 17% to 31%. Interpretation of these trends is difficult. Despite the commonly held notions that the general health of native populations was negatively impacted by European contact, evidence to the contrary is beginning to surface. Storey notes that the mission period Apalachee enjoyed generally better health than even high-status pre-Columbian individuals (1986:268). This paradox of supposedly decaying environmental conditions, disease stress, and improved skeletal health has been noted by a number of investigators from other contact-period collectionsoutside of La Florida (Larsen 1990:23).

Summary

This study demonstrates that disease in extinct populations depends on a dynamic relationship between host, pathogen, and environment. The causal variables affecting each "epidemiological triad" (Duncan 1988:3) are population-specific and, therefore, degree of disease expression will vary with population size, density, and pathogen behavior as dictated by physiological, social, and cultural factors.

Scholars of the contact period in the Southeast readily acknowledge that the repeated European introduction of acute crowd infections decimated aboriginal populations. In this regard the Spanish mission system provided the ideal environment for the transmission of Old World pathogens to La Florida's virgin-soil populations. The economic structure of the mission system required that the northern Utina be reduced to mission confines. This action served to increase sedentariness, aggregation, and population density among a population that had perhaps spent a significant portion of the year scattered and dispersed in small numbers. The establishment of the Spanish mission was thus the precursor of cultural discontinuity and shock that destroyed the northern Utina. Distinctive and dramatic changes in social organization, social structure, culture, religion, politics, economics, and physiological adapting mechanisms were all the products of the reductíon.

The forced changes in the ecological balance of the native Utina also greatly influenced the patterning and frequency of disease. Increased population density will increase the number of potential pathogen hosts, allow the population itself to become a reservoir for infectious pathogens, and result in the quick and efficient transmission of disease within a population (Lallo et al. 1978:22). The biological consequences of the Spanish mission system in this collection have been expressed archaeologically as non-specific stress-induced skeletal lesions, morbidity, and early mortality--all most prevalent among the male subset and related to the repartimiento. Although specific and definitive archaeological evidence does not exist for death by European-introduced pathogens, the affect of these infectious diseases, upon a chronically stressed population, must have contributed significantly to the ultimate destruction of the northern Utina.

CHAPTER XI
BIOANTHROPOLOGICAL INTERPRETATION OF THE PRE-COLUMBIAN NORTHERN UTINAN AND EVIDENCE FOR CHANGING HEALTH PATTERNS

To appreciate fully the patterns of pathology active among the mission Utina, it is necessary to address the disease processes affecting their pre-Columbian ancestors. Comparisons of these data sets are essential to establish variable rates and differential forms of disease processes impacting the populations.

I examined the skeletal remains of 128 individuals excavated from six pre-Columbian period burial mounds from five sites in north-central Florida and maintained at the Florida Museum of Natural History, University of Florida, Gainesville. The temporal sequence represented by these collections begins with the Weeden Island period and ends with the Spanish colonial period. Chapter III describes the archaeological contexts of the collections chosen for analysis, including temporal sequences and general descriptions of each site. The collections demonstrate cultural continuity with the northern Timucua of north Florida.

Although the individuals from each collection were examined separately, relatively small sample size, often less than twenty individuals, indicated that the analysis of pre-Columbian disease and general population-level health would be best served by incorporating the data into a single integrated unit. Archaeological investigations indicate that the populations within each collection inhabited similar environments, shared basic subsistence strategies and settlement patterns, and, perhaps most significantly, lacked any contact with

Old World populations. Together these factors justify compilation of a large data base to establish a more significant and representative pre-Columbian data set and provide a pre-Columbian baseline against which the biological consequences of the Spanish mission period could be evaluated. Individual analyses of numerous small collections cannot show trends in demography and pathology.

Demography

With few exceptions the pre-Columbian skeletal remains were fragmentary and often incomplete. Burials were typically commingled. As discussed in Chapter VII, differential preservation interjects an uncontrollable bias into the analysis of human skeletal remains. As with the San Martín mission-period sample, it must be assumed that a more conservative profile of pathologies was observed among these pre-Columbian individuals than was actually present in the once-living populations they represent. Consistent lack of less-than-optimal preservation in both the pre-Columbian and mission-period skeletal collections, however, indicates that only limited directional error can exist. Similar degrees of detrimental taphonomic processes predispose toward intersite consistencies in incidence rates.

Of the 128 individual remains examined there were 108 adults and twenty preadults. In the commingled burials the minimum number of individuals was derived from a count of the most numerous skeletal element, e.g., right femur, left humerus. The fragmentary, incomplete, and commingled nature of a substantial portion of the small collections, did not permit development of a population-specific aging seriation technique. Frequently observation of sexually dimorphic traits was not possible. As a result, sixty two individuals could be identified as only adult; twenty three females and twenty three males comprise the remainder of the adult sample. The adult age of only thirteen individuals could be determined with confidence and then only within ten-year intervals. Age determination of preadults was greatly enhanced by the application of dental calcification standards. Table 11.1 and Figure 11.1 report the demographic data.

The general nature of this profile prevents little more than speculation on demographic patterning. If the sixty two individuals aged as adult are removed from the sample, and those remains over 30 years of age are combined with the broad age categories "middle" and "old" adult, then this loose manipulation represents 49% of the pre-Columbian population. Although this figure does not reflect an actual population profile, it does indicate that older individuals are fairly well represented.

It appears that preadult remains are under-enumerated. This trend may be attributed to rapid disintegration of incompletely calcified bones by taphonomic forces (Gordon and Buikstra 1981), a correlate of the spatial dimensions of mortuary behavior (Buikstra 1981b), and/or preferential burial treatment based upon the social persona of the deceased (Binford 1971). With the exception of the interment of the religious specialist in McKeithen Mound B, the archaeological record does not indicate spatial or social burial differentiation. It must be assumed, therefore, that either taphonomy or collection methods are partially responsible for the observed pattern.

TABLE 11.1
Pre-Columbian demographic profile

	Sex			
Age	Preadult	Female	Male	Adult
1-5 years	5	0	0	0
6-10 years	6	0	0	0
11-15 years	3	0	0	0
Preadult	6	0	0	0
21-30 years	0	2	1	1
31-40 years	0	2	0	1
41-50 years	0	1	1	0
50+ years	0	0	1	3
Young Adult	0	2	1	3
Middle Adult	0	3	4	2
Old Adult	0	3	7	2
Adult	0	10	8	50
TOTAL	20	23	23	62

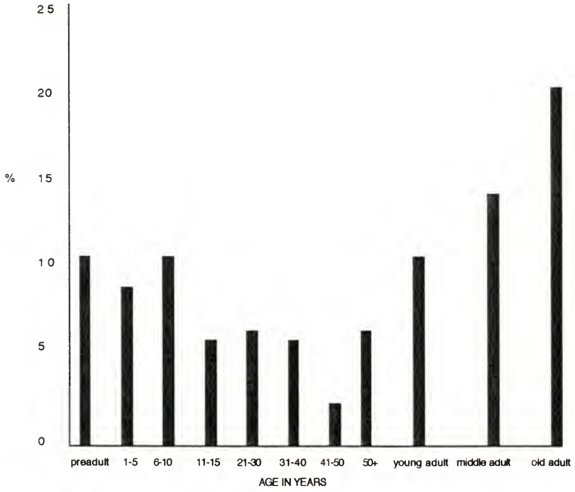

Figure 11.1
Pre-Columbian mortality profile
based on 60 ageable individuals

Dental Pathology

No cases of dental crowding or periodontal disease were observed. It was not possible to develop chronological age stages from seriation of occlusal dental wear patterns based upon the technique pioneered by Miles (1962, 1963, 1978). This method requires a baseline of at least twenty immature individuals aged by standard methods independent of tooth wear. Such a baseline could not be established.

Attrition

Attrition, erosion of the occlusal tooth surfaces from frictional wear of the dentition in tooth-to-tooth contact during mastication, has been reported to be a function of either the nonalimentary uses of the teeth, such as tools, (Powell 1985) or the nature of dietary components and their preparation or lack of preparation (Brothwell 1963, 1989; Molnar 1972; H.B. Smith 1984). Typically, it is the correlation between diet and food preparation techniques that is responsible for the degrees of dental wear observed in both archaeological and modern populations.

In this pre-Columbian collection only one individual, a 50+ year old male, demonstrated evidence for use of the teeth as tools. The upper three left molars and the upper left second premolar all exhibit marked grooving on the occlusal surfaces. A polished and cupped facet on the mesiobuccal cusp of the third molar, the angled and polished distal cusps of the second molar, and the pronounced buccal and lingual cusps of the second premolar, with the remainder of the occlusal surface deeply cupped, suggests repeated abrasion of the tooth surface by a fibrous material, possibly cordage.

Attrition in the remainder of the population appears to have been mainly a function of diet. The pattern of occlusal wear observed here is one of relatively flat, even wear across the crown surfaces. Attrition was predominately observed as enamel faceting and dentine exposure, followed in frequency by relatively shallow dentine cupping. The molar teeth typically demonstrated coalescing cusps, with generally flat and even occlusal surfaces (refer to Table 6.1 and Figure 6.2 for a discussion on wear patterns). This wear pattern suggests a basically hunter-gatherer subsistence mode (H.B. Smith 1984).

Dental Caries

A total of 497 teeth were macroscopically examined on all visible surfaces for carious lesions with a dental explorer. Loose teeth were incorporated into the dental analysis to enhance sample size. Observations on caries size and location are consistent with those reported in Chapter VIII.

The average population frequency of carious lesions was obtained by dividing the total number of dental caries (11) by the total number of teeth observed (497). The population incidence of 2.2% exceeds the mean percent of carious teeth, 1.3%, in hunting and gathering economies, but falls well below the average of 4.8% reported for mixed economies (Turner 1979:622). Turner (1979:632) posits that a caries incidence rate beyond the 2% nonagricultual threshold indicates a diet with high yields of carbohydrates. Of sixty two individuals observable for the trait, only four older adults (6.4%) were affected by dental caries, suggesting that caries was an age-accumulative process (Table 11.2 and Figure 11.2).

The pre-Columbian population rate of carious lesions appears to implicate a diet in which hunting and gathering was supplemented with

TABLE 11.2
Pre-Columbian dental caries rates for total number of teeth and individuals

Teeth	Individuals
2.2%	6.4%

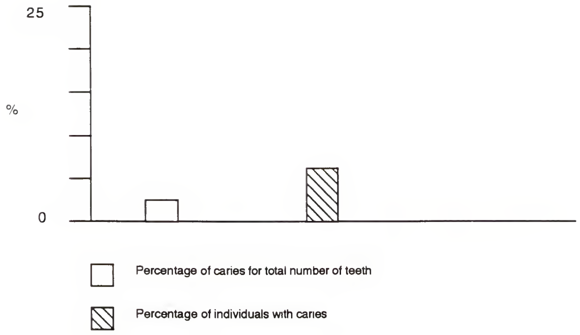

Figure 11.2
Pre-Columbian dental caries rate

carbohydrate-rich cultigens. Artifactual evidence, such as chert hoes, from the Cades Pond period suggests possible cultivation of local plants by some Cades Pond peoples (Loucks 1976:11). Evidence, in the form of corn-cob impressed pottery and ceramic effigies from the late Weeden Island period, suggests a partial reliance on cultigens (Milanich and Fairbanks 1980; Milanich et al. 1984). Maize cultivation has been inferred for the Alachua tradition from corn-cob marked sherds, descriptions by the sixteenth-century Spanish explorers of maize granaries, and charred kernels and cobs recovered from Potano sites (Milanich and Fairbanks 1980:172).

Although direct evidence for maize agriculture does not exist in northern Florida before the beginning of the Alachua tradition, A.D. 700, the 2.2% pre-Columbian population incidence of carious lesions combined with the archaeological data, indicates a diet with relatively high yields of dietary carbohydrates and partial reliance on local cultigens. This scenario is similar to that reported by Rose et al. (1991) for pre-Columbian populations in the central and lower Mississippi valley. Biological data suggest that maize was not adopted as a dietary staple before A.D. 1200 in the central Mississippi valley (Rose et al. 1991:19). The authors suggest that between A.D. 700 and A.D. 1200 Mississippian peoples began growing maize, but the abundance of natural resources, particularly starchy seeds, made the adoption of maize as a dietary staple unnecessary (Rose et al. 1991:21). Thus, high caries rates documented for Mississippian valley skeletal collections predating maize intensification, can be attributed to a diet rich in seedy carbohydrates.

Analysis of the number of carious lesions by specific tooth type revealed that the anterior dentition--the incisors, canines, and premolars--were unaffected by this disease process (Table 11.3 and Figures 11.3 and 11.4). To facilitate analysis, the molars were lumped as either mandibular or maxillary. Mandibular molars, 7 of 115 teeth affected for a 6.1% prevalence rate, are almost twice as likely to demonstrate carious lesions as the maxillary molars--4 of 124 teeth affected for a prevalence rate of 3.2%. The trend, discussed in Chapter VIII, of higher carious frequency among the posterior mandibular dentition in many archaeological skeletal series, has been attributed to larger molar tooth crown size, the more convoluted and complex occlusal surfaces of the molars, and food retention due to gravity following mastication. Observed lesions were incipient in size and affected only the occlusal surfaces.

Enamel Hypoplasias

All dental remains were examined for hypoplastic banding with a dental probe and a hand-held magnifier. The distance of each hypoplasia from the cementoenamel junction was recorded to the nearest tenth of a millimeter using Helios dial calipers. Nine of 57 individuals (15.8%) observable for linear enamel hypoplasias demonstrated evidence for this stressor. Females and males were equally affected. Age-at-occurrence in the pre-Columbian populations falls between the ages of twenty four to forty eight months. This developmental timing of hypoplastic banding is consistent with the generally accepted theory that enamel hypoplasias function as indicators of systemic or nutritional stress associated with the weaning period (Goodman and Rose 1991; Rose et al. 1985). Lack of tighter demographic controls and a generally low prevalence of bone pathologies (refer to following section) does not suggest evidence to the contrary. All bands were multiple, narrow, and shallow, indicating short-term durations of metabolic stress (Blakey and Armelagos 1985).

TABLE 11.3
Pre-Columbian dental caries by tooth

Maxilla

Tooth	Number observable	Number with caries	%
I1	18	0	0
I2	17	0	0
C	29	0	0
P3	43	0	0
P4	37	0	0
M1	38	1	2.6
M2	41	2	4.8
M3	45	1	2.2
TOTAL	268	4	1.5

Mandible

Tooth	Number observable	Number with caries	%
I1	17	0	0
I2	20	0	0
C	22	0	0
P3	26	0	0
P4	29	0	0
M1	33	1	3.0
M2	42	4	9.5
M3	40	2	5.0
TOTAL	229	7	3.1

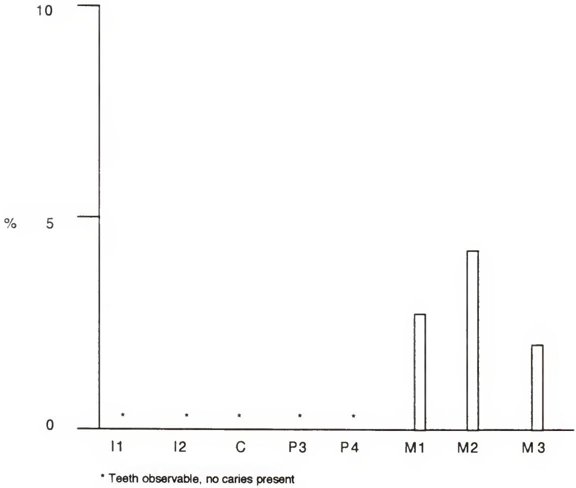

Figure 11.3
Pre-Columbian dental caries by maxillary tooth

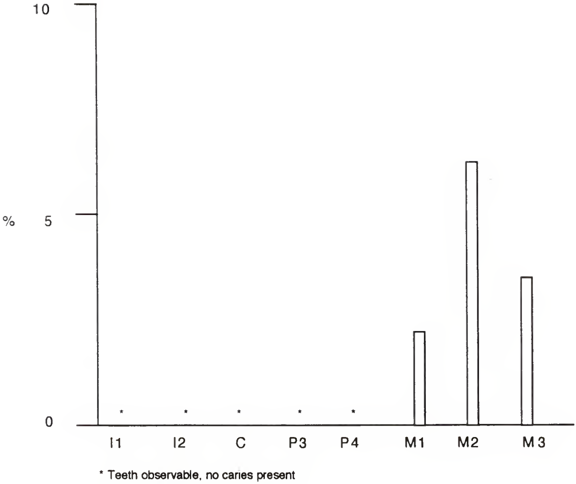

Figure 11.4
Pre-Columbian dental caries by mandibular tooth

Abscesses

Six of 62 observable individuals (9.6%) were affected with apical abscesses. As in the San Martín mission series, abscessing demonstrates a predilection for the molar teeth. In four cases abscessing was associated with a carious lesion. In two instances the site of the abscess was accompanied by antemortem tooth loss and some resorption of the alveolar margin. As caries provide a major avenue for the transmission of bacteria into the pulp cavity, the association of caries and alveolar bone destruction in archaeological populations, typically lacking appropriate hygienic intervention, is a relatively common occurrence.

Calculus

Calculus, the calcified remains of dental plaque, was recorded on 11 of 71 (15.5%) individuals observable for the trait. Plaque is present on the buccal, labial, and lingual surfaces of the dentition. The eleven cases suggest that calculus was an age-accumulative disease process. Five of six cases, in which degree of expression was slight, were observed on the dentition of young adults, with one preadult affected. All five cases of moderate degree of expression occurred in old adults.

Enamel Pearls

Enamel pearls were observed on the roots of the upper third molar of one individual and the upper second molar of a second individual. Enamel pearls form as the result of the chance activity of root sheath epithelium during embryological development, portions of which retain or revert to enamel-forming potential (Sciulli 1978). Extradental enamel pearls, those which project from the surface of the tooth, are fairly common dental anomalies in archaeological populations. They occur only on multirooted teeth and are most frequent on the maxillary teeth (Ortner and Putschar 1985:447).

The Relationship Between Dental Caries, Abscesses, Attrition, and Calculus

Analysis of the pre-Columbian dental pathologies has demonstrated low population levels of carious lesions, (2.2%), abscessing (9.6%), and calculus/plaque (15.5%). Dental attrition, an age-accumulative process, was not particularly severe.

Direct archaeobotanical data from pre-Columbian western Timucuan sites in north-central Florida is rare (Ruhl 1990:565). Some of the earliest evidence of corn remains were, however, recovered from the Sycamore site, a ninth-century Weeden Island household (Ruhl 1990:567). Artifact assemblages from the late Weeden Island period suggest a partial reliance on cultigens (Milanich and Fairbanks 1980; Milanich et al. 1984). Although the Cades Pond populations in north-central Florida may have practiced limited horticulture, the bulk of the diet was still based on foods taken from the lakes and forests (Milanich 1978c). Archaeological evidence indicates that among Cades Pond populations subsistence depended on extensive exploitation of a wide variety of aquatic and forest fauna in addition to intense harvesting of plant resources, especially starchy seeds such as hickory nut (Cumbaa 1972; Hemmings 1978). Hickory, oak, and palm berries have been recovered from Alachua tradition sites and maize agriculture is assumed for the post-A.D. 750 Alachua tradition.

Archaeological data indicate that a steadily increasing reliance on cultivation of maize was developing across north-central Florida during the post-A.D. 750 late pre-Columbian period into the mission period. Mission-period archaeobotanical assemblages of introduced and native, domesticated and wild plant taxa, are consistent across sites (Newsom and Quitmyer 1992:229). These assemblages are, in turn, frequently similar to those excavated from late pre-Columbian sites in northern Florida. This trend seems to indicate a continuity with the basic aboriginal pattern of reliance on wild plants, with a limited emphasis on cutivated species (Newsom and Quitmyer 1992:230). Certainly, by the time of European contact, the northern Utina were practicing maize agriculture.

Sample size has precluded precise interpretation of pre-Columbian microtemporal trends in changing dental patterns. The dentition, however, indicate that the pre-Columbian populations in north-central Florida had moved beyond a strict hunter-gatherer subsistence economy, in which dietary carbohydrates may have initially been derived from the harvesting of starchy seeds, into one that incrementally incorporated a larger percentage of carbohydrates. A steadily increasing reliance on local cultigens could have provided the carbohydrate levels necessary for the percentage of carious lesions reported here, a rate that exceeds the nonagricultural threshold. Pre-Columbian biological dental patterns, in the form of prevalence of carious lesions, abscesses, and calculus, and patterns of attrition, do not, however, indicate that maize constituted a significant portion of the diet.

Bone Pathologies

Periostitis and Osteomyelitis

Although the majority of the post-cranial remains were fragmented, it was still possible to examine the bone surfaces of ninety one individuals for indications of periosteal remodeling. This pathology is virtually absent among these pre-Columbian populations. Only one individual (1.1%), an adult male, demonstrated evidence for healed periostitis along the left fibular shaft.

Four (4.4%) adults were affected with hematogenous osteomyelitis. In one adult the disease process is localized in the proximal shaft of the right femur. Postmmrtem damage to the femur allowed observation of both the external and internal remodeling processes. Externally, a relatively large callus with a cloaca is present. In cross-section the medullary cavity of this callus, adjacent to the opened original medullary cavity of the shaft, is closed. The localized callus and cloaca and absence of additional remodeling along the remainder of the bone shaft strongly implicates a localized injury-induced response.

Three individuals were affected with long-standing and sclerotic hematogenous osteomyelitis, indicating that the skeletal lesions developed as a response to the introduction and dissemination of pyogenic bacteria into the bone through a hematogenous route from a remote septic focus (Ortner and Putschar 1985). One male demonstrates active hematogenous osteomyelitis of the distal right ulnar shaft. The disease process also shows signs of healing-associated remodeling along the entire length of the left clavicle. Another male, 50+ years, exhibits an active osteomyelitic reaction in both the fibulae and tibiae. In one adult the active disease process is present along the mid-shaft of the left femur.

