SETTLEMENT DISPERSAL, ECONOMIC DISINTENSIFICATION,

AND HUMAN HEALTH AT MOUNDVILLE

AN ABSTRACT

SUBMITTED ON THE FIRST DAY OF APRIL 2005

TO THE DEPARTMENT OF ANTHROPOLOGY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

OF THE GRADUATE SCHOOL

OF TULANE UNIVERSITY

FOR THE DEGREE

OF

DOCTOR OF PHILOSOPHY

BY

Shannon Chappell Hodge

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ABSTRACT

This research proposes a model of economic disintensification, applied to the Mississippi period chiefdom of Moundville, in Alabama. I hypothesized the post-A.D. 1300 population dispersal from Moundville to outlying sites would have resulted in economic disintensification. To evaluate this model, I proposed subsistence, settlement pattern, and health correlates of disintensification, and tested these correlates against data from the Moundville site. I reviewed the existing literature on Moundville subsistence, and found that the published data were insufficient for determining if disintensification had occurred. Next, I performed a settlement pattern analysis of the number, mean size, distribution and density of Moundville phase sites, and found that although population dispersal occurred, there was no firm evidence of disintensification. I also collected primary demographic and paleopathological data from Moundville phase human skeletal remains, and made a diachronic comparison of skeletal samples before and after population dispersal, to see if there were any differences in health or nutrition that would signal disintensification. I found no statistically significant differences in rates of disease, trauma, degenerative joint disease, dental pathology or dental wear between pre-dispersal and post-dispersal populations, indicating that disintensification did not take place.

The model of disintensification is upheld, and most of the archaeological correlates I proposed for disintensification are valid tests of the model. However, disintensification did not occur within the Moundville chiefdom. Instead, Moundville

and the outlying communities in the chiefdom appear to have maintained close ties, and continued to act as a single entity in terms of subsistence and social connections, thereby leaving open the vectors of disease at consistent low levels throughout the Moundville era. I believe this low-level exposure partially accounts for the lack of clear distinctions in health between the subphases. Overall, people appear to have maintained good health and an adequate diet across time, regardless of population movements and political change. The dispersal of Moundville's population after A.D. 1300 in no way represents "the beginning of the end" of the chiefdom, but rather an organizational improvement that maintained the social and salutary status quo to the benefit of outlying communities and the residents of Moundville alike.

ACKNOWLEDGMENTS

First, I am humbled to acknowledge the unknown yet much-studied ancient residents of Moundville and surrounding sites, who continue to graciously reveal details of their lives and lifeways for the betterment of those of us living in the present day. My dissertation adviser, Dr. T.R. Kidder, and the members of my doctoral committee, Dr. Harvey M. Bricker, Dr. John W. Verano, and Dr. E. Wyllys Andrews V gave me valuable advice and guidance in the design and execution of this project. I am grateful for their patience and their willingness to cheerfully accommodate short deadlines and swift turnaround of drafts. I am indebted to Dr. Jane E. Buikstra and Dr. Mary Lucas Powell for the initial inspiration for this project, and to Dr. Keith Jacobi, Curator of the University of Alabama Laboratory of Human Osteology, who generously made the Moundville collections and laboratory space available to me. I was kindly granted access to the Research Library and Alabama State Site File by Director Robert A. Clouse and Senior Archaeologist and Curator Eugene M. Futato of the David L. DeJarnette Research Center at the Office of Archaeological Research at Moundville Archaeological Park. I am proud to thank T.R. Kidder, Harvey M. Bricker, and Marie E. Danforth for their mentorship, friendship, and encouragement. They are my role models who have exemplified the skills and standards of professional anthropologists and educators. Without my parents, Maurice and Jennie Chappell, I would never have had the self-assurance to begin such an undertaking, nor the will and wherewithal to finish it. I cannot express how happy and thankful I am that they molded me into the kind of person who has the ability to accomplish this goal. Finally, I am eternally grateful to my husband Phillip for his input and insight, the investment of his intellect and expertise over long hours and late nights, and his ever-present encouragement and love.

I cannot pretend that my data are not limited and my sample sizes are not small, nor do I claim to have thought of, much less answered all of the questions that may be asked of my data. Even so, I hope that the shortcomings in my observations will serve as a catalyst to additional survey coverage and research effort. I am indebted to all who helped me along the way; I have benefited from their insight, expertise, generosity and patience. However, I take full responsibility for the contents and conclusions of this manuscript, and any and all mistakes, misrepresentations, and miscalculations are solely mine.

TABLE OF CONTENTS

TABLES

ILLUSTRATIONS

Figure Page

CHAPTER 1

INTRODUCTION

The late prehistoric mound site at Moundville, Alabama dates to A.D. 1050-1650 and was once home to a Mississippian chiefdom that achieved nearly unparalleled social, political, and especially material elaboration (Knight and Steponaitis 1998a). Second only to their American Bottom counterparts at Cahokia (Powell 1988:2), the chiefs of Moundville directed the construction of earthen monuments and organized the manufacture and trade of fine crafts executed in shell, stone, and clay. In this dissertation, I argue that the chiefs of Moundville also presided over an unprecedented structural reorganization and population movement, which may have extended their "reign" and delayed their "ruin" (Pauketat 1992) by decades if not centuries.

Moundville is also one of the most widely studied archaeological sites in southeastern North America. Beginning with early antiquarians (Brewer 1872; Holmes 1883; Maxwell 1876; Moore 1996a [1905], 1996b [1907]; Peebles 1981; Peebles et al. 1981; Pickett 1900 [1851]; Rau 1876; Squier and Davis 1848; Steponaitis 1983b; Thomas 1891; Thruston 1890) and Smithsonian-funded explorers (Peebles 1981; Steponaitis 1983b) of the nineteenth and early twentieth centuries, Moundville was the object of intellectual curiosity and (literally) groundbreaking research. These pioneers laid the path for relief-funded excavators of the New Deal Era (Baklanoff and Howington 1989; Bozeman 1982; Futato 1989; Lyon 1996; McKenzie 1966; Peebles 1981; Peebles and Black 1987; Peebles et al. 1981; Powell 1985a, 1988; Walthall

1978), who applied newly developing excavation and data recording techniques (Griffin 1978). The past thirty years has marked the acceleration of Moundville research, during which time the essential Moundville ceramic chronology was laid down (Steponaitis 1980a, 1980b, 1983a), and in-depth studies addressed settlement pattern (Bozeman 1982), floral (Scarry 1986, 1993a, 1998) and faunal subsistence (Michals 1981, 1990, 1992, 1998), mortuary patterning (Peebles 1974), and the interplay of status and health in the Moundville chiefdom (Powell 1985a, 1988). Much of the Moundville oriented research was diachronic, including Steponaitis' (1980a) ceramic chronology and Scarry's (1986) comparison of plant subsistence practices across the temporal boundary from Late Woodland to Mississippian. In contrast, Bozeman's (1982) settlement pattern study and Powell's (1985a) analysis of status and health were conducted on a synchronic scale. My research was conceived as a diachronic supplement to Bozeman's and Powell's work – an attempt to understand change over time in settlement pattern and human health at Moundville. In addition, my work extends chronologically beyond the limits usually set for Moundville studies, encompassing data from the preceding West Jefferson phase and succeeding Moundville IV Subphase. I hope to achieve a greater scope of understanding of the impact of the development and denouement (Peebles 1987b) of the Moundville chiefdom.

The Research Problem

The Moundville chronology detailed in the following pages represents a recent re-orientation of conventional wisdom regarding the pace and progression of the development of the Moundville chiefdom. In his original formulation of the Moundville chronology, Steponaitis (1983a) utilized ceramic samples from predominantly mortuary contexts to build a classic chiefdom chronology of nucleation and steadily increasing population. Growth peaked near the end of the Moundville phase, and was followed by rapid depopulation and social collapse. This chronological sequence is the foundation upon which all Moundville studies of the last two decades have been built. However, Steponaitis was dissatisfied with the potential bias introduced by using ceramics from predominantly mortuary contexts to build his chronology. In 1998 he published a corrected chronology based upon a re-evaluation of ceramic and demographic data from midden contexts. These results suggested early and rapid population nucleation at Moundville, followed by equally rapid population dispersal around A.D. 1300, only 150 years into the site's 600-year history. The resulting pattern persisted during the remaining Moundville sequence: small groups living in dispersed settlements throughout the Black Warrior River Valley, with only a small resident elite population living at the main Moundville site (Steponaitis 1998). In this dissertation, I argue that population dispersal triggered a period of economic disintensification, during which agricultural production declined. Disintensification led to changes in diet, which along with changes in population density can have profound impacts on nutritional adequacy and susceptibility to disease (this model is discussed in detail in Chapter 2). I explore the effects of the post-A.D. 1300 settlement pattern shift, focusing on the consequences of settlement change to subsistence and human health. I review extant subsistence studies to assess the pattern of subsistence change, and analyze settlement patterns to discover the extent and impact of the settlement shift. I also conduct a paleopathological analysis of human skeletal remains from Moundville and outlying Moundville phase sites within the Black Warrior River valley to evaluate the impacts of settlement-pattern and subsistence change on human health.

The Mississippian World

The Mississippi stage of North American prehistory marks the development, climax, and decline of Mississippian culture in the Central Mississippi Valley and throughout river valleys and adjacent uplands across the greater southeastern United States. This cultural florescence began in the late tenth century A.D. and lasted in some regions as late as the sixteenth century. Early European explorers in the Southeast made contact with some Mississippian societies as late as A.D. 1566, including the Mabila, Napochies, Chisca, Costehe, and Coca in Alabama (Walthall 1980:249-251). A defining characteristic of Mississippian society is the economic strategy of intensive river-valley agriculture (Scarry 1993b; Smith 1978), focused on production of maize (Griffin 1967, Walthall 1980:185). Mississippian culture is known for complex ceremonialism that was centered on elite warfare, ancestor veneration, and agricultural fertility (Knight 1986). These ritual foci are inferred from a shared iconographic system, referred to as the Southeastern Ceremonial Complex, which was displayed on prestigious artifacts often produced on materials of non-local origin. Such items were often traded over long distances and appear among the items included in Mississippian graves (Muller 1989).

Mississippian social and political organization exhibits a large range of variation, from small, independent horticultural communities to complex paramount chiefdoms with many positions of social prestige and political rank (Beck 2003, Blitz 1993a, Cobb 2003, Earle 1987, Steponaitis 1991). On the periphery of the Mississippian world, in the early stages of the temporal phase, and in smaller-scale Mississippian cultures, societies were organized politically as tribes (Griffin 1992, Nass and Yerkes 1995, Peebles 1987b) or "simple" chiefdoms (Anderson 1994, Blitz 1999, Johnson and Earle 1987:208, Smith 1978), with only minimal social ranking and lacking a hierarchical settlement system (Nass and Yerkes 1995). However, in the Mississippian heartland, and during the Middle Mississippi period, most Mississippian societies were true chiefdoms (Steponaitis 1983a).

Chiefdoms are complex, nonstate political systems (Beck 2003), regionally consolidated (Blitz 1999; Carneiro 1981; Earle 1987, 1989; Hally 1996; Johnson and Earle 1987; Oberg 1955; Peebles and Kus 1977; Smith 1978; Spencer 1987, Steponaitis 1986) into a hierarchical multicommunity settlement structure (Anderson 1994; Beck 2003; Carneiro 1981, 1990; Earle 1987; Johnson and Earle 1987; Jolley 1983; Lorenz 1996; Oberg 1955; Peebles and Kus 1977; Renfrew 1974, Scarry 1996; cf. Spencer 1987, Steponaitis 1978; Steward and Faron 1959). Chiefdom-level social structure is defined by ascribed status (Anderson 1994; Blitz 1993a; Earle 1987; Feinman and Neitzel 1984; Johnson and Earle 1987; Peebles 1987b; Peebles and Kus 1977; Renfrew 1974; Scarry 1996; Service 1962; Steponaitis 1978; Steward 1948; Wright 1977), and sometimes achieved status (Steponaitis 1986) dividing elite and nonelite social strata (Anderson 1996; Oberg 1955; Pauketat 1994; Peebles and Kus 1977; Steponaitis 1986), with the permanent hereditary office of the chief at the apex of this hierarchy (Spencer 1987; Service 1962; Steponaitis 1978, 1986b).

Chiefdoms typically have an agricultural economy (Service 1962, Steponaitis 1986), characterized by the production (Anderson 1996, Earle 1991, Oberg 1955) and redistribution (Anderson 1996, Blitz 1993b; Johnson and Earle 1987, Renfrew 1974, Sahlins 1958, Service 1962; cf. Earle 1977, Feinman and Neitzel 1984, Steponaitis 1978, Peebles and Kus 1977, Wesson 1999) of agricultural surplus, and production and exchange of prestige goods (Anderson 1994; Earle 1977, 1987; Griffin 1985; Pauketat 1997; Service 1962; Spencer 1987, Steponaitis 1986; Welch 1990). Chiefs also have the capacity to collect tribute, enlist and direct communal labor, and organize warriors (Feinman and Neitzel 1984, Oberg 1955, Service 1962, Steward 1948, Welch 1990) in the service of the chiefdom.

Mississippian chiefs controlled trade, built monumental earthen structures, waged war, and promoted craft production and long-distance exchange in exotic goods and materials (Jenkins and Krause 1986:86-87). They maintained "complex interrelationships of tribute, alliance, and warfare" (Blitz 1993a:7) among their constituents and with neighboring chiefs. Mississippian chiefdoms were centered on hierarchically structured multi-community settlement systems (Anderson 1994, 1996a; Earle 1987; Griffin 1985, Hally 1996; cf. Beck 2003), by which archaeologists judge the complexity of their political organization (Anderson 1996, Steponaitis 1978). Mississippians enjoyed a rich material culture characterized by mound-plaza arrangements of platform mound architecture (Hudson 1976:78), rectangular wall-trench structures (Scarry 1996:13), palisaded sites (Griffin 1967), and shell-tempered pottery (Walthall 1980). "In areal extent of influence, ceremonialism, public works, technology, population density, and general richness, the Mississippian is exceeded by no other aboriginal American culture north of Mexico" (Jennings 1947:246).

American archaeologists use the term "elite" to designate an upper social and political stratum, among whom power is held, and from whom authority is delegated. Elite and nonelite social strata are typically found in chiefdoms, and the use of this term stems from the historical legacy of the definition and application of the chiefdom concept, which has been typically rendered in structural terms. Chiefdoms are often defined by the number of hierarchical levels within the social, political, and settlement structure, and as such tend to be perceived in terms of strict social categories rather than a more fluid continuum of social statuses (Renfrew 1974). Unfortunately, this more rigid definition of chiefdom-level social structure lends an unintended state-like quality, implying that social and political status within chiefdoms was more rigid and less fluid than it probably actually was (Feinman and Neitzel 1984, Lorenz 1996, Peebles and Kus 1977, Steward and Faron 1959:175).

Chiefdoms worldwide, including those of the Mississippian southeastern United States, exhibit considerable variation in social and political complexity (Beck 2003; Blitz 1993a, Feinman and Neitzel 1984) and the definition and rigidity of social statuses. For the purposes of this research, the elite social stratum includes the chief and the group of individuals in close genealogical (Anderson 1994:6; Service 1962) or other social proximity to the chief. These individuals would have enjoyed privileges of rank, including residence at Moundville or one of the surrounding single-mound sites (Steponaitis 1991), differential mortuary investment (Peebles 1974), provisioning of food by members of the nonelite social stratum (Belmont 1983; Bogan 1980, 1982; Jackson and Scott 1995a, 1995b, 2003; Michals 1990, 1992; Rees 1997, Rudolph 1984; Sahlins 1958; Scarry 1993c; Scarry and Steponaitis 1992, 1997; Scott 1983; Scott and

Jackson 1998; Welch 1991, 1996; Welch and Scarry 1995; cf. Blitz 1993b; Hammerstedt 2001), and the right to wear chiefly regalia as status markers and symbols of office (J. Scarry 1995:201; Sahlins 1958:8).

The Moundville Culture: Orientation and Description

The Moundville Site

The Mississippian site of Moundville (1Tu500) is located in west-central Alabama, on the southeast bank of the Black Warrior River (Figure 1). Moundville (Figure 2) was a palisaded ceremonial center covering 80 to 100 hectares in area (Steponaitis, Davis, and Ward 1994), and had as its centerpiece a group of twenty-nine earthen platform mounds (Steponaitis 1998) surrounding a 30-hectare plaza (Peebles and Black 1987:23). Moundville's estimated peak population was 1000 (Schoeninger et al. 2000) to 3000 (Walthall 1980:214) individuals. Sites peripheral to Moundville include local centers with single mounds (Bozeman 1981), and various nearby and outlying farmsteads (Hammerstedt 2000), which are scattered across the surrounding floodplain.

The Natural Setting

Moundville is situated on the banks of the Black Warrior River (Figure 3), a major tributary of the Tombigbee River system. The Black Warrior flows southward from the Cumberland Plateau, joins the Tombigbee and Alabama Rivers (Walthall 1980:18), and eventually empties into Mobile Bay and the Gulf of Mexico. This location would have provided optimal access to both inland and coastal resources and

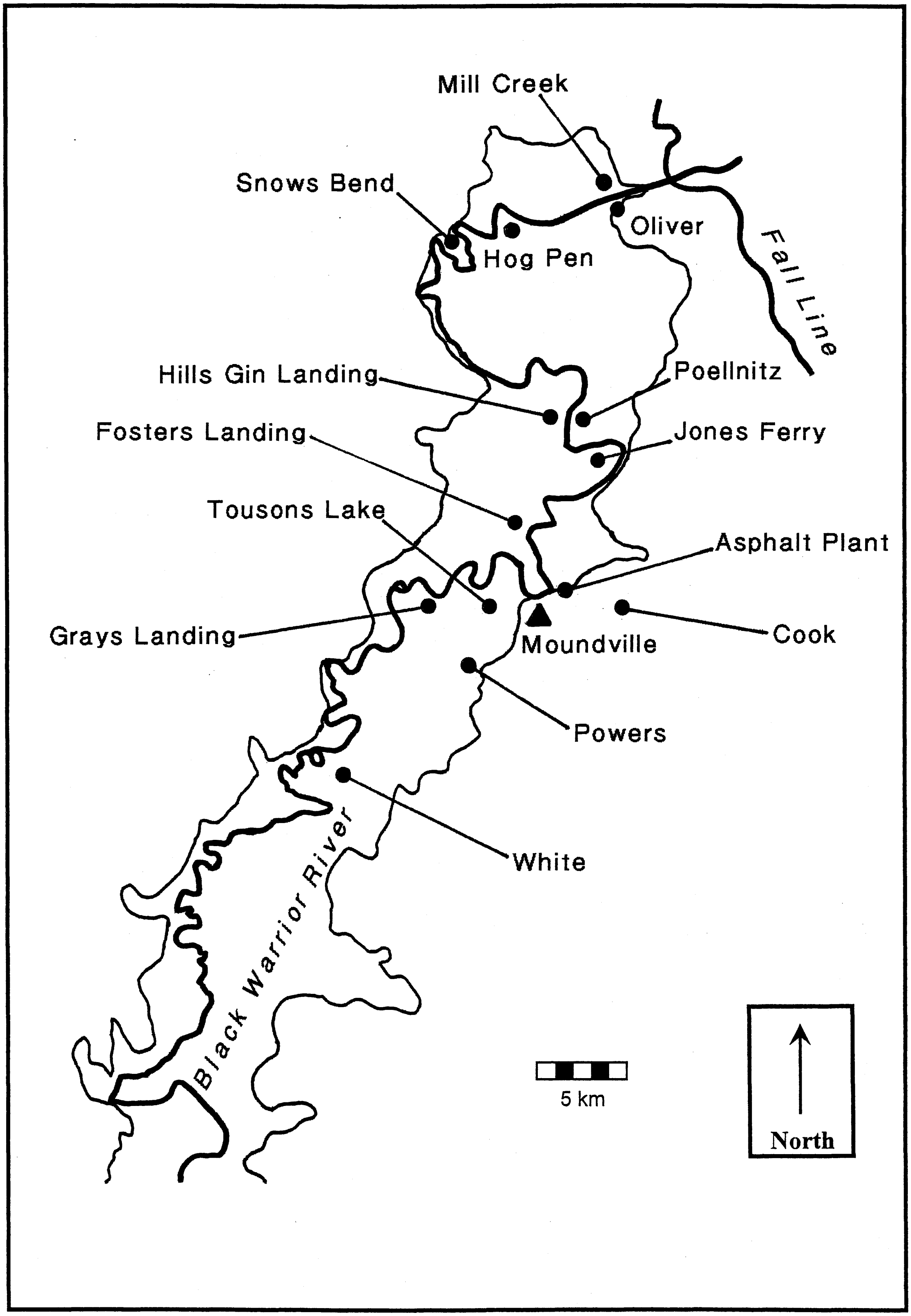


Figure 1. Moundville and the Black Warrior River Valley. *After Welch 1998:Figure 7.*

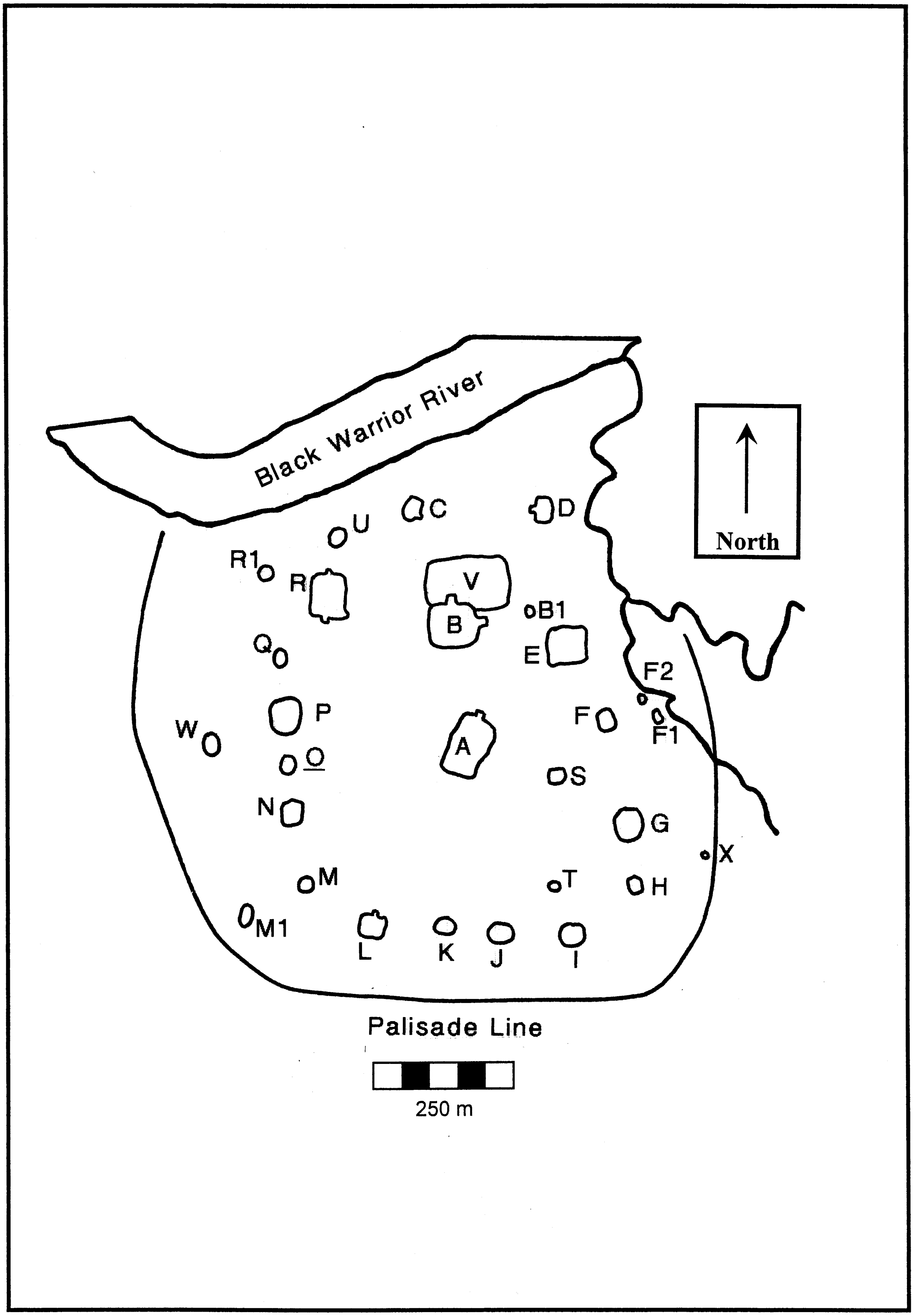


Figure 2. The Moundville Site. *After Knight and Steponaitis 1998b:Figure 1.1.*

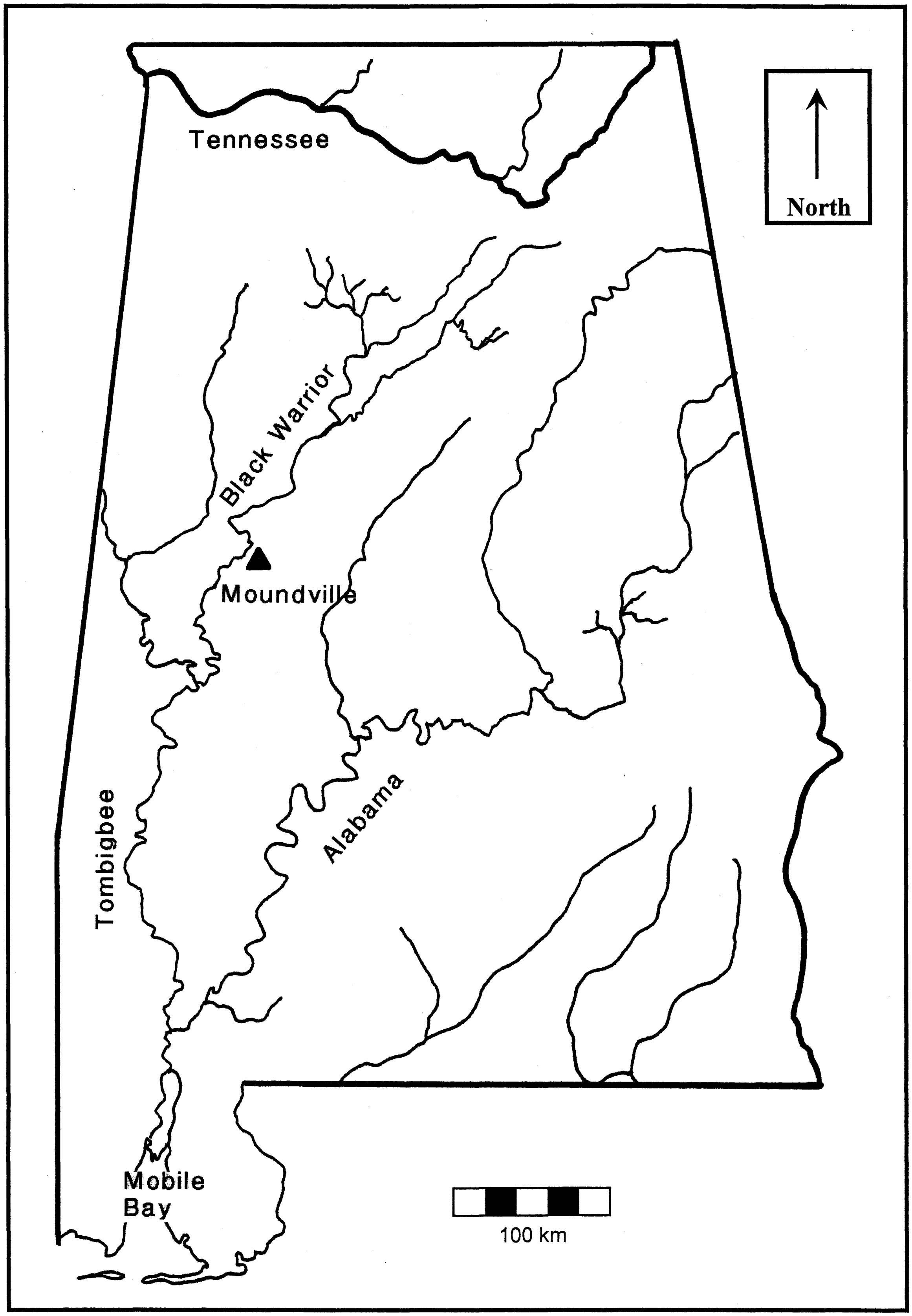


Figure 3. Moundville in relation to Black Warrior, Tombigbee, and Alabama Rivers.

populations (McKenzie 1966). At the location of the Moundville chiefdom, the Black Warrior River floodplain bisects the Fall Line Hills, which mark the transition from the Cumberland Plateau / Tennessee Ridge and Valley to the lowlands of the Gulf Coastal Plain (Steponaitis 1983a:4). Because of its position in this ecotone between the temperate oak-hickory deciduous biome above the Fall Line and the low-water swamp-forest zone below the Fall Line, Moundville residents would have had excellent access to a great variety of nearby resources (Ensor 1993:5).

Moundville is situated on a high terrace overlooking the river, with fifteen- to eighteen- meter bluffs (McKenzie 1966:5). The river valley is almost five kilometers wide at Moundville (McKenzie 1966), and averages six to seven kilometers in width overall (Hammerstedt 2000; Joo 1990). In conjunction, the Fall Line Hills and the river floodplain form optimal conditions for hunting and gathering terrestrial and riverine resources (McKenzie 1966:5). Like other Mississippian peoples, members of the Moundville chiefdom practiced floodplain farming, taking advantage of spring floods and the yearly renewal of soils. Corn agriculture was favored in the humid climate, averaging 52 inches (132 cm) of annual rainfall (Powell 1988:7).

Moundville Chronology

Moundville's chronology is made up of two archaeological phases (Table 1) spanning the Late Woodland, Mississippian, and Protohistoric periods. The first is the terminal Late Woodland West Jefferson phase (Table 1). West Jefferson is derived from local Late Woodland groups (Steponaitis 1980a) and is noted for emergent Mississippian cultural attributes. Among these traits were a preponderance of grogtempered ceramic wares (C. M. Scarry 1995:4), small quantities of shell-tempered ceramics, and early examples of rectangular wall-trench architecture (Steponaitis 1986). Otherwise, however, the phase closely resembles contemporaneous Late Woodland societies of the Miller III variant found elsewhere in the Black Warrior and Tombigbee valleys (Blitz 1993a:33-38; Futato 1989; Jenkins and Krause 1986:73-85), with nucleated villages, incipient corn agriculture, and small-scale, late-phase public architecture in the form of small platform mounds (Steponaitis 1986). West Jefferson villages were autonomous and lacked social and political ranking (C. M. Scarry 1995).

Table 1. Moundville Subphases and Dates (Steponaitis 1983a:142; Knight and Steponaitis 1998b:8)

Stage/Period	Phase	Subphase	Dates
Terminal Late Woodland	West Jefferson	-	A.D. 900-1050
Mississippian	Moundville	Moundville I	A.D. 1050-1250
Mississippian	Moundville	Moundville II	A.D. 1250-1400
Mississippian	Moundville	Moundville III	A.D. 1400-1550
Protohistoric	Moundville	Moundville IV	A.D. 1550-1700

During the Moundville phase, a distinct Moundville culture emerged. This phase is divided into four subphases, numbered I through IV (Table 1). Moundville subphases I, II, and III are Mississippian cultures, while Moundville IV represents the Protohistoric period in this region. Although there is a major cultural shift between Moundville III and IV, they are subsumed within the same phase to emphasize the direct descent of Moundville IV populations from their Moundville chiefdom forebears.

At the beginning of the Moundville I subphase, around A.D. 1050, the settlement pattern shifted from large, nucleated West Jefferson villages to a pattern of small farmsteads scattered across the valley floor. At the same time, the first small Mississippian mounds in the Black Warrior River Valley were built at Moundville and the nearby Asphalt Plant Site (1Tu50). However, for reasons as yet unknown, during the late Moundville I subphase Moundville exploded in size and elaboration (Knight and Steponaitis 1998b:13), while the Asphalt Plant Site was abandoned (Welch 1998:162). Between A.D. 1200 and 1250, the large plaza at Moundville was laid out and the majority of the twenty-nine mounds at the site were constructed (Knight and Steponaitis 1998b:15). During this period, farmsteads continued to be occupied, but Moundville proper reached its peak of population density (C. M. Scarry 1995:4-6). Scarry suggests that this peak of population coincides with the concentration of power at Moundville and the period during which "the labor force was most needed for construction of the mound-and-plaza complex and the palisade" (Scarry 1998:100). At the same time, Moundville I residents progressively increased maize production over time (Schoeninger and Schurr 1998:120), resulting in intensive maize agriculture. Material culture diagnostics of the subphase include shell-tempered ceramic varieties such as Mississippi Plain, *var. Warrior*, Bell Plain, *var. Hale*, Moundville Incised, Carthage Incised, and Moundville Engraved (C. M. Scarry 1995:4).

The Moundville florescence continued into the early Moundville II subphase, during which there is evidence of social ranking and a chiefly elite who maintained long-distance trading relationships with other southeastern polities for the exchange of prestige goods (C. M. Scarry 1995:6). Around A.D. 1300, there was a settlement-pattern shift within the Moundville polity; the majority of the population left Moundville in favor of dispersed farmsteads throughout the valley. Moundville became the center of elite residence and community mortuary ritual. This residential pattern continued until the chiefdom structure collapsed at end of the Moundville III subphase around A.D. 1550 (Steponaitis 1998). During the Moundville IV subphase, the population in the Black Warrior River Valley lived in autonomous villages, and by A.D. 1600 Moundville was completely abandoned (Knight and Steponaitis 1998b:22).

In 1998, Knight and Steponaitis published a fully revised Moundville chronology (Table 2), based upon a better understanding of diachronic population

Table 2. Moundville Chronology and Stages of Development. After Knight and Steponaitis 1998b:8, Figures 1 and 2.

<table>
<tr><th>Phase/Subphase</th><th>Chronology</th><th>Developmental Stage</th></tr>
<tr><td rowspan="3">Moundville IV</td><td>A.D. 1650</td><td rowspan="5">Collapse and Reorganization</td></tr>
<tr><td>1600</td></tr>
<tr><td>1550</td></tr>
<tr><td rowspan="3">Moundville III</td><td>1500</td></tr>
<tr><td>1450</td></tr>
<tr><td>1400</td><td rowspan="3">Paramountcy Entrenched</td></tr>
<tr><td rowspan="3">Moundville II</td><td>1350</td></tr>
<tr><td>1300</td></tr>
<tr><td>1250</td><td rowspan="2">Regional Consolidation</td></tr>
<tr><td rowspan="4">Moundville I</td><td>1200</td></tr>
<tr><td>1150</td><td rowspan="3">Initial Centralization</td></tr>
<tr><td>1100</td></tr>
<tr><td>1050</td></tr>
<tr><td rowspan="3">West Jefferson</td><td>1000</td><td rowspan="3">Intensification of Local Production</td></tr>
<tr><td>950</td></tr>
<tr><td>A.D. 900</td></tr>
</table>

dynamics within the Black Warrior River Valley. Their "New History of Moundville" is laid out in five developmental stages that encompass the existing West Jefferson and Moundville phases (Table 2) (Knight and Steponaitis 1998b:8). These stages were defined according to major developmental themes, rather than the diagnostic ceramic attributes used to define the Moundville phase and subphases. In general, the Moundville subphases have been retained in the literature to describe chronological periods, perhaps because no one has yet identified material culture diagnostics for the developmental stages.

The first stage of Knight and Steponaitis' developmental chronology, "Intensification of Local Production," is characterized by intensification of maize agriculture and craft production, which took place on a local scale within the large, independent villages of the West Jefferson phase (Knight and Steponaitis 1998b:10-11). The second stage, "Initial Centralization," was "marked by the appearance of three material hallmarks of Mississippian culture: platform mounds, quadrilateral wall trench architecture, and shell-tempered pottery" (Knight and Steponaitis 1998b:12). A corn-based agricultural economy was established, and settlement began to nucleate at the Moundville site, presumably under a centralized authority, while the remaining population resided in small farmsteads or hamlets throughout the Black Warrior floodplain (Knight and Steponaitis 1998b:12-13). The third stage, "Regional Consolidation," occupied a 100-year span, during which Moundville became a paramount center within a large and politically consolidated chiefdom. The entire mound-and-plaza complex was built during the first half of this stage, as was the palisade. Approximately 1000 people lived within the palisade, while the remaining

Black Warrior River Valley population settled at three single-mound sites and numerous farmsteads. Under the centralized authority of the chief, there is clear evidence of social ranking, a prestige goods economy, and intensified agriculture and craft production (Knight and Steponaitis 1998b:15-17).

The fourth stage, "The Paramountcy Entrenched," began after A.D. 1300. During this stage, there was evidence of chiefly veneration, with material symbols of wealth and prestige found in elaborate burials. "As Moundville's rulers began to distance themselves radically by symbolic means from their followers, most of Moundville's resident population vacated the center" (Knight and Steponaitis 1998b:18), and are presumed to have moved to dispersed communities throughout the Black Warrior Valley. At this time the palisade ceased to be periodically renewed, as if there were no longer a need for it as a physical manifestation of the social barrier between elites and non-elites. Moundville became a necropolis and a regional center of mortuary ritual; cemeteries replaced the former residential areas at the site (Knight and Steponaitis 1998b:17-19).

During the fifth and final stage, Moundville experienced "Collapse and Reorganization" in the late fifteenth century, marked by gradual abandonment of the mounds and a sharp decline in the mortuary function of the site. A few of the outlying mound centers continued to be occupied, and the local elite continued to thrive. Nucleated villages developed as the population again drew in from the countryside. By A.D. 1600 the Moundville site was abandoned, and all vestiges of consolidated authority disappeared. Residents of the Black Warrior River Valley lived in large villages, farmed less and collected more wild foods, and suffered malnutrition and ill health (Knight and Steponaitis 1998b:21-22).

Organization of the Dissertation

My dissertation is organized in seven chapters, including my introductory remarks presented here in Chapter One. Chapter Two addresses the theoretical basis for economic disintensification and the applicable Moundville subsistence data, followed by my research model and hypotheses. Chapter Three presents original research on the extent and impact of the A.D. 1300 population dispersal and settlement shift away from Moundville proper. Chapter Four presents the materials and methods for my paleopathological analysis of 211 sets of human skeletal remains from Moundville and surrounding Moundville phase sites in the Black Warrior River Valley, including my laboratory methodology. Chapter Five summarizes my skeletal data, analysis, and results. My overall conclusions are presented in Chapter Six, in which I evaluate whether or not the Moundville population dispersal of A.D. 1300 represented a disintensification event, and if so, what impact it had on the subsistence and health of the Moundville people.

CHAPTER 2

THEORETICAL CONSIDERATIONS AND ARCHAEOLOGICAL CORRELATES

Intensification and Disintensification

The theory guiding my argument is interdisciplinary, drawing primarily on the literature of economic intensification and disintensification from both archaeological and modern contexts (Beaton 1991; Boserup 1965; Brookfield 1972; Caraveli 2000; Cohen 1977; Conelly 1994; Cowgill 1975; McGuire 1984; Schurr and Schoeninger 1995; Wiegers et al. 1999). Agricultural intensification occurs when the carrying capacity of a system of agricultural production is outstripped by demand. The resulting imbalance between resources and demand may occur for several reasons. I take Boserup's (1965) classic model as a point of departure. She essentially argued that population pressure intensifies economic demand and thereby overwhelms the carrying capacity of the subsistence system. Although some archaeologists (Brookfield 1972; Cohen 1977; Cohen and Armelagos 1984; Cowgill 1975; Datoo 1978; Leach 1999; Lightfoot and Plog 1984; Morrison 1996; Nassaney 1987) have debated the specifics of Boserup's model, all agree that subsistence pressure takes many natural and cultural forms. For example, decline in the labor force may have the result of decreasing production in proportion to population (Wiegers et al. 1999), climate change and variations in soil fertility may threaten productivity and therefore increase pressure (Brumfiel 1976); or social demands may result in a desire to produce a surplus (Lightfoot and Plog 1984; Wohlgemuth 1996).

Social pressure is particularly relevant to my argument about Moundville. In more specific terms, social pressure on production may include production for surplus, storage (Lightfoot and Plog 1984), risk management (Gallagher and Arzigian 1994), trade (McGuire 1984), tribute, or taxation (Brumfiel 1976). At Moundville, surplus production in particular may have filled a need for social production to finance community feasts, ritual obligations, or celebratory events (Jackson and Scott 1995a; McGuire 1984). It may have also been used as a means for amassing personal wealth and enhancing individual status (Anderson 1996; Lightfoot and Plog 1984; Peebles and Kus 1977). McGuire (1984) argues that although people may apply the least-effort principle to their subsistence needs, they are willing to intensify production for social or ritual purposes. In other instances, however, people will intensify production to minimize the risk of crop insufficiency or failure (McGuire 1984) and in complex agricultural systems like Moundville, food production may reach beyond minimal subsistence needs to support segments of the population that do not perform field labor (e.g., chiefs, priests, or other occupational specialists). Brookfield (1972) refers to these additional pressures on subsistence production as "social production" and "trade production," both of which must be factored into the discussion of agricultural productivity.

Economic intensification refers to additional inputs of capital, technology, or labor against some constant, usually land or another finite resource. Brookfield (1972:31) suggests, "The primary purpose of intensification is the substitution of these inputs for land, so as to gain more production from a given area." The degree to which people intensify production within their agricultural system is dependent on their level of technological investment, which may range from digging-sticks to mechanized commercial farming. Each level of intensity can support a finite population, and if this population threshold is breached, the community must increase their level of production to provide sufficient resources (Brookfield 1972).

Disintensification is the opposite of this process. Disintensification leads to less intensive levels of agricultural production if system pressure is relieved by a reduction or elimination in demand of any type (Brookfield 1972). Relief may take the form of population decline, out-migration, reduction in tribute or tax liabilities, or natural conditions like climate change or natural disasters. Disintensification results in a dispersed, low-intensity agricultural system, requiring minimal capital investment and labor cost.

Three related concepts are important in this context: extensification, diversification, and specialization. Extensification is commonly defined as expansion of territory brought under subsistence production (Beaton 1991; Boserup 1965). Extensive agricultural systems are technologically simple, easily sustained, and have minimal impact upon the environment (Caraveli 2000). Diversification occurs when a geographically constrained population branches out to previously unused resources within its home range, investing time and energy to amass a wider range of resources within an existing territory. Gallagher and Arzigian (1994) suggest diversification is simply a form of intensification where subsistence efforts are focused on a wider array of procurement strategies – agriculture being only one among many. The advantage of this strategy is that it reduces risk from shortages or crop failure by taking advantage of multiple resources (Gallagher and Arzigian 1994). Specialization is yet another form of intensification, but in this case energy is focused on a single resource or very limited range of resources to the exclusion of all others (Gallagher and Arzigian 1994). Risk is higher in specialized economies, but yields are also greater. Specialization often occurs in low-risk environments where there are natural buffers to crop failure, or cultural safety nets in case of seasonal crop losses. Specialization may also occur in less favorable environments when it is the only choice despite greater inherent risk.

Subsistence Correlates of Disintensification

I propose that disintensification typically causes a return to lower levels of agricultural intensity in the true Boserupian sense of reduction in technological and labor investment (Boserup 1965). In the Mississippian Southeast, lower levels of intensity would have resulted in reduced investment in corn agriculture and renewed reliance on nuts and seeds, creating an increased diversity of plant foods in the archaeological record. Knight and Solis recognized this phenomenon when they described small Mississippian farmsteads in the Tombigbee Valley as "remarkable for their apparent lack of economic focus, and for the almost retrogressive degree of dependence on hunted and foraged resources" (1983:7).

In an agricultural economy, reduction in intensity from centralized agricultural monocropping to household gardening results in population and settlement dispersal as production shifts from the community (Scarry and Steponaitis 1997:120) to the family level (Knight and Solis 1983; Waselkov 1997). Faunal correlates of this shift are closely related. In general, hunters will pursue prey species offering the greatest yield for the least effort – what Christenson (1980) calls "first line resources." However, when first line resources are scarce, hunters will adapt by taking lower-yield animals (Christenson 1980:33-34). Nucleated populations exert pressure on local first-line prey species and eventually are forced to exploit second-line resources (Christenson 1980:33-34), increasing the diversity of the archaeological faunal assemblage. In contrast, when populations are dispersed and pressure on animal communities decreases, preferred first-line resources are more plentiful, resulting in decreased diversity of the archaeological faunal signature.

At Moundville, settlement dispersal occurred around A.D. 1300 (Knight and Steponaitis 1998b) and is the independent variable that first led me to hypothesize that disintensification may have occurred. I predict that intensification and disintensification at Moundville altered the diversity of plant and animal food resources in the archaeological record over time as subsistence intensified early in the site's history, disintensified around the time of population dispersal, and then reintensified at the end of the sequence as palisaded villages were re-established.

During the West Jefferson phase (Table 3), we should find greater plant food diversity than in later periods because of lower reliance on corn and greater emphasis on starchy and oily seed crops, supplemented by gathered resources (e.g., nuts). Population nucleation suggests there would have been pressure on first-line resources and residents would have utilized second-line prey species, thereby increasing the diversity of the faunal assemblage. Later during the Moundville I subphase (Table 3), plant food diversity probably decreased, because as Black Warrior River Valley populations adopted core Mississippian traits, they began to rely more on corn and less on gathered resources. Residents of outlying sites may have been provisioning the residents of

Moundville proper (Jackson and Scott 2003, Michals 1990, 1992; Scarry 1993c; Scarry and Steponaitis 1992, 1997; Welch 1991, 1996; Welch and Scarry 1995, cf. Hammerstedt 2001), resulting in increased evidence of corn processing at outlying sites compared to Moundville. As in the West Jefferson phase, population nucleation suggests there would have been greater faunal diversity than during later, less nucleated subphases. However, if the Moundville population was provisioned from outlying sites (Jackson and Scott 1995a; Scott 1995), there may have been even less faunal diversity at Moundville than at outlying sites because Moundville residents would have received preferred cuts of meat from first-line prey species, thereby obscuring the faunal diversity of the period as viewed from Moundville. If so, there would be even greater faunal diversity at the outlying sites, because preferential supply of first-line resources to Moundville requires the residents of the outlying sites to rely even more heavily on second-line resources.

Table 3. Subsistence Correlates of Disintensification.

Phase/Subphase	Floral Diversity	Faunal Diversity
West Jefferson	High	High
Moundville I	Low	High
Moundville II	High	Low
Moundville III	High	Low
Moundville IV	Low	High

After population dispersal, during the Moundville II and III subphases (Table 3), there are two possible scenarios for the floral assemblage. In the first, Moundville's residents continued to be provisioned with corn, resulting in a floral signature at

Moundville similar to the Moundville I subphase. If the residents of Moundville were not provisioned from the outlying sites, they probably consumed a diet similar to the outlying sites, i.e., greater plant food diversity characterized by less reliance on corn and greater reliance on gathered resources such as nuts. With dispersed population during the Moundville II and III subphases (Table 3), pressure on first-line faunal resources would be reduced, resulting in decreased reliance on second-line resources and lower diversity of faunal remains. The only likely discrepancy between Moundville and the outlying sites would result from provisioning, creating possible inequity in the percentage of preferred cuts of meat, though overall faunal diversity would remain consistent.

Finally, during the Moundville IV subphase (Table 3), re-nucleation of population would result in re-intensification of agriculture and increased reliance on corn and decreased reliance on gathered foods, decreasing overall dietary diversity. As in the West Jefferson phase, settlement nucleation would result in reliance on both first-line and second-line resources, and therefore increase the diversity of the faunal signature.

Moundville Subsistence Patterns: Testing the Correlates

The suite of plant foods consumed within the Moundville chiefdom remained essentially the same from West Jefferson through Moundville IV, and between Moundville proper and the outlying sites (Scarry and Steponaitis 1997:112). Corn, hickory nuts and acorns were the most important plant resources, supplemented by native starchy and oily seeds and wild fruits. The differences in resource exploitation lie in the varying proportions of food groups processed and consumed at each location and during each time period. For example, the intensity of corn production changed over time, with an increase in corn production from the early to the late West Jefferson phases. During this period, use of hickory and acorn resources remained constant, but later declined from late West Jefferson to Moundville I, while corn production remained constant (Scarry 1986, 1998; Scarry and Steponaitis 1992:3). In essence, between West Jefferson and Moundville I farming took over from collecting, but the shift in resource exploitation was not simultaneous. Corn farming was fully established before nut gathering was de-emphasized. In this case, my predictions for the West Jefferson phase and Moundville I subphase were partially supported: floral diversity was higher in West Jefferson, measured in continued use of hickory and acorn nuts while corn farming developed and took hold as an economic strategy in the Black Warrior River Valley. Floral diversity remained constant during early Moundville I due to the greater reliance on corn established in the West Jefferson phase, but did not truly decline until the latter part of the subphase when nut resources declined in importance.

For the later Moundville subphases, floral remains are scant. However, Schoeninger and Schurr (1998) examined dietary changes over time using stable carbon isotopes to identify levels of maize consumption. Their results directly contradict my predictions for maize consumption during the Moundville phase. Stable carbon isotope $\delta^{13}C$ values averaged -15.0 ± 4.0 for the Moundville I subphase and -10.4 ± 1.0 for the Moundville II subphase. Because values closer to zero (i.e., smaller negative numbers) indicate greater reliance on maize, these figures would normally indicate an increase in maize consumption through time. However, the Moundville I sample was too small to determine if the difference was statistically significant (Schoeninger and Schurr 1998:122-125). The lack of significance is unfortunate, because the Moundville I to Moundville II transition is the crux of my disintensification argument. If disintensification occurred with the population dispersal around A.D. 1300, I predicted that maize consumption would decrease from Moundville I to Moundville II, increasing floral diversity. Due to the inadequacy of the sample, it is impossible to tell if maize consumption increased, decreased, or remained constant.

For the Moundville III subphase, $\delta^{13}C$ values remained nearly unchanged from the previous subphase, at –10.3 ±1.1 (Schoeninger and Schurr 1998:122). It is not surprising that there was no change between the Moundville II and III subphases, since they both represent the post-dispersal Moundville population, and were likely residents of outlying sites who were returned to Moundville for burial. I had predicted that maize consumption would be lower, resulting in increased floral diversity. Instead, the values differ by only one tenth of a point. It is impossible to tell if this level of maize consumption represents a true departure from the Moundville I subphase, due to lack of statistical significance. Finally, $\delta^{13}C$ values for the Moundville IV subphase were –11.0 ±0.8, indicating a small but statistically significant decrease in maize consumption (Schurr and Schoeninger 1998: 122) coinciding with the total depopulation of the Moundville center. This is a true contradiction of my prediction of increased maize consumption and consequently lower floral diversity for the last subphase of the Moundville sequence. As Peebles remarks, "Another cherished part of my model of Moundville – increased maize consumption in Moundville IV as the cause for a marked decrease in health – has been destroyed" (Peebles 1998:xv).

Michals (1981) examined faunal exploitation patterns at Moundville and discovered that white-tailed deer, gray squirrel, and wild turkey were the most common food species, and that fish were present in every sample. She also found that the relative proportions of each species remained constant over time, revealing no shift in concentration upon any single animal food resource from Moundville I through Moundville III. These results correspond with general expectations for faunal exploitation in relation to agricultural intensification, but not disintensification. However, a later and more intensive examination of additional materials from Moundville (Michals 1990) indicated that relative proportions of fauna did change over time. In particular, between the mixed Moundville I / II contexts north of Mound R and the Moundville II midden west of Mound R, the percentage of fish and reptiles in the faunal sample increased slightly and the percentages of birds (mostly turkey) and small and medium-sized mammals decreased slightly. Throughout all subphases and contexts, large mammal remains (mostly deer) continued to be the dominant faunal category represented in the sample, ranging from 69% to 89% (Michals 1990:table 2).

In the Southeast, Smith (1978b) suggested first-line animal resources in the Lower Mississippi Valley were fish, migratory waterfowl, and the "terrestrial trinity" of white-tail deer, raccoon, and turkey (Smith 1978:483). However, closer to Moundville at the Tombigbee River Valley site of Tibbee Creek in Mississippi, Jenkins (1993) names only deer as a first-line faunal resource, and relegates fish, waterfowl, and smaller mammals to the status of second-line resources. From Michals' results, Powell concludes that Moundville residents appear to have created their own "terrestrial trinity," consuming white-tail deer, wild turkey, and gray squirrel "in quantity" (Powell

1988:56), suggesting that Smith's more diverse model of Mississippian subsistence is most likely to be correct. If so, Michals' (1990) conclusion that deer exploitation remained unchanged suggests that human populations were not large or dense enough to place much pressure on deer populations, even in Moundville I times when population densities were highest. However, the decrease in other first-line resources (turkey and small / medium-sized mammals) concomitant with the increase in fish and reptile remains suggests a degree of subsistence stress sufficient to impact other first-line resources and encourage use of second-line resources such as reptiles. In this case, overall faunal diversity did not change, but proportions of faunal categories indicate that some sort of pressure on animal communities occurred. Therefore, my predictions are at least partially upheld – faunal diversity did change, but in content rather than degree. On the other hand, if I accept Jenkins' (1993) narrower definition of first-line resources, my predictions do not hold true. In fact, Jenkins' definition of first-line resources may be more applicable to Moundville than Smith's definition of first-line resources. Smith's sample from the Lower Mississippi River Valley represents the faunal signature of sites in the heart of the Great American Flyway for migratory birds, especially waterfowl (Smith 1978:485-486). Although Moundville's position on the Black Warrior River should have provided seasonal access to migratory waterfowl, they appear to have been present in Moundville contexts in negligible quantities. If Jenkins' (1993) definition of first-line resources is correct, Michals' (1981) results suggest the inhabitants of Moundville had already branched out into second-line resources by Moundville I, resulting in higher faunal diversity that then continued through the Moundville III subphase. If so, my predictions for faunal diversity are not borne out because I proposed that faunal diversity would increase in Moundville I with population nucleation and subsequently decrease with population dispersal. Unfortunately, there is no evidence for faunal exploitation patterns across the Moundville III and Moundville IV subphases, when Schoeninger and Schurr's (1998) stable carbon isotope analyses indicate a decline in maize consumption.

Subsistence at the Outlying Sites

Scarry and Steponaitis (1992, 1997) analyzed floral data from two Moundville I farmsteads, Oliver and Big Sandy Farms, and discovered patterns of increasing corn production similar to those found at Moundville. Interestingly, residents of Moundville I farmsteads produced quantities of nuts comparable to those of West Jefferson villages suggesting that nut processing was not de-emphasized at outlying sites as it was at Moundville itself. Residents of Moundville I farmsteads also processed more corn than did Moundville residents. Scary and Steponaitis (1997:118) suggest "the relatively low quantities of food by-products at Moundville may be an indication that the residents of the farmsteads were sending provisions to the residents of the paramount center." This pattern also confirms my prediction for outlying sites provisioning Moundville: although maize production increases, floral diversity should be greater at outlying sites if they sent most of their corn to Moundville and supplemented their own diets by continuing to consume nuts at greater levels. Unfortunately, due to limited sampling, there is little evidence of plant-based foodways at outlying sites dating beyond the Moundville I subphase. In the absence of such data, it is impossible to test my predictions for disintensification and reintensification during the later subphases.

Provisioning appears to have occurred at single-mound sites within the Moundville chiefdom as well. Michals (1990; Welch 1991) examined faunal remains from the White site, an outlying single-mound Moundville III subphase site and discovered that mound top (presumably high-status) residents at this site were preferentially provided with hind limb elements. Scott's (1983) analysis of the Lubbub Creek faunal remains from the adjacent Tombigbee River valley indicated that limb elements in general were preferred, and that forelimbs were given even greater preference than hind limbs. Based on this idea, Welch (1991:95-95) speculates that "If it is true that forelimbs were the most prestigious cut, then conceivably the deficiency of forelimbs at the White site reflects the White site's inferior status relative to the elite at Moundville." He goes on to explain that perhaps members of the elite stratum at White were being preferentially supplied with limb elements over axial elements, and they themselves were then supplying the Moundville elite with the preferred forelimb cuts. Welch's conclusions are partially borne out by Michals' (1990:table 3) data from the Moundville site, in which lesser elite contexts west and north of Mound R had equal or slightly greater proportions of hind limb over forelimb elements, while high elite contexts west of Mound C had significantly greater proportions of forelimb elements, suggesting that even within Moundville the higher elite was preferentially supplied with the most choice cuts of venison. Furthermore, high elite contexts west of Mound C also had significantly greater proportions of axial elements (the location of the highly-prized venison "backstrap"), lower elite contexts north of Mound R had moderate proportions of axial elements, and the outlying White mound sites and Oliver farmstead had low proportions of axial elements, suggesting yet another pattern of provisioning the elite social stratum.

At the Oliver farmstead, Michals (1990, 1998) found that hind limb and axial elements indeed appeared at lower frequencies than expected, supporting the idea that farmsteads may have preferentially supplied these elements to the single-mound sites during the Moundville I subphase. However, the frequency of forelimb elements at the Oliver farmstead exceeded expected percentages, and even exceeded the frequency of forelimb elements found at Moundville, implying that perhaps forelimb cuts were not preferred at Moundville after all. Scott (1983) may hold the answer to this conundrum: in her research at Lubbub Creek, she suggested that forelimb elements were preferentially consumed as fresh meat and hind limbs were processed for dried meat. In fact, Jackson and Scott (1995a:116) suggest that fresh meat would have been difficult to transport and impossible to store, and was perhaps smoked for preservation. Furthermore, Kelly (2001) notes that dried meat was "common tribute" among southeastern chiefdoms in the ethnohistoric era. If so, perhaps residents of the farmsteads were the main hunters and butchers, who dried or smoked the meat from the hind limb elements and sent it along to the single-mound sites and lesser elite at Moundville, while sending preferred forelimb elements to the high elite at Moundville, retaining the rest as fresh meat for themselves. While this pattern seems speciously regimented, it may explain the high ratio of deer throughout the Moundville sequence. If the deer were hunted only from the outlying sites, there would have been less pressure on faunal resources due to the greater dispersal of population, and therefore no decline in availability of deer meat over time.

Welch and Scarry (1995) came to more firm conclusions about provisioning at Moundville based on their analysis of Moundville I subsistence remains and ceramic refuse from the Oliver and Big Sandy Farms farmsteads, the single-mound Hog Pen site, and Moundville proper. They found that differential distribution of food resources was mirrored by differential distribution of burnished and unburnished ceramics, suggesting "elite members of the society received food as tribute" (Welch and Scarry 1995:397). As we have seen, there appears to have been differential distribution of beaver, turkey, and preferred cuts of venison in elite contexts at Moundville (Welch and Scarry 1995:405). For plant foods, there was a trimodal distribution, in which the plant subsistence pattern at the single-mound Hog Pen Site was intermediate in relationship to Moundville and the farmsteads, possibly representing an intermediate position in the social and settlement hierarchy. Finally, the ratio of serving to cooking vessels was highest in elite contexts at Moundville and lowest in nonelite contexts at the farmsteads (Welch and Scarry 1995:413). "Food remains and food byproducts, from both plants and animals, suggest movement of processed foods from low-status to high-status individuals" (Welch and Scarry 1995:413).

Scott (1983) and Jackson and Scott (1995a, 1995b, 2003) addressed elite provisioning using faunal data from contexts at the Lubbub Creek site and Moundville. Scott (1983) noted an uneven distribution of deer forelimbs and skulls based on analysis of faunal data from mound and nonmound contexts at Lubbub Creek. Comparatively speaking, skulls are not high meat-bearing elements and are often left behind at the kill site during field dressing. The higher proportion of deer cranial elements in elite contexts suggested to Scott (1983:356) that tongues might have been preferentially consumed by higher status individuals. In 1995 Jackson and Scott re-examined the Lubbub Creek faunal assemblage and slightly revised their conclusions, suggesting that even though differential distribution of preferred deer parts between elite and nonelite contexts "points to chiefly orchestration of production, it does not necessarily indicate chiefly private consumption" (Jackson and Scott 1995a:114). Instead, they suggest the distribution may result from community feasting centered at mound sites. Although these foodstuffs appear to have been provisioned to mound contexts, it may have been for the purpose of chiefly generosity rather than chiefly subsistence.

All in all, provisioning of the chiefly social stratum by the nonelite residing at outlying sites is fascinating, but cannot answer whether or not agricultural disintensification occurred. Data from Moundville indicate that production of maize intensified during the population nucleation of the Moundville I subphase as expected. Inconclusive results for the Moundville II and III subphases are followed by an unexpected drop in maize production in the Moundville IV subphase. It is unclear from the subsistence data whether disintensification occurred at all during the Moundville II and III subphases, and puzzling to observe further disintensification during Moundville IV when production should have instead re-intensified to support village-level populations. Similarly, faunal data are at best inconclusive, and may in fact suggest that faunal exploitation was both intensive and non-intensive simultaneously throughout the Moundville sequence.

Ultimately, however, subsistence data from the Moundville chiefdom may be inadequate for answering the disintensification question. In general, the data suffer from sampling bias due to the limited number of excavation contexts across the site in which both temporally diagnostic pottery and food remains have been systematically collected (Welch and Scarry 1995:402), yielding subphase-specific subsistence data. The floral and faunal samples for the Moundville site itself were drawn from two 2x2 meter test pits dug into elite contexts in the area north of Mound R (Michals 1981, 1990, 1998; Scarry 1986, Welch and Scarry 1995:402), plus additional excavation blocks in elite and high elite contexts along the riverbank at Moundville (C. M. Scarry 1986, 1995; Welch and Scarry 1995). At the outlying farmsteads, Oliver (Michals 1993) and Big Sandy (Ensor 1993), subphase-specific floral and faunal data also came from trash pits associated with nonelite residences (Welch and Scarry 1995:401). Refuse contexts at the Hog Pen Mound were from off-mound midden deposits that may have accumulated from various sources, including the mound-top residents themselves, plus various communal feasts that may have occurred on the mound (Welch and Scarry 1995:401). Considering the wide spread of the Moundville chiefdom, it is entirely possible that these few sources of subsistence information are inadequate to address the entire spectrum of Moundville subsistence across the subphases and social strata, and between Moundville and the outlying sites. In the absence of better data, I propose seeking out other data sources to confirm or refute my contention that subsistence disintensification occurred in the wake of the A.D. 1300 population dispersal in the Black Warrior River Valley.

Archaeological Correlates of Disintensification at Moundville

The following archaeological correlates for agricultural disintensification are divided by subphase, and describe settlement and health patterns before and after the

Moundville dispersal. Although the dispersal occurred around A.D. 1300, fifty years into the Moundville II subphase (A.D. 1250-1400), I have included the entire Moundville II subphase in the post-dispersal period because it is impossible to divide the subphase into smaller temporal increments. I also developed predictions for the post-abandonment Moundville IV subphase, in order to test whether or not re-intensification occurred as populations once again nucleated into villages.

Settlement Pattern: Nucleation and Dispersion

When an agricultural economy disintensifies, the change in cropping strategy from intensive agriculture to household gardening is generally accompanied by population and settlement dispersal. The settlement record of this period should reflect 1) a greater number of sites overall, 2) decrease in average settlement size, 3) decrease in the distance between sites, and 4) decrease in the size and occupational intensity of the parent site (in this case, Moundville) as it is depopulated in favor of dispersed settlements.

During the West Jefferson phase, the population of the Black Warrior River Valley lived in large, nucleated villages (Knight and Steponaitis 1998b). Logically, this pattern should produce a (Table 4) unimodal distribution of site sizes, and larger mean site size than in subsequent periods. The average distance between sites should also be greater than in the Moundville II – Moundville III period, because there should have been fewer, larger sites. During the Moundville I subphase, there should be (Table 4) a shift to a bimodal distribution of site sizes, with one large site (Moundville) and few small sites. Average site size would have been skewed by asymmetry of size between the large site and the smaller sites, resulting in an intermediate signature. Because there would have been fewer sites overall, there also would have been greater average distance between sites.

Table 4. Settlement Correlates of Disintensification.

Phase/Subphase	Settlement Pattern	Site Size Distribution	Mean Site Size	Mean Distance Between Sites	Number of Sites
West Jefferson	Nucleated	Unimodal	Larger	Longer	Fewer
Moundville I	Nucleated	Bimodal	Intermediate	Longer	Fewer
Moundville II	Dispersed	Bimodal	Smaller	Shorter	Greater
Moundville III	Dispersed	Bimodal	Smaller	Shorter	Greater
Moundville IV	Nucleated	Unimodal	Larger	Longer	Fewer

During the Moundville II and III subphases, after population dispersal, (Table 4) a greater number of sites will be present overall as the population spreads out across the river valley into smaller farmstead and single-mound sites. Settlement pattern characterized by one large site and a greater number of small sites would have resulted in a bimodal site size distribution. However, the curve for the smaller sites will be broader than on the Moundville I graph, because of the increased number of sites. Average site size also likely decreased as the size of the larger site was balanced by a greater number of smaller sites. Furthermore, the distance between sites should decrease as the number of sites increases.

Ultimately, during the Moundville IV subphase, after the abandonment of Moundville, population again aggregated into village-sized settlements. In this case, there should be (Table 4) a return to unimodal site size distribution, with a decreased number of sites, increased mean site size, and increased mean distance between sites. We know that Moundville IV sites were larger (Curren 1982:110; Peebles 1986) and more widely spaced (Peebles 1986:31) than those of previous subphases, and were sometimes palisaded (Hill 1996:27; Sheldon 1974). This represents a nucleation of population, possibly in response to external threat (Knight and Steponaitis 1998b:22), although there is no actual evidence of warfare in the skeletal record of Moundville (Bridges, Jacobi, and Powell 2000). However, lack of skeletal evidence of warfare does not discount that it was a significant threat. Recent work by Milner (2005) suggests that aboriginal weaponry penetrated the body with enough force to wound the skeleton directly only about 30% of the time.

Human Health: General Effects of Subsistence and Settlement

Human health is affected both by subsistence and settlement pattern. Subsistence directly impacts the quality of nutrition each individual receives, while settlement pattern mitigates his or her exposure to disease (Kent 1986; Larsen 1997:86; Rose et al. 1984; Powell 1998). Together these elements can form a synergistic pattern of good health or poor health, even in the absence of extreme stressors such as famine or epidemic disease.

As there are no known West Jefferson-phase human skeletal remains from within the geographic boundaries of the Moundville chiefdom; therefore, I cannot test settlement and subsistence effects on human health during this subphase. During Moundville I, and before population dispersal, the effects of population nucleation should be exacerbated by reduced plant food diversity, which would ultimately lead to a decrease in dietary quality and increased risk of infection (Table 5).

Table 5. Human Health Correlates of Disintensification.

Phase/Subphase	Human Health
West Jefferson	No human remains
Moundville I	Less healthy
Moundville II/III	More healthy
Moundville IV	Less healthy

As a result, there would have been poorer health overall, increased rates of infection, higher morbidity and mortality rates, and reduced life expectancy. In addition, the rate of caries should increase due to greater consumption of maize.

Results

My primary research hypothesis concerns the A.D. 1300 dispersal of Moundville populations and the subsequent effect(s) on subsistence, settlement, and human health. I will argue that this is primarily a process of economic disintensification. To that end, this chapter introduced the economic concept of disintensification, and its converse intensification, and set them forth as the theoretical foundation underlying my dissertation research. I used data from archaeological and modern contexts to develop subsistence, settlement, and human health correlates that could be tested to determine if disintensification did in fact occur at Moundville. These correlates were outlined in this chapter and discussed in terms of predictive statements about the archaeological record of subsistence, settlement, and human health at Moundville.

I did not collect original subsistence data. Instead, I relied on previously published research to evaluate my subsistence correlates. Although our understanding of Moundville subsistence is undergoing change, current data suggest Moundville subsistence was characterized by agricultural intensification. This pattern emerged early in the Moundville phase and continued beyond the A.D. 1300 population dispersal. Evidence of this comes from the fact that there are no discernable changes in floral subsistence before or after disintensification. Faunal data from elite and non-elite contexts suggest elites were being provisioned during Moundville I, II, and III. The only recognizable change in Moundville subsistence occurs late, during Moundville IV, where a small, but statistically significant decrease in maize consumption was observed. The subsistence evidence does not support disintensification. It may be that disintensification did not occur at Moundville, or it may be that the correlates I devised are not refined enough to detect subtle patterns in a complex economic system that was tempered by social and political requirements to a greater degree than those of simple food getting.

CHAPTER 3

MOUNDVILLE AND THE MISSISSIPPIAN WORLD: SETTLEMENT PATTERN

Mississippian Settlement Pattern

Size, Spacing, and Setting

Hally (1993) estimated the maximum extent of Mississippian chiefdoms based on ethnographic data suggesting that political and administrative boundaries are demarcated by one day's walking distance from the political center. Multi-mound or large, single-mound sites often served as political centers in Mississippian societies. Accordingly, Hally determined that Mississippian chiefdoms should be no more than 40 kilometers in maximum extent, meaning that the boundaries will fall roughly 20 kilometers from the primary mound center, or about one day's walk. Hally (1993) tested his model using Mississippian data from the South Appalachian region of the Southeastern United States. He identified a bimodal distribution of distances between mound centers and, with few exceptions, concluded that mound centers were either less than 18 kilometers apart, or greater than 32 kilometers apart. He argues that centers lying within 18 kilometers of one another belong to the same chiefdom, whereas those greater than 32 kilometers apart represent separate chiefdoms.