Porotic Hyperostosis and Cribra Orbitalia

Porotic hyperostosis and/or cribra orbitalia is evidenced in 20 of 62 individuals (32%) observable for this indicator of anemic-related low blood iron levels. In eleven cases degree of expression was slight; it was moderate in nine. Eight individuals demonstrated evidence of healing, while the disease process was active at time of death in twelve individuals. Females and males were equally represented, but no preadult remains demonstrated evidence for this disease. Preadult remains were typically best represented by the dentition and long bones, with taphonomic intervention responsible for the under-enumeration of the fragile cranial bones.

Platycnemia

Four cases of platycnemia were observed, all from within the McKeithen Mound C collection. Females and males are equally represented. Unlike the San Martín mission population, it does not appear that dietary stress contributed to the expression of platycnemia. Although the geography of north-central Florida does not firmly support a theory of hypertrophy of the locomotor muscles from extended periods of walking across rough terrain and uneven substrates, evidence for significant mechanical loading of the femora in some of the McKeithen Mound C remains has been observed (see discussion on Additional Pathologies). This finding suggests that the platycnemia observed here may be a correlate of the functional and mechanical demands placed on the lower limbs and thus a skeletal response to muscular stress.

Osteoarthritis

The nature of spongy trabecular bone found in the epiphyses of the long bones and the vertebrae lends itself more readily to the destructive forces of taphonomy than does the denser cortical bone of the long bone shafts. For this reason, osteoarthritis was observable in only twenty eight individuals. Of the nine individuals (32%) affected, expression was slight in seven cases, and moderate in one. One individual displayed pitting of the glenoid cavity of the scapula and head of humerus. No gender or activity-related patterns could be established.

Trauma

Six of ninety one individuals (6.6%) demonstrated evidence for trauma-related injury. Two old adults, one male and one unidentifiable by gender, show evidence for healed depression fractures of the crania. These types of skull fractures, which appear as a cranial concavity, are the result of inward displacement of a portion of the clavarium by trauma. In the male the left parietal bone, approximating the sagittal suture, is the site of fracture. In the other individual the fracture is located on the frontal bone at approximately glabella. In both individuals the nature of the trauma suggests injury from a rapidly moving blunt object (Gurdijian et al. 1950).

A femur and a fibula shaft from two different adults showed evidence for healed fractures. In both cases, callus formation at the fracture site was accompanied by bony response to infection--periosteal reactions along the long bone shafts.

One individual displayed evidence for a compression fracture of the third cervical vertebrae. Schmorl's nodes are present on the inferior body of the third cervical vertebra and the superior body of the fourth cervical vertebrae.

The religious specialist (Burial 1) from within McKeithen Mound B was observed to have had a projectile point embedded in the dorsal aspect of the left ilium, superior to the acetabulum (Figure 5.7 in Milanich et al. 1984:110). The area is remodeled and a drainage canal is present indicating that healing had occurred. Bone had grown over a small portion of the projectile base (Milanich et al. 1984:111). There is no evidence for osteoarthritic involvement, suggesting that either the injury did not interfere with a normal gait or that death occurred before skeletal indicators of osteoarthritis could develop. Rodent gnawing on some of the long bones and the left orbit of the frontal bone indicates that this individual was exposed for a period of time before burial. After an in situ analysis of the remains, Dr. William R. Maples concluded that this person was a gracile adult male in the mid-to-late 30's (Milanich et al. 1984:109). Laboratory analysis of these remains, viewing the individual in a population context, and standard pelvic morphology (Phenicw 1969) suggest that this individual was female. Examination of the auricular surface, a technique not available in 1984, indicates a Phase 3 age of 30-34 years (Lovejoy et al. 1985a).

Additional Pathologies

Three individuals, including two males and the female religious specialist discussed above, display evidence for the form of cranial deformity know as cradle boarding. Fronto-occipital cranial deformation is present in two old adult males from McKeithen Mound C.

Two button osteomas were observed on the frontal bone of an old adult male. One old adult male displayed auditory exostoses of both the left and right temporal bones. The right exostoses is very pronounced, almost occluding the external auditory meatus. The left exostoses is much smaller and does not project beyond the inside of the ear canal.

Four adults, including two females and one male, demonstrated a meningeal reaction of the inner tables of the parietal bones. All cases were active at time of death with slight and moderate degrees of expression. No individuals showed evidence for post-cranial periosteal lesions, but all cases were accompanied by porotic hyperostosis. In this small sample varying degrees of involvement and healing prevented analysis of patterns of interaction between the two disease processes.

Thick and dense cortical bone in the femoral shafts has been observed to be anomalous to the McKeithen Mound C remains. One female and four males display evidence of this trait. Wolff's law states that every change in the use of a bone leads to a change in both its internal structure and its external form and function. Thus, in areas of mechanical demand bone is deposited; it is resorbed in areas where there is a lack of mechanical demand. Bone development is, therefore, directly related to levels of physical stress.

During constant stress, skeletal elements increase the amount of bone tissue necessary to efficiently resist external functional demands (Larsen 1982:240). In a review of physical stress and bone growth research, Larsen (1982) notes that these studies have demonstrated that cortical bone thickness increases with increased functional demand and mechanical burden. Brock and Ruff (1988) and Ruff et al. (1984) have suggested that, as the relative strength of bone is related to mechanical loading, activity types affecting the anteroposterior and mediolateral bending loads in the mid-shaft of the femur are responsible for increased cortical thickness observed among skeletal populations. Ruff and co-workers have speculated that repeated activities, such as running and long distance travel, increase mechanical loading of the femur (Ruff et al. 1984). Other studies have linked increasing sedentariness with decreased geometric robusticity of the lower limb bones (Lovejoy et al. 1976). The relationship between bone strength, geometric properties, and maintenance of function under mechanical loading has also been implicated in the physiological process of bone loss with age (Martin and Armelagos 1985; Martin and Atkinson 1977). These studies suggest that an activity-related force placed on the musculo-skeletal system of the lower limbs was responsible for the combined expressions of thick, dense cortical femoral bone and platycnemia in the McKeithen series.

Summary: Pre-Columbian Population-level Health and Disease

The pre-Columbian mortality trend, which predisposes toward an older population and low disease prevalence, suggests that individuals enjoyed relatively good health and nutrition. This data is reflective of the trends observed in hunter-gatherer archaeological populations across the continents (see Cohen and Armelagos 1984).

Biological interpretation of the dental remains, including low levels of carious lesions, attrition, calculus, and abscesses, indicates that pre-Columbian populations increasingly supplemented a largely hunter-gatherer subsistence with carbohydrate-rich foods. This evidence is consistent with pre-Columbian artifact assemblages and archaeologically interpreted subsistence patterns in which hunting and gathering a wide variety of aquatic and forest fauna, was supported by intensive harvesting of plant resources and non-intensive cultivation and agriculture (Hemmings 1978; Loucks 1976, 1979; Milanich and Fairbanks 1980; Milanich et al. 1984; Newsom and Quitmyer 1992; Ruhl 1990; S. Smith 1971). Both biological patterns and archaeological evidence indicate a partial reliance on dietary carbohydrates, probably squashes and later maize, by the pre-Columbian populations of north-central Florida.

Low prevalence of enamel hypoplasias (15.8%) suggests that on a population level, the post-weaning period was not significantly stressful. An extremely low incidence rate of periostitis, 1.1%, provides strong support for the theory of a relatively stress-free pre-Columbian population. Although three cases of generalized adult osteomyelitis are present, this 3.3% population level involvement does not indicate the presence of chronic infectious diseases processes, but rather individual responses to the localized introduction of pyogenic bacteria.

Observed cases of porotic hyperostosis and cribra orbitalia appear to be relatively high (32%). The cases are evenly distributed between adult females and males. Neither the pre-Columbian diet nor the patterns and incidence of additional skeletal pathologies support an etiology of acute crowd infections. Recently it has been suggested that a high incidence of porotic hyperostosis in a group is indicative of a heavy pathogen load in the environment of that group, for whatever reason (Stuart-Macadam 1992:44).

> Populations that were chronically exposed to heavy pathogen loads have adapted by lowering their iron status, resulting in an increased susceptibility to iron deficiency anemia. Rather than being seen as a sign of weakness or maladaptation, porotic hyperostosis should be viewed as a sign that the population is attempting to adapt to adverse environmental conditions. (Stuart-Macadam 1992:44-45)

Correctly viewing anemia as a symptom of an underlying disorder, and not a disease, implies that iron deficiency may have been a stress response to an environment in which microbial invasion was relatively high. Parasitic pathogenic worms, helminths--including hookworm, tapeworm, and pinworm--are particularly prevalent in moist warm climates. Eggs, deposited on warm, damp soil, develop into the larvae that penetrate the feet of barefoot persons. In the sub-tropical environment of Florida, people walking barefooted are particularly vulnerable to helminithic infection. These parasites rob the body of essential nutrients, especially iron, and can cause hidden blood loss and/or diarrhea, all factors implicated in hypoferremia. Parasitic infection could, therefore, potentially be responsible for iron-deficiency anemia in this pre-Columbian population. The observation of both active and healed lesions indicates that, by and large, the population was adapting to adverse environmental conditions and attempting to cope with the pathogen load.

Low levels of osteoarthritis and the inability to distinguish activity-related patterning, limits analysis of this disease process. A low incidence rate of trauma-induced injury does not indicate a population involved in aggression-related activities. The projectile point recovered from the dorsal ilium of the 30-34 year old female religious specialist is the exception.

The morphology of the femoral cortical bone and the platycnemia of the tibiae among the McKeithen Mound C population suggests that a significant amount of mechanical-functional demand was placed on the lower musculo-skeletal system. Repetition of activities involving the leg muscles could be responsible for these skeletal characterizations. It has been suggested that a lifetime of repeated running and long distance travel are responsible for increased cortical thickness in femur shafts (Ruff et al. 1984). Walking long distances over an uneven substrate has been implicated in platycnemia (Kennedy 1989; Lovejoy et al. 1976). It appears that an activity-related correlation, possibly a lifetime of long-distance travel by foot may exist between femoral cortical thickness and platycnemia as it is expressed in the McKeithen Mound C population.

All skeletal indicators of biological health appear to indicate that the pre-Columbian peoples of north-central Florida led a relatively healthy and stress-free life. There is little direct evidence for infectious disease. Typical markers of chronic stress, dietary inadequacies, and acute crowd infections are absent.

An Analysis of Changing Disease Patterns Among the Northern Utina

Table 11.4 and Figures 11.5 and 11.6 demonstrate the temporal change in rates of dental and bone pathologies. Table 11.5 and Figures 11.7 and 11.8 show the distribution of carious lesions per tooth for both the pre-Columbian and mission-period populations. All skeletal indicators of biological stress, with the exception of porotic hyperostosis, osteomyelitis, and osteoarthritis, have increased over time.

Although dental caries have been shown to be an age-accumulative disease process in both populations, a higher prevalence rate among the mission population is not a factor of age, because the pre-Columbian population demonstrates the relatively older age profile. Differences in dietary regime have been responsible for the differential expression of carious lesions between these populations. It has been suggested that although the pre-Columbian populations approximate the non-agricultural threshold for dental caries (2.0%), the 2.2% population incidence does indicate the presence of

Table 11.4
Temporal trends in disease prevalence among the northern Utina

Disease Process	Pre-Columbian	Mission
Dental caries	2.2%	4.7%
Enamel hypoplasias	15.8%	74.7%
Abscesses	9.6%	14.7%
Calculus	15.5%	49.3%
Dental crowding	0%	28.0%
Periodontal disease	0%	9.3%
Porotic hyperostosis	32.0%	30.0%
Periostitis	1.1%	40.0%
Osteomyelitis	4.4%	2.5%
Platycnemia	4.4%	16.3%
Osteoarthritis	32.0%	31.0%
Trauma	6.6%	16.0%
Harris lines	0%	0%

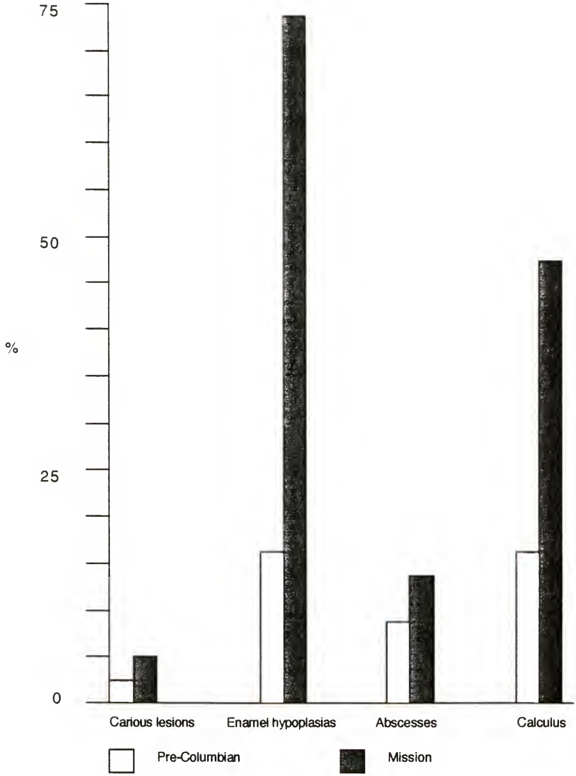

Figure 11.5
Temporal trends in dental pathologies among the northern Utina

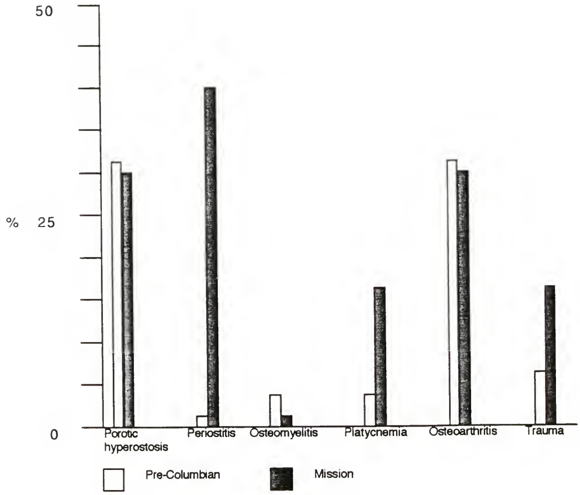

Figure 11.6
Temporal trends in bone pathologies among the northern Utina

TABLE 11.5
Temporal trends in dental caries by tooth

Maxilla

	Mission			Pre-Columbian		
Tooth	N[a]	N[b]	%	N[a]	N[b]	%
I1	82	0	0	18	0	0
I2	84	0	0	17	0	0
C	96	1	1.0	29	0	0
P3	105	4	3.8	43	0	0
P4	108	3	2.8	37	0	0
M1	100	4	4.0	38	1	2.6
M2	94	3	3.2	41	2	4.8
M3	76	4	5.3	45	1	2.2
TOTAL	745	19	2.5	268	4	1.5

Mandible

Tooth	N[a]	N[b]	%	N[a]	N[b]	%
I1	95	0	0	17	0	0
I2	93	0	0	20	0	0
C	103	1	1.0	22	0	0
P3	106	4	3.8	26	0	0
P4	104	6	5.8	29	0	0
M1	91	14	15.4	33	1	3.0
M2	87	16	18.4	42	4	9.5
M3	65	12	18.5	40	2	5.0
TOTAL	744	54	7.3	229	7	3.1

a Number of teeth observable
b Number of teeth with caries

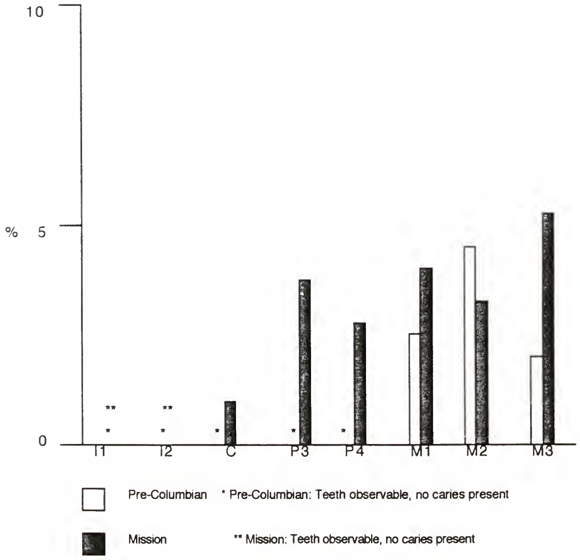

Figure 11.7
Temporal trends in dental caries by maxillary tooth

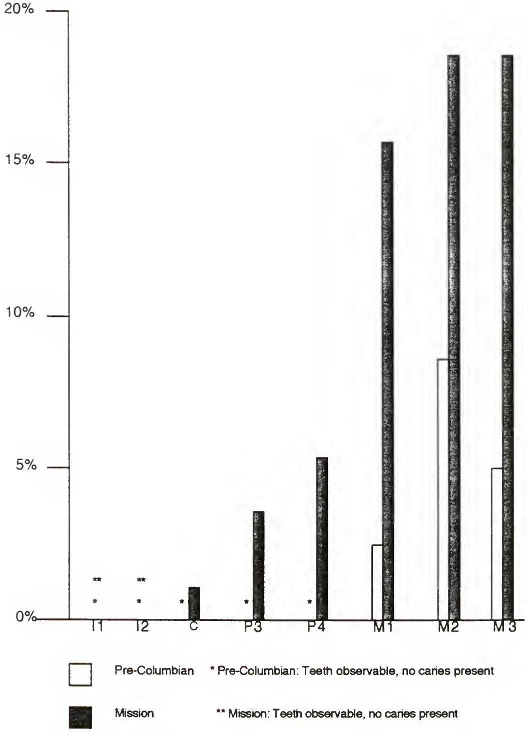

Figure 11.8
Temporal trends in dental caries by mandibular tooth

dietary carbohydrates. Both the archaeological artifact and botanical assemblages support limited maize horticulture among these pre-Columbian populations. The increase in population-level prevalence of dental caries to 4.7% among the San Martín mission-period northern Utina demonstrates that, over time, maize was increasingly incorporated into the diet. However, the incidence among the mission population remains well below the norm reported for groups known to have relied on maize (7.0%) and approximates the mean for a mixed-economic subsistence mode (4.8%). These trends suggest that although maize was a dietary supplement, it was not a substantial portion of the dietary regime of north-central Florida's native pre-Columbian and mission northern Utinan populations.

The association between dental caries, periodontal disease, attrition, abscessing, and calculus in both populations supports this hypothesis. The pre-Columbian population rates of carious lesions, abscessing, attrition, and calculus are low, indicating a subsistence strategy in which extensive exploitation of environmental resources was supplemented with small-scale horticulture or cultivation of local resources. Mission-period prevalence remains relatively low, but rises in dental caries (2.2% to 4.7%), periodontal disease (0% to 9.3%), and especially plaque (15.5% to 49.3%), indicate an increase in carbohydrate-rich resources by the mission population.

The observed dichotomy in dental wear patterns, attrition, also suggests differential population subsistence strategies. Systematic contrasts have been demonstrated to be a function of subsistence and food preparation distinctions (Molnar 1971; H.B. Smith 1984). Dental attrition among the pre-Columbian people has produced flat and relatively even occlusal wear. The dental wear pattern among the mission population is relatively oblique and accompanied by a significant amount of dentine cupping. Hunter-gatherers develop flat molar wear, whereas agriculturists develop oblique molar wear and deeply cupped-out dentine because of an increase in the proportion of ground and prepared food and abrasive particles in the diet (H.B. Smith 1984:39).

Although limited archaeological information exists concerning Indian plant use and practices during the late pre-Columbian and subsequent mission period (Ruhl 1991:559), Florida mission-period archaeobotanical assemblages, that indicate partial reliance on horticulture, are typically similar to those found at pre-Columbian sites (Newsom and Quitmyer 1992). It has been implied that this trend indicates a continuity with the basic aboriginal pattern of reliance on wild plants and limited cultivation and may represent evidence for the initial shift toward greater use of cultivated species (Newsom and Quitmyer 1992). If corn remains were archaeologically visible, then these patterns would suggest a reorientation of native subsistence strategies after missionization.

Two alternative hypotheses deserve consideration. First, peoples undergoing a significant amount of life stress, as was the San Martín mission population, tend to revert to previous and once reliable patterns of maintenance, support, and survival. It may be that the relatively higher, but still generally low, rates of dental pathologies, especially caries, among the mission collections are actually indicative of a population returning to native procurement patterns. Mission aggregation of native populations and disruption of aboriginal lifestyles, may have resulted in a partial return to pre-mission subsistence strategies rather than an increased reliance on cultivated species. Although, it is known that Timucuan mission populations were recruited to cultivate maize to supply the garrison at St. Augustine, we will never know the extent to which these crops were incorporated into the mission diet.

Second, the observed decline in percentage of individuals affected with dental caries between the early and late San Martín mission populations suggests that the majority of maize cultivated by the mission peoples was not retained for their use, but rather was transported to St. Augustine for Spanish consumption. Ethnohistoric documentation supports this scenario.

The most striking indicator of the temporal increase in population-level systemic stress is witnessed by the sharp rise in individuals displaying evidence for enamel hypoplasias. Hypoplasias, indicative of systemic metabolic stress, are typically correlated with the weaning period, but have also been consistently associated with malnutrition and disease (Goodman and Rose 1991:284). The twenty-four to forty-two month age-of-occurrence among the pre-Columbian population indicates that hypoplastic formation was largely the function of weaning-related stress. The low prevalence rate (15.8%) suggests that, on a population level, the weaning and post-weaning periods were not particularly stressful. The high rate of enamel hypoplasias (74.7%) among the mission population indicates a childhood characterized by chronic stress. The figures reported here dictate that the decline in general population health between the pre-Columbian and mission northern Utina coincided with dramatic changes in their cultural and biological environment.