If Hally (1993) is correct, it is possible to count the number of single and multi-mound sites within a radius less than 18 kilometers, and determine whether it was a simple or complex chiefdom. Simple chiefdoms usually have only one mound site within an 18-kilometer radius, whereas complex chiefdoms have a multi-mound site and one or more single-mound sites within an 18-kilometer radius. In instances where there are two or more single-mound sites and no multi-mound sites within the 18 kilometer radius, there is no way of telling if it represents a simple or complex chiefdom, and if it is complex, which site represents the paramount center. Hally suggests instead that in this case "mound construction and use may have shifted between sites within a single chiefdom as a result of factional competition and breaks in the line of chiefly succession" (Hally 1993:160).

Hally goes on to demonstrate that the 32-kilometer radius between polities leaves ample room between resource exploitation zones not only to prevent their overlapping, but also to leave generous buffer zones. He echoes Anderson (1990) in suggesting that these buffer zones could have served as game reserves from within which the more immediate resource exploitation zones would be naturally replenished. This optimal distance of at least 32 kilometers, "in short, served as a spacing mechanism that reduced competition between neighboring polities and human pressure on the natural resources of the region" (Hally 1993:162).

The setting and placement of Mississippian sites, especially mound centers, was traditionally interpreted as wholly dependent on location variables advantageous to intensive agriculture. For example, several studies (Ward 1965; Larson 1970; Futato 1989; Hally 1993) examined the correlation, or lack thereof, between the distribution of Mississippian sites and environmental variables like soil type, distance to water, landform, vegetation zones, or climate boundaries. Without exception, these studies concluded that Mississippian sites are located, in general, on or near the threshold between at least two ecological zones, and in particular, on fertile alluvial soils and terrace landforms within 100-200 meters of a watercourse. On face value, these data seem to suggest that environmental variables, especially soil type, are reliable predictors of Mississippian site location (Green and Munson 1978; Johnson and Sparks 1986:70; Muller 1978; Price 1978).

However, a broader consideration of Southeastern riverine environments and Mississippian site distributions indicate that site locations were guided by cultural rules as much as they were by environmental ones (Lewis and Stout 1998:232-233). For example, Larson (1970) and Hally (1993) suggest that although Mississippian sites are correlated with alluvial soils, all locations with alluvial soils do not have Mississippian sites. Consequently, factors conducive to intensive agriculture must not have been the prime mover, if there is one, in site location because locations that were otherwise equally suited for agriculture were not equally chosen as site locations (Larson 1970; Hally 1993; Lewis and Stout 1998).

Population Aggregation and Dispersal

From an organization perspective, Mississippian societies are classified as chiefdoms and are therefore hierarchical societies. Two basic social ranks are recognized, the elite and the nonelite, and settlements are minimally organized in a two-tiered hierarchy, although complex multi-tiered systems are common. The relationships between settlements in such a system were presumably governed by economic and political obligations within and between social strata (Peebles and Kus 1977).

Mississippian settlements included single or multiple mound local centers and small, outlying farmsteads. The former contained plazas, public structures, or mounds and functioned as elite residences and the locus of civic or ceremonial events. The majority of the nonelite population lived in small, outlying farmsteads, although a smaller cadre of the nonelite resided at the local centers and served as support personnel to the elite.

Smith (1978b:489) argues that Mississippian societies were organized for maximum agricultural efficiency and resource exploitation. For Smith, the optimum Mississippian settlement pattern involves small, dispersed populations living on highly arable soils near abandoned river channels and oxbow lakes. This location is above normal flood levels, provides access to two or more ecotones, and optimizes the productivity of nuclear or extended family groups (Smith 1978, 1985).

Outlying nonelite populations were occasionally aggregated into local centers for civic-ceremonial purposes or collective defense. In this way, a system of one or more local centers interspersed among farmsteads would provide bureaucratic consolidation without compromising the efficiency of agricultural production (Smith 1978:489-490; 1985:77). Although agricultural populations have their greatest energy efficiency with a dispersed settlement pattern in times of peace, the need to maximize energy efficiency is often superseded by the requirement for community defense (Steponaitis 1983a:172).

Prior to the 1990s, explanations of Mississippian population movements focused solely on external conflict or energy efficiency as primary causal factors. Since that time, however, at least two other formal models have been proposed, first by Anderson (1994b) and then by Blitz (1999), to explain the oscillation between aggregation and dispersion. Both models are similar in that they place emphasis on the internal mechanics of chiefdom societies as much as they do external factors in the explanation of social and political change. The major difference between them, as Blitz (1999) argues, is that Anderson's (1994b) "Cycling Model" is too idealized to account for the social and political variability evident in Southeastern Mississippian societies.

Anderson (1994b), in essence, argues that Southeastern chiefdoms "cycled" between simple, single tiered and complex, multi-tiered hierarchical arrangements. He defines cycling as "…the recurrent process of emergence, expansion, and fragmentation of complex chiefdoms amid a regional backdrop of simple chiefdoms (Anderson 1994:9)." According to his model, many contributing factors play a role in these processes, namely, weakness of an individual chief, imbalance of sacred and secular power, diminished resource efficiency and information management, or a top-heavy elite stratum, any or all of which may have resulted in internal power struggles, warfare, or factional competition.

In contrast, Blitz (1999) offers the "fission-fusion" model in which social and political change is affected by the active nucleation and dispersal of basic political units. These units are represented by individual platform mounds and symbolize individual corporate groups within the same community. To Blitz, single-mound sites represent weak, decentralized power in a small chiefdom, whereas multi-mound sites represent strong centralized power in a large chiefdom. The former may have arisen independently or fissioned from a large, centralized multi-mound center. The latter are created through the fusion or centralization of two or more autonomous single-mound centers. This arrangement functions to provide "natural" social boundaries along which the community could split in times of internal or external stress (Blitz 1999).

Beck (2003) envisions an alternative model to both Anderson (1994b) and Blitz (1999), which explains variation among chiefdoms, though not in terms of population movements. Instead, Beck outlines an "apical-constituent model" which describes two different processes of consolidating chiefly hierarchies, which are defined in terms of the way authority is ceded up or down between the chief, community leaders, and the people. The first of these is a "constituent hierarchy", in which power is ceded by community-level leaders (i.e., "constituents") upwards to a regional chief. Local chiefs gain their power through local political ties, and concentrate on building local relationships at the expense of their ties with the regional chief. The regional chief lacks local political ties to legitimize his power at the local level, but he does have the power to alter the local chief's standing among his people through gifting, feasting, and coercion, thereby influencing local chiefs' allegiance to the regional chief. This type of arrangement is unstable on both levels, because the local chiefs can be easily undermined, and because the competition between local and regional chiefs threatens the cohesion of the regional chiefdom at all times.

Beck's second pathway to chiefdom consolidation involves an "apical hierarchy", in which power is delegated downwards to appointed local leaders by the regional chief. Local administrators gain power not through local political ties of their own, but through appointed authority from the regional chief. The regional chief holds his or her own power through regional-scale political ties. "The regional chief often delegates local authority to highly-ranked kin, thereby promoting local allegiance (i.e., stability)" (Beck 2003:646). This eliminates local rivals and creates a "regional aristocracy". Apical hierarchies are much more stable entities, "formal institutions with political, economic, and ritual hegemony over integrated local communities" (Beck 2003:646). In the Mississippian southeast, apical hierarchies would have been much less common, because the relative abundance of land would make it possible for people to shift allegiance, leading to stiff competition between rival chiefs and the inability to develop strong, well-integrated chiefdoms. In these contexts, the success of a chiefdom requires careful courting and persuasion of local chiefs and followers with feasts and gifts, and is costly in terms of economic resources.

Beck does not envision constituent and apical hierarchies as a typology of chiefdoms, or as a progression from simple to complex chiefdoms, though he does suggest that sometimes a constituent hierarchy may be swallowed up by an apical hierarchy as an aristocracy emerges and becomes entrenched. As this happens, chiefs cease to concentrate on persuasive aggregation, and instead concentrate on creating and maintaining ties with the ruling class among the constituent communities, at the expense of relationships with members of the community themselves. This process continues into structural patterns of the chiefdom: "apical hierarchies, once entrenched, may be marked by population dispersal away from the primary center and the founding of secondary centers" (Beck 2003:647). Beck suggests that this very process occurred at Moundville, which accounts for much of the social, political, and population dynamics seen throughout the Moundville phase.

Moundville Settlement Pattern in the Black Warrior River Valley

Geographic Extent and Territory

Conventional wisdom concerning the centralization and geographic extent of the Moundville chiefdom has varied over the last century, from a completely self-contained local chiefdom to a powerful political entity controlling a territory reaching from south-central Tennessee to southern Alabama (Bozeman 1982; McKenzie 1966; Peebles 1974, 1971, 1987a; Steponaitis 1983a; Welch 1991, 1998). Welch (1998) concluded that the Moundville chiefdom falls within the valley walls of the Black Warrior River in west-central Alabama and ranges from 25 km upriver to 15-23 km south of the paramount center at Moundville.

These boundaries are based on the clustering of Moundville phase sites around the site of Moundville. Occupation was relatively dense for 25 kilometers north of the site, and then there is a 50-kilometer gap between the last Moundville-affiliated site and the next contemporaneous settlement to the north. Similarly, occupation was dense for 13 kilometers south of Moundville, and then there are two southern outliers at kilometer 25 and kilometer 35. Another contemporaneous site does not occur beyond this point for 25 kilometers.

Depending upon the conservatism of the archaeologist, the southern boundary could be placed at kilometer 13, 25, or 35. Welch argues for the 25-kilometer boundary, noting that pottery styles show continuity within a 25-kilometer range and differ beyond this point. Also, he argues that the size of many ethnographic and historical chiefdoms was no larger than could be traversed in a day's travel by foot. This distance would closely approximate the Moundville chiefdom's boundaries of 25 kilometers north and south of the main site (Welch 1998:134).

The eastern and western boundaries of the chiefdom have garnered much less discussion, as every researcher appears to accept the valley walls as the territorial limit of the chiefdom (Bozeman 1982; McKenzie 1966; Steponaitis 1980a). This boundary is less arbitrary than it seems, because the closest contemporaneous "sites east and west of the floodplain are 45 and 50 kilometers away, respectively" (Welch 1998:134), and therefore also conform to the pattern of occupational discontinuity used to define the northern and southern borders as well.

Ecology, Site Distribution, and Mound Size

Although Peebles' (1978) model of Moundville settlement is somewhat dated, many of his resulting generalizations remain valid. For example, he notes that individually and collectively, Moundville-affiliated sites cluster in an area "of marked physiographic and ecological complexity" (Peebles 1978:388) between the Fall Line Hills, which mark the southernmost margin of the Cumberland Plateau, and the Black Belt Prairie, a highly fertile grassland to the south. Resources in this ecotone were easily accessible: upland oak-hickory forests, pine belt, magnolia forest, river, floodplain, backwater lakes, and mixed forest zones (Peebles 1978). It is not surprising that Moundville and surrounding sites were situated in order to take maximum advantage of these resources (McKenzie 1966; Larson 1970; Walthall 1980; Steponaitis 1983a, 1991; Futato 1989; Welch 1991; Ensor 1993).

Peebles (1978) and later Bozeman (1982:286-289) found that Moundville-era sites were located on and surrounded by a catchment area composed of the three highest-producing soil types in Tuscaloosa and Hale counties, which were described as "…the best, perpetually river-renewed, corn soils…" (Peebles 1978:405). There was a positive correlation between catchment productivity and site size, where larger sites were located within the most productive catchment areas (Peebles 1974, 1978).

Using the nearest-neighbor statistic, Peebles (1978) grouped the then-known Moundville sites into one of three categories: major ceremonial center, minor ceremonial center, and village-hamlets. He then arranged the sites in each category according to site size and presence / absence of mounds and concluded that the presumed social and political hierarchy among the site residents was reflected by a hierarchical site distribution. For example, the nearest neighbors of the major ceremonial center were all minor ceremonial centers, whereas the nearest neighbors of the minor ceremonial centers were, in order of proximity, 1) the major ceremonial center, 2) other minor ceremonial centers, and 3) village-hamlets (Peebles 1978:399). This pattern suggested to Peebles that the village-hamlets were clustered around the minor ceremonial centers, and the minor ceremonial centers were clustered around the major ceremonial center, and by extension, near one another as well.

Bozeman (1982:266-267) also analyzed Moundville site distribution using the nearest-neighbor statistics, but did so with new data that 1) classified sites by subphase, 2) eliminated erroneous data from Peebles' original analysis, and 3) focused on the relationship between mound sites rather than non-mound sites. The results of his re-analysis suggest that mound sites are not clustered, but are instead regularly distributed.

Bozeman argues this does not contradict Peebles' conclusion because, unlike Peebles, he did not include non-mound hamlet-farmsteads in his analysis. Bozeman reasoned that in a system of site hierarchy, minor centers would not be clustered together, but would instead be arrayed in clusters represented by a minor center and several dependent smaller sites. In this way, minor centers would be "positioned within provinces along the Warrior River floodplain to serve as civic and ceremonial foci for local populations of dispersed farmsteads and hamlets" (Bozeman 1982:273). He further suggests that minor centers would have very small resident populations but would be positioned in a catchment area that could provide for larger populations in times of stress or external threat (Bozeman 1982). Perhaps these sites would also have served as community foci for social and ceremonial occasions.

Although Bozeman identified several hamlet-farmstead size sites, he did not test his suspicion regarding clustering of minor centers with smaller sites. Though he does not state it explicitly, perhaps he was conscious of the lack of adequate survey coverage, and realized that further nearest neighbor analysis would be futile in a statistical universe in which all of the "neighbors" had not yet been discovered. Nearly two decades later, Hammerstedt (2000, 2001), Hammerstedt and Myer (2001), and Myer (2001) determined that farmstead sites do in fact cluster with single-mound sites. Their research identified four clusters of Mississippian farmsteads in the Black Warrior River valley, each of which include a single-mound center. Like Bozeman (1982), however, they did not speculate on the relationships, hierarchical or otherwise, among other site clusters.

Steponaitis (1978) examined Moundville site distribution using location theory and concluded, as did Bozeman (1982), that the spatial relationships between minor centers and Moundville became increasingly more efficient, optimizing the distances between contemporaneous minor centers and Moundville proper. In their view, this pattern reflects the intentional placement of single-mound minor centers in positions to control "…the flow of goods, services, and information between the primary center at Moundville and the outlying districts" (Bozeman 1982:24).

Bozeman performed a similar analysis using fresh data (1982:291-300), and also determined that the spatial relationship between minor centers and Moundville became more efficient over time. This pattern of increasing efficiency peaked in Moundville III, numerically approaching what Steponaitis had predicted to be the ideal (Bozeman 1982:295). Bozeman argues that his research confirms Steponaitis' (1978) and Peebles' (1978) contention that Moundville was a politically unified entity.

These earlier conclusions (Peebles 1978; Steponaitis 1978; Bozeman 1982) contrast with Knight and Steponaitis' (1998b) new history of Moundville, in which greater emphasis is placed on inter-center travel efficiency as the lesser elite moved away from Moundville proper to outlying centers. Bozeman (1982:300) saw this as political unity, but it can also be interpreted as factional splintering accompanied by vestigial faithfulness to the external trappings of the old order in the form of continued reverence of the remnant elite and an enduring spiritual tie to mortuary ritual performed at Moundville.

Three lines of evidence support this notion. First, Steponaitis (1978) observed that mound size increases with distance from Moundville. He originally suggested that minor centers closest to Moundville might have felt the greater brunt of tribute obligation and would have had fewer resources to enlarge and elaborate their own mounds (Steponaitis 1978; Bozeman 1982). It is equally likely that remote minor centers had larger mounds because their leaders were less dependent upon and less controlled by Moundville, and therefore free to symbolically aggrandize themselves to a greater extent than those more closely tied to Moundville (Knight 1998).

Second, Knight (1998) and Wesson (1998) propose that Moundville was a "diagrammatic ceremonial center" in which the arrangement and spacing of habitation mounds reflected social distance from the paramount chief. If they are correct, as I believe they are, factions within the paramountcy had varying ties with the paramount chief. Furthermore, the abandonment of mounds from south to north – from greater to lesser social distance – suggests those factions with remote connections were the first to splinter as the chiefdom's power waned (Knight and Steponaitis 1998b:21). Under this model, the residents of the outlying mound centers may have built larger mounds as a symbol of their autonomy.

Third and finally, Maxham (2000) addressed the role of outlying non-mound communities in her functional analysis of ceramics from Moundville farmsteads, single-mound sites, and Moundville proper. She found the ratio of serving to cooking vessels from elite and residential contexts at Moundville, as well as those from other mounded and non-mounded sites, was within the expected range of variation (Table 6).

However, at the outlying non-mounded Grady Bobo Site (1Tu66), Maxham (2000) found that greater than 90% of vessels were serving wares, a significantly higher ratio than was found at even the most restricted elite contexts at Moundville. The significance of this high ratio is tempered (perhaps destroyed) by the fact that these ceramics were recovered from a single feature (Maxham 2000:342), which appears to be the only feature excavated at the site. Nonetheless, Maxham argues that the discrepancy in serving-to-cooking ratios is far too large to be accounted for by simple sampling error, and bolsters her argument with faunal data pointing toward elite consumption habits.

Table 6. Expected Ratio of Serving-to-Cooking Vessels in Moundville Contexts (Maxham 2000).

Context / Site Type	Expected Proportion of Serving Vessels
Moundville elite context	25-33%
Moundville residential contexts	20-25%
Outlying mound sites	20-25%
Outlying non-mound sites	05-20%

Maxham (2000) argues that Grady Bobo was a locus of public celebration and ceremony performed by and among an outlying nonelite population, which functioned to strengthen kin or community ties and reinforce newly developing lineage-land ties associated with the re-intensification of agriculture during the late Moundville III and Moundville IV subphases. In this instance at least, we see that social ties among the nonelite continued unchanged, regardless of relationships with the elite (Maxham 2000). This pattern implies a focus on tradition in the face of a rapidly changing social and political milieu, and the maintenance of kin and clan ties that would provide natural paths for the fissioning of Moundville society.

Moundville phase Settlement Types

Beyond the paramount center of Moundville, I recognize two basic settlement types: farmsteads without mounds and single-mound centers. Farmsteads have defied definition throughout the course of research at Moundville, if not Mississippian studies at large (Bozeman 1982; Emerson 1992; Ensor 1993; Fowler 1978; Futato 1989; Harn 1978; Hammerstedt and Meyer 2001; Knight and Solis 1983; Maxham 2000; Mistovich 1988; Muller 1997; Myer 2001; Pauketat 1989; Peebles 1978; Rogers 1995; Scarry and Steponaitis 1992, 1997; Steponaitis 1978; Smith 1978; Smith and Moore 1996; Welch 1998; Winter 1976). In some cases, archaeologists make persuasive cases for terming one site type a farmstead and another a hamlet (e.g., Smith and Moore 1996), whereas others suggest the differences are mere semantics (e.g., Winter 1976).

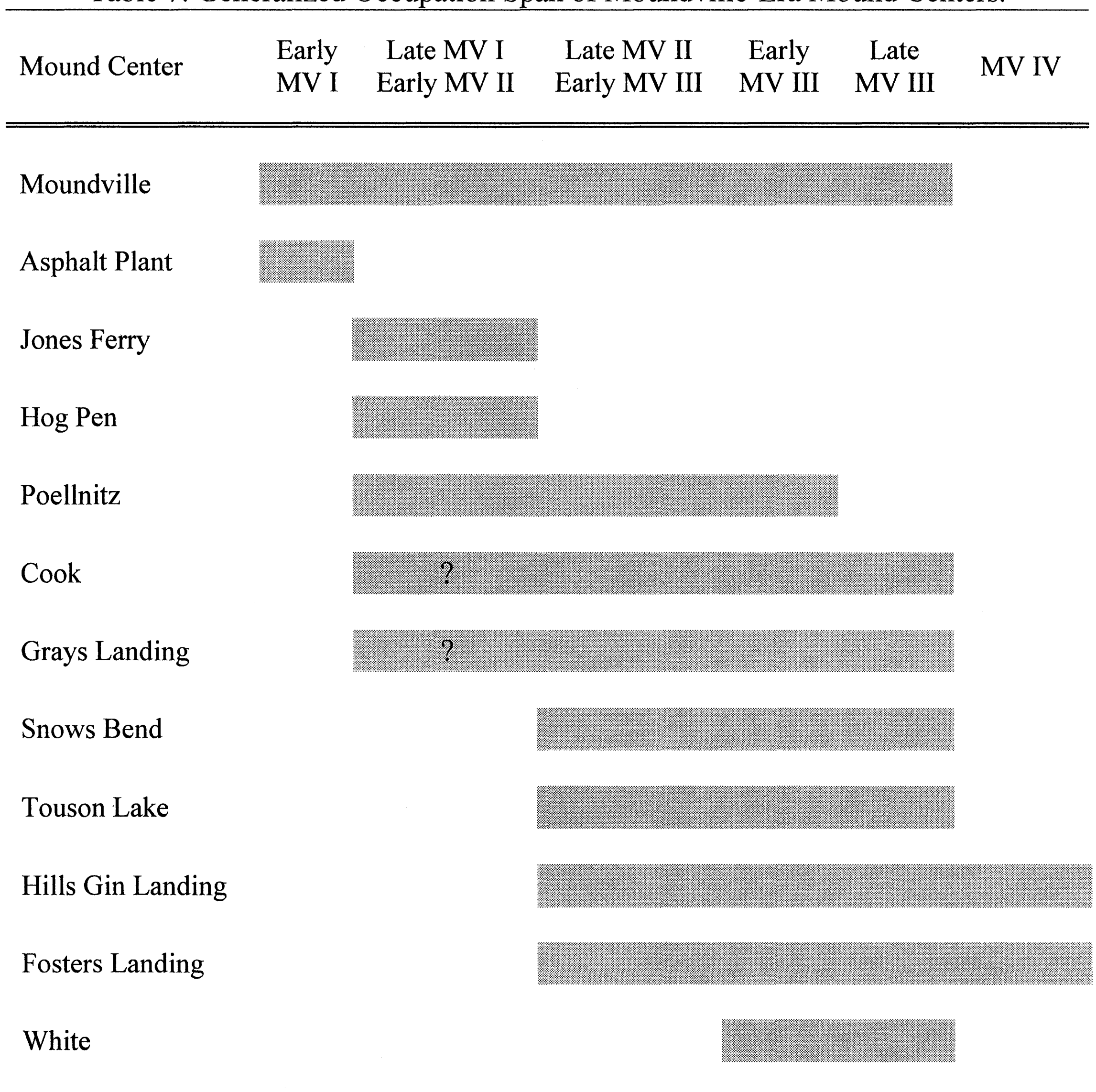
I refer to small sites with evidence of structures and other domestic activities but without mounds as farmsteads (Knight and Solis 1983:1). A range of activities other than farming, and possibly with greater social and political significance than mere residence, may have taken place at such sites (Maxham 2000). I have selected this term for semantic continuity with researchers who have used this term to describe small Mississippian sites in the Black Warrior River Valley (Ensor 1993; Futato 1989; Knight and Solis 1983; Mistovich 1988; Maxham 2000; Peebles 1987b).

Archaeologists have spilled less ink defining single-mound sites in the Black Warrior Valley and the Southeast as a whole than they have on the farmstead / hamlet controversy. This is because the primary attribute of these sites is the simple presence of a single-mound. In the Black Warrior Valley, single-mound sites may or may not contain residential occupations (Knight and Steponaitis 1998b). Single-mound sites may have functioned as the loci of elite feasting (Maxham 2000) and display or may have been responsible for channeling goods and/or tribute between outlying farmsteads and Moundville (Steponaitis 1978). Knight and Steponaitis (1998b:20) suggest that single-mound sites united a dispersed population and maintained ties with the paramount elite.

Welch (1998) has recently rethought Mississippian settlement, tracking the development and decline of single-mound sites and outlying farmsteads (Table 7). He follows the development of Moundville and the single-mound sites, tracking their development and decline with improved survey coverage and a new understanding of the Moundville chronology. Welch argues that single-mound sites were established during Late Moundville I and early-to-late Moundville II, just as Moundville was reaching its ascendancy. The majority of the population is thought to have lived in farmsteads or, in Welch's (1998:162) terms "neighborhoods", centered upon single-mound sites. There is little evidence of dense occupation at Moundville itself during this period, though the overall number of burials increased at the site (Welch 1998:163).

During late Moundville III at least one mound site, Poellnitz, was abandoned, but occupation continued at most remaining mound centers. Population appears to have increased at four of them, suggesting a "trend toward population nucleation at the secondary mound sites in late Moundville III" (Welch 1998: 164). This trend continued throughout Moundville IV, as population increased at Hills Gin Landing and Fosters Landing. Meanwhile, other secondary mound sites were abandoned, and non-mound villages were established (Futato 1989:305; Welch 1998:165) in parts of the valley that previously were unoccupied (Peebles and Black 1987:25). During Moundville IV, "the population was grouped into a set of villages whose mortuary remains indicate that there was no social ranking. Moundville was abandoned by this time and the chiefly model no longer applies to the resultant population' (Ensor 1993:23).

Table 7. Generalized Occupation Span of Moundville-Era Mound Centers.



Williams (1995) proposes a Mississippian settlement model specific to systems in which the bulk of the population resides in dispersed farmsteads and households, like that at Moundville. He suggests that "… in Mississippian settlement systems that included many individual homesteads, the mound sites were smaller and likely were occupied only by the chief and his family" (Williams 1995:127). Williams refers to these small mound sites as "chiefly compounds" and cites analogies from African chiefdoms in which there is no village settlement, merely homesteads, one of which is clearly larger and more sumptuous and is occupied by the chief. He also cites examples from explorers' accounts of the early historic Southeast – for example, the small chiefly communities and dispersed settlement described by Garcilaso of the DeSoto expedition. Williams also cites Steponaitis' (1978) description of the historic Natchez of Mississippi, where even the "Grand Village", the paramount political center of the Natchez, had only two mounds and nine structures arrayed around a plaza. The site covered less than 1.5 hectares and could not have housed more than the Great Sun and Tattooed Serpent, their wives, families and retainers (Williams 1995:131-132). Swanton (1911) also noted this pattern in historic-period southeastern societies, in which only the chief, his family and his functionaries resided in a small chiefly village. The village was surrounded by farmsteads, whose residents visited the central village only for ceremonial occasions (Swanton 1911).

This is an example of the Mississippian settlement pattern proposed by Smith (1978b, 1985). He suggested that the typical Mississippian settlement pattern was a compromise between the competing needs for efficiency of resource exploitation and maintenance of social cohesion and political boundaries. The ideal Mississippian settlement pattern for energy efficiency would be a dispersed pattern of farmsteads located on arable soils in close proximity to backwater lakes and other point resources (Smith 1978:489, 1985:75). Settlements located adjacent to farm fields and fishing holes would minimize the costs of travel and transportation needed to produce food. Unfortunately, this pattern is not conducive to mutual defense and internal social cohesion, both of which are better maintained in a nucleated (and perhaps fortified) village (Smith 1978:490, 1985:77).

Smith believes that Mississippian societies achieved a tidy compromise to these two competing goals by developing a settlement system of centrally located "local centers" surrounded by a dispersed array of farmsteads. Most people within the extended community would work and live at the farmsteads and would travel to the local center for public ceremony, trade, tribute obligation, and occasionally for safety within the palisade walls (Smith 1978:490, 1985:77).

These models of dispersed farmsteads / chiefly compounds are consistent with observations of Moundville phase single-mound sites, which were of small size (Ensor 1993) and bore limited occupation debris (Bozeman 1982, Welch 1998:149). The bulk of the Moundville population resided in dispersed farmsteads (Ensor 1993, Welch 1998), which in at least four instances were clearly clustered around these small single-mound sites (Hammerstedt and Myer 2001; Myer 2001). Perhaps the lesser chiefs of the Moundville phase were living in just such "chiefly compounds" surrounded by a nucleus of small settlements. Mistovich (1986) suggests that such is the case: "It may prove more productive to view these single-mound sites as primarily chiefly residences with a restricted population composed of high status individuals and their immediate kin group, serving as a social focal point for a dispersed population in the adjoining areas" (Mistovich 1986:88). The primary difference between the Moundville settlement system and that of other examples cited above is that the single-mound sites within the

Moundville system were united by allegiance to a large and complex mound center within the context of a paramount chiefdom, while the other models appear to describe simple chiefdoms within a two-tiered settlement hierarchy. Mistovich provides the following summation of his model of the Moundville settlement system:

> In the apparent absence of site types such as nucleated villages, it would appear the farmstead is both the predominant and basic unit of socioeconomic life during the Moundville phase. Within this settlement system, the site of Moundville and single-mound centers are perceived as social, ceremonial, and economic focal points for a highly dispersed population. It is a less rigid system than previously conceived, without inordinate emphasis on tribute flow and complex mechanisms of administrative control in a hierarchical network. Emphasis is shifted to the articulation and interaction of individual farmsteads, from that point to the interaction of discrete sets of farmsteads to single-mound centers, and finally to the relationship of single-mound centers serving as population foci to the site of Moundville itself, the apical focus of the settlement system and its primary point of contact and interaction with Mississippian communities outside the boundaries of the Warrior Valley (Mistovich 1986:89).

CHAPTER 4

DISINTENSIFICATION AND SETTLEMENT PATTERN IN THE BLACK WARRIOR RIVER VALLEY

Two assumptions underlie my settlement pattern model. First, I assume that all of the sites within each Moundville subphase were occupied simultaneously. This assumption is likely untrue, but the discrepancy will affect only limited elements of my analysis. For example, mean site size can be as legitimately taken from a diachronic sample as from a synchronic one, since it is a mathematical average. In contrast, a synchronic sample would be required if one were interested in the number of sites occupied at a single time or actual distances between those sites at any time. For the purposes of my analysis, however, I am interested only in the relative numbers as compared across subphases. Comparisons between subphases are valid if data from them are equally skewed due to the lack of synchronicity.

Second, the range of Moundville settlement will likely remain unknown due to sampling error, site preservation, and formation processes. This factor is compounded by modern development practices that have destroyed many undiscovered sites. These problems are familiar to archaeologists and are unavoidable in settlement pattern studies.

The Settlement Model

Disintensification is defined by and less intensive agriculture, which is most efficiently pursued by living in single, extended, or multifamily settlements near farm fields. The process of disintensification from a formerly intensive agricultural system involves population dispersal, resulting in settlement reorientation. The correlates of this trend are fourfold. First, there will be **fewer sites** prior to disintensification as larger populations are aggregated, and **more sites** after disintensification as people dispersing from large central sites settle into smaller ones. Second, **average settlement size** will be larger before disintensification than after, because the population will be thinly dispersed across the landscape with more sites and fewer people living at each site. Third, in the context of the Moundville chiefdom, **site size** will change from a unimodal distribution during West Jefferson and Moundville IV, to a bimodal, or perhaps trimodal distribution during Moundville I, II, and III. Fourth, **average distance between sites** will be greater before disintensification than after when more sites are dispersed across the same area and are, consequently, closer together.

Materials, Methods, and Hypotheses

I tested this settlement pattern model using data collected from the Alabama State Site Files housed at the David L. DeJarnette Research Center at the University of Alabama's Office of Archaeological Research (OAR). My first task was to define site-file search criteria in spatial and temporal terms. As outlined in Chapter Three, I defined the boundaries of the Moundville chiefdom at 25 kilometers north and south of Moundville proper. I defined the eastern and western boundaries of the chiefdom at the floodplain valley walls, as established by previous researchers (Bozeman 1981, 1982; Futato 1989; Hammerstedt 2000; Welch 1991). Next, I outlined the boundaries of the Moundville chiefdom on the appropriate United States Geological Survey (USGS) 7.5" (1:24,000 scale) topographic quadrangles, and later plotted the location of Moundville and associated sites identified in the site file search.

The temporal boundaries for my site file search included the Moundville phase, its subphases, and the West Jefferson phase. Moundville IV and West Jefferson components were included to permit long-term diachronic comparisons with the Moundville samples. Using these temporal and cultural boundaries, I searched the Alabama State Site File electronic database for currently recorded sites, and the "paper" site files for sites not yet entered into the database or that had been inadvertently omitted. Then, I double-checked site locations to ensure they fell within the geographic boundaries established above.

The resulting sample includes 186 West Jefferson and Moundville phase sites. This sample was obtained by comparing, checking, and re-checking queries of OAR's electronic site database against hard-copies of their site files and master quadrangles. To begin, Eugene Futato, OAR Senior Archaeologist, queried the electronic site files database for the archaeological keywords *West Jefferson, Moundville I, Moundville II, Moundville III, Moundville IV, Moundville, Mississippian,* and *Protohistoric* and quadrangle names *Coker, Englewood, Fosters, Knoxville, Moundville East, Moundville West, Sawyerville, Tuscaloosa,* and *Warrior Dam*. This query identified 147 sites within the geographic boundaries set out above. My search of the paper files identified 33 additional sites from Hammerstedt and Myer's Black Warrior survey, which increased my site sample to 180. Additional searches of the site file and master quadrangles identified 12 additional sites, which yielded a combined total of 192 West Jefferson and Moundville sites. Finally, I checked the location of each site on OAR's master quadrangles, and plotted those sites falling within the geographic boundaries described above. Of these, only six sites fell outside of the valley wall, leaving a final total of 186 sites for analysis.

I divided my sample by phase and then subphase in order to discuss settlement pattern before and after population dispersal (i.e., before and after the hypothesized disintensification). Steponaitis (1998:39) suggests Moundville's population dispersed around A.D. 1300, at the beginning of what Knight and Steponaitis (1998b) would eventually term the "Paramountcy Entrenched" developmental stage. This occurred only 50 years after Moundville was completed. I took West Jefferson and Moundville I sites to be representative of pre-dispersal populations and Moundville II and III to represent post-dispersion. This was done because A.D. 1300 occurs early in Moundville II [A.D. 1250-1400 (Knight and Steponaitis 1998b)], rendering impossible a tidy temporal correspondence between subphase and culture change.

In addition to chronological information, I recorded Universal Transverse Mercator (UTM) coordinates and the length of the long axis and short axis for each site. UTM coordinates were used to calculate distances between sites, whereas the major and minor axes were used to find the size of each site. I used these data to test the four settlement hypotheses presented below.

Hypothesis One:
Before disintensification (Moundville I), a larger portion of the population will reside at the main site of Moundville, resulting in a smaller number of sites within the chiefdom overall. After disintensification and population dispersal (Moundville II / III), there will be a greater number of sites within the chiefdom overall, because a greater percentage of the population will be living beyond the main site at Moundville, but sites must stay small and dispersed to achieve agricultural efficiency, therefore resulting in a greater number of smaller sites. During Moundville IV, after the ultimate decline of the Moundville chiefdom, there will again be a smaller number of sites because the settlement pattern reflects a re-aggregated population.

I sorted the sites by phase and subphase and culled sites that had no subphase affiliation, reducing the sample to 114. The final distribution of sites by phase and subphase is summarized in Table 8.

Table 8. Number of Sites by Phase and Subphase.