The significant increase in the number of mission-period individuals affected with bone pathologies supports a pattern of declining health over time. Periosteal lesions, indicators of non-specific infectious disease affecting the general health of an individual, have increased most significantly over time, from 1% to 40%. This trend suggests the introduction of a not previously encountered endemic infectious disease processes or possibly the presence of endemic treponematosis.

incidence of porotic hyperostosis are virtually equal in both populations. Evaluation of pre-Columbian and mission cultural and environmental contexts and examination of the disease patterns suggests population-specific disease etiologies. Although incidence rates of porotic hyperostosis and cribra orbitalia remain fairly constant, differential cultural and environmental factors have affected their expression. In the pre-Columbian populations, lacking additional skeletal indicators of stress, such as periostitis, it was suggested that iron-deficiency anemia was related to microbial invasion, specifically the parasitic helminths. The association of porotic hyperostosis with high levels of periosteal lesions in the mission population, suggests a synergistic relationship between iron-deficiency anemia and infectious disease processes, one that frequently appears in skeletal collections as an associated pattern of porotic hyperostosis and periosteal responses (Mensforth et al. 1978; Palkovich 1987).

The etiology of platycnemia is not fully understood and has been attributed to pathological stressors, nutritional deficiencies, and muscle stress. It has been suggested that the skeletal expression of platycnemia among the pre-Columbian peoples, specifically the McKeithen Mound C collection, has been a correlate of the functional and mechanical demands placed on the associated musculature. Platycnemia, four times as prevalent among the mission population, may have been either a skeletal expression of a lifetime of less-than-adequate general health and/or diet or a function of shifting activity patterns related to Spanish-imposed labor demands. Postural influences (Kennedy 1989) and walking long distances by foot (Ruff et al. 1984) have been implicated in platycnemia. The economy of the Spanish mission system was dependent upon native cultivating, harvesting, and transporting maize long distances by foot. A lifetime of repeated cultivation-related activities such as bending, lifting, walking, and then carrying maize long distances to supply the St. Augustine garrison would have affected the functional-mechanical demand of the musculoskeletal system in the lower limb. Alternatively, the combination of inadequate dietary resources and activity-related functional-mechanical demands on the skeletal system could have been responsible for the observed platycnemia.

Cases of osteomyelitis are low among both populations, but are slightly more prevalent within the pre-Columbian sample. Low incidence makes further analysis impracticable. In that treponemal infection has been documented for Florida's aboriginal groups, the absence of this disease among both the north-central Florida pre-Columbian populations and the northern Utinan mission population is puzzling. This issue will be addressed in more detail in Chapter XII. Osteoarthritis, equally expressed between populations, is an age-accumulative pathology. No activity related behaviors could be diagnosed. Trauma-related injury increased from 6.6% to 16.0%. Although both prevalence rates are low, the relative rise among the mission population may indicate stress-related social behavior patterns, reflecting increased hostilities between mission inhabitants or between Spaniards and Indians during this time of cultural upheaval.

Conclusions: Populations in Transition

Establishment and implementation of the Spanish mission system provided the primary stimuli for increased stress and morbidity among the northern Utina. Aboriginal inhabitants were reduced to mission confines, native settlement patterns were altered, forced labor was instituted, and many native cultural customs were changed or eradicated.

Although, the physiological stressful effects of life transitions have long been recognized in modern populations (Seyle 1956), these principles have only recently been applied to biological analyses of archaeologically derived skeletal populations. The bioarchaeological record is testimony to the physiological, morphological, and pathological repercussions visited upon numerous populations in transition, whether it be subsistence related (see Cohen and Armelagos 1984) and/or associated with major cultural upheavals (see Larsen 1981a, 1981b, 1982, 1984, 1990). Rather consistently, increased biological stress is indicated by an increase in infectious disease, chronic malnutrition, episodic indicators of stress, and general declines in suvivorship, mean age at death, land owered life expectancy and levels of physical stress.

The research most comperable to this study of the relationship between pathology and cultural and environmental change among the northern Utina has been that conducted by Clark Larsen (1981a, 1981b, 1982, 1984, 1990). Observations of La Florida human skeletal collections from the Georgia coast, displaying cultural continuity over 4,000 years, have enabled Larsen to demonstrate the biocultural effects of both the transition to agriculture and the transition to mission life.

Generally preagriculture, pre-Columbian populations from the Georgia coast enjoyed relatively good health and nutrition. Typically, in the transition to agriculture, the rates of periosteal reactions increased and dental caries prevalence increased dramatically, while decidious tooth size, overall adult skeletal size, general cranial size, facial masticatory complex size, and percentage of osteoarthritis decreased. Demographic profiles reveal that the preagricultural populations exhibit the older age cohort. The agriculture sample demonstrates elevated mortality at twenty years of age, with suppressed mortality in the remaining adults. The greatest percentage of reduction in skeletal size has occurred in the female skeleton. The differential impact of maize on the female cohort, as a result of gender-based activity and consumption patterns, has been implicated. The decrease in osteoarthritic involvement has been attributed to a decrease in the functional and mechanical demand placed on the musculoskeletal system by a more sedentary agricultural lifestyle as well as an increase in nutritional stress associated with this subsistence change.

Research conducted on the human skeletal remains excavated from within the late sixteenth-seventeenth century Santa Catalina de Guale mission, demonstrates a population experiencing a general decline in health, a further reduction in skeletal size, increased osteoarthritis, another shift in musculoskeletal stress, and lower mean age at death (Larsen 1990). A dramatic increase in carious lesions, 47%, observed between the early and late contact populations indicates that cultigens became increasingly important (Larsen et al. 1991). This trend, which indicates a reorientation of native subsistence prior to and after establishment of the mission system, is supported by stable isotopic ratios of carbon and nitrogen in bone organic residues (collagen). The mission population demonstrates lower delta 15 nitrogen and higher delta 13 carbon values indicating a lower dependence on marine foods and an increase in the percentage of dietary maize (Schoeninger et al. 1990:92). Although a shift toward terrestrial sources, particularly maize, appears apparent, the mission population continued to utilize a varied range of dietary items, with marine resources still a significant contributor (Schoeninger et al. 1990:91).

Among the Guale mission population the incidence of dental caries is higherfor the female cohort, suggesting that males ingested less maize than females. This trend appears to have been a function of the sexual division of labor, women as food preparers, and its relationship to dietary habits (Larsen et al. 1990).

The biological data from both the Santa Catalina de Guale and the San Martín northern Utinan populations indicate that native diets generally followed a continuation of pre-Columbian subsistence patterns, with an increased reliance on either carbohydrate-rich cultigens or maize. Unlike the Santa Catalina de Guale population, the San Martín males demonstrate a higher percentage of carious lesions. Males constituted a significant proportion of the labor force responsible for the cultivation of maize to supply the St. Augustine garrison, transported the maize to St. Augustine by foot, and then spent a significant portion of the year in residence at the garrison. These gender-based activities may have increased male access to and ingestion of maize.

Among the Guale the frequency of enamel hypoplasias did not change significantly over time, but a temporal increase in the width of continuous hypoplasias was observed. Age-of-occurrence peaked between 2.5-3.5 years. The greater widths of individual hypoplasias indicate either an increase in severity or duration of metabolic stress or both (Hutchinson and Larsen 1990). Between the pre-Columbian and mission-period northern Utina hypoplastic band widths remain constantly narrow and shallow, but the frequency of hypoplastic banding has significantly increased among the mission population. Although the duration of metabolic stress did not change over time, the dramatic increase from 15.8% to 74.7% of mission-period individuals affected, clearly indicates that the northern Utina mission population was subjected to a stress load unparalleled among their pre-Columbian ancestors.

The low rate, 8%, of porotic hyperostosis among the pre-Columbian Guale suggests that chronic hemolytic anemia was not a major problem (Larsen 1984). The percentage of late contact involvement increased to 27% and has been attributed to dietary change (Larsen et al. 1990). The prevalence of porotic hyperostosis remained relatively consistent for the northern Utina. For the pre-Columbian ancestors of the northern Utina, porotic hyperostosis was posited to be a correlate of microbial infection. Expression of this disease among the mission population indicates a synergistic relationship between iron-deficiency anemia and infectious disease and implicates stress associated with cultural and environmental upheaval of this native population.

Increased rates of osteoarthritis among the late contact-period Guale suggests increased demands on the musculoskeletal system by the repartimiento. At the same time frequency of expression declined between the sexes, suggesting a shift toward more similar gender work loads and subsistence activities (Ruff and Larsen 1990:117). A relatively greater increase in body size among females has resulted in decreased sexual dimorphism. A reduction in the cranial features and dental size is credited to the reduction of masticatory stress associated with a processed agricultural diet. Populations with soft diets and low-demand mastication tend to develop less robust bony architecture.

Although the nature of the pre-Columbian northern Florida skeletal series did not permit comparisons of changing trends in cranial, dental, and post-cranial size, the San Martín mission population is strikingly dimorphic.

Standard pelvic morphology (Phenice 1969) supports a clearly more robust, in both size and general bone shape, male skeleton. It is difficult to assign these gender-based differences to any one factor. Although preferential access to dietary resources, activity patterns, and basic sexual morphological and biological differences may all be implicated, this difference may reflect little more then differential sexual development.

> As a result of the timing and duration of the male pubertal growth spurt, males tend to grow to a larger size, on the average, than females. Two factors intrinsic to the growth curve itself contribute to this size difference. One is simply the greater length of time males are permitted to grow before the process is terminated. The other factor is the greater intensity if growth at the time of peak growth velocity. Combined, these factors yield the sexual dimorphism in stature that characterizes our species. (Stini 1985:214)

The Guale contact-period mortality profile appears to demonstrate a rebound in young adult survivorship from the precontact agricultural sample and may indicate a net increase in overall health as a result of a century of European contact (Russell et al.1990). Santa Catalina de Guale mission population mortality between the ages of 0-5 years is 9.25%. This low figure appears to reflect a sampling error, suggesting that the majority of preadults were buried elsewhere, not buried at all, or were subjected to the effects of taphonomy (Russell et al. 1990:43). At San Martín 6.8 % mortality between the years of 0 to 5 also suggests sampling error. Although I have argued that differential burial treatment and taphonomic forces were not significant factors in the under-enumeration of preadult remains, this low figure is suspect. It is possible, however, that only baptized children were buried beneath the church.

At Santa Catalina de Guale mortality is 32.5% for individuals between the ages of 5-20 years. Mortality between the ages of 20-25 years is also low, but after this age the probability of dying rises consistently (Russell et al.

1990:45). At San Martín mortality between 5-20 years is 17.0%, with a 18.2% mortality rate between the ages of 21-25 years. After age twenty five survivorship declines rapidly. These figures indicate that San Martín individuals were more likely to survive to age twenty, although both mission populations demonstrate elevated mortality after twenty five years of age. Among the Santa Catalina de Guale population mortality was low between the years of 5-35 and followed by high probability of dying in individuals over forty years of age. At San Martín individuals over forty constitute only 4.5% of the mortality cohort. Although both mission populations demonstrate few surviving old adults, it appears that the mortality profile from Santa Catalina de Guale supports a relatively older age profile.

Although neither death by epidemic nor treponemal involvement can be firmly established for either the Guale or northern Utina mission-period populations, their presence and debilitating effects on such chronically stressed populations cannot be ruled out.

Summary

The temporal trends in changing disease prevalence and patterns of expression among the northern Utina are consistent with research conducted on numerous skeletal populations undergoing transition. The pre-Columbian skeletal collections demonstrate longer survivorship and display low disease levels. The younger mission-period populations exhibit a higher probability of dying and demonstrate a higher incidence of bone pathologies.

Analysis of this pre-Columbian series indicates that the initial period of horticulture and cultivation was not associated with a general decline in health.

The Spanish mission system promoted increased sedentariness, aggregation, and population density and provided the ideal environment for the introduction and transmission of pathogens never before encountered by the native northern Utina. In this respect Old World pathogens, such as measles, would certainly have had disastrous effects on the San Martín population.

The synergistic relationship between disease and cultural and environmental disruption is analogous to the ever-constricting effects of a whirlpool. The mission system initiated spiraling momentum, which was fed by population aggregation, sedentariness, density, and nucleation. These forces promoted and accelerated population-level stress until the rushing and absorbing catastrophic effects culminated in total population decline and decimation. The northern Utina were victims of the mission vortex (Figure 11.9).

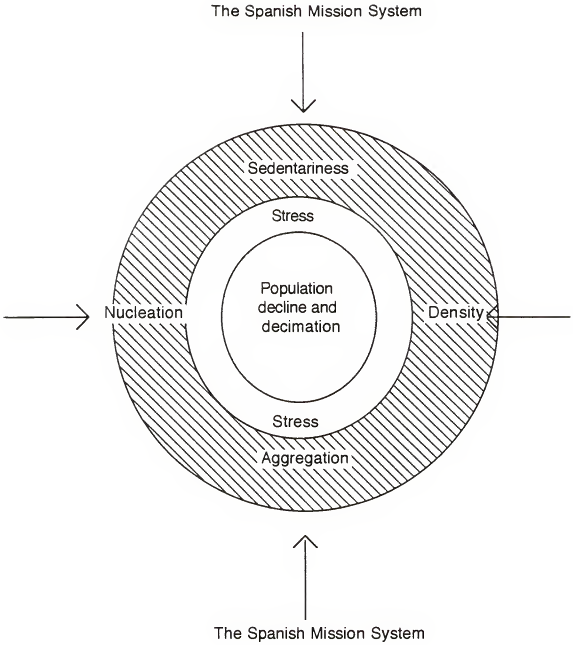

Figure 11.9
The mission vortex

CHAPTER XII
THE ETIOLOGY OF TREPONEMATOSIS AND TUBERCULOSIS AND ITS APPLICATION TO THE FLORIDA NATIVES

The origin and presence of the infectious diseases treponematosis and tuberculosis in New World populations before European contact have long been topics of debate among the anthropological community. That considerable argument and research has focused upon these two specific disease syndromes can no doubt be attributed to the fact that, unlike many infectious diseases, such as measles and smallpox, treponematosis and tuberculosis significantly alter bone in grossly recognizable patterns. These disease morphologies greatly facilitate differential diagnoses in skeletal remains.

Although the presence of tuberculosis in pre-Columbian New World populations is now a matter of record (Allison et al. 1973; Buikstra 1981a, 1981b; 1981c; Buikstra and Williams 1991), the history and origin of treponemal disease is not so clear. Archaeologically derived human skeletal collections do, however, support the presence of treponematosis among pre-Columbian New World populations (Baker and Armelagos 1988; D. Cook 1976; Ortner and Putschar 1985; Ortner et al. 1992; Powell 1988, 1990, 1991; Steinbock 1976). Human skeletal remains, bioanthropological literature, and sixteenth-century French and Spanish chronicles have established the presence of a treponemal syndrome among Florida's aboriginal populations and indicate that venereal syphilis may have affected the Timucua at time of initial contact (A. Bullen 1972, 1973). Evidence of tuberculosis among Florida's native populations is, however, apparently absent in both pre- and post-contact skeletal remains and the ethnographic literature. Neither treponematosis nor tuberculosis was observed in the north-central Florida pre-Columbian and San Martín mission-period skeletal collections. In the following discussion the epidemiology, history, and osteological responses of the treponematoses and tuberculosis will be considered and a review of the relevant Timucuan ethnographic literature will be provided. In addition, several theories, including sampling bias, death before skeletal involvement, geographic and climatic barriers, animal reservoirs, and demographic critical mass are addressed to explain these phenomena. The impact of Timucuan social, cultural, and demographic parameters is also considered.

Treponematosis

The Origin of Syphilis--Conflicting Hypotheses

The geographic origin of the treponemal syndromes has been a major point of controversy among both the medical and anthropological communities for centuries. From these on-going debates three distinct hypotheses have emerged, each of which attempts to explain the origin and spread of treponematosis throughout the world in a unique manner.

The Columbian theory. Advocates of the Columbian theory propose a New World origin for the treponemal syndrome with subsequent introduction into Old World populations. Treponemal disease, indigenous in Amerindian natives, was carried to Europe by Columbus's crew in 1493. There now appears to be rather convincing evidence that a treponemal syndrome was present in the New World before European arrival (Ortner et al. 1992:345). The epidemiological pattern displayed by this syndrome in the fifteenth century suggests the introduction of a previously unknown virulent disease into European populations. The rapid spread of treponemal infection throughout Europe, as documented by state proclamations and personal accounts of the period, clearly implicates peoples with no previous disease contact (Baker and Armelagos 1988; Crosby 1972; El Najjar 1979; Hackett 1976; Steinbock 1976).

The pre-Columbian hypothesis. Proponents of the pre-Columbian hypothesis suggest that a form of treponemal disease was indeed present in the Old World prior to the return of Columbus and his crew. Advocates of this theory propose that, although descriptions of diseases resembling treponematosis were present in the literature before Columbus's voyage, treponemal disease was indistinguishable from a community of diseases, especially leprosy (Hackett 1963; Holcomb 1934; E. Hudson 1961). E. Hudson (1961) reports that thirteenth- and fourteenth-century European references to venereal leprosy were later termed "hereditary leprosy." However, leprosy is neither sexually nor congenitally transmitted. Historically, references to the venereal transmission of leprosy were dropped after sixteenth-century recognition of the venereal syphilis as a separate and distinct disease entity (Steinbock 1976). The word "syphilis" may have first been coined by Girolamo Fracastoro, a student of philosophy and medicine, in the 1530 poem, Syphilis sive morbus gallicus. In this tale the shepherd Syphilis offended the sun god and was punished for his insolence by the dubious honor of being the first person to suffer from venereal disease (Quetel 1990).

The Unitarian hypothesis. Advocates of the Unitarian hypothesis hold that the four treponemal syndromes, pinta, yaws, endemic syphilis, and venereal syphilis, are environmental and cultural variations of a single organism, Treponema pallidum, not separate diseases initiated by a distinctive organism (Baker and Armelagos 1988; Crosby 1972; E. Hudson 1963; Steinbock 1976). E. Hudson (1958, 1963, 1965), the strongest advocate of the Unitarian theory, posits that the treponemal syndromes evolved along with human populations, migrated with them throughout the world, and were thus endemic in both the Old and New Worlds long before Columbus. The four syndromes represent a biological gradient in which the treponematoses reflect adaptations of a single microorganism to various epidemiological conditions, including social and environmental factors (E. Hudson 1958, 1963,1965). Treponematosis will therefore present different clinical patterns under different climatic and social conditions.

Although the precise geographic origin of the treponematoses is still unclear, abundant skeletal evidence convincingly argues for the presence of a treponemal syndrome in the New World before 1492 (Baker and Armelagos 1988; A. Bullen 1972; Cassidy 1984; D. Cook 1984; Ortner and Putschar 1985; Ortner et al. 1992; Powell 1988, 1990, 1991). This discussion adopts the Columbian perspective and advocates that a treponemal syndrome was present among Florida's aboriginal inhabitants before European contact.

The Four Treponemal Syndromes

It is generally accepted that three subspecies of treponemes cause the four clinically distinct chronic granulomatous diseases of pinta, yaws, endemic (nonvenereal), and venereal syphilis. This is also the order of increasing virulence of the respective causative treponemes (Perine 1981:391). *Treponema pallidum* is the etiological agent responsible for both venereal and nonvenereal syphilis, *Treponema pallidum* subspecies *pertenue* causes yaws, and Treponema pallidum subspecies crarateum causes pinta. Although clinically distinguishable, the causative agents remain morphologically indistinguishable. Until definitive genetic evidence proves otherwise, it must be assumed that, pinta, yaws, endemic syphilis, and venereal syphilis, are actually four variations of the single species Treponema pallidum.

> The treponemes, also known as spirochetes, of the four syndromes cannot be differentiated from each other by any known test. They are morphologically identical with a common antigenic structure which differs only quantitatively. . . . In man partial cross-immunity exists between syphilis (both venereal and nonvenereal), yaws, and pinta. . . . Gross and microscopic examination of diseased human tissue from all four syndromes cannot distinguish one form of treponematosis from the other. . . . Thus, all pathological differences are merely quantitative with considerable overlapping between the syndromes. The four syndromes of treponematosis produce a pathological gradient extending from the cutaneous manifestations of pinta to the ulcers of yaws involving both skin and bone, to similar lesions of endemic syphilis affecting the skin, bone, and cardiovascular system, and finally to the lesions of venereal syphilis affecting all of the organs just mentioned in addition to the nervous system. (Steinbock 1976:91-92)

Recent research appears to indicate, however, that the treponemal strains responsible for yaws, Treponemal pallidum subspecies pertenue, and syphilis, Treponemal pallidum subspecies pallidum, may be differentiated at a molecular level (Hay et al. 1990; Noordhoek et al. 1990a, 1990b, 1991). Although a small variability in DNA sequencing allows strain discrimination, the differentiation of treponematoses by serology is still not possible at present (Noordhoek et al. 1990:1606).

Of the four treponemal infections only venereal syphilis, endemic (nonvenereal) syphilis, and yaws affect the skeleton. Pinta, geographically limited to tropical Central America from Mexico to Ecuador, produces white patches on the skin but does not involve the internal organs. As pinta does not manifest itself in bone, it will be excluded from further discussion.

Yaws occurs characteristically in rural populations of the humid tropics and is manifested by a primary cutaneous lesion followed by a granulomatous skin eruption. Late destructive lesions of the skin and bones may follow. Endemic syphilis is typically indigenous to arid, warm climates, either temperate or subtropical, but has occurred historically in Scotland and Scandinavia (Powell, personal communication). The syndromes of endemic syphilis and yaws are similar, both are contracted nonvenereally, are usually acquired in early childhood, and affect the skeleton in a similar manner. Venereal syphilis has no climatic restrictions and may affect any tissue of the body including the internal organs and especially the brain and heart (Hackett 1967; Steinbock 1976).

The distinctions between the treponemal syndromes are ones of subspecies strain. Since the subspecies remain biologically susceptible and responsive to changes in human and physical environment, every human population will exhibit the strain of treponematosis that is most appropriate to its physical and sociocultural milieu (Crosby 1972; El Najjar 1979; Hudson 1958, 1963, 1965; Steinbock 1976). Differential expression of treponematosis may thus be explained by environmental factors, climate, geography, and demography.