Phase/Subphase	n	%
West Jefferson	67	59%
Moundville I	9	8%
Moundville II / III	24	21%
Moundville IV	14	12%
Total (N)	114	100%

The raw distribution of sites by subphase conforms to my predictions in hypothesis one. I did not attempt to predict the number of West Jefferson sites, because the transition from Late Woodland to Mississippian is not of primary concern in my research. I correctly predicted there would be fewer sites overall during Moundville I, which was followed by an increase during Moundville II and III. My model suggested the frequency of Moundville IV sites would decrease as population re-aggregated following the final decline of the chiefdom itself. These results support this assertion.

The distribution of sites in my sample suggests the demographic peak occurred during West Jefferson and, assuming Moundville was an in-situ, descendant development, population was dramatically aggregated into a small number of sites during Moundville I. Site frequencies then show a marked increase between Moundville I and II-III, and then decrease during Moundville IV.

Settlement intensity may be measured using the Occupation Intensity Index (O.I.I.). Blitz and Mann (2000) developed this method as an index to gauge the occupational intensity of a region. This method counts archaeological components in a region, divides by the length of each time period in years, and multiplies the result by 100 to yield an index of occupational intensity. For example:

# of components ÷ length of time period in years x 100 = O.I.I.

I calculated Occupation Intensity Indices for the West Jefferson phase, each Moundville subphase, and for the Moundville phase as a whole (Table 9). The resulting indices are similar to the raw site frequencies in Table 8: occupational intensity is

Table 9. Occupation Intensity Index (O.I.I.) by Phase and Subphase.

Phase/Subphase	Components (n)	Duration (years)	Components ÷ Duration	O.I.I.
West Jefferson	67	150	0.446	44.6
Moundville I	9	200	0.045	4.5
Moundville II / III	24	300	0.08	8
Moundville IV	14	150	0.093	9.3

greatest during West Jefferson, which is followed by lower but steadily increasing intensity of occupation through the Moundville subphases. By figuring in the duration of each phase or subphase, the O.I.I. smooths out the sharp discrepancies in raw numbers between time periods, and seems to return a more realistic profile of settlement changes over time. These results also support hypothesis one, with the exception of the slight increase in intensity of occupation during Moundville IV.

Hypothesis Two:
Average settlement size will be larger before disintensification during Moundville I and smaller after disintensification during Moundville II / III because people will be dispersed more thinly across the landscape, with more sites and fewer people living at each site. Average settlement size will increase during Moundville IV as people move back into aggregated villages.

My site size data originated from two sources, the Alabama State Site File and Bozeman (1982). I used the site files to obtain the lengths of long and short axes of each site in my sample. Bozeman (1982) carried out a controlled surface collection at sites in the Black Warrior Valley, which enabled him to map the spatial distribution of temporally diagnostic artifacts within each site and determine the areal extent of occupation for each phase or subphase component represented. From these data, he concluded that sites once thought to be large Mississippian villages were actually large West Jefferson villages with a spatially constricted Mississippian overlay.

Bozeman's data were also useful to me, because I was able to separate West Jefferson site sizes from their Moundville counterparts, thereby both increasing the sample size for the Moundville subphases and improving the accuracy of my data set. I substituted the dimensions reported in the Site File with Bozeman's (1982) data wherever possible. Improved data were not available for all of the sites in my sample, because many were added to the Site File after Bozeman's survey (1982).

To test my hypothesis, I needed to derive the mean site area for each phase or subphase. I calculated the area of each site using the formula for the area of an ellipse, $X=\pi ab$, in which 2a is the length of the major axis and 2b is the length of the minor axis (Math Forum 1997). I chose to use the area of an ellipse, because, of course, most archaeological sites are not perfectly round, square, or rectangular. Nor are they perfect ellipses, but the ellipse most closely approximates the shape of an area that has asymmetrical dimensions.

I made two alterations to the data set to mitigate potential skewing factors. First, Moundville proper was excluded because its size so completely overshadows that of other sites and, because, as the paramount center, it is not functionally comparable to other sites in the sample. Second, multicomponent sites were placed in the phase or subphase corresponding to its maximum area. This applies specifically to sites with either West Jefferson or Moundville IV components, because extensive villages are characteristic of both. Average site size would be artificially inflated if they were included in the calculations for other subphases. If both West Jefferson and Moundville IV were represented at a site, I entered it for both phases. Sites were included in average site size calculations for Moundville I and Moundville II / III subphases if one or more of these components were present and West Jefferson and Moundville IV were absent. This approach was taken because, unlike West Jefferson and Moundville IV, no baseline site sizes have been established for these subphases. The advantage to this approach is that it increased a small sample and avoided at least one source of potential skewing of the data. The only exceptions to this rule are the sites for which Bozeman

(1982) reported phase- or subphase-specific site sizes, in which case I used these data to calculate the mean site size per subphase.

I culled sites from my sample if phase/subphase affiliation or major/minor axis lengths were unavailable. The resulting sample included a combined total of 55 West Jefferson and Moundville sites. I calculated the area of each site in square meters, converted to hectares, and filtered the data by phase and subphase in order to compare mean site sizes before and after population dispersal (Table 10). The results of paired Student's T-tests indicate no significant differences in mean site size (Table 11). I was unable to reject the null hypothesis, and there is no evidence for change in site size over time at Moundville.

Table 10. Mean Site Sizes in Hectares by Phase and Subphase.*

Phase/Subphase	n	Hectares	Variance	Range
West Jefferson	36	1.30	2.56	.05-6.91
Moundville I	7	0.79	1.15	.009-2.36
Moundville II / III	18	0.32	0.07	.02-.79
Moundville IV	7	0.73	0.66	.02-2.12

* Excludes Moundville (1TU500)

Table 11. Student's T-test of Hypothesis Two.*

Phase/Subphase Tests	Student's t	Degrees of Freedom	One-tailed Value
West Jefferson vs. Moundville I	1.05	14	0.15
Moundville I vs. Moundville II / III	1.14	6	0.14
Moundville II / III vs. Moundville IV	1.34	7	0.11

*Excludes Moundville (1TU500)

These results seem to clearly indicate that even with its position as a paramount chiefdom, Moundville lacked the internal differentiation in the site hierarchy that characterizes more complex polities. Although the different site types are clearly functionally and socially distinct (as detailed in Chapter 3), there was simply not enough morphological difference between West Jefferson or Moundville IV villages and Moundville phase farmsteads and single mound centers to render site size differences statistically significant.

The lack of difference in site sizes may be explained less by the position of the site within a settlement hierarchy, and more by the number of people living at each site type, and living within the Black Warrior River valley as a whole. The most recent estimated peak population of Moundville is 1000 to 1700 during the Moundville I subphase (Steponaitis 1998:42-43), when most of the valley's population was living at Moundville. Assuming that population growth remained stable throughout this period and into the Moundville IV subphase, it is apparent that overall population of the valley was relatively small. Therefore, even though by "eyeball", my predictions seem to be upheld by the figures reported in Table 10, when populations are as small as have been estimated for the Black Warrior valley, even the difference between a farmstead or single mound site and a village is not great enough to render statistical significance.

Hypothesis Three:
Site size distribution will be unimodally distributed during West Jefferson and Moundville IV, because all sites are thought to have been large villages. Conversely, site size will be bimodally or perhaps trimodally distributed during Moundville I and Moundville II / III, because the site size hierarchy will be represented by small farmstead/hamlet sized sites, single-mound local centers, and the paramount center at Moundville.

I used the site size data collected for Hypothesis Two, including Bozeman's amended site dimensions, to test Hypothesis Three. I used similar filtering criteria for representing site sizes within phases and subphases, except that I included the Moundville site in calculations for Moundville I and II / III, because it achieved its full size during Moundville I (Knight and Steponaitis 1998b:14-15), and occupation continued into Moundville II and III, though to a lesser degree (Knight and Steponaitis 1998b: 19-21) (Table 12). I graphed the resulting site sizes by phase and subphase, with the results that West Jefferson shows a unimodal distribution of site sizes (Figure 4), Moundville I (Figure 5) and Moundville II / III (Figure 6) had a bimodal distribution, and Moundville IV returned to a unimodal distribution of site sizes (Figure 7).

Table 12. Mean site size in hectares including Moundville (1TU500).

Phase/Subphase	n	Mean	Variance	Range
West Jefferson	36	1.30	2.56	.047-6.91
Moundville I	8	12.48	1092.96	.009-94.25
Moundville II / III	19	5.26	464.40	.017-94.25
Moundville IV	7	0.74	0.66	.017-2.12

These results support my hypothesis. I proposed that mean site sizes would reflect the overall settlement pattern associated with the prevailing social and economic adaptation during each subphase. The unimodal distribution of West Jefferson and Moundville IV site sizes appropriately reflects the typical village-sized settlements of the phase. Similarly, the bimodal distribution of site sizes during Moundville I and

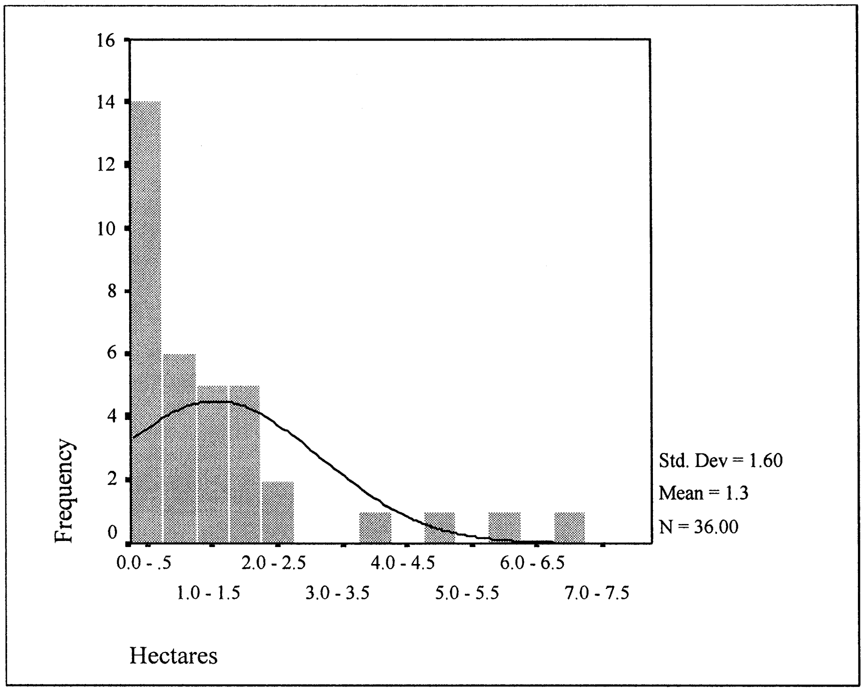


Figure 4. West Jefferson Site Size Distribution.

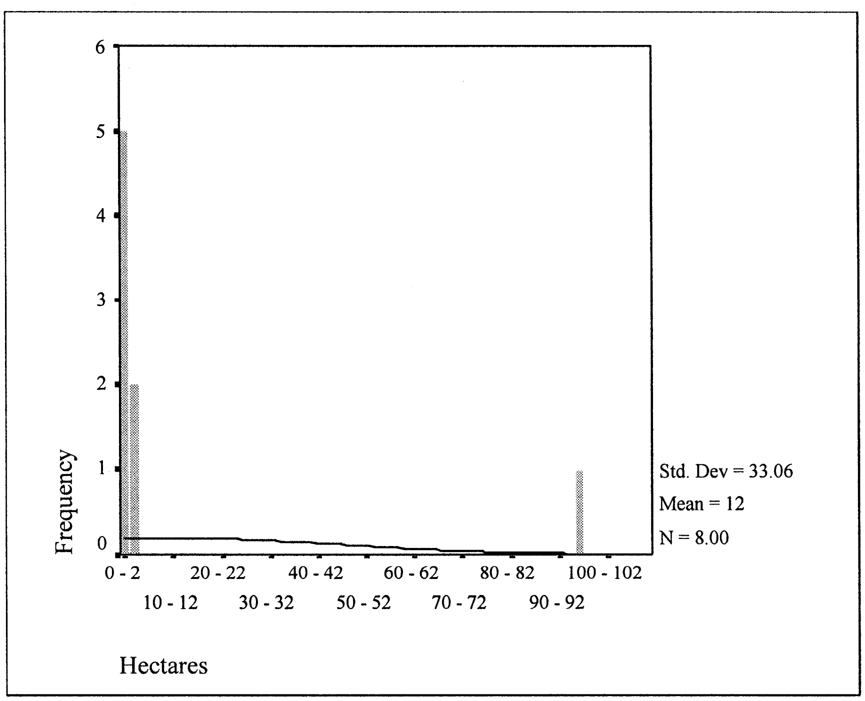


Figure 5. Moundville I Site Size Distribution.

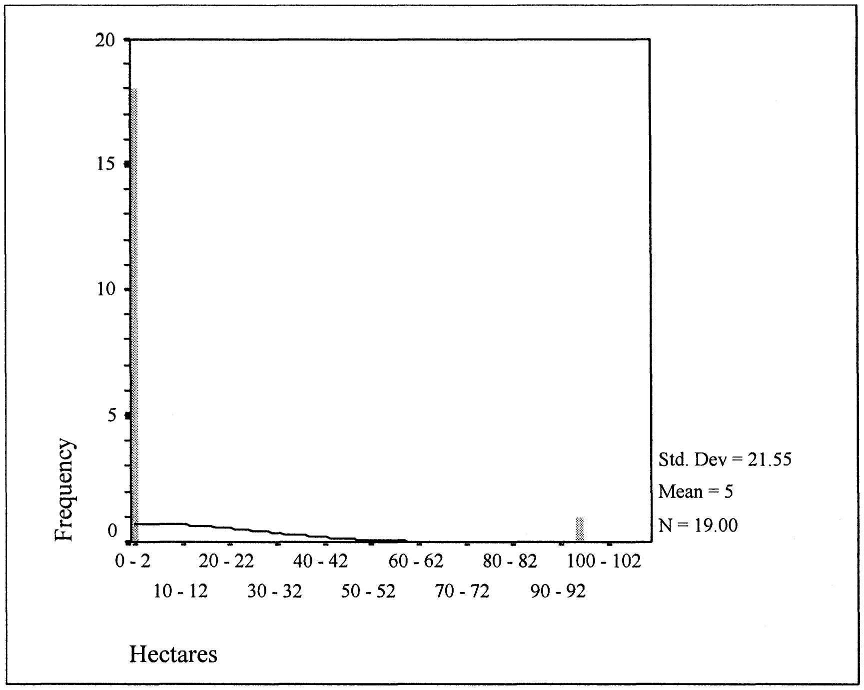


Figure 6. Moundville II / III Site Size Distribution.

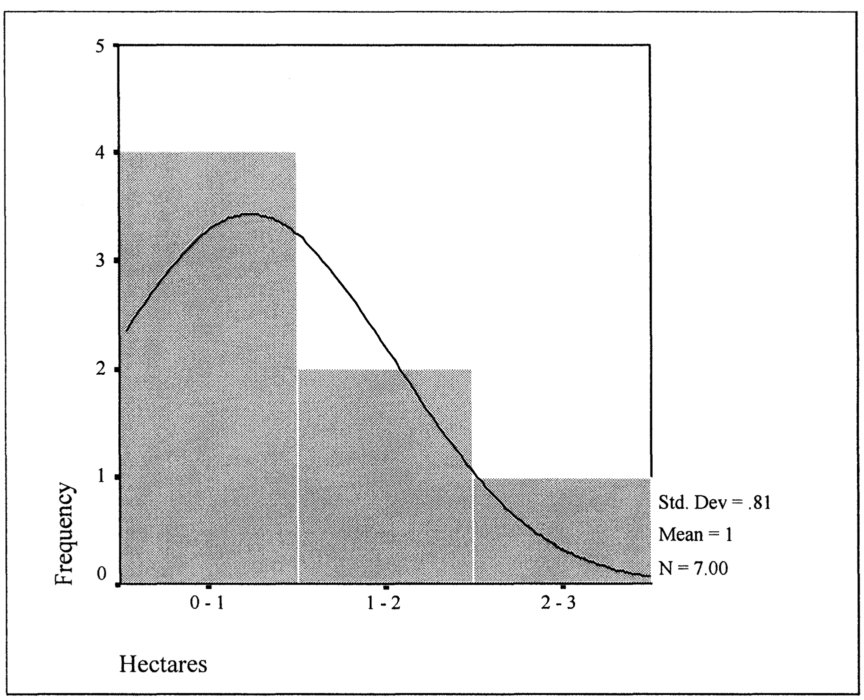


Figure 7. Moundville IV Site Size Distribution.

Moundville II / III reveal the reorientation of settlement towards one large site (Moundville) and several smaller single mound and farmstead-sized sites. Unfortunately, my hypothesis does not support my disintensification model: no differences in site size distribution were identified between Moundville I (before proposed disintensification) and Moundville II / III (after disintensification). Instead, they simply confirm the distinction between chronological phases in which Moundville was active, and the periods before it was established and after it declined.

In support of my disintensification model, I had hoped that a trimodal distribution might be revealed during the Moundville II / III subphases, representing Moundville, single mound centers, and the farmsteads. However, it is clear from the site size variances reported for each subphase in Table 10, and borne out by archaeological evidence of small resident populations at single mound centers (Bozeman 1982, Ensor 1993, Welch 1998) that there is simply not enough difference in site sizes or resident population between farmsteads and single mound sites to distinguish a third mode during this period.

Hypothesis Four:
Distance between sites will be greatest during West Jefferson because population is concentrated in fewer villages of larger size. Distance between sites will be only slightly lower during Moundville I, because population has now become concentrated at Moundville proper and a few smaller sites throughout the valley. After disintensification, during Moundville II and III, distance between sites will become smaller as the population spreads out into a greater number of smaller sites dispersed throughout the valley. During Moundville IV, distance between sites will again increase as population aggregates into fewer large settlements.

It was necessary to know the distance between all sites within each subphase in order to evaluate this hypothesis. I chose to take advantage of the basic location information in the Alabama State Site File, rather than performing the cumbersome and error-prone technique of measuring distances directly from mapped locations. Most sites in the Site File have UTM coordinates. For those sites that did not, I figured them individually, using a clear plastic UTM Coordinate Grid Reader and the plotted site locations on USGS 7.5' (1:24,000 scale) quad maps.

In the UTM system, the globe is divided into sixty zones stretching from pole to pole, each covering approximately six degrees of longitude. Moundville is located in Zone 16. UTM coordinates are expressed in "northing" and "easting" values (meters north and east of the southwest corner of the zone), and represent a single point on a map (USGS 2001). For archaeologists, this point represents the center of an archaeological site. For example, the UTM coordinates of the Moundville site are E441000, N3652000, reflecting a distance of 441,000 meters east and 3,652,000 meters north of the southwest corner of Zone 16.

UTM coordinates follow a Cartesian grid system overlaying a Mercator Projection map, which by definition represents true right angles and distances, rather than a curved projection that represents true shapes and proportions (Wilford 2000:90). Therefore, I reasoned it would be possible to apply basic geometric principles to determine distances between individual points on such a map. Specifically, the distance between two sites could be conceptualized as the hypotenuse of a right triangle, with one leg of the triangle being the distance (i.e., mathematical difference) between the easting values for each site, and the other leg of the triangle being the distance between the northing values for each site. I simply calculated the Euclidean distance between each pair of sites (Doran and Hodson 1975:23-25), and figured the trimmed mean distance between sites within each phase or subphase (Table 13). I used paired Student's T-tests to evaluate the differences between means. There were no significant differences in mean distance between sites from West Jefferson to Moundville I. However, there was a significant increase in mean distance between sites from Moundville I to Moundville II / III, and a significant decrease in mean distance between sites from Moundville II / III to Moundville IV (Table 14). Unfortunately, these results do not support my hypothesis that mean distance between sites would decrease during Moundville II and III following disintensification, or that it would increase during Moundville IV due to population aggregation in larger villages.

Table 13. Mean Euclidean Distances Between Sites by Phase/Subphase.

Phase/Subphase	n	Mean*	Variance	Range
West Jefferson	1700	10.68	42.08	.79-24.207
Moundville I	32	11.06	27.21	1.54-20.94
Moundville II / III	119	12.93	38.10	.75-25.29
Moundville IV	81	9.11	23.08	.39-21.14

*Trimmed Mean

Table 14. Student's T-test of Hypothesis Four.

Phase/Subphase Tests	Student's t	Degrees of Freedom	One-tailed Value
West Jefferson vs. Moundville I	-0.41	33	0.34
Moundville I vs. Moundville II / III	-1.73	58	0.04
Moundville II / III vs. Moundville IV	4.91	197	0.00

In retrospect, this hypothesis should have been more refined, because it fails to take into account the possibility that the size of the territory may have changed over time. This is certainly true of the Moundville IV subphase, which ranges across no more than 25 linear kilometers of the Black Warrior River valley, which at an average valley width of 6.5 km, represents a total area of 16,250 hectares. In contrast, the Moundville I expression of the Moundville chiefdom encompassed 50 linear kilometers (32,500 ha) of river valley. Even if populations remained the same across the temporal boundary (as I asserted in hypothesis two), mean distance between sites would necessarily be smaller because the overall territory of the Moundville IV occupation decreased by half. A better test of this idea would have been site density (perhaps mean number of sites per hectare) rather than mean distance between sites, because it would reflect changes in territory size as well as number of sites.

Results

My diachronic analysis of Moundville settlement pattern was designed to test the proposition of economic disintensification, coincident with the population dispersal of A.D. 1300. Part of this process involved finding out whether the population that dispersed from Moundville actually moved out to the farmsteads and single-mound centers across the Black Warrior River Valley, or if they had relocated altogether.

My model was initially upheld, in that I found fewer sites when I predicted that the population was nucleated and a greater number of sites when I predicted that the population was dispersed. However, mean site size did not change according to my predictions: there was no difference in site size between periods of population nucleation and periods of population dispersal. I was also successful in picking out the different modes of site size between the unimodally distributed West Jefferson and Moundville IV villages and the bimodal distribution of the paramount center and smaller sites during the Moundville I and II / III subphases. Unfortunately, I was unable to identify population dispersal in this pattern, because there was no difference in modes between the Moundville I and Moundville II / III subphases. Finally, I found a statistically significant difference in distance between sites from Moundville I to Moundville II / III and from Moundville II / III to Moundville IV. Unfortunately, the change in distance was opposite to what I had predicted: mean distance between sites increased after disintensification, and decreased in the Protohistoric period, rather than the opposite, as I predicted.

However, the direction of the change in distance between sites may differ when variation in territory size is factored into the equation. This would have the effect of altering distance between sites, even though there were more sites overall during Moundville II / III, and fewer sites during Moundville IV.

Overall, only one of four hypotheses yielded results to confirm that the Moundville population that vacated the ceremonial center had indeed relocated to outlying farmsteads, representing a population dispersal associated with disintensification. The three unsupported hypotheses do not suggest that the migrating population actually left the Black Warrior River valley. The results of my Moundville settlement analysis led me to conclude:

1. When territorial populations are small, even functionally and socially distinct site types may be very similar in size. This may explain why there

was no difference in mean site size between subphases, as demonstrated in hypothesis two.

2. A farmstead is a farmstead is a farmstead. It is clear from the literature review that the Moundville I outlying sites were small farmsteads, and the Moundville II / III outlying sites were farmsteads and single mound centers. Since there is no demonstrable difference in size between these two site types (as reported for hypothesis two), it is not surprising that there was no difference in modes between the Moundville I and Moundville II / III subphases, as reported for hypothesis three. This hypothesis would have only held true if hypothesis two had proven valid.
3. Population dispersal is probably more accurately reflected in a measure of population density. Hypothesis four, which tests population dispersal using mean distance between sites, makes the unstated assumption that territory size remained constant throughout (and beyond) the life of the chiefdom. A population density measure that takes into account changes in territory size over time is a stronger test of population dispersal.

Not unlike my discussion of Moundville subsistence, in which I discovered that the data were inadequate for testing my disintensification model, I find that in the case of settlement pattern, my hypotheses are not completely adequate for testing disintensification. In future iterations of this material, I will attempt to address those inadequacies with additional tests of the model specifically designed to take into account territory size, site size variation, and population. Of the two hypotheses that did appropriately test the model, I found that the number of sites increased post-dispersal as

I had expected, but that site sizes did not change from West Jefferson and Moundville IV villages to Moundville farmsteads and single mound centers, which was not as I had predicted. I cannot claim that my model of disintensification in the wake of population dispersal at Moundville is strongly supported by my analysis of settlement pattern data. In the following chapters, I make a similar test of disintensification using data on human health and nutrition from human skeletal remains recovered from Moundville and surrounding sites. In my initial research model, I proposed that disintensification would have three sets of interrelated archaeological correlates: change in subsistence, change in settlement pattern, and change in human health. I have so far had little success in demonstrating disintensification with the first two sets of correlates, and have suspected that the model is faulty. If the health indicators also fail to show disintensification, I will be forced to draw mixed conclusions: my model is valid, but I was incorrect in suggesting that disintensification occurred in the Moundville chiefdom.

CHAPTER 5

HEALTH AND NUTRITION AT MOUNDVILLE: MATERIALS AND METHODS

Mississippian populations practicing intensive corn agriculture and living in nucleated villages suffered a decline in overall health in comparison with earlier populations (Lallo et al. 1978; Larsen 1981:422). Diets dependent on corn are poor in essential nutrients and proteins, and can lead to protein malnutrition and generalized health stress (McNeill 1991:46). Furthermore, the high levels of simple carbohydrates found in corn-dependent diets result in severe dental problems due to increased incidence of dental caries (Larsen 1980; Larsen 1997:68-69). Residents of nucleated settlements are exposed to health threats in the form of communicable disease due to crowding and increased parasite load due to poor sanitation (Benfer 1984; Roosevelt 1984; Rose et al. 1984). If disintensification occurred at Moundville and brought with it settlement dispersal and subsistence diversity, then we should expect an overall improvement in human health measured in improved nutrition and decreased exposure to crowd diseases and environmental stressors (Powell 1998).

In this chapter, I outline the primary research I undertook to examine the health and nutrition of Moundville and related populations from the Moundville I through Moundville IV subphases. Following an overview of the historical context for this research, I discuss in detail the materials and methods for my analysis. In particular, I address the strengths and limitations of the skeletal sample, followed by step-by-step data collection methods broken down into individual components: skeletal and dental inventory, ageing and sexing, and paleopathological evaluation of the individual remains. Finally, I discuss my data coding and data entry. In the following chapter, I will address my data analysis and conclusions.

Previous Skeletal Research on Moundville Populations

Previous skeletal research on Moundville populations can be divided into two eras: early descriptive studies and later integrative analyses focused either on fitting Moundville human skeletal remains within the context of Moundville studies or on using Moundville human skeletal remains to answer larger questions of regional prehistory or skeletal biology.

The earliest skeletal analysis of Moundville skeletal remains was performed by physicians at the U.S. Army Medical Museum on samples collected by C.B. Moore in his excavations of 1906. Dr. James Carroll, U.S. Army Assistant Surgeon and Curator of the Army Medical Museum, reported that 50 of 70 skeletal specimens submitted from Moore's Moundville excavations showed positive indications of syphilis (Moore 1996b [1907]:339-340). At this time in the history of medicine, it was thought that syphilis was strictly of Old World origin, and did not have a pre-Columbian American counterpart, as is now believed to be the case (Braun, Cook & Pfeiffer 1998; Buikstra & Cook 1981; Cook 1994). Nonetheless, in his 1907 Moundville report, Moore (1996b [1907]:340) went to great pains to forestall any suggestion of a European source of the infection, citing the total lack of archaeological or anecdotal evidence for any early European occupation of Moundville. Also in the course of his investigations, Moore submitted one of two intact skulls recovered from near Mound D to the United States

Army Medical Museum, where it was examined by Dr. Aleš Hrdlička, who reported that the skull exhibited mild cranial remodeling which was in his opinion an accidental byproduct of cradle-boarding (Moore 1996b [1907]:338).

The next phase of skeletal studies coincided with the Alabama Museum of Natural History WPA-era excavations. The first was a medical article by Haltom and Shands (1938), on the "Evidence of Syphilis in Mound Builders' Bones" published in the *Archives of Pathology.* During the same period, Snow (1941a) examined and catalogued all of the human skeletal remains from the WPA Moundville excavations. The University of Alabama's Laboratory of Osteology maintains a card catalog of his inventory and comments on each Moundville skeleton. Snow's major publications on the Moundville collection include monographs on craniometrics and cranial morphology (Snow 1941a), scalping (Snow 1941b), and an analysis of two Moundville achondroplastic dwarf skeletons (Snow 1943).

After World War II, the Moundville skeletal collection was used in several student papers, including Bass's 1956 Master's thesis on *Indian Crania from Moundville, Alabama*, and Coleman's 1965 Master's thesis on *Anthropometric and Morphological Studies on Cranii of the Moundville Indian*. Hutchinson (1979) later used the Moundville collection as part of a master's thesis on the biological relationships between Archaic and Mississippian populations in northern Alabama.

On the cusp of the 1980s, Hill began a long professional interest in Alabama's Protohistoric period when she completed her 1979 Master's thesis on the skeletal biology of the Alabama River phase, now known as the Moundville IV subphase. Among her thesis materials, Hill examined skeletal remains from two sites in the Black

Warrior River Valley, 1Tu4 and 1Tu49. Hill continued her protohistoric research with a skeletal analysis of 22 additional individuals from 1Tu4 (Hill-Clark and Clark 1981), and a five-site study of paleopathology during the Mississippian and Protohistoric phases in Alabama (Hill-Clark 1981). Hill also published an archaeological and bioarchaeological overview of Alabama's Protohistoric period featuring her investigations of skeletal populations from sites 1Tu4, 1Tu49, and 1Wx1 (Hill 1996).

In the mid-1980s Mary Lucas Powell's long-standing research program on the Moundville human skeletal remains began with her doctoral dissertation. Powell (1985a, 1986, 1988, 1991a, 1992a, 1998) examined large samples of the Moundville burial population for correspondence between health and social status, and found slight, though statistically insignificant, differences between elite and nonelite social strata. Powell has also examined dental wear and diet at Moundville (1985b), and in conjunction with various colleagues (Bridges et al. 2000; Jacobi et al. 1996), she has addressed the question of interpersonal violence at Moundville. Powell has also distinguished herself as an authority on tuberculosis and treponematosis in the American Southeast, using Moundville samples as exemplars (Powell 1991b, 1994, 2000).

As part of the University of Michigan Museum of Anthropology Moundville project, Peebles and Schoeninger (1981) performed one of the few bone chemistry analyses on Moundville remains. They tested bone strontium levels to see if there were appreciable differences in meat consumption between elite and nonelite social strata at Moundville. They recorded strontium levels suggesting that the elite ate more meat protein than the nonelite, and that males ate more meat than females. Unfortunately, due to small sample size, these differences were not statistically significant (Peebles and Schoeninger 1981). Likewise, Haddy and Hanson (1981) subjected a small sample of Moundville human remains to nitrogen and fluorine dating, in order to test the feasibility of using the Moundville burials as an index for relative dating of the mounds they were buried near. Their results indicated that with proper consistency of sampling, it was possible to relative date the burial contexts to early, middle, and late periods in the Moundville sequence (Haddy and Hanson 1981).

In the past decade, Schoeninger and Schurr (1998) also reported on stable isotope analyses of human subsistence at Moundville that reflect patterned changes in maize consumption consistent with the major demographic events at Moundville. The wholesale change in settlement pattern in the early Moundville IV subphase is indicated by a statistically significant decrease in maize consumption (Schoeninger and Schurr 1998:120). In a later publication, Schoeninger and colleagues (2000) also discussed these data in the context of the rise and subsequent collapse of the chiefdom at Moundville. They hypothesize that the decrease in maize consumption during the Moundville IV subphase may have been due to a drop in maize productivity, perhaps caused by some type of pest or pathogen, exacerbated by over-reliance on only two varieties of maize as opposed to the greater diversity of maize varieties found in earlier subphases.

Analysis of human burials at Moundville by previous researchers indicates that the population was generally healthy and well nourished through time (Mistovich 1995:168; Powell 1985a, 1986, 1988, 1991a, 1992a, 1998). Armelagos and Hill remarked upon the "absence of significant differences in frequencies of occurrence of stress indicators across status boundaries" (1990:33). In general, Moundville's position in the rich Black Warrior River valley seems to have ensured that the entire population was well fed and healthy. Mortality curves follow the typical pattern seen for most agricultural peoples: high infant and childhood mortality, low mortality among adolescents and young adults, and a slow increase in mortality as individuals aged (Peebles and Black 1987:30).

Powell's (1985a, 1988) synchronic study of 1500 Moundville-era burials reveals normal occurrences of developmental disturbances in childhood, with linear enamel hypoplasia limited generally to the age of weaning (Powell 1998:108), as is expected in preindustrial populations. She also found that porotic hyperostosis did not occur at all, and cribra orbitalia occurred rarely (Powell 1998:109), suggesting limited exposure to nutritional stress and parasite load. In a later diachronic study covering the Moundville I through Moundville III phases, Powell recorded a small increase over time in stature for adults, a small increase in diet-related dental disease probably associated with increase in maize consumption, and a decline over time in severe cases of iron-deficiency anemia among subadults (Powell 1998). Powell also recorded episodes of "possible" treponematoses and tuberculosis at low levels in the Moundville II and III subphases (Powell 1998:117). "The overall picture conforms logically to the site's changing role from a major population center to the paramount regional mortuary site, as the growing population gradually spread throughout the Black Warrior River Valley" (Powell 1998:102).

During the Moundville IV subphase, there is evidence of a decline in overall health, with a slight increase in skeletal pathologies over earlier periods, though the rate remains within the low range overall (Schoeninger et al. 2000). Hill (1996) attributes the increase in skeletal pathologies, especially porotic hyperostosis and dental enamel hypoplasia, to nutritional stress. Rates of anemia during this period increase slightly, possibly due to increased parasite load associated with population aggregation. Tuberculosis continues to appear at Moundville during Moundville IV, and treponemal infection is present within the population at an endemic level. By the end of the Moundville IV subphase, Native Americans of the interior southeast had been in contact with the Spanish via the DeSoto expedition (1539-1543), and even if DeSoto did not visit Moundville, earlier expeditions along the coast may have brought diseases that had penetrated the interior by this time. However, the virulent diseases that were brought by Europeans such as smallpox and influenza do not leave skeletal signatures because they are such quick killers (Schoeninger et al. 2000). Therefore, it is impossible to tell if they were present in a population without evidence of a total demographic collapse associated with a devastating epidemic.