The bone lesions of venereal syphilis, nonvenereal syphilis, and yaws may often be virtually identical and individually indistinguishable (Hackett 1976; Ortner and Putschar 1985; Steinbock 1976). Dental stigmata and osteochondritis are, however, particular to congenital syphilis. As diagnostic differences of individual lesions frequently cannot be established with any degree of certainty, analysis of a treponemal syndrome in skeletal populations must concentrate on the prevalence of lesions across the entire series with particular attention focused on age distribution of affected individuals, degree of infection, lesion morphology and distribution, and cultural and climatic context.

Nonvenereal Syphilis: Endemic and Yaws

Until relatively recently endemic syphilis and yaws were not considered by individuals investigating ancient remains. Current research indicates, however, that nonvenereal syndromes were manifested in pre-Columbian North American populations (Cassidy 1984; D. Cook 1976, 1984; Ortner et al. 1992; Powell 1988, 1990, 1991). Detailed descriptions of bone-lesion morphology and distribution, incorporated with sociocultural data, support a differential diagnosis of endemic syphilis in skeletal collections from Middle and Late Woodland populations in Illinois (D. Cook 1976). Powell (1988, 1990, 1991) also reports that the pre-Columbian Moundville and Irene populations from the American southeast suffered from a "population-wide experience with non-specific stress . . . and infectious endemic diseases (including . . . endemic treponematosis) that affected most members of each generation" (1988:180).

Nonvenereal syphilis is a childhood disease usually acquired under unhygienic conditions. Transmission occurs typically through skin to mucous membrane exchange, such as kissing or indirect use of the fingers, in child-to-child casual contact, or through the communal use of drinking vessels or eating utensils. Skeletal lesions associated with nonvenereal syphilis are uncommon in the early stages of infection and may remain so into the late stages when they resemble those of acquired or late congenital venereal syphilis. In all the treponematoses the infecting organism enters the body through the skin or mucous membrane near the skin surfaces and thus demonstrate a predilection for bones surrounded by a minimum of soft tissue--the tibia and cranium are the most frequently affected bones. The cranial vault, itself, is rarely affected but destructive nasal lesions with perforation of the hard palate are a common and prominent feature. Periosteal deposits on long bones cause fusiform expansion of the periosteum with typically no medullary involvement. On the tibia, bone proliferation primarily occurs along the anterior crest and medial shaft (Ortner et al. 1992:343). This process gives the bone the appearance of curvature--the saber-shin tibia so characteristic of treponematosis. In adolescence and adult life, bone and joint lesions are relatively frequent in both yaws and endemic syphilis with no essential differences in appearance (Grin 1956:969). Frequently these lesions are influenced by exposure to superinfection or reinfection of a host already sensitized from previous infection (Grin 1956:969). Additional skeletal lesions include gummas, but as joint lesions are rare, Charcot's joint is not observed. (Steinbock 1976; Ortner and Putschar 1985). Charcot's joint is a neuropathic joint in which severe destruction, attrition, and fragmentation of the articular cartilage is accompanied by a large mass of bone and subadjacent bone degeneration (Ortner and Putschar 1985:435). A gumma is a nodular foci with a central liquefying necrosis.

Venereal Syphilis: Congenital

Congenital syphilis is acquired through the in utero transmission of the treponemal spirochete when the treponemes invade the placental tissue after the fifth month of gestation (Cotran et al. 1989). Areas of endochrondral growth are affected, with the bone metaphyses most frequently involved. Symmetrical skeletal lesions of the distal femur and proximal tibia are prevalent (Ortner and Putschar 1985). In early congenital syphilis osteochondritis, periostitis, and diaphyseal osteomyelitis represent the typical osseous lesions. Osteochondritis is a form of aspectic necrosis characterized by small sequestrum of articular cartilage on the bone surface and necrotic subchondral cancellous bone (Ortner and Putschar 1985:242). Massive periosteal reaction, periosteal cloaking, is usually associated with syphilitic osteomyelitis of the diaphysis. Diaphyseal osteomyelitis typically originates in the metaphyses and may produce destruction of the bone cortex. Osteomyelitic foci on the proximal ends and medial shafts of the tibia are highly suggestive of congenital syphilis (Steinbock 1976). Isolated expressions of osteochondritis and periostitis are not pathognomonic of syphilis.

Tardive congenital syphilis is a skeletal manifestation in affected children who have survived infancy. Reoccurrence of the latent treponemal infection between five and fifteen years of age denotes a chronic condition with long-lasting deformities. Osteologically, late stage congenital syphilis closely resembles acquired syphilis (Steinbock 1976), and without clinical data it may be impossible to distinguish between the two forms (Ortner and Putschar 1985). Skull lesions, which are relatively infrequent, usually appear as multiple, rounded, necrotic foci, may involve both the inner and outer tables of the skull, and form sequestra. The characteristic caries sicca sequence of venereal syphilis is absent (Ortner and Putschar 1985; Steinbock 1976). Gummatous periostitis, which involves the diaphyses of the long bones, and gummatous osteomyelitis, which produces dense and irregular trabeculae and an uneven cortical border, are often present.

Late-occurring congenital syphilis may be accompanied by saber-shin tibiae, saddle deformation of the nose from destruction of the vomer, and although relatively infrequent, alterations in tooth formation due to spirochetal infection during dental development (Hutchinson's teeth). Incisors are smaller than normal with notched occlusal surfaces. The amount of notching varies and bilateral involvement of the dentition is not necessary. The teeth can also resemble a screwdriver shape, or become pointed, to produce a peg-shaped deformity (Cotran et al.1989). Moon's teeth, also known as mulberry molar or bud molar, are syphilitic alterations of the first molar. The syphilitic first molar is relatively small, especially mesiodistally, and the occlusal surface is rough and irregular with small projections resembling atrophic cusps. Enamel hypoplasias may be present (Steinbock 1976). Dental stigmata alone is not be considered diagnostic of congenital syphilis.

> Although there are a variety of skeletal changes occurring in different phases of congenital syphilis, the findings are more indicative than diagnostic and must be critically evaluated in the entire context of skeletal findings. Individual lesions may not be distinguishable from tuberculosis or other infectious diseases. (Ortner and Putschar 1985:201)

<u>Venereal Syphilis: Acquired</u>

Venereal syphilis is transmitted primarily through sexual intercourse, although bacteria-laden secretions can also transfer the disease by other modes of intimate contact (Cotran et al.1989). Acquired syphilis evolves naturally in three stages. The primary stage follows an incubation period of ten to ninety days, is marked by the development of the chancre at the site of treponemal invasion, and terminates with involvement of the lymph nodes. The secondary stage follows in approximately two weeks to six months with hematogenous dissemination of the organisms. Generalized or, less often, localized skin eruptions and rashes are transitory and disappear spontaneously in about four to twelve weeks. Following the secondary stage is a period of latent syphilis during which the infected individual enters a period of apparent well-being. At this time the lesions of tertiary syphilis appear. This stage is characterized by progressive involvement of the organs, most commonly gummatous necrosis of the liver, testes, and bones. Gummas may occur singly or multiply, and vary in size from microscopic defects resembling tubercles to large tumorous masses of necrotic material (Cotran et al.1989; Ortner and Putschar 1985).

Although a portion of the differential diagnosis of tertiary syphilis in archaeological human remains may require an analysis of population-level lesion prevalence, the bone lesions are quite distinctive and well defined, facilitating a relatively straightforward diagnosis. All lesions display excessive osteocleotic response to infection. Osteological involvement in acquired venereal syphilis most commonly affects the tibia, the cranial vault, particularly the frontal and parietal bones, and the nasal-palatal area. These three areas together constitute 70% of all tertiary osseous syphilitic lesions. Marrow forming bones, such as the ribs and sternum, and the long bones are less involved and the vertebrae are rarely involved (Ortner and Putschar 1985:82).

The most diagnostic criterion of venereal syphilis in dry bone is the caries sicca sequence of the crania and calvariae as detailed by Hackett (1976). The majority of the gummatous, osteoperiostitic lesions begin on the frontal bones and may spread across adjacent sutures to affect the parietal and facial bones. The lesions begin near the osteoperiosteal border and ultimately destroy the outer table, producing a depression that reaches to the diploë. The inner table is almost always completely spared. In an advanced stage of caries sicca, the diploë may be markedly thickened and sclerotic, lending a "worm-eaten" appearance to the outer table. The healed focus of caries sicca is characterized by the depressed, sclerotic, radially grooved stellate scar. Secondary involvement of the facial bones, including the vomer, hard palate, and turbinates, often results in the destruction of these thin bones. The nasal cavity thus appears enlarged and empty in the dry skull and maxillary aveolar damage is frequent (Hackett 1976; Ortner and Putschar 1985; Steinbock 1976).

Syphilitic involvement of the postcranial skeleton is initiated with subperiosteal bone apposition in the metaphyses of the long bones, primarily the tibia. Often the entire periosteum becomes inflamed with subperiosteal response resulting in thickening and deformation of the involved bone. The long bones will exhibit increased density with roughened and irregular areas along the shafts and the medullary cavities will be narrowed by cortical thickening (Hackett 1976; Steinbock 1976).

Syphilitic involvement of the long bones can be separated into nongummatous and gummatous osteoperiostitic lesions (Ortner and Putschar 1985:197). Nongummatous lesions, which range from finely striated nodes and expansions to gross periosteal expansions with cortical thickening, are probably not diagnostic of treponemal infection (Hackett 1976). Diffuse nongummatous osteoperiostitis commonly results in bones that are thick and heavy with a rough hypervascular outer surface (Ortner and Putschar 1985:197). Gummatous lesions may display both proliferative and degenerative changes and are clearly diagnostic of treponemal infection (Hackett 1976; Steinbock 1976). The lesions are represented by rugose nodes/expansions with superficial cavitation and occur either on the periosteum or in the medullary cavity and may be so affected by cortical thickening as to be almost filled. Unlike hematogenous osteomyelitis, the borders of the lesions may be striate, as opposed to smooth and sclerotic, and major sequestra are absent (Hackett 1976).

Syphilitic arthritis occasionally affects the joints with the large joints most frequently involved. Clutton joints, symmetrical bilateral hydroarthrosis of the knee, occur in late congenital syphilis. This infection of the synovial membrane is almost always bilateral. Charcot's joint results from pressure erosion fifteen to twenty years after the onset of treponemal infection. The bones of the hands and feet are rarely involved (Blakiston 1979; Ortner and Putschar 1985; Steinbock 1976).

A Differential Diagnosis of the Treponemal Syndromes

Endemic Syphilis

It has been suggested that over time the treponemal disease process has converted from yaws to endemic and, later, to acquired syphilis then back again (E. Hudson 1963) rendering differential diagnosis of the treponematoses in antiquity relatively unimportant (Goff 1967). D. Cook's (1976) detailed analysis of Middle and Late Woodland populations in Illinois is evidence of the insight that can be gained into pre-Columbian populations from a meticulous differential diagnosis. Her detailed differential diagnosis, including a wide range of pathological syndromes, such as infectious disease and nutritional and metabolic disorders, has demonstrated that the treponemal syndrome of endemic syphilis was present among Illinois' pre-Columbian peoples. Meticulous recording of disease morphology combined with a cultural and environmental perspective has also allowed Cassidy (1984) and Powell (1988, 1990, 1991) to diagnosis the presence of a treponemal syndrome, probably endemic syphilis, among pre-Columbian populations.

Bone lesions in yaws can be similar to those observed in congenital syphilis. Yaws is primarily a disease of childhood and therefore the most active lesions, but not necessarily the most bone lesions, are seen in children and adolescents. Early osseous involvement may heal completely leaving no permanent change in skeletal structure. The most frequently involved bone is the tibia, which may come to resemble the saber-shin tibia of congenital syphilis. Long-bone involvement typically resembles tertiary syphilis. In late yaws destructive dactylitis of the metacarpals, metatarsals, and phalanges can be observed. Cranial involvement, less severe than in venereal syphilis, focuses on the frontal bone, which displays shallow, pitted defects rather than caries sicca. The inner table is not perforated (Ortner and Putschar 1985; Steinbock 1976).

Congenital Syphilis

As late stage congenital syphilis closely resembles acquired syphilis, the major distinction between these treponemal syndromes is very clearly based upon age distribution of infected individuals. Affected infant remains, and to a lesser extent juvenile skeletons, displaying skeletal lesions of treponemal syndromes would provide strong evidence for the presence of congenital syphilis. Circular caries of the deciduous dentition appear to diagnostic of congenital treponematosis (D. Cook 1990). In adolescents the syphilitic lesions, mainly osteoperiostitis and gummatous osteomyelitis, tend to resemble those of acquired syphilis. Congenital syphilis can be distinguished from rickets by the cranial bossing that is common in rickets and extremely rare in congenital syphilis (Steinbock 1976). Syphilitic dactylitis, gummatous infiltration of the subcutaneous connective tissue of the joints and bones of the fingers and toes, is more frequent in congenital than acquired syphilis. The fingers are more often affected than the toes with a predilection for the phalanges, which display widening of the shafts surrounded by a thin bony shell (Blakiston 1979; Ortner and Putschar 1985).

Venereal Syphilis

Venereal syphilitic lesions may imitate other infectious diseases, hereditary disorders, and neoplastic processes. Few infections, however, generate the formation of excess bone in conjunction with gummatous granulation. Caries sicca has been accepted as a diagnostic syphilitic lesion for over a century (Hackett 1976). A differential diagnosis for acquired venereal syphilis would include osteocarcinoma, tuberculosis, pyogenic osteomyelitis, leprosy, Paget's disease, and neoplasm.

Osteocarcinoma

While osteocarcinoma and syphilis may display similar patterns of subperiosteal spiculation, the tumors of osteocarcinoma are small and not necrotic. Tumors are widely scattered and rarely coalesce as they do in the large areas of necrosis in cranial syphilis. In osteocarcinoma the cranial bone seldom displays evidence for regeneration (Steinbock 1976).

Tuberculosis

Cortical thickening resulting from subperiosteal bone apposition is unusual in tuberculosis, but metaphyseal expansion and destruction are common. Expansion of the long bone epiphysis results in an irregular surface with one or two smooth openings into the interior where there may be cancellous tissue sequestra and extension into the neighboring joint. Tubercular erosion of the crania is infrequent, but when it does occur it begins on the inner table and may perforate both tables. Limited external cavitation with extensive inner surface erosion is clearly diagnostic of tuberculosis. In contrast, cranial syphilitic lesions do not perforate both tables. Cranial syphilis begins on the external periosteal border with resultant destruction of the outer table and may affect the diploë, but very rarely the inner table (Hackett 1976). Syphilitic involvement of hemopoietic marrow forming bones is rare. Tubercular involvement of the ribs, sternum, and especially the vertebrae is frequent. The common involvement of the vertebral border in tuberculosis in association with kyphotic collapse, sinus formation, and little new bone formation, all represent a clearly destructive process that is absent in syphilis.

Pyogenic Osteomyelitis

The borders of syphilitic lesions are striate as opposed to smooth and sclerotic in pyogenic osteomyelitis. Sequestra and involucra with cloacae are very diagnostic of osteomyelitis and absent in syphilis (Hackett 1976; Steinbock 1976). Osteomyelitis rarely involves the cranium. The cranial surface is never nodular as in the caries sicca sequence, where the "worm-eaten" appearance indicates involvement of the sequestra in the disease process before becoming necrotic (Ortner and Putschar 1985).

Leprosy

Naso-palatine destruction is more extensive, massive, and rapid in syphilis than in leprosy. In leprosy, pitting and perforation of the palate and nasal bones is accompanied by healing, sclerosis, and absorption of the anterior nasal spine (Hackett 1976; Ortner and Putschar 1985). Perhaps the most reliable bony response characteristic of leorosy is the localized recession of the upper alveolar margins at the incisors. The area of bone destruction is too limited to be mistaken for periodontal disease and the treponemes are highly unlikely to produce these features (Møller-Christensen 1967:297).

Paget's Disease

Massive thickening of the skull vault in Paget's disease is very different from the effects of cranial syphilis. The clavaria is grossly and uniformly thickened and when sectioned is shown to consist of finely cancellous bone (Hackett 1976). Roentgenographic examination of a skull infected with Paget's disease indicates a greater density and a specific mosaic arrangement of the bone cells (Goff 1967; Ortner and Putschar 1985). The syphilitic long-bone cortex is more compact and thickened than in Paget's disease (Hackett 1976).

Neoplasms

Deep, vertical-walled lesions, which lead to perforations on the endocranial surface are suggestive of neoplastic disease. Sequestra and the characteristic caries sicca of syphilis are absent, but bone growth, in the form of large, irregular, fragile bony outgrowth, often with a ray-like formation, are clearly diagnostic of a neoplastic sequence. In the treponemal syndromes extensive destruction of the facial bones is rarely accompanied by healing. Neoplasms in the long bones are usually multiple and may either be destructive or produce new tumor formation.

Treponematosis Among the Northern Utina: A Hypothesis

Although the presence of treponemal infections in the New World before European contact has been amply demonstrated, (Baker and Armelagos 1988; Cassidy 1984; D. Cook 1976; Ortner and Putschar 1985; Ortner et al. 1992; Powell 1988, 1990, 1991; Steinbock 1976), evidence for the presence of treponematosis among Florida's aboriginal populations is not as abundant. Osteological and ethnohistoric documentation does indicate, however, that a treponemal syndrome was present among some Florida populations.

The association between the treponemes and climatic-cultural factors, as advocated by E. Hudson (1958) and outlined by Hackett (1963), suggests that differential patterns of treponemal infection may be observed between the pre-Columbian and mission-period northern Florida Indians. Treponematosis is a single and extremely flexible disease which syndromes are directly related to the host's physical and cultural status (E. Hudson 1958, 1963, 1965).

Archaeologically-derived skeletal collections demonstrate the presence of a low-grade chronic disease resembling endemic syphilis or yaws among Florida's native populations. With increased sedentariness, population aggregation, and cultural exchange a higher frequency of treponemal infection would result. This treponemal syndrome (see next section) should resemble the patterns described by Cassidy (1984), Cook (1976), and Powell (1988, 1990, 1991) in which pathological involvement is typical of endemic syphilis.

Research indicates that the prevalence of endemic syphilis is correlated with community parameters. The smaller and more compact the community, the higher the infection rate, because there is greater opportunity for disease transmission (Grin 1953:23). Thus, differences in manifestations of treponematosis are attributable to differences in mode of transmission, which itself is affected by environmental factors, such as climate and level of social and cultural development.

Increased sedentariness, population density, and aggregation of native populations associated with the mission period suggests an increase in casual contact, sharing of common drinking and eating vessels, and more compact living arrangements, all factors implicated in endemic syphilis. Assuming that an endemic treponemal syndrome was present among the pre-Columbian peoples of north Florida, changing social and cultural patterns over time would suggest at least an increased prevalence in the treponemal syndrome among the mission-period Utina. The form of treponemal expression is still in question. One might posit that mission aggregation of diverse groups with distinct disease histories could have also affected mode of disease transmission. Mission nucleation of distinct groups would produce a diverse disease pool to which not all members of the new community would have had equal exposure. For example, although nonvenereal syphilis acquired in childhood confers immunity to venereal syphilis in adults, different strains of Treponemal pallidum could easily have been introduced into the disease community by aggregation of distinct groups. Thus, adults acquiring the disease for the first time from a child with an open lesion, may have been more likely to transmit the disease to another adult venereally. Alternatively, venereal syphilis could have been introduced by the Spanish.

Skeletal Evidence for Treponematosis Among Pre-Columbian North Florida Peoples

> In no previous mound work have we found so great a percentage of pathological specimens as in this mound, and, as has not been the case in other mounds, entire skeletons seemed affected, and not one or possibly two belonging to a skeleton. The pathological conditions were so marked and cranial nodes so apparent that, in view of the fact that no objects positively indicating White contact were discovered in the mound . . . we must look upon these bones as of pre-Columbian origin. (C. Moore 1922:57-59)

This report of the pathology encountered in the skeletal collection (n=74) excavated from the Lighthouse Mound on Amelia Island, off the northeast coast of Florida, suggests the presence of a treponemal syndrome among this pre-Columbian population. Although limited, the description of bone lesion morphology, 'cranial nodes so apparent,' strongly indicates a disease process with a treponemal origin.

In 1898 D.S. Lamb, M.D., described these lesions:

> in regard to the question of precolumbian syphilis on the American continent prior to the coming of Columbus. The testimony which I have to offer on the affirmative side consists in the fact of a series of human bones from one and the same skeleton, which show the lesions of osteo-periostitis, both hyperostotic and ulcerative; lesions therefore showing a constitutional disease . . . the ulcerative stage is well marked. In the present state of our knowledge I know of no disease except syphilis in which a series of bones of the same skeleton show the lesions illustrated and described. (Lamb 1898 in A. Bullen 1973:85)

In 1922 Hrdlicka suggested that the commonness of inflammatory disease lesions among pre-Columbian Florida skeletal remains, especially the tibiae, are highly indicative of a syphilitic origin. Additional skeletal collections with bone lesions suggestive of a pre-Columbian treponemal syndrome among Florida's aboriginal populations have been described by Işcan (1983) and

Işcan and Miller-Shavitz (1985) for both the Archaic and Weeden Island periods.

Charles Snow (1962) described 115 pre-Columbian skeletal remains from the Weeden Island Bayshore Homes site in St. Petersburg, Florida, in which inflammatory lesions are the most prevalent form of bone disease.

> A common condition which the author dubbed "coral disease", because of the characteristic fine perforations that often extended in multiple rows resembling coral, is a unique finding. In some instances the bone also had a "bloated" appearance. "Coral disease" porosity was found in individuals of all ages from infants to middle-aged adults. It was found on the forehead, cheekbones, lower jaw, across the left nasal area involving the nose and maxilla of one female skull, the frontal surfaces of one man and two women, as well as the clavicle of two men and two women and in several arm, leg, and foot bones. (Snow 1962: 19-20)

The bones were examined by Ellis Kerley, Lent Johnson (pathologist), Walter Putschar (pathologist), and T. Dale Stewart, all of whom pronounced a diagnosis of syphilis. Bone lesion morphology and demographic distribution in this skeletal collection suggests a nonvenereal treponemal syndrome.