In general, there also seem to have been fairly high levels of violence and warfare in the Southeast during late prehistory. With the exception of Moundville, at which there is little evidence of violence, mortality from interpersonal conflict is three times higher among Late Woodland and Mississippian populations than it is in Archaic populations (Bridges et al. 2000:44). Also, before the Mississippi period, males and females had roughly equal chances of dying violently. In the Mississippi period, males were more frequently killed, and there was consistently higher adult mortality from violence (Bridges et al. 2000). "Warfare between elites as a means of achieving power and prestige and as a mechanism for establishing and enforcing tributary relationships

… is well documented” (Anderson 1996:246) among chiefdom level societies in the Southeast. Conventional wisdom suggests that endemic warfare among the Mississippian elite would result in higher rates of violent trauma among males than females, and higher rates among the elite than among the nonelite. Ultimately, however, the paleopathological record of interpersonal violence at Moundville reflects no evidence of violent death and only two cases of healed scalping from Moundville burial contexts (Bridges et al. 2000:40). Steinen argues that Mississippian warfare was largely symbolic, “conducted for limited objectives that ranged from punishment to revenge to the desecration of temples, and they were not conducted to destroy whole populations or occupy territory” (Steinen 1992:134). For this reason, he argued that raids were directed at the chiefly mound centers rather than at the outlying settlements and therefore only the centers needed to be palisaded and protected. Furthermore, individual vulnerability to injury or violent death was directly proportional to the quality of defensive palisades at a site (Bridges et al. 2000). Perhaps it is the case that Moundville was so well protected by its palisade that the internal residents were not vulnerable, and that the external residents were equally protected because they were not seen as appropriate symbolic targets of war.

The most detailed studies of human health and diet for Moundville have been synchronic, and limited to either a generalized Moundville population (Powell 1985a, 1988), or specifically to the Moundville IV subphase (Hill 1979, 1996). The only diachronic investigation has been by Powell, who made a limited study of Moundville I through III phase burials in her 1998 contribution to Knight and Steponaitis’ Moundville volume, with a sample of 144 individuals (Powell 1998:113). My goal is to expand the physical and temporal boundaries of this diachronic study, to include not only Moundville I through Moundville III subphase burials from Moundville proper, but also to include individuals who lived during the Moundville IV subphase, and those who lived at outlying sites within the Moundville chiefdom.

The Skeletal Analysis

Materials

Over the course of seven months in 2002 and 2003 I collected paleopathological data on human skeletal remains from the Moundville chiefdom. These remains are curated at the University of Alabama Museums Osteological Laboratory, in Tuscaloosa, Alabama. I examined nine collections of human skeletal remains dating from the Moundville I through Moundville IV subphases (Table 15).

Table 15. Osteological Data Sources.

Site Number	Site Name	Moundville Subphase	Sample (n)	% of Total Curated Remains
1TU1	Pride Place	Moundville IV	6	1%
1TU2	Snows Bend	Moundville II-III	12	2%
1TU4	Moody Slough	Moundville IV	43	7%
1TU42/43	Moon Lake	Moundville IV	6	1%
1TU44/45/346	Jones Ferry	Moundville I	5	1%
1TU49	Baker	Moundville IV	30	5%
1TU93/5	Lon Robertson	Moundville IV	3	0%
1TU343	Phillips	Moundville IV	19	3%
1TU500	Moundville	Moundville I-IV	505	80%
Total			629	100%

<u>The Moundville Sample</u>

Steponaitis (1980a, 1983a) assigned each burial to a specific Moundville subphase or range of subphases based on diagnostic ceramic styles found in each gravelot. In his analysis, each vessel from a burial context was dated independently by ceramic type/variety, vessel form, or various decorative modes, and assigned a subphase designation of Moundville I, II, or III. Individual vessels were then grouped into gravelots associated with each burial, and the range of dates for the entire gravelot was established, representing the range of dates for the burial itself (Steponaitis 1980a:233-234). I am using only those burials that could be assigned to a single subphase, so as to be absolutely certain of the date for each individual set of human remains. It could be argued that when the burial dated to a range of subphases, the interment itself must necessarily date to the terminal end of the range, and that earlier subphase diagnostics represent curated specimens used in a special context. However, prehistoric burials were commonly reopened for subsequent interments, and may also have been intruded upon by later burial shafts or other features, which might have resulted in mixing. Since closed contexts are not guaranteed, those from multiple subphases were ruled out to guard against mixing of subphases within the skeletal sample. For the purposes of this diachronic study, I needed to know the exact chronological position of each set of remains to make comparisons between and among subphases. Of the roughly 1500 sets of remains (Powell 1985a) housed at the University of Alabama Laboratory of Osteology, less than five percent dating to a single-Moundville subphase (Steponaitis 1980a) were sufficiently complete for analysis (Table 16).

Table 16. Moundville Skeletal Sample by Subphase.

Subphase	Sample (n)	% of Total
Moundville I	11	16%
Moundville II	17	24%
Moundville III	41	59%
Moundville IV	1	1%
Total	70	100%

The Outlying Sites

To compare the health and nutrition of non-Moundville residents with their Moundville counterparts, I also examined burials from outlying sites within the presumed political boundary of the Moundville chiefdom and the physical boundary of the Black Warrior River Valley. I was initially concerned about the comparability of social status between the individuals in the Moundville and non-Moundville samples. The Moundville sample was dated by the ceramic styles of pots in the graves, and the outlying sites were dated according to the phase affiliation of the site as a whole. More specifically, I was concerned that the individuals in the Moundville burials might have been of higher status than those outside of Moundville because they were buried with diagnostic (and therefore probably more elaborate) grave goods. However, Powell's (1985) dissertation did not discover any statistically significant health differences between the status groups at Moundville. Therefore, even if the two samples were of different status, it would have no effect on the validity of a paleopathological analysis.

The skeletal samples from outlying sites were generally small due to site size and poor preservation (Table 17), coupled with the limited excavation coverage of most outlying sites. The largest samples were from Moundville IV subphase sites, Moody

Slough (1TU4) and Baker (1TU49). Overall, Moundville IV skeletal remains dominate the sample from the outlying sites, making up over ninety-two percent (N=93) of the entire sample. This ratio further supports Knight and Steponaitis' (1998b) contention that the Moundville site acted as a necropolis throughout most of the Moundville phase. It was only during the Moundville IV subphase, after the decline of Moundville's authority, that burials commonly took place in outlying villages. By way of comparison, only a single burial at Moundville (1% of the total sample) dates to the Moundville IV subphase.

Table 17. Skeletal Samples from Outlying Sites.

Site Number	Site Name	Subphase	Sample (n)	% of Total
1TU1	Pride Place	Moundville IV	3	3%
1TU2	Snows Bend	Moundville II-III	8	8%
1TU4	Moody Slough	Moundville IV	43	41%
1TU42/43	Moon Lake	Moundville IV	4	4%
1TU44/45/346	Jones Ferry	Moundville I	5	5%
1TU49	Baker	Moundville IV	27	25%
1TU93/5	Lon Robertson	Moundville IV	6	6%
1TU343	Phillips	Moundville IV	10	9%
Total			106	100%

Methods

Data Collection

At the University of Alabama Osteology Lab, human skeletal remains are stored in paper bags and curated in steel cabinets organized by site number. A comparative collection is available in the osteology lab to double-check bone identification and siding, including a large collection of fetal and subadult comparative specimens. In addition, the osteology lab provides essential tools, specifically an osteometric board and spreading caliper. For my research, I supplied the remaining tools, including a metric cloth tape and Mitutoyo 150mm digital sliding caliper.

My goal in data collection was to maximize time and minimize extraneous paperwork. The coding sheets are designed to ensure comparability of data, and are based on numerical and alphabetic codes that can easily be entered into a database for analysis. My methods follow the protocol set out by Buikstra and Ubelaker (1994) in their *Standards for Data Collection from Human Skeletal Remains* (SOD), but are not identical. The SOD was intended to comprehensively record skeletal collections that might be destined for repatriation and reburial, and thus was designed to collect comparable data on all aspects of human remains including pathology, nonmetric variation, and osteometrics. As such, large volumes of data are collected and carefully coded to preserve the information should the skeletal collection become unavailable. Furthermore, this coding system is particularly useful for large skeletal samples that may number in the thousands of individuals, and for the purposes of standardizing data in order to run exploratory multivariate statistics on a large scale. In the interests of efficiency, I chose to perform a more abbreviated analysis with a simpler recording system, since all of the data that Buikstra and Ubelaker suggest collecting were not required for my analysis. I collected my data according to the following seven steps.

Step 1: Getting Started

I retrieved the bags for each set of skeletal remains from the curation room, and double-checked the site number, bag number, and skeleton number with the inventory list I created during my preliminary research and feasibility study. Next, I emptied the bags and placed the skull (when present) on a beanbag for stability and protection against damage. I sorted the remains on trays, according to element and side. This sorting process prepared me for the skeletal inventory.

Step 2: Skeletal inventory

I recorded the skeletal elements present, their side, and completeness. I did not attempt to identify or side individual ribs, since they were typically very fragmentary, except for the first and second ribs when present. Similarly, I recorded most hand, foot, wrist, and ankle elements as unsided, other than the talus and calcaneus. For complete or near complete skeletons, I used SOD Attachment 1, *Inventory Recording Form for Complete Skeletons*. For incomplete or isolated remains, I used SOD Attachment 2, *Inventory Recording Form for Commingled Remains and Isolated Bones*.

Step 3: Adult sex and age, Subadult age

Using SOD Attachment 11, *Adult Sex / Age Recording Form* for adult remains, and SOD Attachment 12, *Immature Remains Recording Form: Bone Union and Epiphyseal Closure* for subadult remains, I recorded diagnostic characteristics of age and sex. In most cases only a few of the pelvic and/or cranial sexual characteristics were present, because of the fragmentary nature of the remains. I was unable to use the pubic symphysis for ageing adults, because it was not preserved in any of the specimens that I examined. I also chose not to use the auricular surface of the innominate for age estimation because it was rarely preserved. For ageing adults, I was often able to record closure of the external and internal cranial vault sutures along the sagittal and coronal planes, but rarely any of the temporal or palatine sutures. These suture closure scores permit identification of age for adults within broad age categories (Buikstra and Ubelaker 1994: 36-38). For a more precise ageing method I used Lovejoy's (1985) dental wear stages, which divide the adult age spectrum into nine (maxillary) or ten (mandibular) wear stages between age 12 and age 55. As both White (1991:311) and Lovejoy (1985:54) suggest, dental wear is not a precise indicator of the age of an isolated individual, but is a valuable tool in the context of an entire skeletal population. For the Moundville and outlying samples, I am not confident that the ages designated for each stage actually correspond to the chronological age of each individual because overall, they seemed to have a lesser degree of dental wear than other prehistoric populations and therefore may have been scored erroneously young. However, I recorded the scores consistently across the sample, so although I cannot be confident that, for example, an individual from the Moundville sample who scored a dental wear stage E is really 24 to 30 years old (Lovejoy 1985:51-52), I am confident that two individuals from the Moundville sample who each scored in dental wear stage E really are of roughly the same age as one another.

For ageing subadults, the major epiphyses were usually present, such as those of the scapula, clavicle, humerus, femur, tibia, and innominates. The degree of fusion of long bone epiphyses to diaphyses can be used to estimate a subadult's age within a range as narrow as one year or as broad as five to ten years, depending on the skeletal element and the age of the child (Scheuer and Black 2000; Schwartz 1995). Because subadults are still growing and the lengths of their long bones change over time, it is also possible to estimate a child's age by comparing individual long bone diaphysis lengths to population averages of long bone diaphysis lengths from individuals of known age at death. I used comparative long bone osteometric charts from Sundick's 1972 analysis of the Archaic period Indian Knoll population from Kentucky (Ubelaker 1989:72-74) to estimate subadult ages for the Moundville and outlying samples. Although the Indian Knoll population is fairly far removed from Moundville in time, it is geographically closer to Moundville than the Arikara comparative population cited by Ubelaker (1989) and temporally and ethnically closer than the modern clinical sample cited by Scheuer and Black (2000). Furthermore, Ubelaker suggests that the growth curves show "little variability in rates of growth" (1989:69) across all prehistoric Native American populations. For fetal, perinatal, and neonatal remains I used Scheuer and Black's (2000) tables of long bone lengths, which can be used to age infant remains within a one- to two-week time frame of gestational or natal weeks. In instances where the subadult bone was incomplete, I was often able to match it with a complete bone of the same size and developmental stage in the comparative collection, and then use the length measurement of the complete bone as a proxy for the incomplete archaeological specimen.

Subadults and young adults are also easily aged using dental development stages of tooth development and eruption. I recorded the presence / absence of each tooth, its degree of development, and the estimated subadult dental age, using SOD Attachment 17, *Dental Inventory Recording Form, Development and Pathology: Deciduous Teeth.* Using dental developmental stages, it is often possible to identify an infant or child's age within a range of as little as two months and as great as three years (Ubelaker 1989:64). Deciduous teeth provide an extremely tight chronology in their development, eruption, and eventual root atrophy and tooth loss, which when compared with the simultaneous development and eruption of permanent teeth allows identification of a relatively narrow window of time for the age of the child at death. As with osteometrics, however, these age ranges become broader as the child gets older, ending with the eruption and occlusion of the third molars around age 21 (Ubelaker 1989:64). Dental stages are extremely useful in physical anthropology, because we know that dental development is the growth factor that has the greatest genetic component and the least effect from environmental conditions (Goodman et. al 1984:21; Liversidge et al. 1998:420). Even in environments of physical or nutritional stress a child's dental age will remain relatively accurate, while his growth and development may be stunted or delayed due to malnutrition or illness and he may appear physically to be younger than his true chronological age. This is especially valuable in archaeological samples because we often test models of nutritional and physical stress, and it is useful to compare children's dental ages to their physical developmental ages, to see if there is a large discrepancy between the two. If so, we may hypothesize that stress has occurred. In cases where dental remains are not available, skeletal analysts collect as many estimates of age as possible and compare them against one another, to ensure consistency and guard against misidentifying a child's chronological age because of some environmentally mediated physical developmental delay.

I have also created two additional coding sheets for attributes not covered by, or otherwise modified from Buikstra and Ubelaker (1994). *Pathology Coding Sheet I* includes Section I on the osteometrics of sex and skeletal height. In this section, I recorded maximum diameter of the humeral and femoral heads, femur midshaft circumference, and femur anterior-posterior midshaft diameter. Powell (1988:88) created a comparative chart to estimate adult sex from these variables, using metric data from Moundville adults whose sex had been estimated using other diagnostic criteria. These measurements were then graphed for adult males and females, and can be used to estimate the sex of individuals for whom other diagnostic criteria were not well preserved. I took the measurements as they are defined in the SOD (Buikstra and Ubelaker 1994:80, 82-83), using digital sliding calipers and a cloth tape.

Step 4: Dental Inventory

The same form used for gauging subadult dental development is also used for a dental inventory, SOD Attachment 17, *Dental Inventory Recording Form, Development and Pathology: Deciduous Teeth.* I recorded the presence / absence of each tooth, its degree of development, and the estimated subadult dental age. For adults, I used SOD Attachment 16, *Dental Inventory Recording Form, Development, Wear, and Pathology: Permanent Teeth.* This form records tooth presence, development, wear, and dental pathology such as caries and abscesses. I did not record dental calculus for any skeletal remains in this sample, and recorded only caries that were visible to the unaided eye.

Step 5: Skeletal Height

Using *Pathology Coding Sheet I*, I also recorded long bone lengths for the femur, humerus, and tibia, if they were present and complete. I used these data to estimate adult skeletal height according to regression formulae as established by Sciulli and Giesen (1993) for prehistoric Native Americans of the Eastern Woodlands. These three skeletal elements were chosen because they were the most frequently preserved elements that had the highest confidence intervals. Skeletal height has 85-90% confidence when derived from the maximum femur length, 79-89% confidence from the maximum tibia length, and 87-92% confidence for the two measurements combined. Skeletal height calculated from the maximum humerus length has 78-83% confidence (Sciulli and Giesen 1993:398). Under the circumstances this is the greatest confidence I can achieve given the general absence of the more reliable indicators such as foot height or the sum of the heights of lumbar vertebrae. All long bone measurements were taken using a sliding osteometric board according to methods set out in the SOD (Buikstra and Ubelaker 1994:80-83).

<u>Step 6: Pathology</u>

Pathology Coding Sheets I and II condense information that is generally recorded on several additional SOD recording forms. In addition, I simplified the recording system for some of these traits, because the level of detail suggested by the SOD is more than necessary for my purposes. I divided pathology into several categories on these recording forms, including osteoarthritis, vertebral pathology, general pathology, porotic hyperostosis / cribra orbitalia, and cranial remodeling.

On *Pathology Coding Sheet I*, Section II, I recorded osteoarthritis by bone and side, and scored degree of lipping, eburnation, and surface porosity, with an estimate of the percent of the joint surface affected for each of these attributes. I used Section III of *Pathology Coding Sheet I* to score vertebral pathology, including lipping, osteophyte formation, and Schmorl's nodes. These sections are modified from the SOD protocol for evaluating arthritis and vertebral pathology (SOD Attachment 26). I recorded presence/absence of the condition, and the severity of its expression. The final section of *Pathology Coding Sheet I*, Section IV, covers general pathology, recording presence /

absence of treponematosis, periostitis, osteomyelitis, trauma and other pathological conditions.

Pathology Coding Sheet II, Section V, covers porotic hyperostosis and cribra orbitalia. Again, I modified it from the coding methods suggested by Buikstra and Ubelaker in the SOD, but developed a simplified recording grid that indicates presence / absence and whether the condition was remodeled or active at the time of death. Similarly, *Coding Sheet II*, Section VI addresses cranial remodeling as discussed in SOD Chapter 11, using a simplified coding system to record type, location, and symmetry.

Step 7: Wrap-up

Once the skeletal inventory was complete, measurements were made, and pathology was recorded, I took additional lab notes in a separate notebook, in which I recorded my general impressions of the health status of each individual. I also noted any problems or questions that I had, and anything that required a follow-up. Any remains that had pathology or other attributes of interest were digitally photographed at various standard and macro ranges, from all necessary angles. This created a visual file to go along with the primary data. I stapled together the entire set of data forms for each set of remains, and numbered them sequentially with a master catalog number as I analyzed them. Finally, I re-bagged the skeletal remains, double-checked the site, bag, and skeleton numbers, made sure that they matched what I recorded on the skeletal inventory, and returned the remains to the curation room.

Step 8: Data Coding and Data Entry

With data collection complete, I summarized the data on simplified coding sheets for ease of data entry. For each individual, I estimated chronological age as defined by each ageing technique (dental development, epiphyseal union, suture closure, osteometrics, and dental wear). Different ageing techniques deliver ages in differing degrees of precision, and ages are often reported as ranges (i.e., age 24 to 30) rather than single chronological ages (i.e., age 28). Therefore, when more precise ages were unavailable, I used the median of each age range as the chronological age for each individual. When ageing techniques contradicted one another, I allowed the dental indicators to take precedence, followed in order by epiphyseal and sutural diagnostics, osteometrics, and dental wear stages. For the purposes of gross comparison between adults and children, I then lumped these categories into infant (aged less than one year), subadult (one year to age 14.9) and adult (age 15 and over) designations (Powell 1986:132, 1992a:85, 1998:107,113).

Similarly, sex was coded as female, probable female, indeterminate, probable male, and male, using diagnostic indicators of the pelvis or skull and osteometric measurements. For purposes of gross comparison between the sexes, females and probable females were lumped together, as were males and probable males. On rare occasions when there were contradictory scores for more than one sex indicator, I allowed the score derived from the pelvis to take precedence, followed in order by the skull and osteometrics.

Next, I calculated skeletal height using the appropriate formula for males and females found in Table 18.

Table 18. Skeletal Height Formulae (Sciulli and Giesen 1993:398).

Sex	Element	Abbreviation	Formula
Males	Femur	(XF):	SkHt = 42.805 + 2.443 (XF)
	Tibia	(XT):	SkHt = 50.721 + 2.680 (XT)
	Femur + Tibia	(XF + XT):	SkHt = 39.630 + 1.360 (XF + XT)
	Humerus	(XH)	SkHt = 48.829 + 3.229 (XH)
Females	Femur	(XF):	SkHt = 44.253 + 2.336 (XF)
	Tibia	(XT):	SkHt = 49.527 + 2.668 (XT)
	Femur + Tibia	(XF + XT):	SkHt = 34.189 + 1.404 (XF + XT)
	Humerus	(XH)	SkHt = 62.360 + 2.706 (XH)

Pathological conditions were coded as present, absent, or as having insufficient preservation. This final category was used to distinguish true absence of a condition from cases in which a condition was "absent" because the relevant skeletal element or suite of elements was missing or too poorly preserved. In this way, the sample could include partially complete individuals who had relevant data to contribute, if only on a single element or pathology.

My greatest difficulty for partial remains was deciding when to code a condition as absent or simply incomplete. I developed different criteria for each pathological condition, depending upon the skeletal elements where evidence of each condition is most commonly found. In Buikstra and Ubelaker's (1994) SOD protocol, skeletal elements are scored 1, 2, or 3 for completeness. Bones that are greater than 75% present are scored "1," bones that are 25% to 75% present are scored "2", and bones less than 75% present are scored "3." Bones that are completely missing are not scored at all (Buikstra and Ubelaker 1994:7). I used these completeness scores to gauge how much of an element was left, and if there was enough present to know if a condition were present or not. In all cases, if a pathological condition was present, it was coded as "present." If it was not present, then I moved on to deciding if the condition should be scored as absent or insufficient preservation. In general, if more than 50% of the relevant skeletal elements were scored as "1" or "2" (i.e., more than 25% present), I concluded that there was sufficient preservation to score the presence or absence of a particular condition. I based these conclusions on Powell's 1991 overview of demography, status, and skeletal representation at Moundville, in which she considered individuals for whom more than one-fourth of the skeleton was present to have a "fair to good" degree of skeletal completeness (Powell 1991a:28, 1998:106). The following sections describe merely the coding methodology for each pathological condition that required coding for presence, absence, or insufficient preservation. Specific diagnostic criteria are more fully discussed in the relevant sections of Chapter Six.

Porotic hyperostosis appears most frequently on the frontals and parietals. If porotic hyperostosis was present, it was scored as present, and a second score was entered indicating whether it was active or remodeled at the time of death. In the SOD skeletal inventory, even though the frontal is a single bone in most adults, the left and right halves of the bone are scored as separate entities, as are the left and right parietals. In coding for porotic hyperostosis, there were two possible entries each for completeness of the frontal and the parietals. If porotic hyperostosis did not appear to be present, and one or both entries for either the fontal or parietal scored a 2 or higher (i.e., greater than 25% complete), I coded the condition as absent. Otherwise, it was coded as insufficient preservation. Cribra orbitalia is related to porotic hyperostosis, but is limited to the inner surface of the orbit on the frontal. Again, if cribra orbitalia was present, it was scored as present, and a second score was entered for whether it was active or remodeled at the time of death. If cribra orbitalia did not appear to be present, and if either or both halves of the frontal scored a 2 or higher (i.e., greater than 25% complete), I coded the condition as absent. Otherwise, it was coded as insufficient preservation.

Cranial remodeling is also identified on the skull, primarily on the large flat bones of the cranial vault, specifically the frontal, parietals, temporals, and occipital. Like the frontal, the occipital is a single bone, but completeness is scored for left and right halves separately. Therefore, among the bones of the cranial vault, there are eight possible entries for completeness. If cranial remodeling was observed, I coded it as such, and then coded the type (tabular, circumferential or other) and symmetry (symmetrical or asymmetrical). If cranial remodeling did not appear to be present, and four or more of the eight possible entries (50%) for the frontal, parietals, temporals, and occipital scored 2 or higher (i.e., greater than 25% complete), then cranial remodeling was scored as absent. Otherwise, it was scored as insufficient preservation.

Treponematosis is most easily observed on the anterior surfaces of the diaphysis of the tibia. In the SOD skeletal inventory, long bones are scored for each epiphysis, and for proximal, middle, and distal thirds of the diaphysis. Therefore, there are three possible entries for the left and right tibiae, for a total of 6 possible entries. Individuals exhibiting any diagnostic criteria of treponematosis were scored as "present". If the condition did not appear to be present, and 3 or more of the six possible entries (50%) for the diaphyses of the tibiae scored 2 or higher (i.e., greater than 25% complete), then treponematosis was scored as absent. Otherwise, it was scored as insufficient preservation.

Periostitis and osteomyelitis are bony reactions resulting from infection, and can appear with equal probability on any bone of the body. Because of the generally uneven preservation of most of the remains, I allowed the completeness of the long bone diaphyses to stand as proxy for the completeness of the entire skeleton. On the SOD skeletal inventory, there are entries for the left and right humerus, radius, ulna, femur, tibia, and fibula, for which the diaphyses are divided into proximal, middle, and distal thirds. There are a total of 36 possible entries for completeness of these skeletal elements. If periostitis or osteomyelitis was present, it was scored as present, except in the cases of periostitis associated with treponemal infection, which was scored separately and not included here to avoid redundancy. If 50% or more of 36 total entries scored 2 or higher (i.e., greater than 25% complete), periostitis and osteomyelitis were scored as absent. Otherwise, they were scored as insufficiently preserved.

Within Moundville and the surrounding population, trauma appears overwhelmingly on the long bone diaphyses and clavicles. In the SOD skeletal inventory, left and right clavicles are scored individually for completeness of the entire bone. Long bones are scored as described above for periostitis and osteomyelitis. If trauma was present anywhere in the skeleton, it was scored as present. Trauma was scored as absent if 50% or more of the 38 possible entries for all long bone diaphyseal segments plus left and right clavicles scored 2 or above (i.e., greater than 25% complete). Otherwise, it was scored as insufficiently preserved.

Unlike the previous conditions, which appear most frequently on long bone diaphyses, vertebral osteophytosis appears on vertebral centra and osteoarthritis appears on long bone epiphyses, the talus, and the calcaneus. In the SOD skeletal inventory, there are 11 possible entries for individually identified vertebral centra, and 28 possible entries for the left and right long bone epiphyses, tali, and calcanei. If osteoarthritis was present anywhere in the skeleton, it was recorded as present. If osteoarthritis did not appear to be present, and either 5 of the 11 possible entries (45%) for vertebral centra or 14 of the 28 possible entries (50%) for the long bone diaphyses, tali and calcanei scored 2 or higher (i.e., greater than 25% complete), osteoarthritis was scored as absent. Otherwise, it was scored as insufficient preservation. Note that I chose the cutoff of five instead of six out of eleven possible entries for vertebral centra, even though the latter would have brought the completeness over 50%. In many cases, only the five lumbar vertebrae were preserved, which are also the most common site for vertebral osteophytosis (Steinbock 1976:287). In cases where only the five lumbar vertebrae were preserved, and they were clearly not arthritic, I preferred not to code them as insufficiently preserved when spinal arthritis was most likely absent.

For dental health, I counted the number of permanent and deciduous teeth, and the number of caries and abscesses associated with each dentition. I used these data to standardize the degree of dental pathology by figuring the percentage of carious teeth and the mean number of abscesses per dentition. In addition, I also scored tooth wear for the permanent dentition for each adult. Typically, wear scores are collected for the maxillary and mandibular first and second molars, which can then be averaged across a population for comparative purposes. For posterior teeth, tooth wear is a composite score consisting of separate scores for each cusp of the tooth, which are then added to derive a single score for each tooth (Scott 1979). Wear scores from teeth on the left side of the arch were used when present, and if not, the antimere was used (Buikstra and Ubelaker 1994, Hillson 1996:236).

These data were entered into a Microsoft Excel spreadsheet for preliminary organization and data filtering. They were then translated to the Statistical Package for the Social Sciences (SPSS) or proprietary statistical software written by Dr. Harvey M. Bricker (Tulane University) for analysis. Data analysis and results of my investigations are detailed in the following chapter.

CHAPTER 6

HEALTH AND NUTRITION AT MOUNDVILLE: DATA ANALYSIS AND CONCLUSIONS

Data Analysis

My analysis is designed to examine patterns of health and nutrition among Moundville and related populations, particularly in terms of demography, chronic and acute infections, trauma, degenerative conditions, generalized health stress, and dental pathology. Specifically, I tested differences between adults and subadults and between adult males and adult females within Moundville subphases. I also tested for differences in health before and after the A.D. 1300 population dispersal, and again after the decline of the Moundville chiefdom.

My data are reported as rates of incidence of each pathological or degenerative condition. Qualitative data (i.e., presence / absence) were tested with the chi-squared statistic where sample sizes were sufficiently large and the distribution met the conditions of the test. I followed Drennan's (1996:197) "middle-course" rule of thumb for using chi-squared: "no expected value be less than 1 and that no more than 20% of the expected values be less than 5." Fisher's Exact Test was used in cases where the rates of pathological and degenerative conditions could not be evaluated statistically with the chi-squared test (Thomas 1986). Quantitative data were tested using Paired Student's t tests and Analysis of Variance (ANOVA) where appropriate. The results of all statistical tests were evaluated at a p value of .05 (Drennan 1996).

Paleodemography and Population Dynamics

Traditional demographic tools such as life tables and mortality curves are not appropriate for prehistoric populations, because the assumptions inherent in these techniques do not hold true for archaeological samples (Goodman et al. 1984; Howell 1982; cf. Meindl and Russell 1998). Some critics have even suggested that paleodemography should be completely thrown out of the analytical arena, or at least limited to reporting of age and sex ratios (Bocquet-Appel and Masset 1983). Specific criticisms are that archaeological samples are typically not representative of the population from which they were drawn, nor are they sufficiently large or normally distributed (Angel 1969; Buikstra and Mielke 1985; Goodman et al. 1984:16-17; Moore et al. 1975). In addition, it is difficult to determine age-at-death with the degree of accuracy assumed for standard demographic models of living populations (Bocquet-Appel and Masset 1982; Buikstra and Mielke 1985, Meindl and Russell 1998). Furthermore, demographic techniques assume stasis in terms of population growth or population size (Acsádi and Nemeskéri 1970; Goodman et al. 1984:16-17; Johansson and Horowitz 1986; Sattenspiel and Harpending 1983; Weiss 1973:6; Wood et al. 1992), which can rarely be assumed in archaeological populations. In particular, stasis in population growth is necessary for the most basic demographic statistic to be accurate – that mean age at death equals life expectancy at birth (Acsádi and Nemeskéri 1970). If this assumption is not upheld, then the remaining calculations in a life table are not valid. Ultimately, there are simply too many potential sources of error in paleodemographic analyses, and until and unless they can be overcome, I choose to report only age and sex ratios for comparison with other populations.

The first order of business is to determine if age and sex ratios within the population are normally distributed, in order to determine if any segment of the sample is under-represented. In a typical living population, the proportion of adult males to adult females is roughly 50/50 (Weiss 1972, 1973). Powell's (1988:89-94, 1991a:28, 1992a:85) synchronic study found a male / female ratio of 41 / 52% of the adult skeletal sample (Table 19). Similarly, in Powell's (1998:113) diachronic study she found similar ratios of adult males to females: 38 % males and 61% females (Table 19). Powell

Table 19. Adult Sex Ratios.

	Males		Females		Indeterminate		Total	
	n	%	n	%	n	%	n	%
Control Population	-	50%	-	50%	-	0%	-	100%
Powell Synchronic	173	41%	222	52%	29	7%	424	100%
Powell Diachronic	34	38%	54	61%	-	-	88	99%
Hodge Synchronic	43	45%	41	43%	12	12%	96	100%
Hodge Moundville I	5	42%	5	42%	2	16%	12	100%
Hodge Moundville II / III	21	46%	18	39%	7	15%	46	100%
Hodge Moundville IV	17	45%	18	47%	3	80%	38	100%

suggests that the discrepancy may be due to differential burial practices favoring interment of young males and older females within mounds (recalling that the available Moundville skeletal sample consists entirely of non-mound burials), possibly exacerbated by loss of young males in distant warfare, who would not have been returned home for burial (Powell 1986, 1992a, 1998). In my synchronic analysis, the ratio of males to females across all subphases was 45 / 43% (Table 19), reflecting a population almost evenly divided between males and females. In my diachronic sample, the male / female ratios before disintensification (Moundville I), after disintensification (Moundville II / III), and after the dissolution of the Moundville chiefdom (Moundville IV) are also comparable to one another and to my sample overall (Table 19), again reflecting an evenly divided population.

In a normally distributed nonindustrial population, subadults should comprise 30 to 50 percent of the population (i.e., a juvenile mortality rate of thirty to fifty percent) (Weiss 1973:49; Angel 1969). Powell found that subadults (age fifteen and younger) made up only 20% of the skeletal population in her synchronic Moundville sample (Table 20) (Powell 1985a:174, 1986:132, 1991a:29, 1992a:85, 1998:107), and 22% of her diachronic sample (Table 20) (Powell 1998:113).

Table 20. Population Ratios by Age Category.

	Infants		Subadults		Adults		Total	
	n	%	n	%	n	%	n	%
Control Population	-	50-80%	-	30-50%	-	-	-	100%
Powell Synchronic	25	4%	110	20%	429	76%	564	100%
Powell Diachronic	5	4%	32	22%	107	74%	144	100%
Hodge Moundville I	1	6%	3	19%	12	75%	16	100%
Hodge Moundville II / III	5	7%	15	22%	49	71%	69	100%
Hodge Moundville IV	14	16%	29	32%	47	52%	90	100%

This discrepancy suggests consistent under-representation of subadults, either by artificial selection at the time of burial, poorer preservation of the smaller, less dense and more fragile subadult remains, or bias on the part of excavators, who often fail to recognize fetal and infant remains in the field (Weiss 1973:12). Milner (1991:59) cautions that under-representation of infants may also result from the practice of secondary burial of infants, which would lead to loss of tiny infant bones prior to secondary interment. In particular, infants less than one year in age appear to have been starkly under-represented at Moundville, comprising only 4% of Powell's synchronic skeletal sample (Table 20) (1986:132, 1992a:85, 1998:107) and 4 % of Powell's diachronic sample (Table 20) (1998:113), in comparison to expected percentages of 50-80% infant mortality in a normally distributed nonindustrial population (Angel 1969:431, Table 3).

In my analysis, I found that the proportions of adults, subadults and infants in the Moundville subphases before and after disintensification paralleled Powell's synchronic and diachronic results fairly closely (Table 20), including their lack of fit with the expected ratio of 30-50% subadults. The likely explanation for this trend, as it was for Powell's analysis, is underrepresentation of subadults due to preservation and excavation bias.

Interestingly, during the Moundville IV subphase after the dissolution of the Moundville chiefdom, I found that proportions of adults and subadults closely reflected the expected ratios for a nonindustrial population (Table 20). These figures represent a decrease in the proportion of adults and an increase in the proportion of subadults from the previous subphases. Normally this might reflect a strong decline in life expectancy and increase in infant mortality. However, the Moundville IV mortuary pattern is distinct from earlier subphases, involving burial in large jars or urns (Cottier 1970; Curren 1982; Curren and Little 1981; Hill 1996). Adults were often bundled and placed in the urns as secondary burials, but infants and small children may have been placed in urns as primary interments (Cottier 1970; Curren and Little 1981; Brannon 1938:231, 1948:11), which would naturally be reflected in greater representation and preservation of infant and subadult remains. I do not believe that the differences I observed in proportions of adults, subadults, and infants between the Moundville chiefdom and the subsequent Protohistoric period have any bearing on change in health and survivorship in these populations. Instead, I believe that Powell was correct when she suggested that subadults were underrepresented during the earlier Moundville subphases. Furthermore, underrepresentation appears to have been corrected in the Moundville IV subphase due to better preservation and recovery of infant remains.

Porotic Hyperostosis and Cribra Orbitalia

Porotic hyperostosis and cribra orbitalia are part of a single disease process (Holland and O'Brien 1997, Stuart-Macadam 1987a, 1987b, 1989a, Wapler et al. 2004) attributed to varying etiologies (Angel 1966, Carlson et al. 1974; Goodman 1994:166-168; Hengen 1971; Holland and O'Brien 1997; Kent 1992; Lallo et al. 1977; Martin et al. 1985; Mensforth et al. 1978; Palkovich 1987; Stuart-Macadam 1987a, 1988, 1989b, 1991, 1992a). Porotic hyperostosis and cribra orbitalia are associated with hypertrophy of red blood cell producing (hemopoietic) marrow (Hengen 1971), which results in thickening of the diploë and subsequent thinning of the bone cortex due to pressure atrophy of cortical bone cells (Schultz 2001). The resulting porous lesions appear symmetrically on the frontal, parietal, and occipital bones in porotic hyperostosis, and on the upper inner surfaces of the orbit in cribra orbitalia (Goodman et al. 1984:29;

Stuart-Macadam 1987a, 1991, 1992a). The lesions have a characteristic sponge-like or coral-like appearance, and in radiographs exhibit an unmistakable "hair-on-end" profile (Moseley 1961, 1965, 1966; Ortner and Putschar 1981:259-260; Stuart-Macadam 1987a:522-523; Williams 1929:854-855). In adults, hemopoietic marrow only persists in the flat or spongy bones of the skeleton, but among infants and children the metaphyses and epiphyses of long bones also contain hemopoietic marrow (Stuart-Macadam 1985:393). Consequently, marrow hypertrophy may also occur in the long bones among subadults resulting in a spongy, porous and weakened bone structure (Angel 1967:379). However, Ortner and Putschar (1981:257; Moseley 1965, 1974; cf. Lanzkowsky 1968) suggest that such changes in long bones are limited to the hereditary anemias.

Cribra orbitalia and porotic hyperostosis have been attributed to various possible etiologies. These include external irritation or pressure from carrying water jars (Wood-Jones 1910a) or other burdens, or even from infant cradleboarding or artificial cranial remodeling (Williams 1929). Hrdlička (1914) also suggested that porotic hyperostosis and cribra orbitalia were caused by exposure to environmental toxins.

More recently, the etiological spectrum for porotic hyperostosis and cribra orbitalia has broadened (Ortner 2003a). In fact, Schultz (2001) emphasizes that these terms are mere descriptors of specific cranial lesions, and are symptomatic of several disease processes. In particular, possible causes are: anemia (Angel 1966; Carlson et al. 1974; El-Najjar 1976; El-Najjar and Robertson 1976; El-Najjar et al. 1975; El-Najjar et al. 1976; Hengen 1971; Holland and O'Brien 1997; Lallo et al. 1977; Mensforth et al. 1978; Moore 1929; Moseley 1965; Stuart-Macadam 1987a, 1991, 1992a; Williams

1929), inflammatory processes of cranial bone tissue (periostitis, osteitis, and osteomyelitis) and of the scalp (infection, hemorrhage) (Henschen 1961; Schultz 2001:131, 2003, Wapler et al. 2004), bone and soft tissue tumors (Schultz 2001:131, 2003), subperiosteal hematoma (Ortner 2003a), scurvy (vitamin C deficiency) (Schultz 2001:131, 2003; Williams 1929), and rickets (vitamin D deficiency) (Schultz 2001:131, 2003; Williams 1929). Some cases of porotic hyperostosis and cribra orbitalia are even attributed to postmortem erosion of bone surfaces (Wapler et al. 2004). These alternative hypotheses require careful differential diagnosis and consideration of population epidemiology in determining lesion etiology or etiologies. Schultz suggests that gross visual inspection and radiography, as have been commonly used by paleopathologists, are not sufficient to distinguish among the potential causes of porotic hyperostosis and cribra orbitalia. Instead, he advocates histological examination of affected samples (Schultz 2001:132-134).

Ortner (2003a:375) proposes that differential diagnosis of the varying causes of porotic hyperostosis and cribra orbitalia hinges on the association between anemia and marrow hypertrophy. Infection, scurvy, and rickets associated with porous lesions of the skull are limited to the bone cortex and are not associated with expansion of the diploë. With reference to scurvy, Hengen (1971:67) specifically discounts vitamin-C deficiency as a potential cause of porotic hyperostosis and cribra orbitalia. Upon differential diagnosis, Hengen suggests that cranial lesions of cribra orbitalia and porotic hyperostosis do not physically resemble those associated with scurvy, nor do anemic individuals exhibiting cribra orbitalia and porotic hyperostosis bear the postcranial stigmata of scurvy such as thinning of bone cortex. Similarly, Ortner and colleagues

(2001:345) caution that when diagnosing scurvy it is essential to *rule out* anemic porotic hyperostosis and cribra orbitalia, which feature similar cortical porosity, but scurvy does not result in marrow hyperplasia and enlargement of the diploë. Furthermore, they cite numerous additional skeletal stigmata of scurvy, including periosteal inflammation of the greater wing of the sphenoid, the "lateral margins of the orbit, the posterior maxilla, the interior surface of the zygomatic bone, the infraorbital foramen, the palate, and the alveolar process of the maxilla" (2001:344), as well as the coronoid process of the mandible and the metaphyses of long bones (Ortner et al. 2001:344).

Most commonly, however, porotic hyperostosis and cribra orbitalia are attributed to hereditary hemolytic anemias (Angel 1966, Moore 1929, Williams 1929) or acquired iron-deficiency anemia (Moseley 1965; Stuart-Macadam 1987a, 1991, 1992a). In the pre-Columbian New World these conditions are typically linked with iron-deficiency anemia (Angel 1966; Carlson et al. 1974; El-Najjar 1976; El-Najjar and Robertson 1976; El-Najjar et al. 1975; El-Najjar et al. 1976; Hengen 1971; Holland and O'Brien 1997; Lallo et al. 1977; Mensforth et al. 1978). "They tend to occur more often in populations that relied on diets featuring a considerable maize content (Milner 1991:63)", (also El-Najjar 1976; El-Najjar and Robertson 1976; El-Najjar et al. 1975; El-Najjar et al. 1976; El-Najjar et al. 1982; Lallo et al. 1977; Parham and Scott 1980). Iron-deficiency anemia may stem from several culprits: dietary deficiency, parasitic infection, nonspecific infection, or weanling diarrhea (Goodman et al. 1984), and probably can be traced to the synergistic effect of several of these factors (Carlson et al. 1974; Goodman 1994:166-168; Hengen 1971; Holland and O'Brien 1997; Kent 1986, 1992; Lallo et al. 1977; Martin et al. 1985; Mensforth et al. 1978; Palkovich 1987; Stuart-Macadam 1988, 1989b, 1991, 1992a). As such, they are considered to be nonspecific indicators of poor health and dietary insufficiency (Goodman et al. 1984). As Holland and O'Brien (1997:191) suggest, "the answer may well be that nothing is the major factor; rather, there may be (and most likely is) a multitude of more-or-less equally important, and interdependent, factors".

Following Hengen (1971), Kent (1986) and Stuart-Macadam (1988:285, 1992a:158-159, 1992b) have elaborated on the hypothesis that infection and parasite load are positively associated with the expression of porotic hyperostosis and cribra orbitalia. They suggest that the tendency for these conditions to co-occur with high-maize-content diets in the New World is due not merely to poor nutrition, but to the increased incidence of infection and parasite load associated with settled village life among maize agriculturalists (Kent 1986). Furthermore, these conditions may exacerbate low hemoglobin levels as part of a defense mechanism launched by an individual's own immune system, in which the body reduces iron absorption in order to deprive pathogens of the iron they need to survive and reproduce (Kent 1992:5-8; Stuart-Macadam 1988:285, 1992a:158-159, 1992b; Weinberg 1992).

In 1992, Wood and colleagues proposed that there was an "osteological paradox" at play in paleopathological interpretation of presence-absence data for skeletal analyses. In particular, they point to the dual nature of acute diseases, which tend to kill quickly and silently, leaving no impression on the bones of their victims, and of chronic diseases, which linger but do not kill outright, leaving their marks on the skeletons of their survivors. They suggest, therefore, that individuals who left behind pristine skeletons may have actually been less healthy and succumbed earlier to diseases that were survived by their healthier counterparts whose bones bear the marks of chronic disease and malnutrition. In an argument presaging the osteological paradox, Stuart-Macadam (1991:37-38) suggests that porotic hyperostosis is actually a sign of a healthy immune system, rather than a signal that the individual is less than fit for his environment. "Individuals with chronic bone lesions can be seen to have been more successful than individuals who did not live long enough to produce bony response to a pathogen (Stuart-Macadam 1991:38)."

Porotic hyperostosis and cribra orbitalia may also be "representative of a childhood condition" (Stuart-Macadam 1985, 1991) – i.e., healed lesions observed on adult skulls reflect survival of an episode of iron-deficiency anemia in childhood rather than a more recent bout with anemia in adulthood. Adults rarely, if ever, develop porotic hyperostosis or cribra orbitalia in response to iron-deficiency anemia (Stuart-Macadam 1985). Adult skulls can accommodate the increase in volume of hemopoietic marrow without experiencing bone changes, but subadult cranial bones are more malleable and are already filled with red-blood-cell producing marrow, so that if marrow volume increases the trabecular space in the bone must also increase in volume (Stuart-Macadam 1991:37). Adults who exhibit active lesions at the time of death are thought to represent a chronic state of anemia continuing from childhood into adulthood, resulting from some form of hereditary anemia (Stuart-Macadam 1985:392). Those who exhibit partially-healed lesions represent incomplete bone remodeling (Holland and O'Brien 1997:189). The implication is that our interpretation of porotic hyperostosis must be reoriented towards childhood sources of stress. Although adults may have suffered similar bouts of marrow hypertrophy, we cannot know how many or how much, because there is no equivalent stress marker among adults.

At Moundville, Powell reported no cases of porotic hyperostosis, but did record a low rate (4.0%) of remodeled (i.e., healed) cribra orbitalia for adults (Powell 1991a:35, 1992a:86), and a moderate rate (21.0%) for subadults (Powell 1986:138, 1991a:35, 1992a:86, 1998:109). These rates are slightly higher than those reported for Mississippian and Protohistoric populations at the nearby Lubbub Creek site, where 6.9% of the total population exhibited porotic hyperostosis, and 2.3 % of the population exhibited cribra orbitalia (Powell 1983:439).

When Powell broke down the prevalence of cribra orbitalia at Moundville by age, a pattern of higher subadult incidence followed by lower adult incidence emerged (i.e., 21% vs. 4%) (1991a:35). This pattern is interesting, implying that individuals in Powell's sample did not suffer severe iron-deficiency anemia, which would have resulted in porotic hyperostosis of the cranial vault, but that the mild iron-deficiency anemia indicated by the presence of cribra orbitalia apparently created a sufficient health impact to contribute to infant mortality. Because all of the lesions were remodeled (i.e., healed at the time of death), it suggests to me that iron-deficiency anemia was not the immediate cause of death, but rather an indicator of generalized health stress contributing to infant mortality.

In my analysis, the Fisher's Exact test indicated no difference in rates of porotic hyperostosis between adults and subadults within each Moundville subphase (Table 21). The Fisher's Exact also indicated no differences in rates of cribra orbitalia between adults and subadults within Moundville I and Moundville IV. However, a significant difference was noted during Moundville II / III, where a higher incidence of cribra orbitalia was observed among subadults (Table 22), following the pattern established by Powell (1991a, 1992a). Furthermore, Fisher's Exact also indicated no difference in incidence of porotic hyperostosis or cribra orbitalia between males and females within subphases (Tables 23 and 24).

Table 21. Rates of Porotic Hyperostosis by Age.

Moundville I

	Present		Absent		Total
	n	%	n	%	N
Adult	1	14%	6	86%	7
Subadult	1	100%	0	0%	1
Total	2	25%	6	75%	8

p = .2500

Moundville II / III

	Present		Absent		Total
	n	%	n	%	N
Adult	4	15%	23	85%	27
Subadult	3	33%	6	67%	9
Total	7	19%	29	81%	36

p = .95028

Moundville IV

	Present		Absent		Total
	n	%	n	%	N
Adult	9	39%	14	61%	23
Subadult	6	60%	4	40%	10
Total	15	45%	18	55%	33

p = .23383

Table 22. Rates of Cribra Orbitalia by Age.

Moundville I

	Present		Absent		Total
	n	%	n	%	N
Adult	1	14%	6	86%	7
Subadult	2	100%	0	0%	2
Total	3	33%	6	67%	9

p = .0833

Moundville II / III

	Present		Absent		Total
	n	%	n	%	N
Adult	1	4%	22	96%	23
Subadult	3	38%	5	63%	8
Total	4	13%	27	87%	31

p = .04316

Moundville IV

	Present		Absent		Total
	n	%	n	%	N
Adult	4	22%	14	78%	18
Subadult	5	63%	3	38%	8
Total	9	35%	17	65%	26

p = .06255

Table 23. Rates of Porotic Hyperostosis by Sex.

Moundville I

	Present		Absent		Total
	n	%	n	%	N
Female	1	25%	3	75%	4
Male	0	0%	3	100%	3
Total	1	14%	6	86%	7

p = .5714

Moundville II / III

	Present		Absent		Total
	n	%	n	%	N
Female	1	7%	13	93%	14
Male	3	27%	8	73%	11
Total	4	16%	21	84%	25

p = .20870

Moundville IV

	Present		Absent		Total
	n	%	n	%	N
Female	3	27%	8	73%	11
Male	2	29%	5	71%	7
Total	5	28%	13	72%	18

p =.72794

Table 24. Rates of Cribra Orbitalia by Sex.

Moundville I

	Present		Absent		Total
	n	%	n	%	N
Female	1	25%	3	75%	4
Male	0	0%	3	100%	3
Total	1	14%	6	86%	7

p = .5714

Moundville II / III

	Present		Absent		Total
	n	%	n	%	N
Female	1	8%	11	92%	12
Male	0	0%	10	100%	10
Total	1	5%	21	95%	22

p = .5454

Moundville IV

	Present		Absent		Total
	n	%	n	%	N
Female	1	14%	6	86%	7
Male	0	0%	7	100%	7
Total	1	7%	13	93%	14

p = .5000

I used the chi-squared statistic to test differences in incidence of porotic hyperostosis and cribra orbitalia over time. There was no significant difference in the rates of porotic hyperostosis and cribra orbitalia between the Moundville I and Moundville II / III subphases. This suggests that members of the Moundville chiefdom did not see an improvement in health associated with hypothesized subsistence and settlement disintensification following the dispersal of population early in the Moundville II / III subphase, and therefore these results do not support my disintensification model.

I did observe a significant increase in the rate of porotic hyperostosis and cribra orbitalia between Moundville II / III and Moundville IV (Tables 25 and 26). A devil's advocate for the osteological paradox might suggest that the trend of increasing porotic hyperostosis and cribra orbitalia during the Moundville IV subphase represents a healthier population, who survived infection and anemia and lived to exhibit the stigmata.

Table 25. Rates of Porotic Hyperostosis between Moundville Subphases.

	Present		Absent		Total
	n	%	n	%	N
MV I	2	25%	6	75%	8
MV II/III	7	19%	29	81%	36
MV IV	15	45%	18	55%	33
Total	24	31%	53	69%	77

Chi-square = 5.588
Degrees of Freedom = 2

Table 26. Rates of Cribra Orbitalia between Moundville Subphases.

	Present		Absent		Total
	n	%	n	%	N
MV I	3	33%	6	67%	9
MV II/III	4	13%	27	87%	31
MV IV	9	35%	17	65%	26
Total	16	24%	50	76%	66

Chi-square = 4.099
Degrees of Freedom = 2

In contrast, Moundville I and II / III populations might have been less healthy, and would have succumbed to health stress before the effects of infection and anemia could be expressed as porotic hyperostosis and cribra orbitalia. This model is supported by Schoeninger and Schurr's (1998) findings of a statistically significant decline in maize consumption for Moundville IV populations, though it contradicts known patterns of population nucleation during Moundville IV.

However, a straightforward reading of the results suggests they represent a fairly precipitous decline in health during the Moundville IV subphase following the collapse of the Moundville chiefdom. Populations re-aggregated into nucleated villages during the Moundville IV subphase (Knight and Steponaitis 1998b), and newly dense populations may have led to an increase in transmission of infectious disease and particularly intestinal parasites, which are unmistakably implicated in iron-deficiency anemia (Hengen 1971, Holland and O'Brien 1997, Kent 1986, 1992, Stuart-Macadam 1992c; Wapler et al. 2004, Weinberg 1992). Although there are other possible etiologies for porotic hyperostosis and cribra orbitalia, I believe that iron-deficiency anemia may have been the source of the increase in these conditions during the Protohistoric period in the Black Warrior River valley.

This pattern is reflected in data from Moundville and other Black Warrior River Valley sites. At the time of Powell's synchronic study of Moundville skeletal remains (1985a, 1988), the settlement pattern was thought to reflect increasing population density over time, leading Powell to predict high rates of iron-deficiency anemia due to nutritional stress and crowd transmission of disease and parasites. The low rates of cribra orbitalia and porotic hyperostosis in the synchronic sample were therefore surprising. Greater clarity emerged from Powell's diachronic study, in which she found higher levels of iron-deficiency anemia during the Moundville I subphase and decreasing prevalence over time (Powell 1998:116), consistent with the revised settlement pattern of Moundville I subphase population aggregation followed by population dispersal in later subphases. However, Powell's diachronic sample did not include a Moundville IV subphase protohistoric component. For populations at the Mississippian-Protohistoric transition, Hill-Clark (1981) reported that forty-eight percent of individuals exhibited porotic hyperostosis among five sites across Alabama dating between A.D. 1200 and 1600. This figure appears to increase through time, because among protohistoric populations in the Black Warrior River Valley, Hill observed porotic hyperostosis at a rate of 58.8 percent among the combined adult and subadult population at the Moody Slough site (1Tu4) (Hill 1979:31).

Infectious Disease: Treponematosis

There are four recognized treponemal syndromes: pinta, yaws, endemic syphilis (bejel), and venereal syphilis (Baker and Armelagos 1988:704). These syndromes are distinguished from one another by their mode of transmission (venereal vs. nonvenereal), symptoms, and geographic region. Pinta tends to cause only skin lesions, yaws and endemic syphilis cause more significant soft tissue and bone damage, and venereal syphilis causes significant soft tissue and bone damage, major organ failure, neurological damage, and death (Steinbock 1976:92). Geographically, pinta is found in the New World tropics, and yaws is found in tropical regions worldwide (Koff and Rosen 1993:520), though the presence of yaws in the New World tropics has been attributed to importation of enslaved Africans during the sixteenth through nineteenth centuries (Hackett 1963:15, Hudson 1964). Endemic syphilis is found in arid regions of southern Europe, Africa and Southwest Asia (Powell 2000:8), and venereal syphilis is found in temperate regions worldwide (Hackett 1963:31). In the New World, treponemal infection is typically described as simply "endemic treponematosis", a term which encompasses all nonvenereal treponemal syndromes. A nonspecific term was chosen to reflect the generally mild (i.e., nonvenereal) manifestations of the disease, and the inability to distinguish among the syndromes immunologically (Powell 2000:12, Ortner et al. 1992)

The medical and anthropological literature on treponemal infection is as contentious and contradictory as any topic addressed in paleopathology. The various authorities cannot even agree whether the four treponemal syndromes are caused by the same organism. Some argue that all treponemal infections are caused by the bacterium

Treponema pallidum, suggesting that various strains of the organism produce the varying manifestations of the individual treponemal syndromes (Baker and Armelagos 1988:705; Hackett 1963, 1967; Hudson 1963b, 1965a, 1965b; Powell 1992b:48), or that varying environmental and social factors account for the differing effects of the disease (El-Najjar 1979:604). Others (Brothwell 1981, Hackett 1963, Koff and Rosen 1993:519, Powell 2000:9) contend that *Treponema pallidum* is responsible only for venereal syphilis and endemic nonvenereal syphilis, pinta is caused by *T. carateum*, and yaws is due to *T. pertenue* (Kiple 1993:1053; Powell 2000, Ross-Stallings 1989). A third hypothesis suggests that these are merely subspecies of a single species: *Treponema pallidum pallidum* (venereal syphilis), *T. pallidum endemicum* (endemic syphilis), *T. pallidum pertenue* (yaws), and *T. pallidum carateum* (pinta) (Koff and Rosen 1993:519), while a fourth hypothesis suggests only two subspecies, *T. pallidum pallidum*, responsible for syphilis and bejel, and *T. pallidum pertenue*, associated only with yaws (Fieldsteel 1983; Miao and Fieldsteel 1980; Ortner et al. 1992). These organisms were originally thought to be a single species because they are microscopically and immunologically indistinguishable, but recent DNA sequencing suggests that there are genetic "microvariations" among them, though whether they represent species or subspecies of *Treponema* is unclear (Powell 2000:9).

Endemic treponematosis differs significantly from syphilis, the venereal form of infection, in that it is transmitted through casual skin contact during childhood, and occurs in higher frequencies with less severe pathological consequences to bone and soft tissue (Powell 1986:142). While tertiary syphilis notoriously leads to brain damage and death, endemic treponematosis is almost never fatal, and occurs at high rates within affected populations. In fact, it has been suggested that in populations exposed to both endemic treponematosis and syphilis, childhood infection with endemic treponematosis may lend adult immunity to venereal syphilis (Powell 2000:33), and that infection by any of the various treponemal syndromes may lend at least partial immunity to the others (Baker and Armelagos 1988:705; Crosby 1969:224; El-Najjar 1979:607; Hackett 1983:110; Rothschild and Rothschild 1994, 1995; Steinbock 1976:91-92). In fact, Rothschild and Rothschild (1995:1407) have discovered that in 20th century populations on Guam, syphilis rates rose only in communities where public health efforts were effective in reducing rates of yaws.

In modern regions where treponemal infection is endemic, nearly one hundred percent of the population may be infected (Powell 1991b:173, 1992b:42-43, 2000:9). In clinical contexts, as much as ten to twenty percent of individuals who contract treponematosis show pathological involvement of bone tissue (Ortner et al. 1992:343). Archaeologically speaking, rates of bone pathology in endemic treponematosis are generally low, ranging from one percent (Hackett 1983:125, Ortner and Putschar 1981:180), to one to five percent of the **total** population (Baker and Armelagos 1988:705).

Though there is a significant discrepancy between the archaeological visibility of treponemal infection (1-5% of the population) and the expected rates of bone pathology in affected populations (10-20% of the population assuming near-total rates of infection), at least some of the discrepancy may be explained by poor preservation of pathological bone in archaeological contexts. Furthermore, in clinical contexts, the less specific effects of treponematosis such as generalized periostitis can be confidently attributed to a serologically or otherwise diagnosed treponemal infection, leading to higher rates of bony involvement in clinical cases of treponematosis. On the other hand, paleopathologists must consider differential diagnoses of such pathology (Buikstra 1976), and refrain from attributing nonspecific pathological indicators to specific disease processes, leading to lower reporting of specific diseases and higher reporting of generalized stress.

Bone pathologies associated with endemic treponematosis are similar to the mild manifestations of syphilis (Cook 1994), particularly periostitis and reactive bone deposition on long bone shafts. More rarely destructive lesions of the nose and palate (Baker and Armelagos 1988:704-705) and *caries sicca* – stellate lesions of the cranial vault – occur (Baker and Armelagos 1988:704-705; Williams 1932). Periostitis associated with treponematosis typically occurs on bone surfaces in close proximity to the skin, such as the anterior crest of the tibia, the superior surface of the clavicle, and areas of the cranial vault, due to infectious transmission from skin lesions (Powell 1992b:43, 2000:10). In archaeological samples, treponemal infection is identified by bilateral expression of the "saber shin" trait (Powell 2000) – extensive pathology of the anterior surfaces of the tibiae in which reactive bone builds up in plaque-like adhesions resulting in the *appearance* of anterior bowing (Ortner 1992; Orton 1905). In endemic treponematosis, the saber-shin trait is invariably bilateral (Rothschild and Rothschild 1995). Treponematosis may also be identified by lytic lesions of the nasal-palatal regions of the skull (Hackett 1976:63-66; Ortner and Putschar 1981:181-182) and stellate lesions (Bullen 1972; Hackett 1976:30-31, 40-47; Powell 1991b:176-177) or clustered pits and cavities on the ectocranial cortical surface (Bogdan and Weaver 1992; Hackett 1976:27, 36-37; Sandford et al. 1994:167).

One of the great difficulties of identifying treponematosis in archaeological samples is the dual nature of this disease. In some cases, treponemal infection produces specific diagnostic characteristics such as caries sicca or saber shins, but more frequently long term treponemal infection results in generalized periosteal inflammation that is indistinguishable from other disease or stress processes (Powell 1991a, 1991b, 2000). It is therefore difficult to gauge the true prevalence of treponematosis within an archaeological population, and it is surely underestimated a great percentage of the time. However, as with many other paleopathological indicators used to compare prehistoric populations, the under-counting of treponematosis cases does not invalidate comparisons if we are comfortable in the knowledge that only the most severe cases are being counted. As long as the populations being compared are scored using similar dry bone criteria, prevalence rates should be comparable, if not entirely accurate. Modern or historical clinical data should not be compared with data from skeletal samples.

The question of a New World or Old World origin of venereal syphilis has been hotly debated (Baker and Armelagos 1988; Brothwell 1981; Cockburn 1961; Crosby 1969, 2003 [1972]; Dennie 1962; El-Najjar 1979; Guerra 1978; Harrison 1959; Hackett 1963, 1967, 1976, 1983; Holcomb 1934, 1941; Hudson 1961, 1963a, 1963b, 1964, 1965a, 1965b, 1968; Kiple 1993; Ortner 1992; Ortner et al. 1992; Powell 1993, 1994, 2000; Steinbock 1976; Williams 1927, 1932; Wood 1978). Sixteenth century Neapolitans called it the "French Disease" (*Morbus gallicus*), the French blamed it on the Italians, and some even thought to blame it on expeditions to the Indies (Baker and

Armelagos 1988:709; Holcomb 1934; Powell 1994, 2000; Williams 1927). However, there is little argument that some form of treponemal infection was present in the pre-Columbian New World (Baker and Armelagos 1988; Bogdan and Weaver 1988, 1992; Cook 1994; El-Najjar 1979; Goff 1967; Hackett 1963, 1967, 1976; Hutchinson 1993; Orton 1905; Powell 1990, 1994, 2000; Ross-Stallings 1989; Sandford et al. 1994, Warren 1972).

Among Mississippian populations in the Southeast, endemic treponematosis was first identified by Dr. Joseph Jones, who diagnosed "syphilis" in skeletal remains recovered from stone box graves in Tennessee (Jones 1970 [1876]:65-67). Scarcely thirty years later, syphilis was identified at Moundville in a sample sent by C. B. Moore to Dr. James Carroll at the Army Medical Museum (Moore 1996b [1907]:339-340), and again three decades later by Haltom and Shands (1938), in their analysis of "Evidences of Syphilis in Mound Builders' Bones." In fact, Griffin (1946:81) declared the presence of syphilis "almost a Mississippi[an] 'determinant'."

Powell found evidence of endemic treponematosis in her synchronic analysis at Moundville, observing an overall 50.7% rate of proliferative lesions of the anterior tibia shaft (N=285/562) (Powell 1988:137-138, 1998:110). Not all cases of periostitis of the anterior tibia shaft can be attributed to endemic treponematosis, but many of the lesions are consistent with a developed or developing "saber-shin" trait such as is typically found in treponemal infection (Powell 1985a:357, 1988:169). In addition, she recorded twenty-three cases (21 adults, 2 subadults) of external cranial lesions specifically attributable to endemic treponematosis (Powell 1986:138-139, 1988:169-175, 1991a:41, 1992a:88, 1998:111), and three cases of healed caries sicca (Powell 1991a:44-45, 1992a:88, 1998:111). These lesions represent an infection rate of 26/637 calvaria, or 4.1%. In Powell's later diachronic study of Moundville skeletal remains, she temporally isolated the earliest cases of treponematosis and stated definitively that this infection did not occur at identifiable endemic levels at Moundville until the Moundville II and Moundville III subphases (1998:102, 117), although "its presence may have been covertly responsible for the dramatic increase in nonspecific skeletal lesions during Moundville II (Powell 1998:118)." Powell's later diachronic analysis also identified three additional cases of treponematosis at Moundville, identified by the presence of the saber-shin trait (Powell 1998:117).

In my analysis I coded specifically for incidence of treponematosis. I found only one case of cranial stigmata of treponematosis, but ten cases of treponemal lesions of the anterior tibia. The cranial lesions were stellate, located on the frontal and left parietal of a 16-20 year old female who also suffered severe porotic hyperostosis and cribra orbitalia. However, the stellate lesions were deep and pitted lytic foci with peripheral remodeling, consistent with treponematosis, and quite morphologically distinct from the coral-like appearance of the cranial lesions associated with porotic hyperostosis. Furthermore, they were located on the lower regions of the frontal and parietal, an uncommon location for the expression of porotic hyperostosis, which occurs most commonly near lambda on the parietals and occipital (Schultz 2001:132). In eight out of ten cases, I identified treponemal infection based on the presence of strong anterior bowing of the tibia shaft representing a saber shin trait, combined with localized periostitis of the anterior tibia shaft. This periosteal reaction was very distinctive, forming a plaque of woven bone characterized by surface porosity, vascular "tracks" radiating across the surface of the lesion, and in some cases development of mature lamellar bone at the apex of the lesion surrounded by less mature woven bone at the margins. In the remaining two out of ten cases, the identification of treponematosis was made solely on the presence of this distinctive lesion, in the absence of anterior bowing. In six cases the condition exhibited bilateral symmetry, in the remaining four cases only one of the two tibiae was present or sufficiently preserved to gauge presence or absence of treponemal stigmata.

I found no evidence of treponematosis during the Moundville I subphase, mirroring Powell's findings in that treponematosis does not appear until after the Moundville I subphase. I found moderate rates of treponemal infection during the post-disintensification Moundville II / III subphases, and lower rates during the protohistoric Moundville IV subphase. A Fisher's Exact Test of within-subphase variation indicated no statistically significant differences in expression of treponematosis between adults and subadults (Table 27), or between males and females (Table 28). Similarly, Fisher's Exact Test indicated no statistically significant differences in incidence of treponematosis between Moundville subphases (Table 29). There was no change in rates of treponematosis over time, contrary to my prediction of improved health with disintensification during the Moundville II / III subphases, and subsequent decline in health during the protohistoric Moundville IV subphase. These results do not support my disintensification model.

Table 27. Rates of Treponematosis by Age.

Moundville I

	Present		Absent		Total
	n	%	n	%	N
Adult	0	0%	3	100%	3
Subadult	0	0%	0	0%	0
Total	0	0%	3	100%	3

p = 1.0000

Moundville II / III

	Present		Absent		Total
	n	%	n	%	N
Adult	7	37%	12	63%	19
Subadult	0	0%	3	100%	3
Total	7	32%	15	68%	22

p = .2954

Moundville IV

	Present		Absent		Total
	n	%	n	%	N
Adult	3	15%	17	85%	20
Subadult	1	8%	11	92%	12
Total	4	13%	28	88%	32

p = .5151

Table 28. Rates of Treponematosis by Sex.

Moundville I

	Present		Absent		Total
	n	%	n	%	N
Female	0	0%	0	0%	0
Male	0	0%	2	100%	2
Total	0	0%	2	100%	2

$p = 1.0000$

Moundville II / III

	Present		Absent		Total
	n	%	n	%	N
Female	2	40%	3	60%	5
Male	3	38%	5	63%	8
Total	5	38%	8	62%	13

$p = .7505$

Moundville IV

	Present		Absent		Total
	n	%	n	%	N
Female	0	0%	7	100%	7
Male	1	13%	7	88%	8
Total	1	7%	14	93%	15

$p = .5333$

Table 29. Rates of Treponematosis between Moundville Subphases.

	Present		Absent		Total
	n	%	n	%	N
MV I	0	0%	3	100%	3
MV II/III	7	32%	15	68%	22
MV IV	4	13%	28	88%	32
Total	11	19%	46	81%	57

Fisher's Exact Test
MV I vs. MV II / III: $p = .3547$
MV II / III vs. MV IV: $p = .0834$

Infectious Disease: Tuberculosis

Tuberculosis is a chronic respiratory disease that existed at endemic levels in prehistoric populations throughout the Americas. At these levels, most individuals are exposed and infected in childhood, and develop an immune reaction that destroys the infectious agent, Mycobacterium tuberculosis. However, individuals with immune systems compromised due to poor nutrition or pre-existing health problems may develop an immediate active infection leading to death, or may harbor long-term infectious lesions in their lungs and lymph nodes that can persist for years and even decades before becoming active (Powell 1991b, 1992b, 2000), due to re-exposure to the disease or change in the individual's host resistance (Roberts and Buikstra 2003:5).

Between three and seven percent of long-term tuberculosis cases affect bone tissue (Allison et al. 1981:58-59; Kelley and Eisenberg 1987:93; Steinbock 1976:175). Skeletal stigmata of tuberculosis in early stages of bone involvement may include smooth-walled focal, resorptive lesions on the ventral aspect of thoracic and lumbar vertebrae and proliferative lesions of the visceral surfaces of the ribs (Baker 1999, Roberts 1999; Roberts and Buikstra 2003:88, Ortner 1999). Because the bacterium shows predilection towards red blood cell producing marrow, skeletal lesions occur not only on the vertebrae and ribs, but also on the sternum, pelvis, and metaphyses and epiphyses surrounding the major joints in the body: hip, knee, ankle, shoulder, and elbow (Ortner and Putschar 1981:144-162; Roberts and Buikstra 2003:89-92). In addition, a tubercular abscess of the psoas muscle may result in destruction of adjacent bone tissue of the lumbar vertebrae, ilium, and head, neck, and greater trochanter of the femur (Ortner and Putschar 1981; Roberts and Buikstra 2003). The vertebrae are affected in twenty-five to fifty percent (Aufderheide and Rodríguez Martin 1998; Resnick and Niwayama 1995) of cases in which there is skeletal involvement. Destruction of vertebral bodies may lead to Pott's disease – vertebral collapse and anterior kyphosis of the spine (El-Najjar 1981, Ortner and Putschar 1981; Powell 1992b, 2000; Roberts and Buikstra 2003). In rare cases, pleural tissue may become calcified, but it is impossible to definitively associate this condition with tuberculosis (Roberts and Buikstra 2003:107). Among children, tuberculosis may cause isolated osteitis of the phalanges of the hands and feet (Lagier 1999:287), and childhood tuberculous meningitis leaves shallow, granular depressions on the endocranial surface of the occipital, squamous portion of the temporal, and the greater wing of the sphenoid, resulting from pressure atrophy due to meningeal inflammation (Schultz 1999).