A. Bullen's (1972) survey of human skeletal remains from fourteen mound excavations across Florida documents considerable evidence for the presence of a pre-Columbian treponemal syndrome. The most obvious evidence is generated from the Tick Island Archaic site (5300 B.P.) and the Weeden Island period Palmer Mound site (A.D. 850).

Palmer site Burial 352 is a relatively complete skeleton of a middle aged female. The tibiae, expanded and irregular with lytic lesions surrounded by sclerotic bone, provide evidence of a chronic inflammatory response involving the entire shaft. Focal areas of destruction on the right humerus with smooth ostetis, thickening of the radii and left fibula from a periosteal reaction, and <u>especially</u> resorptive foci and healed stellate scars of caries sicca indicate a treponemal condition, possibly venereal syphilis.

> The distribution of the lesions throughout the skeleton is almost as important in the determination of syphilis as the nature of the lesions themselves. A single tibia might resemble Paget's disease or pyogenic osteomyelitis, but a skeleton presenting the lesions that are typical of syphilis in the areas typical of syphilitic involvement is overwhelming evidence--particularly in the absence of any other known disease that might produce such lesions in a geographic area where yaws is uncommon. Burial 352 is such a skeleton. . . . All available evidence indicates that this specimen represents syphilis of bone and there are no indications that it might be anything else. (A. Bullen 1972:148-150)

Periosteal responses resulting in markedly enlarged and thickened tibiae and fibulae, with medullary involvement, and skulls displaying cranial lesions reminiscent of treponemal infection have been recovered from the Tick Island Archaic site (5300 B.P.). Photographs of the tibiae and fibulae (A. Bullen 1972) show a disease distribution typical of treponematosis.

The pathologies exhibited on pre-Columbian Florida skeletal remains from the Tick Island Archaic site (A. Bullen 1972) and the early Weeden Island period sites of Palmer (A. Bullen 1972), Crystal River (A. Bullen 1972), Hog Island (A. Bullen 1973), Bayshore Homes (Snow 1962), Lighthouse Mound (C. Moore 1922), and Margate-Blount (Işcan 1983) all demonstrate that a treponemal syndrome, probably endemic syphilis or yaws or some intermediate form, was present among pre-Columbian Florida native populations. This syndrome appears to have been most prevalent among populations of the Weeden Island culture, a culture characterized by large ceremonial complexes promoting intergroup contact, long distance trade routes, satellite villages, and increased population sedentariness and aggregation. While the evidence is not as abundant nor as conclusive as that documented for the Weeden Island Period, it seems that Safety Harbor Period (A.D. 1300-1800) populations also suffered from treponemal infections (A. Bullen 1972).

Ethnographic Evidence for Treponematosis Among the Contact-Period Timucua

Although historical documents suggest the presence of syphilis among the Timucua, such accounts are not numerous. Réne de Laudonnière, the Frenchman who established Fort Caroline at the mouth of the St. Johns River, the geographic location of the eastern Utina, stated that: "Most Indians were found to be diseased by the 'pox', for they were exceedingly fond of the opposite sex, calling their female friends daughters of the sun" (Gatschet 1877:472).

> The priests . . . carry always about them a bagge full of herbs and drugs to cure the sicke diseased which for the most part are sicke of the Pocks, for they love women and maydens exceedingly which they call the daughters of the Sunne (Laudonnière 1587 in Basanier 1964:3).

Le Moyne, the Huguenot mapmaker who traveled among the Utina in the early sixteenth century, accompanied his artistic rendering "How they treat their sick" with the text "Venereal disease is common among them, and they have several natural remedies for it" (Lorant 1946:75). This etching depicts a Utinan medical practice in which patients were stretched over a bed of hot coals to force vomiting out disease. Another common Utinan medical cure entailed bleeding the patient by cuts on the forehead with a shell and then sucking out the blood. Interestingly mid-seventeenth-century Europeans believed that "syphilis could be cured if the body could be obliged to bleed, defecate, sweat out, and spit out the excess of the offending humor; phlegm, in this case" (Crosby 1972:153). Could a connection exist between these two practices, one based on and the other suggesting the humoral theory, whereby the Utina imparted their medical "knowledge" upon the Spanish--or vice versa?

Straight (1968,1989) posits that before Columbus the Timucua were infected with endemic syphilis and that they utilized the leaves of the guaiacium tree as a remedy. Oviedo wrote that

> the Indian guayacan is famous . . . splinters of filings of the wood are boiled to a certain quantity of water according to the amount of wood used. . . . Those afflicted with the disease drink this potion early in the morning (for several days) on an empty stomach. They maintain a rigid diet. During the day they drink other water that has been boiled with guayacan. Undoubtedly many are cured of syphilis by this treatment. (in Stoudemire 1959: 88)

This remedy has, however, no medical effect on syphilis.

The combination of reviews of the literature on the treponematoses, contemporary analysis of New and Old World prevalence and type of treponemal infections, bioanthropological data, and ethnohistoric accounts together suggest that a treponemal syndrome was present among some pre-Columbian and post-Columbian north Florida Timucuan populations.

Tuberculosis

Tuberculosis is a chronic infectious disease caused by Mycobacterium tuberculosis, a nonmotile, acid-fast bacillus. Mycobacteria share the basic structure of all bacterial organisms and include pathogens for many animals. Most infections are acquired by sustained exposure rather than casual contact Although M. tuberculosis is predominately opportunistic, affecting individuals with reduced immunity or pre-existing lung disease, it demonstrates a marked ability to persist in tissues either in dormant form or as a chronic, destructive pathogen. In addition to the tubercle bacilli, there are about thirty other human pathogenic species, atypical mycobacteria, which are classified by their rate of growth, reaction to light, and production of pigment on artificial media. Atypical, or environmental, mycobacteria are widespread in soil, water, plants, and animal excreta, and may be introduced into the body through flesh wounds, inhalation, or drinking infected water. Transmission from host-to-host is rare. Atypical mycobacteria are the causative agents of human diseases pathologically similar to tuberculosis, including M. karsasil, M. marinum, M. scofuladeum, M. intracellulare, M. avium, and M. fortuitum. Progressive tuberculosis is less frequently caused by atypical mycobacteria than by M. tuberculosis (Berkow 1982; Cotran 1989). The two species of M. tuberculosis which typically infect humans, are M. tuberculosis hominis and M. tuberculosis bovis.

The pathogenesis of tuberculosis involves four considerations:

> (1) the virulence of M. tuberculosis, (2) the role of induced hypersensitivity, (3) the role of immunity or resistance, and (4) the genesis of the granulomatous pattern of reaction so characteristic (but not necessarily diagnostic) of tuberculosis. (Cotran 1989:375)

Although much remains unknown about the pathogenesis of tuberculosis, it is clear that the fundamental tissue reaction is granulomatous and that hypersensitivity and immunity play major roles in disease development.

Transmission of the human tubercle bacillus is typically through the respiratory tract by inhalation of droplets coughed or sneezed into the air by an individual infected with active pulmonary lesions. Primary tuberculosis is the infection of an individual lacking previous contact with tubercle bacilli. The bacilli normally develop as a primary focus in the lungs, usually in the lower or middle lung region. A single lesion, a Ghon focus, is typically found at the area of the lung which receives the greatest volume of inspired air. This primary lung lesion, in combination with tracheobronchial lymph node involvement and resultant granulomas, is referred to as the Ghon complex. If these active lesions fail to heal, the tubercle bacilli may disseminate through the bloodstream and involve virtually any organ or tissue in the human body. Bone marrow is one favored site. This process is referred to as miliary tuberculosis, with tuberculosis meningitis (rupture of the tubercle focus into the central nervous system) a common complication (Burnet 1962; Cotran 1989).

Individuals who become tuberculin positive usually remain so for the rest of their lives. In most instances tuberculosis is the result of reactivation of a tubercular infection initiated years before, not a new infection. Secondary tuberculosis, the reactivation of asymptomatic primary tuberculosis, may occur at any time following a primary infection, presumably when immune defenses are lowered. The persistence of the bacilli, either latent or actively multiplying, may result in drainage of the bacilli via lymph nodes and/or the blood stream to distant sites where they may die, remain dormant, or induce a disease focus. Skeletal tuberculosis is primarily and virtually without exception the result of hematogenous dissemination of the bacilli (Burnet 1962; Cotran 1989; Ortner and Putschar 1985).

Bovine tuberculosis is typically a disease of domesticated animals. The M. tuberculosis bovis bacillus, transmitted to humans by milk from diseased cows, produces primary lesions in either the intestines or tonsils. The bacteria causing bovine tuberculosis has never established itself entirely as a human parasite and is not communicable between humans. In developed countries with dairy disease control and the pasteurization of milk this mode of transmission has been virtually eradicated. Currently in the United States tuberculosis is assumed to have been initiated by the human bacillus unless otherwise established. In other parts of the globe, extrapulmonary tuberculosis may sometimes be due to bovine bacilla or to distinctive human strains (Cotran 1989; Ortner and Putschar 1985; Steinbock 1976).

A Question of Origin

The pathogenesis, geographic origin, and natural history of tuberculosis and the distinctions between M. tuberculosis hominis and M. tuberculosis bovis continue to be subjects of intense inquiry among the medical and anthropological communities. Cockburn (1971) posits that tuberculosis initially arose from a zoonotic infection requiring crowd-type conditions. Hare (1967) has suggested that the human tubercle bacillus is a mutant form of the bovine type. This hypothesis implies that tuberculosis did not exist until after the domestication of cattle. Steinbock (1976) suggests that the tubercle bacillus first became endemic in humans with the domestication of cattle. Disease transmission would have been facilitated by human contact with herds, especially in corral-like environments. Repeated close contact and human consumption of dairy milk propagated endemic tuberculosis in humans.

The arguments put forth by Cockburn (1963, 1971) and Hare (1967), that tuberculosis developed from domestic animal hosts, have been repeatedly disputed by investigators of tuberculous-like expression in skeletal remains from pre-Columbian North America. Recent alternative hypotheses include mathematical models to predict paleoepidemiology (McGrath 1986; Milner 1980), the implication of atypical (environmental) mycobacteria in tubercular infection (Clark et al. 1987; Eisenberg 1986), and the observation that tuberculosis-like pathology reported for late pre-Columbian populations in

North America is reminiscent of infectious disease spread through host-to-host transmission (Katzenberg 1987; Klepinger 1987).

McGrath (1986) has developed a computer simulation model to gauge the spread of tuberculosis among pre-Columbian populations. The model is based upon pre-Columbian populations from west-central Illinois, collections with abundant archaeological data and well established evidence for a tuberculosis-like pathology (Buikstra 1981b; Buikstra and Cook 1978). McGrath estimated regional population parameters, aggregation and its relationship to disease transmissibility, and social and cultural factors affecting disease transmission. When disease prevalence, the infectious portion of population, and mortality patterns were modeled, all but one of the simulated populations experienced severe disease stress and became extinct within a hundred years. McGrath concluded (1986) that it is effective population size, rather than group size, number of neighbors, population age structure, and regional population size, which influences the course of the epidemic.

Buikstra and Williams (1991) posit that, as tuberculosis-like lesions have been amply documented in west-central Illinois, McGrath's model is either misspecified or the disease was acting in a manner distinct from that of modern tuberculosis caused by M. tuberculosis. Indeed, McGrath's computer simulation suggests that a modern M. tuberculosis pathogen could not have been maintained within certain pre-Columbian populations. Perhaps current studies of tuberculosis in pre-Columbian populations are investigating a disease no longer in existence either by pathogen extinction or evolution of the pathogen into an entity which no longer causes acute infection in humans (Buikstra 1976, 1981a). It is also possible that the archaeological skeletal record is documenting a flexible host-parasite relationship, one that is not common in recent history.

Clark et al. (1987) emphasize the importance of ecological and environmental factors in the transmission of and immunity to mycobacterial infections. The authors suggest that tuberculosis in pre-Columbian Amerindians was not caused by M. tuberculosis, but may have been the product of one or more related species of mycobacteria. The host may either develop partial immunity or become more susceptible to infection by one or more of the pathogenic mycobacteria.

> What is known about the ecology of mycobacterial disease raises the possibilities that pre-Columbian "tuberculosis" was caused (1) by M. tuberculosis but in a population immunized by exposure to environmental ("atypical") mycobacteria; (2) by M. tuberculosis but a strain of low virulence; (3) by M. bovis transmitted by wild animals (e.g., butchering and tanning skins of infected bison) with infection resulting in self-limiting disease and long-lasting immunity; and/or (4) by one or more of the environmental mycobacterial species. (Clark et al. 1987:51)

The hypothesis that atypical mycobacteria so intensely affected pre-Columbian populations has not gone unchallenged. Katzenberg (1987) and Klepinger (1987) argue that the prevalence of a tuberculosis-like pathology in pre-Columbian populations is consistent with that of an infectious disease transmitted host-to-host. The social patterns of late pre-Columbian populations, increased density, sedentariness, and aggregation, support the higher incidence of skeletal lesions found among these groups. Such findings are inconsistent with the hypothesis that environmental mycobacteria were responsible for tubercular infection, as these strains are rarely transferred between humans.

Kelley and Eisenberg (1987) suggest that blastomycosis and tuberculosis co-existed in a late pre-Columbian population from the Averbach site. They have posited that skeletal lesions produced by environmental mycobacteria are "essentially identical" to those produced by M. tuberculosis. Clark and co-workers concur with this view: "Occasionally, environmental mycobacteria gain access to living tissue and produce pulmonary and extrapulmonary skeletal lesions that are virtually indistinguishable from those caused by M. tuberculosis" (Clark et al. 1987:48). This concept has not, however, been accepted by all researchers (Buikstra and Williams 1991).

Thus the debate rages on. Continued research and collaboration between the medical and anthropological fields may supply the necessary data with which to resolve these issues. Clark and co-workers have indeed realized their objective to "shed new light on the debate and stimulate further research" (Clark et al. 1987:51).

Tuberculosis in the Anthropological Literature and the Antiquity of Tuberculosis in Pre-Columbian Populations from the Americas

A combination of human skeletal remains, art objects, including figurines, effigy bottles, and pictographs, and historical documents collectively demonstrate that tuberculosis existed in both the Old and New Worlds (Buikstra 1981a, 1981b; Clark et al. 1987; El Najjar 1979; Kelly and Micozzi 1984; Morse 1967; Ortner and Putschar 1985; Powell 1988, 190, 1991). While physical anthropologists readily agree that tuberculosis was well established in the Old World, numerous conflicting hypotheses still attempt to answer questions concerning diagnosis, distribution, frequency, and the contribution of the bovine and human strains to disease expression in antiquity. As tubercular skeletal lesions affect a relatively small portion of infected individuals, and the lesions cannot be diagnosed to a specific form of tuberculosis, many of these questions remain unanswered.

Dan Morse may be cited as a "founding father" of the combined medical and anthropological approach to the study of tuberculosis in the New World. Although numerous isolated cases of tuberculosis were reported in the physical anthropological literature, Morse was the first to focus on explicit regional tubercular patterning. During the 1960s and 1970s Morse published a series of papers on the diagnosis of tuberculosis in skeletal and mummified remains, with emphasis on pre-Columbian remains from the Midwest (Morse 1961, 1967, 1979). Although Morse basically ignored the dynamic relationship that must exist between host, pathogen, and environment, and assumed that the disease rate among pre-Columbian natives was identical to that observed in modern populations, he did provide a clear and objective set of standards with which to recognize tuberculosis in pre-Columbian populations:

> 1. Tuberculosis of the spine usually involves one to four vertebrate. Involvement of more vertebrate does occur, but this is rare.
> 2. Bone destruction occurs with little or no bone regeneration.
> 3. As the disease advances, the bone in the vertebral bodies becomes eroded and decalcified. Under the pressure of body weight the spine collapses forward to give the characteristic deformity, the angular kyphosis.
> 4. Involvement of the neural arches and transverse spinous processes is rare.
> 5. Extravertebral "cold" abscesses are frequent. In the cervical and upper dorsal region these can occur posteriorly, and the sinus tracks can open externally. In the lower thoracic and lumbar areas, abscesses will develop anteriorly and occasionally rupture into the peritoneum or proceed to the psoas area, but they will almost never open through the skin posteriorly.
> 6. Massive regeneration of the bone is a great rarity, and even spontaneous fusion is uncommon. That is why, before tuberculosis of the bone was treated with specific antituberculous drugs, so many cases necessitated surgical intervention. (Morse 1961:489)

Application of these standards to skeletal collections led Morse to conclude that tuberculosis could not have been present in the New World prior to European contact.

Morse's hypothesis stimulated significant interest in the issue of pre-Columbian tuberculosis among both medical and anthropological scholars. Buikstra (1976,1981a), perhaps the individual most critical of Morse's model and its applicability in differential diagnosis of bone pathology, also has been a major force in establishing the presence of pre-Columbian tuberculosis in the New World.

> Thus, a diagnosis of tuberculosis may be questioned if more than four vertebrae are involved, if neural arch lesions appear, or if ankylosis has occurred. This standard, if rigorously applied, would indeed exclude most previously-reported pre-Columbian skeletal materials from prior involvement with M. tuberculosis. . . . To diagnose tuberculosis as it may have affected aboriginal populations, one must divest oneself of recent clinical bias, and create a disease model which allows for variable and extreme expression of pathology in the total skeleton. (Buikstra 1976:358)

In a study of disease expression among the Caribou Eskimo, Buikstra developed a rigorous differential diagnosis which incorporated environmental and epidemiological data, attributes of lesion morphology and distribution, and evidence from the literature and ethnographic accounts. Her case study established the foundation for the diagnosis of pre-Columbian tuberculosis, one that continues to be applicable today.

A subsequent increase in osteological case studies has established, without doubt, the presence of tuberculosis in pre-Columbian New World populations. The presence of tuberculosis-like pathological lesions have been reported in geographically dispersed pre-Columbian North American skeletal from New York (Ritchie 1952), Tennessee (Lichtor and Lichtor 1957), California

(Roney 1966), South Dakota (Owsely and Bass 1979), and the Midwest (Morse 1961).

El Najjar, who reviewed pre-Columbian skeletal collections from New Mexico and Arizona, supports "earlier authors who found tuberculosis to have been endemic in the pre-Columbian New World" (1979:616). Evidence for tuberculosis has been documented among the pre-Columbian Moundville, Alabama, and Irene Mound, Georgia, populations (Powell 1988, 1990, 1991). Vertebral skeletal lesions producing the anterior kyphosis characteristic of spinal tuberculosis, rib lesions characteristic of chronic pulmonary tuberculosis, and the extensive remodeling in all areas of pathological involvement "indicates survival for some considerable length of time despite severe deformity, as has been abundantly documented in modern clinical cases" (Powell 1991:177).

Buikstra and Cook (1981) report a pattern of pathology from a west Illinois series that is consistent with a diagnosis of tuberculosis. This bony pathology, observed among Mississippian groups (A.D. 1050-1300), was not found in the earlier Middle and Late Woodland populations. Hartney (1981) presents evidence for tuberculosis lesions in pre-Columbian Iroquoian (A.D. 1300) remains from southern Ontario. Palkovich (1981) demonstrates the presence of tuberculosis among the pre-Columbian Arikara. Widmer and Perzigian (1981) report on endemic tuberculosis present among the late pre-Columbian populations from the Turpin, Ohio, and Arnold, Tennessee, sites. Milner and Smith (1990) discuss the presence of tubercular skeletal lesions in a Mississippian Oneota (A.D. 1300) population from central Illinois. Kelly and Eisenberg (1987) re-evaluate tuberculosis in the Auerbuch site in Tennessee.

Rehydrated soft tissue from a South American Nazca child mummy (A.D. 700) has established without a doubt, the histological presence of acid-fast bacilli and psoas abscess in pre-Columbian populations (Allison et al. 1973). Allison and co-workers (1981) have also documented expressions of tuberculosis in pre-Columbian skeletal remains from Chile and Peru. Additional evidence for pre-Columbian tuberculosis in Peru has been reported in the Moquegua valley (Buikstra and Williams 1991). Vertebral involvement in adults is accompanied by sacroiliac and rib lesions in extreme cases. Disease patterning in juveniles mirrors the form and distribution of tubercular involvement reported for large North American series and the Peruvian material discussed by Allison and co-workers (Buikstra and Williams 1991:166 and 167).

Typical tubercular skeletal lesions, described in multiple individuals from numerous archaeological sites, establishes a pre-Columbian tuberculosis pattern, post-dating A.D. 1000, among eastern North American population centers (Buikstra and Williams 1991:165). The evidence appears to indicate that tuberculosis became manifest in North America after A.D. 1000 among populations that aggregated around regional centers for communal events. This theory holds particular interest in an evaluation of the apparent absence of tuberculosis among Florida's aboriginal populations and will be discussed later.

A Differential Diagnosis of Tuberculosis

Estimates of Incidence

Modern studies of tubercular bone lesions among American Indians suggests that approximately five to seven percent of all cases of tuberculosis will involve the bones and joints (Steinbock 1976). Morse (1969) posits that of every 1000 specimens from excavated skeletal populations, 320 deaths would have been caused by tuberculosis--22.4 individuals would show evidence of bone tuberculosis, and 6.7 would involve vertebral tuberculosis. Although Morse's computations of morbidity statistics from reservation conditions may be high for pre-Columbian populations (Buikstra 1981a), one study of a pre-Columbian North American skeletal series has demonstrated a three percent involvement of tubercular vertebral lesions (Buikstra and Cook 1978)--a relatively high frequency given Morse's figures. This finding may, however, reflect a chronic form of tuberculosis-like disease endemic to small populations, in which juveniles, with a relatively high rate of skeletal involvement, would comprise the majority of susceptible individuals.