The typically low level of bone involvement suggests that tuberculosis infection within a population occurs far more frequently than is borne out in skeletal remains;

"lesions identifiable by paleopathological criteria represent merely the tip of the tip of the iceberg of tuberculous infection in past populations (Powell 2000:21)". When tuberculosis occurs in skeletal populations, it can be differentiated from other conditions that might result in kyphosis of the spine (such as trauma or osteomyelitis) by the tendency of tubercular lesions to be purely or predominantly lytic, whereas other lesions will be characterized by reactive or proliferative bone (Ortner and Putschar 1981; Powell 1992b, 2000). Furthermore, tubercular lesions of the spine are localized to the vertebral bodies, and rarely involve the neural arches or transverse and spinous processes (Morse 1967:249), as might occur in another type of infection or trauma.

For many years, clinicians and paleopathologists have debated whether or not tuberculosis existed in the Americas before contact with the Old World (Allison et al. 1981; Blakely and Matthews 1986; Braun et al. 1998; Buikstra 1976, 1981; Buikstra and Cook 1978; Buikstra and Williams 1991; El-Najjar 1979; Hrdlička 1909; Morse 1961, 1967, 1969a, 1969b; Ortner 1992; Ortner and Putschar 1981; Ritchie 1952; Roberts and Buikstra 2003; Steinbock 1976). Allison and colleagues (1973) challenged these arguments with the successful isolation of acid-fast bacilli resembling *Mycobacterium tuberculosis* from a Peruvian Nazca period (A.D. 700) child, though they were unable to positively identify the bacterium. More than two decades later, in 1994, Salo and colleagues put the argument to rest with the recovery of DNA from the *M. tuberculosis* complex from a Peruvian mummy with a corrected ^{14}C date of A.D. 1040 ± 44 years before present (Salo et al. 1994:2091). Since then, pre-Columbian *M. tuberculosis* complex DNA has been identified in several instances (Arriaza et al. 1995; Braun et al. 1998; Herrmann and Hummel 2003; Roberts and Buikstra 2003:128;

Spigelman and Donoghue 1999), and paleopathologists have identified numerous cases of pre-Columbian tuberculosis in New World archaeological populations (Buikstra 1999; Buikstra and Cook 1978, 1981; Buikstra and Williams 1991; El-Najjar 1979; Katzenberg 1977; Morse 1961; Pfeiffer 1984, 1991; Powell 1988, 1990, 1991, 1992, 2000; Widmer and Perzigian 1981). Although some early cases of tuberculosis have been recorded in the Eastern Woodlands, conventional wisdom suggests that frequency of the disease increases over time and is particularly concentrated in late prehistoric agricultural groups (Buikstra 1976; Buikstra and Cook 1981; Widmer and Perzigian 1981:99, 111), probably due to increasing population densities (Buikstra and Cook 1981).

At Moundville, Powell recorded a single case of tuberculosis evidenced by kyphosis of the vertebral column and nine cases of rib lesions consistent with tubercular infection (Powell 1985a, 1988, 1991b, 1992a, 1998). These cases were evenly distributed between males and females, and included one infant, one subadult, and eight adults (Powell 1992a:45). Powell's later diachronic analysis identified one additional case of tuberculosis evidenced by extreme lytic destruction of lumbar vertebrae in an adult female (1998:117). More importantly, the diachronic focus of Powell's later analysis allowed her to pinpoint the earliest occurrence of tuberculosis at Moundville to the Moundville II subphase (1998:117-118).

I found no such evidence of tuberculosis in the Moundville sample that I examined, probably due to my limited sample size (N=176) in comparison to Powell's original study (N=564). Only 20 percent (36/176) of individuals in my sample were represented by thoracic vertebrae, and 20 percent (35/176) were represented by lumbar vertebrae, which might mask a higher true percentage of tubercular infection. Powell suggests that even her larger sample may have underestimated tuberculosis due to poor preservation of the axial skeleton. In her sample, only 30 percent of individuals had well-preserved lumbar vertebrae and 38 percent had well-preserved thoracic vertebrae (1992b:45). The better-preserved Irene Mound Mississippian skeletal sample yielded a tuberculosis rate of 3.6% (10/280), which Powell considers to be more representative of a typical Mississippian tuberculosis rate, in comparison to Moundville's 1.8% rate (10/564) for a poorly preserved skeletal sample (Powell 1992a). Because of the destructive nature of tuberculosis lesions, even in cases of good preservation the affected bones are less likely to be preserved because they are more fragile and would be less likely to survive the burial and excavation environments (Powell 1991b:175).

Infectious Disease: Periostitis and Osteomyelitis

Periostitis

Periostitis and osteomyelitis can be thought of as occupying adjacent ranges in the continuum of bone infection (Larsen 1987:380). Periostitis results from a traumatic insult or nonspecific infection localized to the periosteum, and may appear as an acute and localized proliferative reaction to a single factor, or as a chronic systemic condition throughout the skeleton (Goodman et al. 1984). Periosteal reactions are quite common in archaeological populations, both in primary form (due directly to trauma or infection at the site of the lesion) and in secondary form (as part of a suite of reactions to a systemic infection or a disease such as treponematosis) (Ortner and Putschar 1981:131-132, Ortner 2003b). Periostitis is identified by the formation of woven bone overlaying the original bone cortex, often with an irregular surface and featuring thin spicules of newly formed bone radiating from the focus of the periosteal lesion in a linear or sometimes "sunburst" pattern. These bone spicules may be oriented parallel to the surface of the bone or perpendicular to the cortical surface. Often there is evidence of increased vascularization of the new woven bone (Ortner 2003b:206).

In her synchronic analysis, Powell recorded periostitis at a staggering rate of 50.7% of adult tibiae (Powell 1986:139, 1988, 1991a:41-42, 1992a, 1998) and 27% of subadult tibiae (Powell 1986:139), which she identifies as possible endemic treponemal infection (Powell 1986, 1991a). For other skeletal long bone elements, rates of periostitis ranged from a high of 14.7% of femora to a low of 3.5% of ulnae (Powell 1991a:41), and are more likely to indicate nonspecific bacterial infection or localized simple trauma (Powell 1998:117). In her diachronic analysis of health at Moundville, Powell found that over time, nonspecific infections evidenced by periostitis increased from the Moundville I subphase to the Moundville III subphase (Powell 1998:117).

In her synchronic study, Powell found no statistically significant differences in rates of periostitis between adult males and females or between status subgroups, a further indicator that the infectious process was endemic, and experienced equally by all segments of the population (Powell 1986). In my analysis, I also found that rates of periostitis between the sexes were comparable within each subphase. Fisher's Exact Test revealed no statistically significant differences in the incidence of periostitis between adult males and females during any of the Moundville subphases (Table 30).

Although periostitis appears to have been experienced equally by adult males and females, Powell found a sharp distinction between age groups. Of the periosteal infections to the tibia, 63% of subadults and only 9% of adults had active lesions at the time of death (Powell 1986:139). This indicates that although subadults were likely to succumb to the synergistic effects of infection and other forms of stress, an individual

Table 30. Rates of Periostitis by Sex.

Moundville I

	Present		Absent		Total
	n	%	n	%	N
Female	1	100%	0	0%	1
Male	2	67%	1	33%	3
Total	3	75%	1	25%	4

p = .7500

Moundville II / III

	Present		Absent		Total
	n	%	n	%	N
Female	4	67%	2	33%	6
Male	5	63%	3	38%	8
Total	9	64%	5	36%	14

p = .6573

Moundville IV

	Present		Absent		Total
	n	%	n	%	N
Female	1	17%	5	83%	6
Male	0	0%	7	100%	7
Total	1	8%	12	92%	13

p = .4615

who survived the initial insult was likely to live into adulthood and eventually die of unrelated causes. Similarly, I found that periostitis appears to be an age-dependent phenomenon, but the trend in my data was opposite that found by Powell. In my sample, no infants or subadults exhibited periostitis during any subphase (Table 31).

Table 31. Rates of Periostitis by Age.

Moundville I

	Present		Absent		Total
	n	%	n	%	N
Adult	3	75%	1	25%	4
Subadult	0	0%	0	0%	0
Total	3	75%	1	25%	4

p = 1.0000

Moundville II / III

	Present		Absent		Total
	n	%	n	%	N
Adult	14	70%	6	30%	20
Subadult	0	0%	3	100%	3
Total	14	61%	9	39%	23

p = .0474

Moundville IV

	Present		Absent		Total
	n	%	n	%	N
Adult	3	18%	14	82%	17
Subadult	0	0%	8	100%	8
Total	3	12%	22	88%	25

p = .2956

The results of Fisher's Exact Test indicate the discrepancy in the incidence of periostitis between adults and subadults was not statistically significant during Moundville I and Moundville IV, but a significant difference was observed in Moundville II / III, where periostitis occurred exclusively in adults. Perhaps this trend is indicative of improved health (as I had predicted) during the Moundville II and III subphases. If populations were healthier during this period, greater infant and subadult survivorship may have resulted in a population of adults bearing the evidence of long-term generalized infection, having survived a childhood health crisis that would have ended the lives of less robust children during periods of poorer health.

In my analysis, rates of periostitis were surprisingly high during the Moundville I and Moundville II / III subphases, and then sharply declined during the Moundville IV subphase (Tables 30 and 31). I used Fisher's Exact to test rates of periostitis between Moundville I and Moundville II / III, which revealed no statistically significant differences between these subphases (Table 32). I was able to use the chi-squared test to compare Moundville II / III with Moundville IV because sample sizes were larger. Results indicate that there was a statistically significant decline in incidence of periostitis (Table 32) between Moundville II / III and Moundville IV. Unfortunately, these results directly contradict my predictions for health during these subphases. As a general indicator of health stress, I expected periostitis to be higher during Moundville I before disintensification and also during Moundville IV due to population nucleation. I expected rates of periostitis to decline after disintensification, during the Moundville II and III subphases. Instead, there was no difference in incidence of periostitis between Moundville I and Moundville II / III, and a surprising drop in incidence during Moundville IV. A straightforward interpretation of these results suggests that Moundville I, II and III populations were less healthy, while Moundville IV populations were healthier, which supports Schoeninger and Schurr's contention that maize consumption remained steady throughout the first three Moundville subphases, and then declined significantly during Moundville IV. Unfortunately, these results also contradict the known nucleated settlement pattern of the Moundville IV subphase.

Table 32. Rates of Periostitis between Moundville Subphases.

	Present		Absent		Total
	n	%	n	%	N
MV I	3	75%	1	25%	4
MV II/III	14	61%	9	39%	23
MV IV	3	12%	22	88%	25
Total	20	38%	32	62%	52

Fisher's Exact Test: Moundville I vs. Moundville II/III
$p = .5230$

Chi-Square Test: Moundville II / III vs. Moundville IV
Chi-Square = 12.51
Degrees of Freedom = 1

However, in terms of the osteological paradox, these rates may actually reflect better health conditions during the Moundville I and II / III subphases. Individuals during the Moundville I and II / III subphases may have survived the health insult associated with periostitis and lived to manifest it, while those living during the Moundville IV subphase may have died before periostitis set in. This explanation still does not favor disintensification, however, because there was no distinction in rates of periostitis across the population dispersal / disintensification boundary between the Moundville I and Moundville II / III subphases.

Osteomyelitis

Osteomyelitis occurs when an infection invades the medullary cavity of a bone, producing bone necrosis and forming pus, which eventually seeks an exit through the living bone tissue by producing a cloaca (literally, "drain" or "sewer"). Necrotic bone is walled off from living tissue, forming a sequestrum, which may remain in situ or may flow out as part of the pus discharge depending upon the size of the fragment of dead bone. As the infection rages, an envelope (*involucrum*) of reactive bone forms subperiosteally around the site of the infection, resulting in the granular, irregular surface of bones afflicted with osteomyelitis (Steinbock 1976:64-66). The diagnostic criteria of osteomyelitis are defined by the presence of sequestra, cloacae, and an involucrum characterized by abundant periostitis, surface porosity and hypervascularization (Ortner 2003b:185). Because osteomyelitis is defined specifically as an infectious process of the medullary cavity of the bone, early stages of infection that do not yet show surface manifestations of the condition may go uncounted in gross examination of dry bone specimens. For this reason, incidence of osteomyelitis is often undercounted in archaeological samples (Ortner 2003b:196).

Osteomyelitis may result from a direct traumatic insult to the bone such as a compound or comminuted fracture or projectile injury (Ubelaker 1989:114-115), direct contact with adjacent infected soft tissues (Ortner 2003b:181), or a blood-borne (hematogenous) infection (Ubelaker 1989:114-115) of bacterial, viral, fungal, or parasitic origin (Ortner 2003b:181). Osteomyelitis can be classified as a chronic or acute infection (Steinbock 1976:60-61), depending upon the source, onset, and longevity of the infection. In the chronic form, infection may persist for decades. In the acute form, osteomyelitis is generally a significant threat to an individual's health and longevity. Even if a person survives the initial infection, the bone changes generally persist throughout life (Powell 1988:150).

In her synchronic study, Powell observed five cases of infectious response consistent with osteomyelitis, including simultaneous osteoblastic and osteolytic bone response involving both the bone cortex and medullary cavity, resulting in formation of cloacae (Powell 1985a:313-314). These cases included four adult males (ages 30 to 45) and one adult female (aged 30 to 35). In four cases the infection appeared to be active at the time of death, suggesting recent acute or ongoing chronic infection. The fifth case probably represents a well-healed episode of childhood hematogenous infection (Powell 1988:149-152), which commonly occurs in rapidly growing bone metaphyses (Steinbock 1976:62). Powell (1998) recorded no cases of osteomyelitis in her diachronic sample of the population at Moundville.

In my analysis there were only three cases of osteomyelitis. Two were individuals from the Moundville II / III subphase, one associated with extensive trauma to the right tibia of an adult male, and another subsequent to fracture of the right innominate of an adult male. The third case was a Moundville IV adult female who exhibited osteomyelitis of the left tibia and fibula. Subadults did not exhibit osteomyelitis (Table 33), and there was no consistent pattern of incidence between adult males and females (Table 34). Fisher's Exact Test revealed no significant difference

Table 33. Rates of Osteomyelitis by Age.

Moundville I

	Present		Absent		Total
	n	%	n	%	N
Adult	0	0%	3	100%	3
Subadult	0	0%	0	0%	0
Total	0	0%	3	100%	3

p = 1.0000

Moundville II / III

	Present		Absent		Total
	n	%	n	%	N
Adult	2	18%	9	82%	11
Subadult	0	0%	3	100%	3
Total	2	14%	12	86%	14

p = .6043

Moundville IV

	Present		Absent		Total
	n	%	n	%	N
Adult	1	7%	14	93%	15
Subadult	0	0%	8	100%	8
Total	1	4%	22	96%	23

p = .6521

Table 34. Rates of Osteomyelitis by Sex.

Moundville I

	Present		Absent		Total
	n	%	n	%	N
Female	0	0%	1	100%	1
Male	0	0%	2	100%	2
Total	0	0%	3	100%	3

p = 1.0000

Moundville II / III

	Present		Absent		Total
	n	%	n	%	N
Female	0	0%	4	100%	4
Male	2	40%	3	60%	5
Total	2	22%	7	78%	9

p = .2777

Moundville IV

	Present		Absent		Total
	n	%	n	%	N
Female	1	17%	5	83%	6
Male	0	0%	7	100%	7
Total	1	8%	12	92%	13

p = .4615

between any of these categories within Moundville subphases. Similarly, there were no significant differences in incidence of osteomyelitis between the Moundville subphases, as tested by Fisher's Exact and chi-squared (Table 35). I am reluctant to place any interpretive value on these data because the sample is so small: slightly greater than 1% (0.01724) of my diachronic sample of the Moundville population exhibited osteomyelitis at all. This is comparable to Powell's rate for her synchronic sample, which was also slightly greater than 1% (0.01179). These rates suggest that osteomyelitis was not a significant health threat at any time during the Moundville phase, and at this level of incidence have no bearing on the validity of my disintensification model.

Table 35. Rates of Osteomyelitis between Moundville Subphases.

	Present		Absent		Total
	n	%	n	%	N
MV I	0	0%	3	100%	3
MV II/III	2	14%	12	86%	14
MV IV	1	4%	22	96%	23
Total	3	8%	37	93%	40

Fisher's Exact Test: Moundville I vs. Moundville II / III
p = .6691

Chi-Square Test: Moundville II / III vs. Moundville IV
Chi-Square = 1.15
Degrees of Freedom = 1

Trauma

Trauma occurs when deliberate or accidental physical force is applied to the human body, and has been classified as resulting from fracture, dislocation, intentional modification of bone and teeth (Goodman et al. 1984; Ortner and Putschar 1981; White 1991), or disruption in nerve or blood supply (Ortner and Putschar 1981). In the case of penetrating wounds or compound fractures, trauma can lead to subsequent infection, causing periostitis or osteomyelitis and possible necrosis. In the case of fracture or dislocation, trauma may also lead to osteoarthritis if bones and joints are not properly repositioned (Steinbock 1976:39), or pseudarthrosis if a fracture fails to re-unite and forms a false joint (Steinbock 1976:21). Other possible complications of trauma are infection, tissue necrosis due to disruption of blood supply, and nerve damage (Ortner 2003c:128-129). Infection, age and general health of the individual, type of fracture, and the degree of movement (i.e., splinting or immobilization of the fracture site) can affect the quality of fracture repair (Goodman et al. 1984:34-35), sometimes leaving bones grossly angulated or misshapen. Under optimal conditions, a long-term well-healed fracture can be nearly invisible (Jurmain 1991:241; Ortner and Putschar 1981:63; White 1991:23). Furthermore, "skeletal evidence of trauma occurring in subadults may be completely obliterated by the modeling and remodeling associated with normal growth" (Ortner 2003c:119). Using known rates of bone healing and repair, it is possible to determine how long before death trauma occurred (Goodman et al. 1984:34; Steinbock 1976:20), and whether or not it may have been a direct or indirect cause of death (Steinbock 1976:22). Potential sources of error in estimating rates of trauma in prehistory stem from undercounting due to thorough remodeling (rendering the trauma site difficult to detect), and also from the tendency for analysts to confuse perimortem trauma (trauma incurred around the time of death and lacking evidence of healing) with postmortem damage (Ortner 2003c:119).

Certain types of trauma indicate specific incidents or activities, and patterning of trauma for a single individual or segment of a population may allow inference of specific activities or behavior patterns (Goodman et al. 1984:34; Shermis 1982). In particular, patterns of trauma can be indicative of endemic warfare and interpersonal violence (Angel 1974; Bridges 1996; Courville 1967:621; Jurmain 1991; Lahren and Berryman 1984; Lambert 1997; Lovejoy and Heiple 1981; Milner 1995, 1998; Milner et al. 1991; Ortner 2003c; Ortner and Putschar 1981; Owsley et al. 1977; Smith 1997; Walker 1989, 1997; Wood 1979; Wood-Jones 1910b). Such trauma might include scalping, mutilation, embedded projectile points, cranial fractures, rib fractures, and parry fractures. A parry fracture is a fracture of the midshaft or distal ulna (or radius and ulna together), most frequently on the left side (Angel 1974; Jurmain 1991), due to defensive parrying of a blow (Angel 1974, Armelagos 1990; Ortner and Putschar 1981; Salib 1967; cf. Smith 1996a, 1996b). Evidence of several of these indicators on a single individual may indicate individual interpersonal violence such as spousal or child abuse (Smith 1996a, 1996b; Wells 1964:53; Wilkinson and van Wagenen 1993). Evidence of such indicators on many members of an entire segment of a population suggests chronic socially sanctioned domestic violence or endemic warfare.

Powell predicted that evidence of warfare would surface in the Moundville population: "Given the important role of warfare as a means for social advancement for males in the late prehistoric southeastern chiefdoms, it seems reasonable to expect more skeletal evidence of war-related trauma among elite males than in their lower-status contemporaries (Powell 1992a:83)." However, Milner (2005) discusses incidence of arrow wounds suffered by nineteenth-century soldiers, scouts, and civilians involved in the "Indian Wars" of the American West. He discovered that only one in three medically recorded arrow injuries resulted in damage to bone, suggesting that at least in the case of penetrating wounds, traumatic injury due to personal violence is significantly undercounted.

Powell found generally low trauma rates at Moundville: only 0.7% of the population exhibited traumatic injuries to the skeleton (Powell 1991a), and healed fractures were found only in adults (Powell 1988:144-146, 1992a:87, 1998:110). The most common fracture sites were the ribs, hands, feet, radii, and ulnae (Powell 1986, 1992a). Powell also found that members of the elite stratum exhibited even lower rates of trauma than members of the nonelite social stratum (though not statistically so), contrary to predictions suggesting that Mississippian elite males might have achieved and maintained their status through prowess in war (Powell 1991a:41). Any comparison of the elite to the nonelite at Moundville suffers from a troubling potential bias – none of the mound burials excavated by C.B. Moore in 1905 and 1907 have survived the curatorial vagaries of the last century (Steponaitis 1980a:18-19; Peebles 1981; Powell 1986:129, 1992a:84; 1998:105). Therefore, the elite individuals identified by Peebles (1974) and analyzed by Powell (1985, 1991) were at best part of the minor elite who only rated burial in cemeteries, albeit with finer grave goods than the hoi polloi. However, the pattern of low rates of trauma among the elite has been confirmed at other Mississippian era mound centers whose mound burials have been analyzed in comparison with nonmound burials. At the Chucalissa, Dallas, and Hixon sites in Tennessee there were appreciable differences in skeletal height between mound burials and nonmound burials, but no patterned differences in diet or health indicators, and at the Etowah site in Georgia, there were no significant differences between mound and nonmound burials for any indicators of health or diet (Powell 1991a:46-50). So, even without the mound burial segment of the skeletal population, it is reasonable to assume that the lack of differentiation between the elite and nonelite strata at Moundville represents a true lack of difference between elite and nonelite health in life.

In my analysis, I observed ten individual cases of trauma. Three were cases suggestive of falls, perhaps from a considerable height. These included one probable male adult from the Snow's Bend site, a Moundville II / III single mound center, who had complete fusion of the second cervical through second thoracic vertebrae. There was also an adult male from a Moundville IV subphase village who exhibited extensive well-healed trauma to the left femoral head, and a probable male adult who was buried at Moundville during the Moundville II subphase who suffered a comminuted fracture of the right innominate, including the acetabulum, with subsequent traumatic osteoarthritis to the right femoral head. This latter case was extremely pathological though well-healed. This type of fracture typically occurs when the femur is flexed (i.e., the body is bent forward at the hip) (Connolly 1981:466), and may occur in a fall to the hands and knees, though in modern usage it is often referred to as a "dashboard fracture" (Keith Jacobi, personal communication 2003), because it is most frequently associated with automobile accidents (Connolly 1981:464). Two additional cases of trauma were a fracture of the right distal fibula of an older adult of unknown sex who lived at a Moundville IV subphase farmstead, and two broken ribs of a young adult female who was buried at Moundville during the Moundville III subphase.

The remaining five cases of trauma can be classified as suggesting interpersonal violence. Three were individuals of unknown or indeterminate sex with possible parry fractures to the left ulna. One lived at Moundville during the Moundville I subphase and two lived at outlying villages during the Moundville IV subphase. The other two possible cases of interpersonal violence were an adult female with a fractured left clavicle who lived at one of the outlying sites during the Moundville I subphase, and an adult of indeterminate sex with a fractured left maxilla who was buried at Moundville during the Moundville II subphase. As Smith (1996b) cautions, parry fractures are usually sustained in defense of a blow to the head. Therefore, apparent parry fractures in the absence of accompanying head trauma cannot be uncritically ascribed to interpersonal violence. Similarly, fractures to the clavicle and face, particularly on the left side, may be sustained during violent personal attacks or may simply result from accidental trauma. Other evidence of violence (i.e., greater frequencies of fractures or head and facial trauma among females or the elderly), or perhaps differential burial practices for members of an age-, gender-, or ethnicity-determined underclass (Smith 1996b) is usually necessary to corroborate an interpretation of interpersonal violence.

Overall, I found that rates of trauma in the Moundville chiefdom are moderate to low, totaling 6% of the population. No subadults or infants exhibited trauma within any segment of the Moundville chronology, and incidence of trauma among adults is so low that results of Fisher's Exact Test indicate no statistically significant differences in incidence of trauma between adults and subadults within Moundville subphases (Table

36). There are also no consistent patterns in incidence of trauma between adult males and females within Moundville subphases, and Fisher's Exact Test indicates no significant differences (Table 37). Although rates of trauma appear to decrease over

Table 36. Rates of Trauma by Age.

Moundville I

	Present		Absent		Total
	n	%	n	%	N
Adult	2	50%	2	50%	4
Subadult	0	0%	0	0%	0
Total	2	50%	2	50%	4

p = 1.0000

Moundville II / III

	Present		Absent		Total
	n	%	n	%	N
Adult	4	31%	9	69%	13
Subadult	0	0%	3	100%	3
Total	4	25%	12	75%	16

p = .3928

Moundville IV

	Present		Absent		Total
	n	%	n	%	N
Adult	4	22%	14	78%	18
Subadult	0	0%	8	100%	8
Total	4	15%	22	85%	26

p = .2046

Table 37. Rates of Trauma by Sex.

Moundville I

	Present		Absent		Total
	n	%	n	%	N
Female	1	100%	0	0%	1
Male	0	0%	2	100%	2
Total	1	33%	2	67%	3

p = 1.000

Moundville II / III

	Present		Absent		Total
	n	%	n	%	N
Female	1	25%	3	75%	4
Male	1	20%	4	80%	5
Total	2	22%	7	78%	9

p = .8333

Moundville IV

	Present		Absent		Total
	n	%	n	%	N
Female	0	0%	6	100%	6
Male	1	14%	6	86%	7
Total	1	8%	12	92%	13

p = .5384

time, there were also no statistically significant differences in incidence of trauma between Moundville subphases (Table 38). It appears that Moundville populations were generally free of accidental trauma and intentional violence across time.

Table 38. Rates of Trauma between Moundville Subphases.

	Present		Absent		Total
	n	%	n	%	N
MV I	2	50%	2	50%	4
MV II/III	4	25%	12	75%	16
MV IV	4	15%	22	85%	26
Total	10	22%	36	78%	46

Fisher's Exact Test
MV I vs. MV II / III: p = .9391
MV II / III vs. MVIV: p = .8791

Degenerative Joint Disease: Osteoarthritis and Osteophytosis

Osteoarthritis is caused by the degeneration of cartilage and subsequent damage to the articular surfaces of bone, eventually leading to arthritic lipping of the margins and remodeling and eburnation of the of articular surfaces of the bone (Bourke 1967; Rogers and Waldron 1995; Steinbock 1976). Because it is due to everyday biomechanical wear and tear, osteoarthritis is one of the most common forms of pathology among humans (and, in fact, all vertebrates) (Jurmain 1977, Rogers and Waldron 1995:32). In general, if a person is fortunate to live long enough he or she will eventually develop osteoarthritis in some form or another (Goodman et al. 1984:36).

Traumatic osteoarthritis may also form as a result of acute trauma to a joint, causing total remodeling of the opposing articular surfaces. As opposed to degenerative joint disease, traumatic osteoarthritis can strike at any age (Steinbock 1976:289).

Vertebral osteophytosis (marginal lipping of the vertebral bodies) is a distinct degenerative process caused by herniation of vertebral discs in response to wear-and-tear on the spinal column. Compression of the intervertebral disc causes the periosteum of the adjoining vertebrae to be squeezed outwards, and the resulting periosteal reaction causes osteophytes to form (Bourke 1967:355). Osteophytosis most commonly affects the lower thoracic and lumbar vertebrae due to the excessive load these weight-bearing vertebraecarry (Steinbock 1976), exacerbated by heavy mechanical stress associated with bipedalism (Bridges 1994). Osteophytes form preferentially on the anterior margins of the vertebrae, because this is the area of greatest compression. In some cases, osteophytes may grow into one another (termed "kissing" osteophytes), and may even fuse, causing ankylosis of the adjacent vertebrae (Steinbock 1976:287-289). Vertebral osteophytosis is similar to osteoarthritis in that nearly everyone who lives long enough develops problems with disc degeneration. In fact, vertebral osteophytosis begins as early as age 30, and affects nearly 100% of the population that reaches age 60 (Goodman et al. 1984:36). Due to their common etiology of old age wear-and-tear, vertebral osteophytosis and osteoarthritis commonly co-occur (Steinbock 1976:302), and are often thought of as components of a single degenerative process (Ortner and Putschar 1981:421) (i.e., vertebral osteophytosis is often classified as a subset of osteoarthritis). Note also that true osteoarthritis can also occur on the vertebrae, on the joint surfaces between the transverse processes (Bourke 1967).

Much like trauma, individual or population-wide patterning of osteoarthritis can give clues as to behavioral patterns and habitual activities (Bridges 1992; Goodman et al. 1984:35-36; Larsen 1987:388-394; Ortner 1968; Ubelaker 1989:108). "The pattern, distribution, severity, and onset by age class and sex in adults can be used to interpret the role of cultural activity in the etiology of degenerative joint disease" (Goodman et al. 1984:36). In particular, mechanical-functional stress (mitigated by age, sex, heredity, or individual predisposition) associated with lifestyle is an excellent indicator of osteoarthritis (Jurmain 1977; Ortner 1968:145). A commonly-cited occupational factor in the development of degenerative joint disease is the overall subsistence regime of a population. In particular, the transition to agriculture is associated with a decline in the incidence of osteoarthritis: hunter-gatherers appear to have been working harder than their agricultural counterparts, and suffering more degenerative joint disease (Cohen and Armelagos 1984; Larsen 1984; Roosevelt 1984; Rose et al. 1984). Unfortunately, in archaeological samples it is often difficult to determine specific contributing factors such as occupation or habitual activities; but from a population perspective we can determine if overall lifestyle contributed to increased or decreased incidence of degenerative joint disease (Jurmain 1990).

Powell did not record osteoarthritis as a separate category of pathology, but instead included arthritic pathology within her category of "focal osteoblastic lesions" (Powell 1985a, 1988). I chose to record osteoarthritis as a separate category because I felt that as a lifestyle-related condition, frequency of osteoarthritis had the potential to reveal interesting differences between the Moundville subphases.

In the Moundville population, the majority of osteoarthritis I recorded was in the form of vertebral osteophytosis: thirteen of seventeen cases. Of these thirteen, five were over age 40, five were between age 30 and 40, one was below age 30, and the remainder were of indeterminate age. Nine of seventeen cases exhibited osteoarthritis of the major joints (sometimes more than one per individual), including the sacroiliac (n=2), shoulder (n=1), elbow (n=2), knee (n=4), and ankle (n=2). I also observed osteoarthritic changes to the left costal notch of the manubrium, and the metatarsophalangeal joint of the first toe. This latter condition may result from trauma associated with a stubbed toe, sometimes referred to as a "midnight fracture". Of the ten individuals who exhibited osteophytosis or non-vertebral osteoarthritis for whom age estimates were available, one was under age 30, three were between age 30 and 40 and five were over age 40. Incidence of osteophytosis and non-vertebral osteoarthritis were fairly well matched during the Moundville I and Moundville IV subphases, but during the Moundville II / III subphases, incidence of osteophytosis outnumbered non-vertebral osteoarthritis by a ratio of nine to three.

Although males appear to outnumber females in incidence of osteoarthritis, results of a Fisher's Exact Test indicate no significant differences between males and females within the Moundville subphases (Table 39). Over time, osteoarthritis declines precipitously, a trend which is not statistically significant between the Moundville I and Moundville II / III subphases. However, there was a statistically significant decrease in incidence of osteoarthritis from Moundville II / III to Moundville IV (Table 40), representing a true change in rates of degenerative joint disease. I had originally hypothesized that Moundville IV populations would reintensify their agricultural economy as populations settled in nucleated villages. Recalling that a decline in osteoarthritis is associated with the advent of agriculture, my Moundville IV re-intensification scenario is supported by my results showing a decline in incidence of osteoarthritis in the Moundville IV subphase. Unfortunately, Schoeninger and Schurr's

Table 39. Rates of Osteoarthritis by Sex.

Moundville I

	Present		Absent		Total
	n	%	n	%	N
Female	0	0%	0	0%	0
Male	3	100%	0	0%	3
Total	3	100%	0	0%	3

p = 1.0000

Moundville II / III

	Present		Absent		Total
	n	%	n	%	N
Female	1	33%	2	67%	3
Male	5	100%	0	0%	5
Total	6	75%	2	25%	8

p = .1071

Moundville IV

	Present		Absent		Total
	n	%	n	%	N
Female	0	0%	3	100%	3
Male	4	57%	3	43%	7
Total	4	40%	6	60%	10

p = .1666

(1998:122) stable carbon isotope analysis of Moundville remains revealed a decline in maize consumption, suggesting that Moundville IV populations did not, in fact, re-intensify maize production. As a result, it is difficult to interpret this pattern in light of changing health conditions over time, other than to conclude that later Moundville and

Black Warrior River Valley populations were working less hard and creating less wear and tear on their bodies.

Table 40. Rates of Osteoarthritis between Moundville Subphases.

	Present		Absent		Total
	n	%	n	%	N
MV I	3	100%	0	0%	3
MV II/III	10	83%	2	17%	12
MV IV	4	29%	10	71%	14
Total	17	59%	12	41%	29

Fisher's Exact Test: Moundville I vs. Moundville II / III
p = .6285

Chi-Square Test: Moundville II / III vs. Moundville IV
Chi-Square = 7.80
Degrees of Freedom = 1

In the disintensification scenario that I have suggested, I also expected rates of degenerative joint disease to decrease from Moundville I to Moundville II / III. This expectation was also not met by the results of my analysis. A possible mitigating factor is that osteoarthritis is an age-dependent condition, and age profiles of populations under comparison ideally should match. The Moundville I and Moundville II / III subphases are generally well matched in age, with an average age at death of 19.75 and 20.10 years, respectively. Therefore, age profiles cannot explain the similarity in is that osteoarthritis is an age-dependent condition, and age profiles of populations under comparison ideally should match. The Moundville I and Moundville II / III subphases are generally well matched in age, with an average age at death of 19.75 and 20.10 years, respectively. Therefore, age profiles cannot explain the similarity in incidence of osteoarthritis in Moundville I and II / III populations. The population from the Moundville IV subphase is considerably younger, with a mean age at death of only 14.56 years. Normally, a decrease in mean age at death indicates a decline in health and nutrition. Remember, however, that the Moundville IV subphase had a different mortuary

program that may have resulted in improved preservation and recovery of infant and subadult remains. Therefore, the mean age at death statistic is likely skewed downward by the increased representation of children and infants. Unfortunately, there is no way of knowing how this impacted rates of osteoarthritis, because we cannot know if the Moundville I, II / II and IV samples were from age-matched populations or not.