General Epidemiological Skeletal Characteristics

The pattern of widely scattered granulomas characteristic of bony tuberculosis develop from miliary seeding of the marrow in the course of hematogenous dissemination of organisms from a primary source elsewhere, usually the lungs. Tuberculosis is an insidious chronic infection, usually initiated in early childhood, with the spine as the favored site of bone localization. The skeletal remains of adults with vertebral tuberculosis probably reflect a host response adequate to have insured survival through childhood. Peripheral joint involvement, usually monarticular, includes the hip, knee, ankle, elbow, wrist, and all the phalanges. The joints of the lower extremities are generally more affected than the upper joint extremities. The infection, which spreads through large areas of the medullary cavity and the epiphyseal cartilage into joint spaces, causes extensive necrosis of cortical bone (Ortner and Putschar 1985; Steinbock 1976).

Hematogenous dissemination of the tubercle bacillus dictates that the bony lesions of tuberculosis are commonly located in cancellous bone rather than the cortex or medullary cavity. Formation of localized sequestra in the cancellous bone, particularly in areas of hemopoietic (red) marrow, is typical. Lesions are generally single in the same bone with direct spread to other bones. The high prevalence of spinal tuberculosis in all age groups is related to the fact that the vertebral column represents the largest focus of hemopoietic marrow in the human body throughout life. Vertebral tuberculosis first attacks the intervertebral discs then the vertebral bodies (most frequently the eighth thoracic through the second lumbar). Bone necrosis may result or bony bridging and fusion of sclerotic bone masses may occur from spontaneous healing, osteophytosis is uncommon. Rarefaction of the bone is radiographically observable (Allison et al. 1981; Ortner and Putschar 1985).

Although spinal involvement is the outstanding feature of skeletal tuberculosis, caution must be employed in differential diagnosis of pre-Columbian populations on the basis of vertebral response alone. Skeletal lesion morphology should be treated as suggested by Buikstra (1976,1977)--by contrasting patterns for lesion form and distribution, by observing demographic patterning, and by combining this data with epidemiological information.

Specific Regions of Bone Involvement

The spine. The three major sites of bony tubercular lesions are, in descending order, the vertebral column, the hip, and the knee (Steinbock 1976). In recent clinical and autopsy cases, about 80% of the affected individuals displayed involvement of at least two adjacent vertebrae (Ortner and Putschar 1985). Tubercle infection appears to display a predilection for the lower thoracic and upper lumbar vertebrae, with peak incidence in the first lumbar vertebrae, possibly as a result of infectious dissemination from the kidneys (Steinbock 1976) .

Of all the osseous elements comprising the spine, tuberculosis almost exclusively affects the vertebral body and seldom involves the transverse processes, pedicles, lamina, or spinous processes. The central and anterior portions of the vertebral bodies are the most common sites of necrosis. Even with extensive destruction of vertebral bodies, involvement of the vertebral arches is rare. Destruction of the intervertebral discs, Pott's disease, produces compression fractures and increases susceptibility to additional deformities such as kyphosis and scoliosis. Kyphosis, the anterior curvature of the thoracic spine is usually very marked. Scoliosis, a lateral spinal curvature, is particularly marked in the thoraco-lumbar region. Healing in the form of bony fusion will permanently preserve the deformity. Bone regeneration is extremely minimal and original cavitations may remain (Ortner and Putschar 1985; Steinbock 1976).

Characteristic psoas abcesses of the vertebral bodies are the result of the spread of infection from the vertebral bodies into the sheath of the paravertebral psoas muscle (Berkow 1982; Cotran 1989). These bony abscesses are characterized by shelf-like downward projecting bony extensions, which follow the line of gravity beneath the anterior longitudinal ligament and along the fascial sheath of the psoas muscle. The abscesses facilitate spread of infection into adjacent vertebrae, erosion of the cortical surfaces, and secondary extension into adjacent ribs (Ortner and Putschar 1985:148).

The hip. The hip joint is the second most frequently affected area. As in vertebral tuberculosis the majority of cases begin in childhood, usually around four to six years of age. Hematogenous spread of the infection will focus at the joint of the acetabulum and the femur. The primary region affected in the acetabulum is the posterior superior rim and the cartilage-free center around the origin of the round ligament. Lesions in the femoral head and/or neck may be small and cavitating or larger triangular foci with spongy sequestra in the center. Continued erosion of the articular surfaces will ultimately result in partial or complete dislocation of the remnant of the femoral head or neck. A neo-acetabulum can form on the lateral side of the iliac wing if dislocation is complete. If healing occurs, it takes the form of bony ankylosis (Ortner and Putschar 1985; Steinbock 1976). Although tubercular involvement of the greater trochanter is rare, it is a very characteristic lesion. The lesion usually remains localized in the trochanter, is progressively destructive, "and actually represents the most identifiable tuberculosis bone lesion of the adult with the exception of tuberculosis spondylitis" (Ortner and Putschar 1985:154).

The knee. Tubercular skeletal lesions are also frequent in the knee. The majority of cases are initiated and remain in the synovial fluid. The infection then spreads along the attachments of the cruciate ligaments and the capsular insertions of the femur and tibia. Erosion and destruction of the articular surfaces occurs. Marked destruction of the femoral condyles is uncommon and present only in association with a primary or simultaneous hematogenous osseous focus (Ortner and Putschar 1985; Steinbock 1976).

The joints. The hematogenous dissemination of the tubercle baculus sets up tubercular inflammation in either the bone or the synovial membrane of a joint and can foment destruction of the articular cartilages. Erosion of articular surfaces may be widespread or localized. Lesions are characteristically present on both opposing joint surfaces. Healing is never complete and permanent indicators are present in the form of a coarse cancellous network. Occasionally conical shaped sequestra are found in the articular ends of the bones. Tubercular destruction may spread to the diaphysis and metaphysis without affecting the joint (Steinbock 1976).

The ribs. Tubercular rib lesions are not uncommon. While the infection is primarily the result of hematogenous dissemination, direct extension from paravertebral abscesses can occur. Initially, hematogenous lesions localize near the osteocartilaginous border and may secondarily involve the cartilage. Infrequently the infection may spread to the sternum with primary focus in the manubrium (Ortner and Putschar 1985). In clinically-diagnosed tuberculosis, rib lesions were present in more than half of the cases, and were more frequently associated with chronic pulmonary tuberculosis than had been recognized by radiographic examination (Kelly and Micozzi 1984). The lesions commonly affect the middle ribs, numbers four through eight, in the center of the rib body rather than at the head and neck regions.

> The rib lesions are characterized by light to moderate periostitis on the internal aspect of one or more ribs. When the ribs are laid out in anatomical fashion, a rounded or oval-shaped area of periostitis covering several ribs often emerges. (Kelly and Micozzi 1984:382)

Less involved joints. The sacroiliac joint is the most common area of pelvic involvement. The sacral wings may show destruction in association with reactive osteosclerosis. The ischium, ilium and pubic symphysis are rarely affected (Ortner and Putschar 1985).

The tibiotalar joint is the most common area of tuberculosis involvement in the ankle. The lesion is most common in children with maximum incidence at three years of age. The disease process begins with a primary focus in the talus and leads to cavitation and destruction of the talus. Healing takes the form of tibiotalar bony ankylosis. Involvement of the talocalcaneal joint is secondary and healing terminates in broad bony fusion of the talus and calcaneus (Ortner and Putschar 1985:155).

Multiple involvement of the phalanges, metacarpals, and metatarsals is the most frequent tubercular focus among infants and children. As hemopoietic marrow still exists throughout the bone shafts in these age groups, infection will occupy the entire diaphysis. Periosteal reaction gives the phalange a "ballooned" appearance and may leave permanent shortening of the bone. If the lesion heals it will disappear completely with remodeling. Tuberculosis in the adult wrist usually begins in the radiocarpal joint and spreads rapidly until ultimately the carpal bones become a solid bone block fused to the radius and often to the base of the metacarpals (Ortner and Putschar 1985:156).

Tubercular infection in the shoulder joint follows extensive synovial involvement. In the humerus, synovial reaction occurs along the capsular attachment and will leave a resorptive groove along the lateral portion of the head. Extensive destruction of the humeral head and glenoid fossa of the scapula is common. Tuberculosis of the elbow is most frequent in the distal humerus, followed by involvement of the proximal ulna and radius. Healing takes the form of bony ankylosis (Ortner and Putschar 1985).

Cranial tuberculosis is rare except in young children, with the majority of cases present in children under ten years of age. Hematogenous dissemination of the infection often leads to multiple lesions characterized by a round lytic focus not more than two centimeters in diameter, with or without a "moth-eaten" central sequestrum that can perforate both the inner and outer tables. The inner table margin is more involved than the outer table. Lesions rarely cross suture lines. In adults the lesion is often larger than in children and is virtually always solitary. The cranial base is rarely involved. Involvement of the facial bones in children is not uncommon with involvement of the maxilla, zygoma, and nasal cavity most frequent (Ortner and Putschar 1985).

Differential Diagnosis in Skeletal Populations

Primary reliance on radiographic examination of the skeleton to differentiate tuberculosis from other pathogenic conditions that similarly affect bony tissue has been suggested by Jansenns (1970) and Steinbock (1976). While this technique will determine if any lesions have broken through to the cortex, it alone is not sufficient in differential diagnoses of skeletal pathology. The most thorough and comprehensive treatment of differential diagnosis of tuberculosis in pre-Columbian populations can be found in Buikstra's 1976 study, "The Caribou Eskimo: General and Specific Disease." There is little one can add to this model and it will not be reiterated here other than in summary form with some additional disease considerations for a differential diagnosis.

Buikstra's analysis of skeletal pathology in Caribou Eskimo skeletons employed both macroscopic and radiographic examination to determine evidence of bone remodeling not attributable to normal aging. A differential diagnosis was developed through a comprehensive model that incorporated attributes of lesion form, distribution, and epidemiology. After consideration of the epidemiology and pathogenic skeletal involvement of actinomycosis, echinococcosis, histoplasmosis, malignant tumors, osteitis deformans, pyogenic osteomyelitis, rheumatoid arthritis, sacoidosis, Scheuermann's disease, traumatic arthritis, compression fractures, and tuberculosis, tuberculosis was found to be the "best fit" model for the disease infecting the Caribou Eskimo (Buikstra 1976:361-363).

In addition to those diseases discussed by Buikstra, blastomycosis, treponematosis, septic arthritis, dislocations, and cryptococcosis deserve attention. In differential diagnosis of tuberculosis, blastomycosis requires reconsideration in that these two diseases may have co-existed in a single pre-Columbian population (Kelly and Eisenberg 1987). The importance of the incorporation of physical and cultural environmental patterns with osteological and epidemiological data is clearly evident in this case.

The differential diagnosis of treponematosis and tuberculosis has been discussed on page 256. In an examination of tuberculosis of the joints, septic arthritis should be considered. In the femoral head the septic process is rapid with relatively limited bone destruction. Upward or central dislocation is not observed. If bony ankylosis is found, there is usually little, if any, bone loss of the joint constituents. Septic infection in infants may lead to complete destruction of the femoral head, but this necrosis is normally accompanied by osteomyelitis of the shaft. Septic arthritis of the shoulder region is notably less destructive and extensive, with complete absence of the lateral grooving of the humeral head (Ortner and Putschar 1985).

A differential diagnosis between tuberculosis, septic arthritis, and rheumatoid arthritis of the knee may be difficult and even impossible if bone destruction is absent or limited. Osteoporotic involvement of the lower limbs often accompanies rheumatoid arthritis and tuberculosis. Tuberculosis and septic arthritis are more frequently unilateral than is rheumatoid arthritis (Ortner and Putschar 1985). Differences appear to be a matter of degree and are difficult to access in individual cases.

In tubercular dislocation of the hip, the femoral head is markedly more eroded than in congenital or traumatic deformities. As the round ligament is destroyed by tubercular infection before dislocation occurs, there is no groove evident on the bone at place of origin. The original acetabulum is not rudimentary and the neo-acetabulum shows signs of infection (Ortner and Putschar 1985).

Crypotococcosis, one of the fungal pathogens acquired by inhalation into the lungs, may result in osseous lesions. The predicted areas of involvement are bony prominences, cranial bones, and vertebrae. Periosteal proliferation is rare. Lesions are usually multiple, destructive, chronic, and widely disseminated. The major geographic focus of this infection appears to be Europe and is probably not a major consideration in differential diagnosis of tuberculosis in North American pre-Columbian populations (Shadomy 1981; Ortner and Putschar 1985).

As has been demonstrated tubercular bone involvement frequently includes extra-vertebral areas, commonly the joints. Although absolute frequency of joint involvement will vary, studies of clinical populations have demonstrated that approximately one-third of all individuals with vertebral involvement will also show extra-vertebral lesions. Morse's (1961) standards must, therefore, be supplemented by consideration of the patterning of non-vertebral lesions in association with conventional lesion foci, such as the spine, hip, and knee. This integrated and comprehensive differential diagnosis will clearly provide a more accurate estimation of the incidence of tuberculosis in pre-Columbian skeletal collections.

Models to Explain the Absence of Tuberculosis in North Florida

There appears to be no skeletal or ethnographic evidence to support the presence of tuberculosis among north Florida's native peoples. The available bioanthropological literature contain no descriptions of vertebral tuberculosis among any pre-Columbian populations from northern Florida. Given the apparent absence of this most obvious form of skeletal tuberculosis, it seems unlikely that the more subtle indicators, such as joint and rib involvement, would have been observed. Arthritis of the joints is commonly found among Florida's pre-Columbian archaeological skeletal samples, but joint dislocations and necroses, ankylosed vertebral columns, and fusion of the tarsal and carpal bones have not been identified. Although French and Spanish documents contain numerous references to ambiguous disease symptoms such as chills, fevers, and pestilence, and specifically mention of the prevalence of smallpox, measles, and "venereal" syphilis, the records are silent on disease patterns that could be interpreted as evidence for tuberculosis. Clinical signs and symptoms of tuberculosis include low-grade fevers (usually most marked in the afternoon), coughing, blood-streaked sputum, night sweats, weakness, fatigability, and loss of appetite and weight. Either these signals were too subtle and escaped detection by the early chroniclers, or such symptoms were not present among contact-period Florida populations, or disease symptoms may have been so common as not to have excited notice.

Because skeletal analysis of Florida's native populations is essentially in its infancy, discussions of disease patterns must be tempered by the fact that few bioanthropological data actually exist. The following models were developed on the premises that: (1) the early chroniclers, given their verbosity on many aspects of Timucuan life, would have noticed and documented symptoms of tuberculosis if present; (2) had tuberculosis existed among the Timucua, a native method of treatment would have been developed to cope with the disease and this too would have been observed by early Europeans (as was "venereal" syphilis); (3) that the available archaeological documentation of skeletal remains is an accurate reflection of pathology present among the pre-Columbian populations; and (4) that even in skeletal collections adversely affected by taphonomic forces, the proliferative bony responses of vertebral tuberculosis would greatly enhance preservation of such typically compact and dense bone. Geographic and climatic barriers, domestic animal reservoirs, population size, and the natural and cultural environments must all be evaluated in an attempt to develop a model to explain the apparent absence of tuberculosis among the Florida natives.

Animal Reservoirs

Although mycobacteria can affect both wild and domestic animals, the pre-Columbian Florida Indians never had domestic herd animals. Cattle ranching, typically detached from aboriginal villages, is reported to have been a Spanish endeavor in interior northern Florida during the late seventeenth century (Bushnell 1981:13). Land grants were issued to Spaniards for cattle ranches, providing the center of the proposed ranch was no closer than three leagues from any native village (Bushnell 1981:80). After the 1672 to 1674 unidentified epidemic that severely reduced Timucuan populations, the Spanish gave land in Timucuan Province to anyone who would introduce cattle (Bushnell 1981:13). But cattle ranching was limited. Thus, infection from bovine tuberculosis is highly unlikely, especially regarding the pre-1656 San Martín population. It is also highly unlikely that fowl, such as turkeys, or dogs would have been maintained in numbers sufficient to have served as disease reservoirs. Faunal analysis of mission site middens support this contention (Loucks 1976; Reitz 1991; Reitz and Scarry 1985). Faunal remains from the San Martín mission aboriginal structure associated with the convento and mission church contain one pig, Sus scrofa, bone and one wild turkey, Meleagris gallapavo, bone. A dog burial was associated with the structure. These data strongly suggest that typical domesticated animal carriers of mycobacteria were not present at San Martín or other mission sites, nor were they present at pre-Columbian sites.

Geographic and Climatic Barriers

Balanced gender ratios of tuberculosis reported for pre-Columbian North American skeletal collections appears to eliminate occupation-related hazards in disease acquisition. In that tuberculosis is a world-wide, chronic, communicable disease, it does not appear that geographic and/or climatic boundaries would have presented obstacles to the spread of tuberculosis. Although atypical mycobacteria may certainly have influenced the expression of tuberculosis-like disease in some individuals, its role as a major progenitor of the disease is certainly questionable. It seems unlikely that atypical, environmental, mycobacteria are causative agents for the tuberculosis-like skeletal lesions described among late pre-Columbian North American populations.

> Although the environmental mycobacteria can produce subclinical human infection and variable cross-immunity to tuberculosis, it is inconceivable that one of these forms could be the pathogen for pre-Columbian tuberculosis. They have not evolved as obligate pathogens with host-to-host transmission, they produce clinical disease rarely and then predominately in severely immune-compromised hosts, and their recent recognition seems in fact to reflect a loss of cross-immunity by decreased prevalence of childhood primary tuberculosis. (Steinbock 1987:56)

Effective Population Size (Critical Mass)

Typically, infectious disease models maintain that a large population is required for pathogen maintenance--tuberculosis is one such pathogen. Models describing the predilection of tuberculosis for late North American pre-Columbian populations focus on the social patterns of these groups, characterized by more sedentary, densely settled, aggregated, and agriculturally dependent populations. Although tuberculosis is expected in excavated skeletal collections from high-density urbanized pre-Columbian sites, Black (1975) has demonstrated that the chronically infectious nature of tuberculosis allows the pathogen to persist in even small populations. McGrath's (1986) computer-simulation model supports the view that urban levels are not entirely necessary for tuberculosis to be present in a population. It appears, therefore, that the key variable in tuberculosis maintenance is effective population size, not group size (McGrath 1986). Population aggregates must, however, achieve and maintain a certain density to assure pathogen persistence.

The correct combination of population aggregation and density necessary to create an environment conducive to the propagation and transmission of the tuberculosis bacillus, may have been present at large pre-Columbian centers, such as Cahokia in Illinois. Regular interaction between small, dispersed, satellite communities, in close geographic proximity, during cyclic aggregations at large pre-Columbian ceremonial centers, would have ensured population aggregation. It is at times such as these that effective population size would have been achieved, ensuring the spread of infectious pathogens as a function of social interactions.

Small, dispersed, and self-contained pre-Columbian populations would, over time, acquire immunity to a new disease and the pathogen would virtually disappear. A relatively small portion of the population would, however, remain susceptible and serve as a human reservoir for the pathogen. These human hosts would, in times of population aggregation, reinfect adjacent groups. The time interval between group aggregation, producing effective population size, becomes a critical factor in this scenario. A receptive population depends upon susceptible, non-immune individuals. A sufficient time interval between ritual events is necessary for the reintroduction of the disease into groups lacking immunity. There is some evidence to indicate that ceremonial events were conducted at least annually and that a more typical pattern involved time lapses of two to five years. This scenario would ensure a highly susceptible non-immune population in newly born infants and young children under five years of age. When a new infection enters a community, it will first impact all ages, with mortality peaking among infants and old adults. With the persistence of disease in a population, the only susceptible, non-immune individuals are those who enter the community by birth. Infection and death will thus be highest in infancy and childhood (Burnet 1962). Small dispersed groups, with cyclic congregation patterns, can therefore maintain a pathogenic level not attainable in small, isolated populations. Effective population size, as opposed to group size, number of neighbors, or regional population size influences the course of pathogen dissemination and must have existed among some pre-Columbian populations to have allowed tuberculosis to exist (Figure 12.1). However, archaeological evidence does not indicate that ceremonial centers in pre-Columbian Florida were of the magnitude of those elsewhere--such as Cahokia.

The questions that now need to be addressed concern population size, what is effective population size and what constitutes critical mass? To answer these questions it will be vital to incorporate biological and cultural parameters to provide the framework necessary to evaluate the pattern(s) of tuberculosis among pre-Columbian populations.

Discussion

Treponematosis

Differential diagnosis of disease parameters in pre-Columbian skeletal collections must rely on bone-lesion morphology and distribution with added support provided by epidemiological patterns and social, cultural, and biological dimensions. At the most basic level, differential diagnosis begins with careful scrutiny of each individual skeleton. Meticulous description of abnormal remodeling processes is followed by a compilation of osteological data on a population level, which when applied to the epidemiological and biocultural parameters of a differential diagnosis will establish the "best fit" disease scenario.

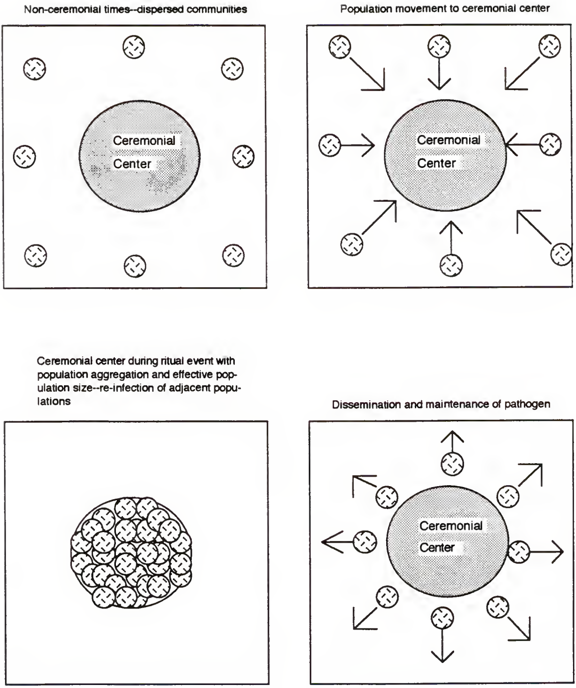

Figure 12.1
Effective population size/critical mass model

Patterns of treponemal infection described by Cassidy (1984), D. Cook (1976), and Powell (1988, 1990, 1991), appear to indicate that a syndrome reminiscent of endemic syphilis was responsible for pathologic manifestations in pre-Columbian North American populations. At time of contact there can be little doubt that a treponemal syndrome was present among the Timucua, probably the eastern Utina. Sixteenth-century French and Spanish chroniclers not only describe disease symptoms, but, being familiar with the clinical signs, specifically isolated syphilis as a common ailment among these populations. In addition, several native medical practices, that sought to alleviate disease symptoms were described. Laudonnière (1587) commented on bags of herbs and drugs utilized to cure individuals affected with the "pox." Le Moyne noted that the Indians were particularly subject to "venereal" disease and provided both written and pictorial documentation of Timucuan medicinal cures for the disease. Bioanthropological literature demonstrate the presence of a treponemal syndrome in pre-Columbian Florida skeletal remains (A. Bullen 1972, 1973; Hrdlicka 1922; Hutchinson 1991; Işcan 1983; Işcan and Miller-Shavitz 1985; C. Moore 1922; Snow 1962).

Neither the pre-Columbian nor mission-period north Florida skeletal collections described here provide evidence for a treponemal syndrome. Although the extremely low incidence of periosteal lesions (1%) in the pre-Columbian collection may indicate sampling error, a low prevalence of pre-Columbian periostitis must be assumed. In the San Martín mission remains 40% of the sample was affected by periosteal involvement. Males represent 53% of the individuals affected, females 31%, and preadults 12.5%. Consistently the degree of periosteal involvement was slight and focused along the lateral borders of the tibiae shafts. In tibiae affected with treponematosis the anterior crests and the medial shafts, are the areas of most bone proliferation (Ortner et al. 1992). Saber-shin tibiae are not present, periosteal lesions of other post-cranial skeletal elements are extremely rare, and caries sicca of the cranial vault was not observed. Lesion morphology does not support a diagnosis of a treponemal syndrome among this mission population, but does appears to indicate a pattern of periosteal reactions stimulated by localized infectious foci.

The presence of a treponemal syndrome among the pre-Columbian ancestors of the Timucuan and sixteenth-century ethnographic accounts of "venereal" syphilis among the northern Timucua, make the lack of any treponemal syndrome among the collections analyzed here is difficult to explain. It seems unlikely that a sampling bias would effectively eliminate all evidence for the disease. Skeletal involvement in treponematosis occurs in 10-20% of individuals having any one of the three syndromes that can affect bone tissue (Ortner et al. 1992:343). The pre-Columbian collection is comprised of 128 individuals and the mission sample consists of 88 individuals. Although it is impractical to speculate on the total number of interments that may have been present in the living pre-Columbian population, minimal skeletal disease expression would suggest that at least thirteen individuals in this sample would be affected with treponemal disease. In the early history of the San Martín mission, Martin Prieto baptized 100 children in residence, suggesting a total population of 250-400 individuals (Johnson 1991:104). A total of 400-500 burials, interred throughout the mission's history, are estimated to exist beneath the floor of the mission church (Hoshower and Milanich 1992:224). Minimal skeletal involvement in treponematosis (10%) indicates that between 25 to 50 individuals should have been infected with the disease. If present, then both the pre-Columbian and mission-period skeletal collections should demonstrate evidence for a treponemal syndrome.

Among Archaic populations in Illinois, it has been demonstrated that individuals who had suffered debilitating traumas were not buried in the community cemetery (Buikstra 1981b). Among more recent pre-Columbian populations no differential burial treatment was afforded to individuals suffering from tuberculosis-like pathology (Buikstra, personal communication). With the exception of the religious specialist interred in McKeithen Mound B, the pre-Columbian burial program displays no evidence for preferential or differential interment treatment. All (baptized?) San Martín individuals are interred beneath the church floor. It must be assumed therefore, that both collections are representative samples of their respective populations, indicating that if treponematosis was present, then it should have been observed.

The etiology of endemic syphilis and its presence in geographically dispersed skeletal populations throughout the ages, indicates that the disease should have been present in both the pre-Columbian and mission-period northern Florida skeletal collections. Although the high prevalence, morphology, and distribution of periosteal lesions on the San Martín tibiae indicates the presence of a chronic, but localized disease process, skeletal lesions diagnostic of endemic syphilis, a chronic systemic condition, are not present. As endemic treponematosis is a disease typically associated with unhygienic conditions (Steinbock 1976:138), it may be suggested that such an unsanitary environment did not exist among Florida's aboriginal populations. This scenario does not, however, seem plausible as it cannot eliminate the spread of endemic syphilis by skin to mucous membrane in children or by common use of eating utensils and drinking vessels. As endemic syphilis is a disease acquired in childhood, an under-enumeration of preadult remains in both samples may have precluded observation of the disease.

It has been demonstrated that endemic syphilis is not evenly distributed over different areas despite what appears to be identical living conditions (Grin 1953). That the northern Timucua, probably the eastern Utina, were documented to have suffered from a treponemal infection, and the northern Utina lack evidence for the syndrome, suggests that the skeletal collections represent pockets of uninfected populations existing within a larger disease scheme.

> Sometimes one village is heavily infected while a neighboring one may remain free or have only a few cases, infections may be found in one group of houses in a village while other groups remain unaffected. There may be considerable variations in infection rates within one region and even within smaller communities. (Grin 1953:22)

These data portray the Florida landscape as a mosaic of disease experiences with emphasis on heterogeneity as a function of diverse cultural and natural environments.

Tuberculosis

One explanation for the absence of tuberculosis among the pre-Columbian ancestors of the northern Utina and the mission-period Utina may reflect an earlier predilection for selective excavation and curation of skulls and gross manifestations of pathology, such as ankylosed spine. For example, Hrdlicka reports that C. B. Moore, known for his many excavations of pre-Columbian mounds across Florida, excavated seventeen crania, but only one skeleton from an aboriginal site in Louisiana. "Opposed to the very healthy state of the skulls, the bones of the skeleton show considerable disease . . . a very pronounced form" (Hrdlicka 1913:98). As late as 1961 Morse indicated that tubercular lesions in locations other than the spine are indistinguishable from many other diseases, predisposing differential diagnosis to vertebral involvement.

It is possible that some form of geographic and/or climatic barrier affected differential distribution of the disease. Case studies presented in the volume Prehistoric tuberculosis in the Americas, (Buikstra 1981a), suggest that a tuberculosis-like pathology occurred in eastern pre-Columbian North America, with lesser involvement observed in other geographic regions. Cases of tuberculosis-like skeletal involvement have been reported, however, for the pre-Columbian Southwest (Merbs 1985), suggesting that differences in reporting may be responsible for the biased distribution of the disease. Changing pathogen dynamics and the globally wide-spread prevalence of tubercular infection does not indicate that geography and/or climate alone was responsible for the absence of tuberculosis among Florida's aboriginal peoples. The most recent review of North American skeletal collections with tuberculosis-like pathology is presented in Buikstra and Williams (1991).

It is possible that tuberculosis was present among these populations and that infected individuals died before hematogenous dissemination of the pathogen provoked skeletal involvement. A recent study has suggested that an inter-relatedness exists between airborne infectious diseases and immunity induced by micro-organisms, such as those found in measles, smallpox, and scarlet fever. Such micro-organisms, conveying immunity, might also temporarily depress the immune response to tuberculin (Mercer 1986:133). This scenario suggests that such a dynamic interaction between measles and M. tuberculosis may explain the absence of tuberculosis among the mission northern Utina, a population reported to have suffered from numerous measles epidemic. Infection with the measles virus may have induced temporary resistance to the tuberculin.

The suppression of tuberculin sensitivity found in measles, scarlet fever, and especially smallpox, will also disrupt the lungs. The common epidemics of childhood are even more of a problem when poor diet and bad living conditions are involved (Mercer 1986:136). Protein-calorie malnutrition impairs disease immunity, prevents complete expulsion of the virus, and indicates that secondary complications of common childhood diseases are frequently respiratory (Mercer 1986:137). The pattern of mortality in eighteenth-century Europe was characterized by the predominance of regular smallpox epidemics. Respiratory tuberculosis was well known as a sequel to smallpox and probably caused more than 10-20 percent of deaths directly attributed to smallpox (Mercer 1986:129).

These data suggest that tuberculosis may have been introduced into northern Florida's native populations, but were erroneously attributed to smallpox epidemics. Lack of previous tuberculosis disease experience among the natives would have ensured rapid death preventing diagnosis of distinct disease symptoms by European observers and skeletal involvement.

Although it appears unlikely that atypical mycobacteria are the causative agents for the tuberculosis-like skeletal lesions described among many late pre-Columbian populations in North America (Buikstra and Williams 1991; Steinbock 1987), atypical mycobacteria can simulate the pathology of tuberculosis. Infection with mycobacteria prior to tuberculosis confers a measure of cross-immunity and lowers population-level rates of tuberculosis. Although the low prevalence of tuberculosis among the pre-Columbian

Moundville skeletal collection has been attributed to an atypical mycobacteria present in the community (Powell 1990, 1991), transmission of atypical mycobacteria from domesticated animal hosts to the northern Utina was highly unlikely. Total lack of skeletal involvement makes it impractical to assume that environmental mycobacteria were contracted from the soil and water.

An effective population size/critical-mass model may be invoked to explain the absence of tuberculosis among both pre-Columbian and mission-period northern Utinan populations. Many infectious diseases require minimum host populations for maintenance, a critical mass of susceptible individuals is necessary to support the chain of transmission. These processes are dependent upon the dynamic interrelations between the host, pathogen, and environment--environment in this instance representing the social and cultural milieu of the northern Utina.

The complex burial ceremonialism associated with the Weeden Island groups has been related to the culture represented by pre-Columbian burial mounds located in northern Suwannee and Columbia counties, historically northern Utinan territory. Weeden Island I (A.D. 250-700) occupation sites are small. Burial mounds do not accompany all village sites. If temple mounds "did occur they were rare. It is possible in some cases that they may have served both temple and mortuary functions" (Wiley 1949:403). Society was organized around small villages, or possibly groups of two or three villages, which were probably autonomous in political and religious matters. Weeden Island II (A.D. 700-900) in north-central Florida is marked by an overall increase in site distribution, suggesting larger population densities (Milanich et al. 1984:11). Weeden Island II societies were not chiefdoms, but were beginning to display evidence for the development of more complex forms of social and political structure. Trade was conducted along the Gulf Coast, six or more villages may have been associated with ceremonial centers, nucleated settlements with one or two burial mounds were common, and while weak social stratification was present, centralized power was absent (Milanich and Fairbanks 1980).

Historic period northern Utinan villages are believed to have contained as many as several hundred inhabitants. Each town was ruled by one chief, with one chief dominate over all the others. The French noted that one eastern Utinan chief oversaw 40 vassal villages. This alliance afforded the Utina increased numbers and established a form of confederacy with centralized authority located in a major town (Milanich and Fairbanks 1980).

A trend of increasing population size and density over time characterizes the northern Utina. Ethnohistoric documentation demonstrate that periodic Timucuan social interactions, between small satellite villages, occurred at large central ceremonial centers. The populations of small, dispersed satellite communities would each bring with them their own separate disease histories to cyclic social aggregations. At these times effective population size/critical mass would have established the human reservoir necessary for propagation and transmission of infectious diseases, such as tuberculosis and endemic treponematosis. Thus, the key variable to infectious disease maintenance suggests effective population size/critical mass, not group or community size.

Unfortunately, the constituents of effective population size have yet to be determined. In addition, as noted in Chapter II, population estimates for the Timucuan-speaking peoples continue to be a matter of much conjecture and range from 13,00 to 722,00 individuals (Ramenofsky 1987). Lack of tighter population parameters hinders analysis of population-level critical mass. Such an analysis is truly mutidisciplinary and will require cooperation between medical professionals, epidemiologists, and anthropologists to define the model's parameters. This theory is particularly attractive as it is not population-specific and can have definite applicability to spatially and temporally extinct and contemporary populations.

For the pre-Columbian Timucua and mission-period northern Utina it must, thus, be assumed that effective population size/critical mass was never reached at time of demographic peak or in times of ceremonial aggregation. These inferences must be treated with caution as further research is essential to define the population parameters necessary for the maintenance of tuberculosis.

The most straightforward hypothesis to lack of tubercular involvement among the Utinan populations is one that evaluates the natural environment of Florida and the etiology of tuberculosis. Tuberculosis is a chronic, infectious, respiratory disease spread through inhalation of airborne droplets and typically acquired by sustained exposure rather than casual contact. In pre-Columbian times, tuberculosis is a disease commonly found among populations demonstrating evidence for increased size, density, and a sedentary lifestyle and one which demonstrates a predilection for northeastern North American populations. The prevalence of tuberculosis among these populations suggests common social and environmental variables affecting disease transmission. Large sedentary populations in colder climes develop dwelling arrangements to cope with a seasonally harsh environment. Typical living arrangements would aggregate peoples in enclosed dwellings, fortified against inclement weather, inhibit proper ventilation, and promote the spread of tuberculosis. In Florida such environmental precautions would not have been necessary. Archaeological evidence indicates that both pre-Columbian and mission-period Utinan dwellings were basically open-aired structures, often open on several sides and sometimes little more than a thatched roof supported by posts (Milanich and Fairbanks 1980; Weismann 1992a). De Soto noted that it was north of Apalachee that winter houses (wigwams) first appeared.

> In Biedma's narrative of the de Soto expeditions, there was a change in the habitations which were now in the earth, like caves; heretofore they were covered with palm leaves and with grass. (Swanton 1922:353)

These living arrangements, in which crowding of inhabitants in enclosed quarters is not a necessity and adequate ventilation is assured, are certainly not conducive to unsanitary dwelling conditions and the spread of tuberculosis.

CHAPTER XIII
CONCLUSIONS

The Spanish mission system itself profoundly affected the health of La Florida's Native Americans. The pre-Columbian ancestors of the northern Utina have demonstrated little evidence for infectious disease processes, systemic and metabolic stressors, or nutritional inadequacies. In contrast, the mission-period northern Utina were heavily impacted by environmental disturbances, nutritional deficiencies, and infectious disease processes that fostered a lifetime of chronic stress and generally compromised levels of health. The impact of mission rule upon native political, religious, subsistence, settlement, and economic networks produced profound alterations in the mechanisms of northern Utinan social and cultural integration. The reductíon, which disrupted the host-pathogen-environment equilibrium, greatly altered northern Utinan physiological-adapting mechanisms.

The Effects of Transition Upon the Northern Utina: The Cultural and Natural Environments

Before European contact the pre-Columbian ancestors of the northern Utina were basically hunter-gatherers who lived in small villages dispersed across the landscape. They were seasonally nomadic. During the winter months, January through March, villages would disband and move further into the forests to avail themselves of the local flora and fauna. Florida is, and was, a land of rich natural resources and one in which many different ecozones exist within a relatively limited geographic area. As a result, several villages that shared a similar environmental zone developed similar cultural and social mechanisms to cope with the environment. A cluster of villages may have maintained loose political affiliations. This is certainly the pattern of social interaction described by French and Spanish documents written at time of contact. These documents tell us that one chief typically controlled as many as twenty satellite villages.

The Spanish mission system itself disrupted northern Utinan life-styles at all levels. The economy of the Spanish mission system was founded upon Indian labor and mission success, therefore, depended on the aggregation and control of native peoples. To establish a sufficiently large mission-labor force numerous aboriginal groups, who had lived dispersed across the landscape, were now congregated within mission confines. Different groups, who typically had lived in unique ecozones with only limited contact, now shared the same environment on a daily basis. Each village brought with then their own distinct pathogen load to which they had adapted. The aggregation of numerous dispersed groups into one large sedentary population ensured that the majority of the population was now subjected to a variety of new diseases against which they had no natural immunity. Thus, the nucleation of numerous distinct, small villages into a relatively large mission population provided, for the first time, an environment conducive to the development and transmission of pathogens not previously encountered.

The mission system dramatically altered native cultural, social, political, technological, and religious systems. The assimilation of Spanish traits appears to have progressed very rapidly. One report from the period states that the first generation of mission northern Utina ridiculed their elders for attempting to maintain native customs and practices. Increasing control of the Indians by the missionaries finally resulted in the chief's loss of power and total collapse of the northern Utinan social and political systems.

The Effects of Transition upon the Northern Utina: The Biological Environment

The remains of 128 individuals demonstrated to have been the pre-Columbian ancestors of the mission-period northern Utina show very little skeletal or dental evidence for any disease processes. Skeletal lesions that indicate the presence of specific or non-specific infectious diseases are absent in both children and adults. The infectious diseases tuberculosis and treponematosis, reported for many North American pre-Columbian skeletal collections, are not present in this collection. There are no bone pathologies to suggest the presence of anemias or dietary deficiencies. Trauma-induced injuries are not common. The dental arcades are relatively free of caries and periodontal diseases. In general, the pre-Columbian ancestors of the mission-period northern Utina led a healthy and stress-free life. This pattern is opposite that demonstrated for the San Martín mission-period northern Utina.

At San Martín mortality peaks between the ages of twenty six to thirty years. A large portion of the population, 34%, died between these ages. Few adults lived beyond thirty five years of age and after forty five years all individuals had died. In comparison, the pre-Columbian ancestors typically survived into their fifth decade and individuals over fifty years of age were not uncommon.

In addition to high mortality the mission collection demonstrates much evidence for increased morbidity. Infectious diseases, dietary deficiencies, anemias, stress associated with the weaning period, and relatively poor dental health are the norm.

Forty percent of the mission sample was affected by periostitis. In contrast only 1% of the pre-Columbian collection demonstrated evidence for this disease. The very marked increase in the percentage of the mission-period population affected by periostitis demonstrates that a dynamic relationship existed between the pathogen and the natural and cultural environments. The high prevalence of this infectious disease among the mission-period northern Utina and its virtual absence among the pre-Columbian population must be viewed as a direct correlation of the nucleation and aggregation of large numbers of peoples as mandated by the Spanish mission system.

Thirty percent of the pre-Columbian population and 31% of the mission population were affected with some combination of porotic hyperostosis and cribra orbitalia. Equal disease expression suggests that different pathological processes may have been active within the respective natural and cultural environments. It has been suggested that macroscopic parasitic worms, which deplete the body's iron supply, were primarily responsible for the pre-Columbian skeletal expression of an anemic response. At the San Martín mission evidence for prepared living floors suggests that this practice may have greatly reduced the number of parasites introduced into the body through the soles of the feet of people walking barefoot. The presence of an anemic response among the mission-period northern Utina may be more closely related to the conditions imposed upon the natives by the mission system. As individuals attempted to adapt to environmental increases in pathogen load, nutritional deficiencies developed. Nutritional resources typically earmarked for normal maintenance at the cellar level were mobilized to fight infection. Daily minimal nutritional requirements were no longer met and as a result a state of pathology ensued. Low iron levels in the mission population can be viewed as a product of forced changes in the biological, cultural, and natural environments of the northern Utina.

The drastic increase in enamel hypoplasias, from a 15% prevalence among the pre-Columbian population to a 75% incidence in the mission population, indicates a dramatic rise in infectious diseases, nutritional deficiencies, and/or systemic stressors during the childhood years. Among the pre-Columbian collection, the low prevalence in hypoplastic banding and mean age of occurrence, twenty four to thirty six months, suggests that although enamel hypoplasias were the result of protein deficiencies associated with weaning, that this period was not particularly stressful for the population as a whole.

The high incidence and age-of-occurrence, twenty four to sixty months, of enamel hypoplasias among the mission-period northern Utina implicates the presence of population-level systemic stressors, metabolic stressors, and/or infectious diseases. The fact that individuals display enamel defects until five years of age suggests that the post-weaning period was especially stressful.

Spanish mission records tell us that the introduction of Old World diseases, such as measles, devastated New World peoples. Measles epidemics have been recorded for numerous mission populations across La Florida, and recent research had indicated that measles were introduced into the San Martín population. After weaning the child is particularly vulnerable to the disease challenges presented by the environment. Amino acids typically required for skeletal growth are mobilized in the fight against infection--in this case a measles epidemic. Enamel hypoplasias may be one product of severe stress encountered during the period of growth and development.

The increase in dental caries, calculus, and periodontal disease among the mission-period northern Utina implicate an increase in carbohydrate-rich foods, such as maize. The data indicate, however, that although the northern Utina steadily increased the percentage of maize in their diet, that maize dependence never reached the levels characteristic of many protohistoric peoples from North America.

The Effects of Transition Upon the Northern Utina: The Micro Trends

The data from the San Martín mission collection have demonstrated three additional and rather striking trends. First, the adult males residing at the San Martín mission were more severely stressed than the females. Second, the late mission population demonstrates more evidence for stress than the early mission poulation. Third, the diversity of the Florida landscape had an effect on disease patterning.

Adult males were overwhelming more likely to have been affected by systemic and specific diseases than were females. Males also demonstrate a higher prevalence of trauma-induced injury and dental caries and calculus (Refer to Table 10.1, page 189). This strict disease dichotomy has been contributed to the harsh and demanding conditions of the repartimiento, the native labor force organized by the Spanish and comprised of male members of the mission population.

The San Martín data also indicate a trend for a temporal increase in stressful conditions at the mission. The trend suggests that infectious diseases and systemic stressors became even more prevalent in the later history of the mission. This pattern indicates that the effects of the Spanish mission system upon the northern Utina were not only negative, but also cumulative, and ultimately culminated in population extinction.

Some archaeologically recovered northern pre-Columbian Timucuan skeletal collections demonstrate evidence for treponematosis. Sixteenth- and seventeenth-century documents discuss the presence of venereal syphilis among these post-Columbian peoples. Treponematosis was not, however, observed among either the pre-Columbian ancestors of the northern Utina or the mission-period northern Utina. The infectious disease tuberculosis, documented for many pre-Columbian skeletal collections, is also absent in these collections. These data paint the Florida landscape as a mosaic of disease experiences with emphasis on heterogeneity as a function of diverse cultural and natural environments.

Summary

The biological record of the San Martín mission-period northern Utina is testimony to the pathological, morphological, and physiological consequences of prolonged European-Indian contact. This native population demonstrates evidence for continued exposure to endemic diseases and systemic stressors. Maladaption to the rapidly changing environment has been recorded in the cumulative physiological record of the northern Utina and has allowed interpretations of the stressful effects of life transitions in this extinct population.

The Spanish mission system provided the primary stimuli for increased stress and morbidity among the northern Utina. Table 13.1 demonstrates the dramatic increase in disease expression in the northern Utinan transition from a pre-Columbian lifestyle to a mission-period existence. This transition has been marked by general declines in health, suvivorship, mean age-at-death, and life expectancy at birth, and dramatic increases in morbidity, prevalence of infectious disease, chronic malnutrition, and episodic and environmental stressors.

These data show a sharp increase in stressful-living conditions among the mission population, indicate that the environment was, for the first time, conducive to the development and transmission of endemic infectious diseases, and clearly indicate the introduction of new diseases processes by the Spanish mission system. Although epidemic diseases are rapid killers and preclude skeletal involvement, the mission environment was certainly conducive to the quick and efficient transmission of infectious diseases. European-introduced pathogens, such as measles, upon a chronically stressed population would have contributed significantly to the ultimate destruction of the northern Utina.

The Last Word

> Differential diagnosis of lesions in bone. . . does not, unfortunately, take into account the dynamic adaptive relationship between host and pathogen. . . . From the anthropological perspective, differential diagnosis is unproductive, at least when adaptation and evolution are the primary foci (Clark et al. 1987:46 and 58).

This dissertation has demonstrated that differential diagnosis is absolutely essential for a full and accurate reconstruction of health patterns and

Table 13.1

Temporal trends in disease prevalence Among the Northern Florida populations

Disease Process	Pre-Columbian	San Martin Mission
Dental caries	2.2%	4.7%
Enamel hypoplasias	15.8%	74.7%
Abscesses	9.6%	14.7%
Calculus	15.5%	49.3%
Dental crowding	0%	28.0%
Periodontal disease	0%	9.3%
Porotic hyperostosis	32.0%	30.0%
Periostitis	1.1%	40.0%
Osteomyelitis	4.4%	2.5%
Platycnemia	4.4%	16.3%
Osteoarthritis	32.0%	31.0%
Trauma	6.6%	16.0%
Harris lines	0%	0%

Note: Refer to Tables 8.2, 8.6, 8.7, 9.1, and 11.3 for actual numbers of observable and affected individuals.

status among past populations. Skeletal lesions observed in archaeological skeletal collections are not isolated phenomena, but represent a cumulative record of the biology of extinct peoples. The importance of cultural and environmental factors in the biological analyses of the lifeways of once-living populations cannot be over emphasized. Just as modern epidemiological inquiry depends on patterning and prevalence of disease in a social, cultural and environmental context, so too must the study of epidemiology in ancient populations view disease as a population-based phenomenon in an environmental context. Differential diagnosis is essential to an interpretation of the host-pathogen relationship and the range of variables operating in human adaptation. To abandon differential diagnosis relegates a vital portion of human history into obscurity.

APPENDIX
SAN MARTÍN BURIAL DESCRIPTIONS

Burial 90-1/1: A 26-30 year old male

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Healed periostitis on fibulae and tibiae

Burial 90-1/2: A preadult of indeterminate age

Skeletal Representation: Cranial fragments

Artifacts: None

Positioning: Disarticulated

Pathology: None

Burial 90-1/3: A 13-15 year old preadult

Skeletal Representation: Cranial fragments; partial permanent dentition

Artifacts: None

Positioning: Disarticulated

Pathology: None

Burial 90-2: A 31-35 year old adult

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Compression fracture of third and fourth cervical vertebrae; healed periostitis on fibulae and tibiae; enamel hypoplasias; dental crowding

Burial 90-3/1: A 26-30 year old male

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Caries; dental crowding

Burial 90-3/2: A 26-30 year old female

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Slight osteoarthritis on elbow articular surfaces; carie; enamel hypoplasias; dental crowding

Burial 90-4: Not excavated

Burial 90-5: Not excavated

Burial 90-6/1: A 26-30 year old adult

Skeletal Representation: Virtually complete

Artifacts: Aborignial pot sherd in pit fill

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Enamel hypoplasias; dental crowding

Burial 90-6/2: A 26-30 year old adult

Skeletal Representation: Cranial fragments; mandible; permanent dentition

Artifacts: None

Positioning: Disarticulated

Pathology: Enamel hypoplasias

Burial 90-6/3: An adult

Skeletal Representation: Cranial fragments

Artifacts: None

Positioning: Disarticulated

Pathology: Active porotic hyperostosis with hair-on-end appearance

Burial 90-7: A 2.5-3.5 year old preadult

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Active periostitis on left femur with slight expansion of diaphysis

Burial 90-8: A 31-35 year old male

Skeletal Representation: Complete

Artifacts: Spanish olive jar sherd in pit fill

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Schmorl's nodes on first through third lumbar vertebrae; fractured left fourth metacarpal; slight osteoarthritis; caries; enamel hypoplasias; abscess; calculus; dental crowding

Burial 90-9: A 4-5 year old preadult

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Active and healed porotic hyperostosis and cribra orbitalia; lipping and eburnation of first cervical vertebrae and occipital condyles; caries on decidious dentition; enamel hypoplasias

Burial 90-10: A 26-30 year old female

Skeletal Representation: Complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Slight osteoarthritis; healed periostitis on right fibula; active porotic hyperostosis; button osteomoa on tibia; abscess; enamel hypoplasias

Burial 90-11: A 31-35 year old male

Skeletal Representation: Complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Healed porotic hyperostosis; healed periostitis on right ulna; depression fracture at glabella; caries; enamel hypoplasias

Burial 90-12: A 21-25 year old female

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Healed periostitis on right humerus and right femur; enamel hypoplasias; calculus; dental crowding

Burial 90-13: A 26-30 year old female

Skeletal Representation: Complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Active porotic hyperostosis; three button osteomas on each parietal; osteoarthritis; collapsed fifth and sixth cervical vertebrae accompanied by osteophytosis; enamel hypoplasias; calculus

Burial 90-14: A 36-40 year old male

Skeletal Representation: Complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Active porotic hyperostosis; healed periostitis on right humerus and right femur; caries; abscesses; calculus

Burial 90-15: A 4.5-5.5 year old preadult

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Disarticulated

Pathology: None

Burial 90-16: Not excavated

Burial 90-17: A 45+ year old female

Skeletal Representation: Virtually complete

Artifacts: Broken knife point in area of right scapula

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Healed periostitis on tibiae; enamel hypoplasias; calculus; dental crowding

Burial 90-18: A 21-25 year old male

Skeletal Representation: Complete

Artifacts: Nineteen blue tubular heat-altered beads

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Active periostitis on right humerus; healed periostitis on tibiae; active porotic hyperostosis; slight osteoarthritis; caries; enamel hypoplasias; caries

Burial 90-19: A 26- 30 year old male

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed eas

Pathology: Slight osteoarthritis; active periostitis on right femur and right fibula;

expanded hand phalange shafts; enamel hypoplasias; calculus; dental crowding

Burial 90-20: A 36-40 year old male

Skeletal Representation: Complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Active periostitis on tibiae; active porotic hyperostosis; enamel hypoplasias

Burial 90-21: A 31-35 year old male

Skeletal Representation: Virtually complete

Artifacts: Turtle carapace fragment in pit fill

Positioning: Extended, supine, and oriented east to west, with head placed east

Pathology: Slight osteoarthritis; compression fracture of fifth lumbar and first sacral vertebrae with osteophyte activity; fusion of fourth and fifth cervical vertebrae; greenstick fracture of femur; abscess; calculus; enamel hypoplasias

Burial 91-1: A 31-35 year old female

Skeletal representation: Virtually complete

Artifacts: One heat-altered tubular blue bead near mandible

Positioning: On left side with head east and face to south

Temporal Placement: Early

Pathology: Two healed focal points of infectious disease on right ulna; slight osteoarthritis; tempromandibular joint disease; abscess; cares; calculus; periodontal disease; enamel hypoplasias

Burial 91-2: A 31-35 year old male

Skeletal representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Late

Pathology: Moderate osteoarthritis; healed porotic hyperostosis and cribra orbitalia; active periostitis on tibiae; platycnemia; calculus; abscesses; caries; periodontal disease; dehiscence; enamel hypoplasias

Burial 91-3: A 21-25 year old male

Skeletal representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Healed porotic hyperostosis; enamel hypoplasias; caries; calculus; dental crowding

Burial 91-4: A 21-25 year old male

Skeletal representation: Cranium; mandible

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Late

Pathology: Healed slight porotic hyperostosis and cribra orbitalia; tempromandibular joint disease; caries; abscess; calculus; enamel hypoplasias; dental crowding

Burial 91-5: A 31-35 year old male

Skeletal representation: Complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Slight osteoarthritis; fractured left navicular, fused to talus; healed periostitis on fibulae and tibiae; cradle boarding at lambda; carie; calculus; periodontal disease; enamel hypoplasias

Burial 91-6: A 12-14 year old preadult

Skeletal representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Late

Pathology: Active porotic hyperostosis; calculus; dental crowding; enamel hypoplasias

Burial 91-7: A 26-30 year old male

Skeletal representation: Cranium; mandible; long bones

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Slight osteoarthritis; enamel hypoplasias

Burial 91-8: A 26-30 year old female

Skeletal representation: Cranium; mandible; long bones; cervicle vertebrae

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Healed periostitis on fibulae; slight osteoarthritis; platycnemia; carie; calculus; dental crowding; enamel hypoplasias

Burial 91-9: A 45+ year old male

Skeletal representation: Cranium; mandible; long bones

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Late

Pathology: Healed periostitis on fibulae; platycnemia; calculus; enamel hypoplasias

Burial 91-10: A 7-8 year old preadult

Skeletal representation: Cranium; mandible; long bones

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Late

Pathology: Platycnemia; caries on decidious dentition; calculus; enamel hypoplasias

Burial 91-11: A 21-25 year old male

Skeletal representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Late

Pathology: Carie; calculus; dehience; enamel hypoplasias; dental crowding

Burial 91-12: A 26-30 year old male

Skeletal representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Healed cribra orbitalia; platycnemia; slight osteoarthritis; healed periostitis on fibulae; carie; calculus; periodontal disease; enamel hypoplasias

Burial 91-13: A 31-35 year old male

Skeletal representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Healed fracture of left radius with subsequent infection of left unla; healed periostitis on tibiae; healed porotic hyperostosis; caries; periodontal disease; calculus; enamel hypoplasias

Burial 91-14: A 21-25 year old female

Skeletal representation: ranium; mandible; arm long bones; vertebrae; ribs; scapulae; clavicles; innominate

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Unknown

Pathology: Slight osteoarthritis; depression fracture at glabella; caries; dental crowding; enamel hypoplasias

Burial 91-15: A 10-12 year old preadult

Skeletal representation: Cranium; mandible; right arm long bones; right leg long bones

Artifacts: None

Positioning: Disarticulated

Temporal Placement: Late

Pathology: Active porotic hyperostosis; caries on decidious dentition; enamel hypoplasias

Burial 91-16: A 21-25 year old male

Skeletal representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Slight osteoarthritis; healed cribra orbitalia; long-standing and scelerotic osteomyelitis; caries; abscesses; calculus; dental crowding

Burial 91-17: A 26-30 year old male

Skeletal representation: Cranium; mandible; all long bones

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Calculus; mottled dentition; dehiscence; dental crowding; enamel hypoplasias

Burial 91-18: A 31-35 year old adult

Skeletal representation: Cranium; mandible; left scapula; left clavicle; left humerus; left ulna; right femur

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: None

Burial 91-19: A 15-17 year old male

Skeletal representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Hematogenous osteomyelitis on left illium and frontal and parietal bones; dental crowding; enamel hypoplasias

Burial 91-20: A 3-7 year old preadult

Skeletal representation: Cranium; mandible fragments

Artifacts: None

Positioning: Disarticulated

Temporal Placement: Early

Pathology: None

Burial 91-21: A 21-25 year old female

Skeletal representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Platycnemia; caries; abscesses; dental crowding; enamel hypoplasias

Burial 91-22: A 26-30 year old adult

Skeletal representation: Cranium; mandible; right arm long bones; leg long bones

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Healed periostitis on left tibia; platycnemia; carie; enamel hypoplasias

Burial 91-23: A 26-30 year old male

Skeletal representation: Cranium; mandible; arm and leg long bones; innominate

Artifacts: No ne

Positioning: Disarticulated

Temporal Placement: Unknown

Pathology: Healed porotic hyperostosis and cribra orbitalia; platycnemia; caries; dehiscence

Burial 91-24: A 26-30 year old male

Skeletal representation: Complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Late

Pathology: Healed porotic hyperostosis; healed periostitis on tibiae; calculus; mottled dental enamel; enamel hypoplasias

Burial 91-25: A 21-25 year old female

Skeletal representation: Complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Calculus; enamel hypoplasias

Burial 91-26: A 3-6 year old preadult

Skeletal representation: Mandible; left humerus and ulna; innominate; femora; ribs

Artifacts: None

Positioning: Articulated and placed on right side

Temporal Placement: Unknown

Pathology: None

Burial 91-27: A 2-2.5 year old preadult

Skeletal representation: Cranial fragments; decidious dentition

Artifacts: None

Positioning: Unknown

Temporal Placement: Early

Pathology: None

Burial 91-28: A 8-9 year old preadult

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Healed periostitis on on tibiae; expansion of left fibula shaft; caries on decidious dentition; abscess; dental crowding; enamel hypoplasias

Burial 91-29: A 3-4 year old preadult

Skeletal Representation: Cranial fragments; mandible; arm and leg long bones

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: None

Burial 91-30: A 9-10 year old subadult

Skeletal Representation: Cranium; mandible

Artifacts: None

Positioning: Disarticulated

Temporal Placement: Unknown

Pathology: None

Burial 91-31: A 26-30 year old male

Skeletal Representation: Cranium; mandible; arm and leg long bones

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Carie; mottled dental enamel; enamel hypoplasias

Burial 91-32: A 3-5 year old preadult

Skeletal Representation: Cranium; mandible; arm and leg long bones

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Enamel hypoplasias

Burial 91-33: A 8-9 year old preadult

Skeletal Representation: Cranium; mandible

Artifacts: None

Positioning: Disarticulated

Temporal Placement: Early

Pathology: Enamel hypoplasias

Burial 91-34: A 8-9 year old subadult

Skeletal Representation: Cranium; mandible; leg long bones

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Enamel hypoplasia

Burial 91-35: Preadult

Skeletal Representation: Cranium; femora; tibiae

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: None

Burial 91-36: A 26-30 year old male

Skeletal Representation: Cranium; mandible; arm and leg long bones

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Enamel hypoplasias

Burial 91-37: A 26-30 year old female

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Late

Pathology: Slight osteoarthritis; healed porotic hyperostosis; caries; abscess; calculus; dental crowding; enamel hypoplasias

Burial 91-38: A 21-25 year old male

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed eas

Temporal Placement: Late

Pathology: Slight osteoarthritis; healed periostitis on tibiae; tempromandibular joint disease; caries; calculus, dental crowding; enamel hypoplasias

Burial 91-39: A 21-25 year old male

Skeletal Representation: Cranial fragments; mandible; maxilla; tibiae; left humerus; right talus and femur

Artifacts: None

Positioning: Disarticulated

Temporal Placement: Late

Pathology: Platycnemia; calculus; dental crowding; enamel hypoplasias

Burial 91-40: A 5-6 year old preadult

Skeletal Representation: Cranial fragments and mandible

Artifacts: None

Positioning: Disarticulated

Temporal Placement: Late

Pathology: Enamel hypoplasias

Burial 91-41: A 26-30 year old adult

Skeletal Representation: Cranium; mandible

Artifacts: None

Positioning: Disarticulated

Temporal Placement: Late

Pathology: Carie; enamel hypoplasias

Burial 91-42: A 26-30 year old female

Skeletal Representation: Cranium; mandible; all long bone shafts

Artifacts: Three blue heat altered tublar glass beads

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Unknown (Early chapel?)

Pathology: Meningeal reaction on parietal bones; caries; enamel hypoplasias

Burial 91-43: A 21-25 year old female

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Unknown (Early chapel?)

Pathology: Dental crowding; enamel hypoplasias

Burial 91-44: A 26-30 year old female

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Unknown (Early chapel?)

Pathology: Platycnemia; healed cribra orbitalia; slight osteoarthritis; healed periostitis on tibiae; periodontal disease

Burial 91-45: An adult

Skeletal Representation: Cranial fragments

Artifacts: None

Positioning: Probably extended, supine, and oriented east to west, with head placed east

Temporal Placement: Unknown (Early chapel?)

Pathology: None

Burial 91-46: An adult

Skeletal Representation: Cranium; left illium

Artifacts: None

Positioning: Disarticulated

Temporal Placement: Early

Pathology: None

Burial 91-47: A 26-30 year old male

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Late

Pathology: Moderate osteoarthritis; healed periostitis on tibiae and fibulae; platycnemia; carie; slight calculus

Burial 91-48: An adult

Skeletal Representation: Cranium; mandible; leg long bones

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: None

Burial 91-49: A 26-30 year old male

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Healed periostitis on tibiae and fibulae; healed porotic hyperostosis; slight osteoarthritis; Schmorl's nodes on fourth and fifth lumbar vertebrae; dental crowding; calculus; dehiscence; caries; enamel hypoplasias

Burial 91-50: A 26-30 year old female

Skeletal Representation: Cranium; mandible; leg long bones

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Unknown (Early chapel?)

Pathology: Dental crowding; enamel hypoplasias

Burial 91-51: A 26-30 year old female

Skeletal Representation: Cranium; mandible; leg long bones; innominate

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Unknown (early chapel?)

Pathology: Abscess; enamel hypoplasias

Burial 91-52: A 8-9 year old preadult

Skeletal Representation: Cranial fragments; mandible

Artifacts: None

Positioning: Disarticulated

Temporal Placement: Early

Pathology: Enamel hypoplasias

Burial 91-53: A 41-45 year old male

Skeletal Representation: Virtually complete

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Healed periostitis on tibiae and fibulae; calculus; enamel hypoplasias

<u>Burial 91-54</u>: A 14-14 year old preadult

Skeletal Representation: Cranial fragments; mandible

Artifacts: None

Positioning: Disarticulated

Temporal Placement: Early

Pathology: Enamel hypoplasias

<u>Burial 91-55</u>: An adult female

Skeletal Representation: Cranial fragments; mandible; all long bones; innominate

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Healed periostitis on tibiae

<u>Burial 91-56</u>: A preadult

Skeletal Representation: Cranial fragments

Artifacts: None

Positioning: Disarticulated

Temporal Placement: Unknown (Early chapel?)

Pathology: None

<u>Burial 91-57:</u> An adult

Skeletal Representation: Cranial fragments

Artifacts: None

Positioning: Unknown

Temporal Placement: Unknown (Early chapel?)

Pathology: None

Burial 91-58: A 21-25 year old adult

Skeletal Representation: Cranium; mandible

Artifacts: None

Positioning: Unknown

Temporal Placement: Unknown (Early chapel?)

Pathology: Dental crowding; abscess

Burial 91-59: A 26-30 year old female

Skeletal Representation: Cranium; mandible; ribs; innominate; leg long bones

Artifacts: Cut silver alloy cross

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Unknown (Early chapel?)

Pathology: Remodeled lesion at glabella

Burial 91-60: An adult

Skeletal Representation: Cranial fragments

Artifacts: None

Positioning: Unknown

Temporal Placement: Unknown (Early chapel?)

Pathology: None

Burial 91-61: A 26-30 year old adult

Skeletal Representation: Cranium; all long bones

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Unknown (Early chapel?)

Pathology: None

Burial 91-62: A 13-16 year old preadult

Skeletal Representation: Cranium; mandible; right humerus; right fibulae and tibia

Artifacts: None

Positioning: Partial articulation--extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: None

Burial 91-63: A 31-35 year old male

Skeletal Representation: Cranium; mandible; humeri; ulnae; leg long bones

Artifacts: None

Positioning: Partial articulation--extended, supine, and oriented east to west, with head placed east

Temporal Placement: Early

Pathology: Healed depression fracture on frontal bone adjacent to bregma; carie; enamel hypoplasias

Burial 91-64: A 13-14 year old preadult

Skeletal Representation: Permanent dentition only

Artifacts: None

Positioning: Disarticulated

Temporal Placement: Early

Pathology: Carie; enamel hypoplasias

Burial 91-65: Not excavated

Burial 91-66: A 26-30 year old female

Skeletal Representation: Cranium; mandible; tibiae

Artifacts: None

Positioning: Extended, supine, and oriented east to west, with head placed east

Temporal Placement: Unknown (Early chapel?)

Pathology: Abscess

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BIOGRAPHICAL SKETCH

Lisa Marie Hoshower was born on October 12, 1956, in Lebanon, Pennsylvania. She graduated from Annville-Cleona High School in 1974. Between 1974 and 1978 she majored in Criminal Science and Administration at Pennsylvania State University and earned a Bachelor of Science in the social sciences. She was employed by the Pennsylvania State Capitol Police as a police officer in 1980 and subsequently attended and graduated from the Pennsylvania State Police Academy in Hershey, Pennsylvania.

After her marriage and retirement from the rigors of police work, Lisa returned to academia in 1984 as an undergraduate student in the Department of Anthropology at Harrisburg Area Community College, Harrisburg Pennsylvania. In the summer of 1986 she attended the University of Chicago Archaeological Field School as a volunteer, an experience which significantly altered her life. She received her Master of Science in anthropology from the University of Illinois at Chicago in 1989. She earned her Doctor of Philosophy from the University of Florida, Gainesville, in 1992.

Lisa is a physical anthropologist who specializes in human osteology, paleopathology, and skeletal biology. She has also trained as a forensic anthropologist. While earning her graduate degrees Lisa worked on various human osteology projects in Peru, Turkey, Spain, Illinois, and Florida.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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