The high rates of osteoarthritis for the Moundville I and II / III samples are not surprising, compared to rates for similar societies elsewhere in the Southeast. For example, in the Dickson Mounds Middle Mississippian population from Illinois, Chapman (1962:61) found that 84% (47/56) of adult males and 67% (30/46) of adult females exhibited mild to severe degenerative joint disease (combined osteoarthritis and osteophytosis). These high frequencies were confirmed in a later analysis by Martin and colleagues (1979:60), in which they found an overall adult frequency of 69.5% for mild to severe osteoarthritis among Middle Mississippians at Dickson Mounds.

I also found that the location of osteophytosis in the Moundville sample is well matched with comparable populations. At Moundville, I found that 35% of adults exhibited osteophytosis of the thoracic and lumbar spine. An additional 24% of adults showed involvement of the cervical and thoracic spine. By comparison, in the pooled Archaic and Mississippian populations from the Pickwick Basin in Northern Alabama, Bridges observed highest frequencies of osteophytosis in the lumbar region (25-36% minor involvement and 20-46% moderate to severe involvement), followed by second-highest frequencies in the cervical vertebrae (12-30% minor involvement and 5-27% moderate to severe involvement) (Bridges 1994:85, table 2).

My results for incidence of osteoarthritis are difficult to interpret in terms of my disintensification model. There was no difference in incidence of osteoarthritis between the Moundville I and Moundville II / III subphases, which fails to support my contention that rates of osteoarthritis would have changed in response to disintensification of agriculture. Furthermore, I observed a statistically significant decline in osteoarthritis from Moundville II / III to Moundville IV. Because osteoarthritis typically decreases in agricultural populations, these results support my original contention that osteoarthritis would decline as Moundville IV populations re-intensified their investment in maize agriculture. Unfortunately, subsistence evidence suggests that Moundville IV populations actually consumed less maize than their predecessors, contradicting both my model and my paleopathological results.

Dental Pathology and Wear

Dental Caries

Dental caries and dental abscesses are the two main forms of dental pathology recorded for the Moundville population. Dental caries result from the destruction of tooth enamel and dentin of the tooth in response to acids produced by bacteria present in dental plaque (Caselitz 1998; Hillson 1979, 1996:269; Larsen 1980, 1981, 1982, 1983, 1987, 1995; Larsen et al. 1991). These bacteria feed on saliva and simple carbohydrates, and produce acid as a waste product of digestion (Hillson 1979, 1996:254-255). Caries rates can be influenced by individual factors such as age, sex, general health (Larsen 1983), heredity (Caselitz 1998:204), immune response (Hillson 1979:150), tooth crown size and morphology (Paynter and Grainger 1962), developmental enamel defects (Ortner 2003d:591), malnutrition, periodontal disease, mineral composition of tooth enamel, oral chemistry and bacterial flora (Larsen et al. 1991), and personal hygiene (Hillson 1979:149; Lambert 2000:174); also by environmental factors such as minerals in the local water supply, particularly fluoride (Larsen 1983; Larsen et al. 1991). Prevalence of dental caries represents the interplay between one or more of these predisposing factors, the cariogenic nature of the diet (i.e., starchiness and stickiness) (Larsen 1995) and the degree of dental wear, which can wear away incipient carious defects on occlusal surfaces before they can invade the matrix of the tooth (Larsen et al. 1991; Milner 1984; Powell 1985b:309). In the Americas, there is a distinct rise in caries rates associated with the advent of maize agriculture (Behrend 1978; Cassidy 1984; Cook 1984; Huss-Ashmore et al. 1982:441; Larsen et al. 1991;

Milner 1984; Rose et al. 1984), which resulted in a diet high in simple carbohydrates. Furthermore, the texture of the diet – whether it is hard and crunchy, leading to cleansing of tooth surfaces, or soft and sticky, tending to adhere to tooth surfaces – mitigates the rate of caries development (Larsen et al. 1991). Even Aristotle observed that "soft sweet dried figs adhered to the teeth and were associated with dental caries (Powell 1985b:313)."

Prevalence of caries is calculated simply as a percentage: number of carious teeth divided by the total number of teeth present (Powell 1985b:321). In general, a caries rate over 8.56% of teeth (generalized to a broad range of 2.3 to 26.9%) is considered to represent an agricultural population (Turner 1979:622-624). In addition, Larsen and colleagues (1991:186) found that in the New World, a caries rate of greater than 7% indicates a maize-dependent population. Dental caries are also often reported as mean caries per dentition, but this statistic may be skewed by sampling error if not all individuals in the sample are represented by a full complement of adult teeth due to antemortem or postmortem loss (Larsen et al. 1991). For the purposes of this statistic, a rate of two or more caries per dentition indicates a high-carbohydrate diet (Rose et al. 1984; Rose et al. 1991; Turner 1979). It also appears that the rate of dental caries increases with age, since older teeth have had greater exposure to cariogenic foods and conditions (Larsen et al. 1991), though the statistical relationship between increased age and increased caries is weak (Caselitz 1998:209). Still, a population with a higher average age will also tend to have a higher percentage of caries; therefore, the relative age of populations must be considered in order to make comparisons (Larsen et al. 1991).

At Moundville, Powell (1985a, 1986:134) found that adults suffered an average 3.5 carious lesions per dentition, and subadults suffered an average of 1.8 carious lesions per permanent dentition. Powell found no statistically significant differences in caries rates between status segments of the Moundville population, or between adult males and females (Powell 1988:120-135, 1992a:86, 1998:109), suggesting that all segments of the population "consumed diets similar in texture and cariogenic properties" (Powell 1992a:88). The adult rate of 3.5 carious lesions per dentition reported by Powell is clearly within the range of agricultural populations. Over time, Powell also found that caries rates for young adults increased from the Moundville I to the Moundville II subphase, "an expected result of the increase in maize consumption during that period (Powell 1998:115-116)." Dental health then appears to have improved in the Moundville II / III and Moundville III samples for young adults, though it continued to decline for older adults (Powell 1998:115-116).

In my analysis, I found no statistically significant differences in incidence of caries between adult males and females within any subphase (Tables 41 and 42). Significant differences in incidence of caries did occur between subadults and adults during the Moundville II / III and Moundville IV subphases (Tables 43 and 44). Clearly, this significance is associated with the total absence of caries among subadults during Moundville II / III, and the near absence of caries among subadults during Moundville IV. These rates are not surprising. Deciduous teeth are formed and lost during the first ten years of life (Ubelaker 1989), and therefore have less exposure to the cariogenic environment (Larsen et al. 1991:184). Permanent teeth in a subadult's mouth (recall that subadults are defined as less than age 15, and therefore have a partial complement of adult teeth) are also less likely to exhibit caries, because at the most they have been exposed to sources of dental decay for less than ten years (i.e., since eruption of the permanent first molars around age six) (Ubelaker 1989). Overall, I also found no statistically significant differences in incidence of caries between Moundville subphases (Tables 45 and 46), suggesting there was no dramatic change in diet or exposure to cariogenic factors over time.

Table 41. Mean Caries per Permanent Dentition by Sex.

Subphase	Sex	n	Mean	Variance	Range
Moundville I					
	Male	3	1.00	0.33	0-3
	Female	3	0.33	3.00	0-1
Moundville II/III					
	Male	15	1.20	1.60	0-4
	Female	14	1.36	4.40	0-6
Moundville IV					
	Male	9	1.89	4.11	0-6
	Female	15	1.33	1.52	0-4
Total					
	Male	27	1.41	2.48	0-6
	Female	32	1.25	2.64	0-6

Table 42. Student's T-test of Mean Caries by Sex.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I	0.63	3	0.28
Moundville II/III	-0.24	22	0.40
Moundville IV	0.74	12	0.26
Total	0.38	58	0.35

Table 43. Mean Caries per Total Dentition by Age.

Subphase	Age	n	Mean	Variance	Range
Moundville I					
	Adult	7	0.57	1.29	0-3
	Subadult	1	0.00	0.00	0
Moundville II/III					
	Adult	34	1.21	2.17	0-5
	Subadult	13	0.00	0.00	0
Moundville IV					
	Adult	28	1.36	1.49	0-4
	Subadult	31	0.35	0.90	0-3
Total					
	Adult	69	1.20	1.81	0-5
	Subadult	45	0.24	0.64	0-3

Table 44. Student's T-test of Mean Caries by Age.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I	1.32	6	0.11
Moundville II/III	4.78	33	0.00005
Moundville IV	3.52	53	0.00006
Total	4.77	113	0.00005

Table 45. Mean Caries between Moundville Subphases.

Subphase	n	Mean	Variance	Range
Moundville I	8	0.50	1.14	0-3
Moundville II/III	47	0.87	1.85	0-5
Moundville IV	61	0.90	1.82	0-6
Total	116	0.86	1.77	0-6

Table 46. Student's T-test of Mean Caries between Moundville Subphases.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I vs. Moundville II/III	-0.86	12	0.29
Moundville II/III vs. Moundville IV	-0.11	101	0.45

At Moundville, I found that caries rates were lower than I expected. No segment of the population returned a trimmed mean caries rate that was within the range of an agricultural population. Adults averaged 1.20 caries per dentition and subadults averaged 0.24 caries per dentition across Moundville subphases. Similarly, adult males averaged 1.41 caries per dentition and adult females averaged 1.25 caries per dentition across subphases. I calculated a trimmed mean because the Moundville I population included two extreme outliers: one adult female who suffered eleven dental caries and another adult female who had twenty-two caries.

The first and most likely explanation for the low overall caries rates at Moundville is that I may have seriously undercounted caries in my sample, rendering the difference between my results and Powell's (1985a, 1986) an artifact of interobserver error. However, there are also differences within my sample in how well each subphase is represented by teeth. In my Moundville I subphase adult sample, an average of 19.1 teeth per mouth (out of 32 possible adult teeth) were present. These figures drop to an average of 10.5 teeth per mouth during the Moundville II / III subphases and 13.0 teeth per mouth during the Moundville IV subphase. These low figures suggest that caries rates may have been affected by preservation bias, or more likely by antemortem tooth loss (AMTL).

The clinical literature clearly establishes that caries directly contribute to loss of teeth during life (Lukacs 1992, 1995; Powell 1985). Therefore, there may actually be an inverse relationship between caries rates expressed in death and caries rates in life: those who suffered more caries in life may have fewer remaining caries in death because they suffered antemortem loss of badly decayed teeth. When I compared AMTL frequencies, I found that they were generally low, with males averaging 1.72 teeth lost before death and females averaging 2.52 teeth lost before death (Table 47), across Moundville subphases. Not all teeth lost antemortem are due to caries, so AMTL is not a direct proxy for amending the caries rate. Even so, it is clear that caries rates at Moundville would remain low even if AMTL were factored in appropriately. Lukacs (1992, 1995) presents a method of calibrating caries rates using AMTL data, but it requires specific caries data that I did not collect in my analysis, so I am unable to calculate Lukacs' "caries correction factor".

When I calculated statistical significance for AMTL rates, I found that females had a significantly higher rate of AMTL than males within the Moundville II / III subphase (Table 48), even though there was no statistical difference in raw caries rate between the sexes during Moundville II / III. There is also a statistically significant change in AMTL between the Moundville subphases (Tables 49 and 50): AMTL increases from an average of 0.78 during Moundville I to 2.77 during Moundville II / III, and declines to 1.23 during Moundville IV. Because AMTL is not exclusively

Table 47. Mean Antemortem Tooth Loss by Sex.

Subphase	Sex	n	Mean	Variance	Range
Moundville I					
	Male	3	1.00	3.00	0-3
	Female	5	0.80	0.70	0-2
Moundville II/III					
	Male	18	1.89	5.39	0-8
	Female	11	4.45	12.87	0-10
Moundville IV					
	Male	8	1.63	3.69	0-6
	Female	9	1.11	3.86	0-6
Total					
	Male	29	1.72	4.49	0-8
	Female	25	2.52	9.84	0-10

Table 48. Student's T-test of Mean Antemortem Tooth Loss by Sex.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I	0.18	3	0.42
Moundville II/III	-2.11	16	0.02
Moundville IV	0.55	17	0.29
Total	-1.08	43	0.14

Table 49. Mean Antemortem Tooth Loss between Moundville Subphases.

Subphase	n	Mean	Variance	Range
Moundville I	9	0.78	1.19	0-3
Moundville II/III	31	2.77	9.11	0-10
Moundville IV	22	1.23	3.42	0-6
Total	62	1.94	6.55	0-10

Table 50. Student's T-test of Mean Antemortem Tooth Loss between Moundville Subphases.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I vs. Moundville II/III	-3.04	39	0.002
Moundville II/III vs. Moundville IV	2.29	52	0.01

associated with caries, I suspected the difference between males and females, and between subphases, might be due to unmatched age profiles within the population. However, when I calculated mean age at death for the adult population at Moundville, I found that there were no significant differences in age at death between males and females during the Moundville II / III subphase (Tables 51 and 52). I also found no change in mean age at death between Moundville subphases (Tables 53 and 54), suggesting that although AMTL rates change, the results are not biased by the age of the population.

Although AMTL is not exclusively associated with dental caries, there is clearly a dietary connection in the rate of tooth loss before death. The trend of significant change in AMTL between Moundville subphases mirrors Schoeninger and Schurr's (1998:125) stable carbon isotope results for the Moundville subphases, reflecting maize consumption. They found that maize consumption was moderate during the Moundville I subphase (-14 per mil), higher during both Moundville II and III (-10 per mil), and then slightly lower during Moundville IV (-11 per mil). These results were not statistically significant between Moundville I and Moundville II / III due to sample size,

Table 51. Adult Mean Age at Death by Sex.

Subphase	Sex	n	Mean	Variance	Range
Moundville I					
	Male	3	32.83	248.58	19-50
	Female	5	21.20	15.70	18-28
Moundville II/III					
	Male	16	31.34	101.52	18-50
	Female	13	25.88	77.38	18-50
Moundville IV					
	Male	12	34.79	112.93	21-47.50
	Female	13	23.57	33.32	16-33.50
Total					
	Male	31	32.82	111.45	18-50
	Female	31	24.16	49.27	16-50

Table 52. Student's T-test of Adult Mean Age at Death by Sex.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I	1.25	2	0.16
Moundville II/III	1.55	29	0.06
Moundville IV	3.24	18	0.002
Total	3.80	54	0.0003

Table 53. Adult Mean Age at Death between Moundville Subphases.

Subphase	n	Mean	Variance	Range
Moundville I	8	25.56	116.24	18-50
Moundville II/III	29	28.89	95.18	18-50
Moundville IV	25	28.96	101.12	16-47.50
Total	62	28.49	98.11	16-50

Table 54. Student's T-test of Adult Mean Age at Death between Moundville Subphases.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I vs. Moundville II/III	-0.78	11	0.27
Moundville II/III vs. Moundville IV	-0.02	52	0.48

but the decline during Moundville IV was statistically significant. Even though raw caries rates in my sample did not reflect these dietary changes at Moundville, it is remarkable that AMTL frequencies appear to do so.

Dental Abscess

Dental abscesses may arise from an injury or insult to the surface of a tooth such as caries, wear, or chipping and cracking, which creates a pathway for bacteria to travel through the pulp chamber and the apex of the tooth root, causing infection. (Hillson 1996:285; Alt et al. 1998:247-250). More commonly, a dental abscess forms as a result of periodontal disease, which causes the gum to pull away from the tooth root and forms a periodontal pocket. This pocket may fill with plaque, setting up a prime breeding ground for bacteria and infection (Roberts and Manchester 1997:50). In both pathways, these bacteria set up an infectious process that invades the alveolar bone surrounding the tooth root, forming an abscess. A pocket of pus develops, which is at first walled off within the alveolar bone by reactive bone tissue, but eventually breaks through the outer table through a fistula, draining through the tissues of the mouth, nose, or maxillary sinus (Hillson 1996:285). Untreated, dental abscesses can invade the general bone matrix causing osteomyelitis, and may also invade other tissues of the skull, leading to sinus infection, meningitis, brain abscess, sepsis, and death (Alt et al. 1998:259). Archaeologically, dental abscesses appear as large cavities within the alveolar bone, bounded by reactive bone tissue. Often they are broken due to the fragile nature of the bone tissue near the fistula, which is typically thinned due to pressure atrophy of the bone resulting from the buildup of pus.

Powell (1985a, 1988) did not record prevalence of dental abscesses in her examination of Moundville skeletal materials. In my analysis, I found very low rates of dental abscesses overall (Table 55). There were no significant differences in incidence of dental abscesses between adult males and females within any Moundville subphase (Table 56). However, there were statistically significant differences in abscess rates between adults and subadults within the Moundville II / III and Moundville IV subphases (Tables 57 and 58). As I discovered for caries, the source of this significant difference is that there were no abscesses among subadults during any of the Moundville subphases. Because abscesses are associated with caries (Hillson 1996; Alt et al. 1998), and subadults also exhibited low to nonexistent rates of dental caries the Moundville phase, it is not surprising that these two patterns parallel one another. There were also no significant differences in incidence of dental abscesses between Moundville subphases (Tables 59 and 60), again reflecting the lack of dramatic change in diet, caries rates, or periodontal disease that might have led to changing rates of abscess over time.

Table 55. Mean Abscesses per Permanent Dentition by Sex.

Subphase	Sex	n	Mean	Variance	Range
Moundville I					
	Male	3	1.33	2.33	0-3
	Female	5	0.80	3.20	0-4
Moundville II/III					
	Male	17	0.29	0.34	0-2
	Female	14	0.14	0.13	0-1
Moundville IV					
	Male	11	0.55	1.07	0-2
	Female	15	0.13	0.26	0-3
Total					
	Male	31	0.48	0.79	0-4
	Female	34	0.24	0.61	0-3

Table 56. Student's T-test of Mean Abscesses by Sex.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I	0.44	7	0.33
Moundville II/III	0.87	29	0.30
Moundville IV	1.24	14	0.11
Total	1.15	62	0.12

Table 57. Mean Abscesses per Total Dentition by Age.

Subphase	Age	n	Mean	Variance	Range
Moundville I					
	Adult	9	0.89	2.36	0-4
	Subadult	1	0.00	0.00	0
Moundville II/III					
	Adult	37	0.19	0.21	0-2
	Subadult	13	0.00	0.00	0
Moundville IV					
	Adult	32	0.25	0.51	0-3
	Subadult	32	0.00	0.00	0
Total					
	Adult	78	0.29	0.60	0-4
	Subadult	46	0.00	0.00	0

Table 58. Student's T-test of Mean Abscesses by Age.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I	1.73	8	0.05
Moundville II/III	2.52	36	0.007
Moundville IV	1.98	31	0.02
Total	3.30	77	0.0009

Table 59. Mean Abscesses between Moundville Subphases.

Subphase	n	Mean	Variance	Range
Moundville I	10	0.80	2.17	0-4
Moundville II/III	50	0.14	0.16	0-2
Moundville IV	64	0.13	0.27	0-3
Total	124	0.19	0.39	0-4

Table 60. Student's T-test of Mean Abscesses between Moundville Subphases.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I vs. Moundville II/III	1.40	9	0.09
Moundville II/III vs. Moundville IV	0.11	114	0.45

As I had suggested for dental caries, because caries, abscesses, and antemortem tooth loss are so closely associated, it is possible that AMTL also contributed to the low rates of dental abscesses. When teeth are lost to abscess, the abscess may heal completely (Ortner 2003d:590), leaving it uncountable in a paleopathological analysis. However, as I found with dental caries, the only statistically significant difference in AMTL falls between males and females during the Moundville II / III subphase, when there is no statistically significant change in abscess rate. Similarly, although there are significant differences in AMTL incidence between Moundville subphases, there are no equivalent differences in abscess rates between Moundville subphases.

Dental Wear

Dental wear is the gradual wearing away of tooth enamel as a result of chewing food (Rose and Ungar 1998; Molnar 1972) or using the teeth as tools for gripping, processing, or masticating non-food items (Milner and Larsen 1991; Molnar 1972). Degree of dental wear is directly affected by the amount of grit or abrasive particles found in food, generally as a result of food processing. In general, cereal foods processed in stone grinders have a greater prevalence of grit than those processed using different technology (Powell 1985b:309). For example, Powell (1986:134, 1998, 1991:31, 1992a:86, 1998:109) suggests that moderate dental wear she observed at Moundville may have been due to plant processing in wooden mortars rather than stone metates, resulting in less grit in the food, and therefore less extreme dental wear.

In general, Powell (1985a, 1985b, 1986, 1988, 1991a, 1998) found that dental wear at Moundville was moderate and well within the range observed for other Mississippian populations using similar food processing tools (Powell 1986:135, table 8.2). Furthermore, Powell found no statistically significant differences in dental wear between social strata at Moundville (1986:134-136, 1992a:86), and also found no differences in dental wear across Moundville subphases (Powell 1998:116), suggesting that all segments of the population ate similar diets. However, Powell did discover that males exhibited higher rates of wear than females, but when she broke the population down by age categories, she discovered a "strong age effect" (Powell 1991:31), suggesting that the greater dental wear among males was due to greater average age at death.

In my analysis, I found that wear scores were slightly higher than those reported by Powell (1985a, 1988). Within subphases, I found that males consistently had significantly higher rates of dental wear than females during the Moundville II / III subphase, for the maxillary first and second molars (Tables 61, 62, 63, and 64)

Table 61. Maxillary First Molar Mean Wear Scores by Sex.

Subphase	Sex	n	Mean	Variance	Range
Moundville I					
	Male	1	19.00	0.00	19
	Female	3	21.00	57.00	14-29
Moundville II/III					
	Male	9	21.22	35.44	15-32
	Female	8	14.63	38.26	10-29
Moundville IV					
	Male	6	24.50	87.10	15-35
	Female	8	19.88	19.83	12-28
Total					
	Male	16	22.31	51.29	15-35
	Female	19	17.84	37.02	10-29

Table 62. Student's T-test of Maxillary First Molar Mean Wear Scores by Sex.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I	-0.45	2	0.34
Moundville II/III	2.23	17	0.01
Moundville IV	1.12	7	0.14
Total	1.96	31	0.02

Table 63. Maxillary Second Molar Mean Wear Scores by Sex.

Subphase	Sex	n	Mean	Variance	Range
Moundville I					
	Male	2	25.50	144.50	17-34
	Female	4	16.75	67.58	12-29
Moundville II/III					
	Male	10	16.20	29.73	10-27
	Female	5	11.80	8.20	8-15
Moundville IV					
	Male	7	20.43	60.28	12-31
	Female	8	14.88	30.41	9-25
Total					
	Male	19	18.74	52.76	10-34
	Female	17	14.41	31.63	8-29

Table 64. Student's T-test of Maxillary Second Molar Mean Wear Scores by Sex.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I	0.92	2	0.27
Moundville II/III	2.04	15	0.02
Moundville IV	1.57	12	0.06
Total	2.01	35	0.02

and the mandibular first and second molars (Tables 65, 66, 67, and 68). Males had statistically significant higher rates of dental wear for the mandibular second molar during Moundville IV (Table 68).

Table 65. Mandibular First Molar Mean Wear Scores by Sex.

Subphase	Sex	n	Mean	Variance	Range
Moundville I					
	Male	2	25.50	144.50	17-34
	Female	3	16.67	69.33	10-26
Moundville II/III					
	Male	14	22.14	56.90	11-35
	Female	7	14.86	13.47	11-22
Moundville IV					
	Male	7	20.00	22.66	12-28
	Female	10	17.00	21.11	11-24
Total					
	Male	23	21.78	48.72	11-35
	Female	20	16.20	22.58	10-26

Table 66. Student's T-test of Mandibular First Molar Mean Wear Scores by Sex.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I	0.90	3	0.28
Moundville II/III	2.97	21	0.003
Moundville IV	1.29	15	0.10
Total	3.00	41	0.001

Table 67. Mandibular Second Molar Mean Wear Scores by Sex.

Subphase	Sex	n	Mean	Variance	Range
Moundville I					
	Male	2	25.00	162.00	16-34
	Female	4	16.50	49.66	12-27
Moundville II/III					
	Male	12	18.08	36.44	13-31
	Female	7	11.29	2.23	9-13
Moundville IV					
	Male	9	18.00	42.00	10-29
	Female	5	11.60	6.80	10-16
Total					
	Male	23	18.65	44.87	10-34
	Female	16	12.69	17.82	9-27

Table 68. Student's T-test of Mandibular Second Molar Mean Wear Scores by Sex.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I	0.87	2	0.26
Moundville II/III	3.70	14	0.001
Moundville IV	2.60	13	0.01
Total	3.40	39	0.0009

There were no statistically significant differences in degree of dental wear between any of the Moundville subphases (Tables 69, 70, 71, 72, 73, 74, 75, and 76). This is not surprising as the overall diet and processing technology did not change during the Moundville and Protohistoric eras. It is not unreasonable that wear rates remained through time.

Table 69. Maxillary First Molar Mean Wear Scores between Moundville Subphases.

Subphase	n	Mean	Variance	Range
Moundville I	4	20.50	39.00	14-29
Moundville II/III	17	18.12	45.98	10-32
Moundville IV	14	21.86	49.82	12-35
Total	35	19.89	47.33	10-35

Table 70. Student's T-test of Maxillary First Molar Mean Wear Scores between Moundville Subphases.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I vs. Moundville II/III	0.67	6	0.26
Moundville II/III vs. Moundville IV	-1.49	29	0.07

Table 71. Maxillary Second Molar Mean Wear Scores between Moundville Subphases.

Subphase	n	Mean	Variance	Range
Moundville I	6	19.67	89.86	12-34
Moundville II/III	15	14.73	26.06	8-27
Moundville IV	15	17.47	49.26	9-31
Total	36	16.69	46.39	8-34

Table 72. Student's T-test of Maxillary Second Molar Mean Wear Scores between Moundville Subphases.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I vs. Moundville II/III	1.20	7	0.13
Moundville II/III vs. Moundville IV	-1.22	27	0.11

Table 73. Mandibular First Molar Mean Wear Scores between Moundville Subphases.

Subphase	n	Mean	Variance	Range
Moundville I	5	20.20	94.20	10-34
Moundville II/III	21	19.71	53.41	11-35
Moundville IV	17	18.24	22.69	11-28
Total	43	19.19	43.67	10-35

Table 74. Student's T-test of Mandibular First Molar Mean Wear Scores between Moundville Subphases.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I vs. Moundville II/III	0.10	6	0.45
Moundville II/III vs. Moundville IV	0.74	36	0.26

Table 75. Mandibular Second Molar Mean Wear Scores between Moundville Subphases.

Subphase	n	Mean	Variance	Range
Moundville I	6	19.33	81.46	12-34
Moundville II/III	19	15.58	34.36	9-31
Moundville IV	14	15.71	38.06	10-29
Total	39	16.21	41.85	9-34

Table 76. Student's T-test of Mandibular Second Molar Mean Wear Scores between Moundville Subphases.

Subphase	Student's t	Degrees of Freedom	One-tailed Value
Moundville I vs. Moundville II/III	0.95	7	0.31
Moundville II/III vs. Moundville IV	-0.06	29	0.47

Powell (1991a) attributes differences in wear between males and females as age-related bias rendered by the higher mean age at death among males. I found no statistically significant difference in mean age at death between males and females during the Moundville II / III subphase (Table 52), although there are significant differences in wear between males and females during Moundville II / III. However, I found that during the Moundville IV subphase, males had a significantly greater age at death than females (Table 52), and also a significantly higher rate of dental wear for the mandibular second molar (Table 68). Therefore, age-related bias can explain the difference in dental wear between males and females during the Moundville IV subphase, but the question remains: what were males doing differently from females during the Moundville II / III subphase that would render a statistically significant increase in tooth wear? The answer must lie in either dietary or behavioral differences. Schoeninger and Schurr (1998:129) report no differences in maize consumption between males and females at any time during the Moundville phase, though they demur that their sample sizes of individuals of known sex are small and sampling error may be a factor. Besides, it is already established that Moundville populations overall suffered less dental wear because they were processing corn in wooden rather than stone mortars, so the source of wear may not stem from maize consumption anyway. Schoeninger and Schurr (1998:129) also tested stable nitrogen isotope values, which distinguish between aquatic and non-aquatic food resources, and again found no differences between males and females throughout time. The second-most likely source of grit in the diet is shellfish, but stable nitrogen analyses cannot distinguish between fish and shellfish, so the association is less clear. Using strontium analysis, which measures the proportion of meat in the diet, Peebles and Schoeninger (1981) did discover a difference in consumption of meat between males and females in samples drawn from the late Moundville II through late Moundville III subphases. However, when I tested Peebles and Schoeninger's data, the difference was not statistically significant. Even if the difference had been significant, I am unsure how greater consumption of meat would translate to greater dental wear among males. Unfortunately, there have also been no studies of gender-specific behavior in the Black Warrior River valley during the Moundville subphase, as there have been for other intensively-studied regions in the Mississippian southeast, so there are no known gender-biased occupations or activities that might account for the discrepancy in dental wear during Moundville II / III. Until a behavioral or dietary distinction is found between males and females during Moundville II / III, this question will remain unanswered.

Overall, rates of caries, abscesses, and dental wear remained constant throughout time at Moundville. There were no differences between pre-disintensification and post-disintensification populations of the Moundville I and Moundville II / III subphases, or between dispersed and aggregated populations of the Moundville II / III and Moundville IV populations. In terms of my disintensification model, the lack of difference in dental health between Moundville I and Moundville II / III does not support disintensification, because it reveals no significant dietary differences across the temporal boundary at which I hypothesized disintensification to have taken place. It is not surprising that dental wear did not change across time, because overall dietary composition and food processing techniques do not appear to have changed appreciably between the Moundville subphases, regardless of subsistence disintensification or population dispersal (Scarry and Steponaitis 1997:112). It is interesting that there were higher rates of dental wear among males for the later subphase, though these appear to be at least minimally associated with higher mean age at death during the Moundville IV subphase. This trend does not hold true for the Moundville II / III subphase, leaving us with the unanswered question of what males and females were doing differently from one another during the middle period of Moundville's history. The Moundville II / III subphase is the same subphase during which I predicted that the economy would disintensify, which might suggest that the difference is related to different economic roles for males and females in a disintensified system. In the absence of a statistically significant difference in total dental wear from earlier and later subphases, it seems as if the difference between males and females during the Moundville II / III subphase may be more of an artifact of gender differences within the subphase than economic differences between subphases.

Results

The Predictions

In Chapter Two, I suggested that health in the Moundville I subphase would be compromised by decreased dietary diversity and increased population density associated with the development of the nucleated settlement at Moundville proper. In particular, I suggested that health would be poorer overall, and rates of general and specific infection, physical wear and tear, and caries would be high compared with subsequent time periods. Next, I predicted that human health would improve during the Moundville II / III subphases as a result of increased dietary diversity and reduced exposure to infectious disease, associated with population dispersal and disintensification. I expected to find the evidence of this improvement in health in lower rates of infection, physical stress, and dental disease. Finally, during the Moundville IV subphase, after Moundville abandonment, I predicted that population nucleation led to a less diverse diet and greater exposure to communicable disease. This pattern would result in a negative impact on overall health, particularly increased rates of infection, physical stress, and dental pathology.

The Results

Overall, the significant increase in rates of porotic hyperostosis and cribra orbitalia between the Moundville II / III and Moundville IV subphases suggest that before and during the period of dispersed population associated with disintensification, Moundville populations may have been less subject to crowding and sanitation problems (i.e., chronic infection and parasite load), which are clearly associated with these conditions. Later, during the period of village nucleation following the decline of the Moundville chiefdom, populations were more subject to such sanitary and infectious stressors. However, looked at in light of the osteological paradox, the Moundville IV population may have been healthier, and may have survived the health insult that produces porotic hyperostosis and cribra orbitalia. In contrast, Moundville I and II / III populations may have been less healthy and succumbed to health stress before the effects of infection or anemia set in.

Another indicator of generalized stress, periostitis, also had a statistically significant distribution over time, with high rates before and during disintensification, and low rates after the collapse of the Moundville chiefdom. There are two ways to read this pattern. Taken at face value, Moundville I and II / III populations were less healthy and Moundville IV populations were healthier, which contradicts my prediction of improved health during the Moundville II and III subphases and poorer health during Moundville IV. This pattern does not support my dispersal and disintensification model, though it does support Schoeninger and Schurr's (1998) findings that Moundville I and II / III populations consumed similar amounts of maize, followed by a small but statistically significant decrease in maize consumption during the Moundville IV subphase. In another possible interpretation of the data, populations before and during disintensification may have been healthy enough to survive endemic levels of generalized infection and therefore live to manifest periostitis in their skeletons. In contrast, Moundville IV populations may have had such compromised health that they succumbed to some swift-acting and osteologically invisible stressor before the generalized infection associated with periostitis had time to produce skeletal lesions. This application of the osteological paradox supports my predictions that health would have been poorer during the Moundville IV subphase, but still does not represent a change in health between Moundville I and Moundville II / III, when I expected to find the effects of disintensification.

As an infectious process, I expected rates of osteomyelitis to be higher during periods of population aggregation (Moundville I and IV), and lower during periods of population dispersal (Moundville II and III). Instead, I observed only three cases, slightly greater than one percent of my total sample. I am reluctant to identify temporal trends for such a small sample, and therefore cannot say whether or not my prediction was upheld.

As a specific infection, I expected rates of treponematosis to be higher during Moundville I and Moundville IV when populations were nucleated, and lower during Moundville II / III when I predicted that populations were dispersed. Instead, my data yielded no statistically significant differences between subphases, which fails to support my predictions for population dispersal or disintensification from Moundville I to Moundville II / III, nor does it support my prediction for population aggregation and poor health after the decline of the Moundville chiefdom. My sample was fairly large; I recorded treponematosis in 19% of cases with sufficient preservation to gauge expression of treponemal infection, and therefore cannot resort to crying "sampling error" to explain my unfavorable results.

My prediction for rates of tuberculosis was also not upheld. I expected that rates of this density-dependent crowd disease would decrease as population dispersed after A.D. 1300, and increase again as populations re-aggregated into fortified villages during the Moundville IV subphase. Instead, I recorded no cases of tuberculosis in my sample at all. However, this result is not unreasonable. Powell (1992a) recorded only a handful of tuberculosis cases in her synchronic sample: ten out of 564 individuals, or 1.8% of the total. Had I recorded a similar rate of tuberculosis, I would have found only three cases of TB in my sample of 175 individuals. Furthermore, my Moundville sample was not as well preserved as Powell's, particularly in the locations where tubercular lesions tend appear most frequently: the thoracic and lumbar vertebrae. Therefore, I believe that the absence of tuberculosis in my Moundville sample is an artifact of sampling error rather than a true rate.

In terms of occupational, interpersonal, or lifestyle hazards, rates of trauma and osteoarthritis are generally low. For trauma, my sample is extremely small (n=10), though at 6% of the population, it is much higher than the one percent that Powell found exhibiting evidence of trauma at Moundville. At these rates, trauma does not appear to have been a significant health threat. I made no predictions of how population dispersal or disintensification might affect rates of trauma, and found no statistically significant differences between any of the Moundville subphases.

Likewise, I looked at rates of osteoarthritis as examples of occupational stress, and expected lower rates during disintensification and higher rates before and after. Overall, rates of osteoarthritis were low, and I found no difference in frequency of osteoarthritis between Moundville I and Moundville II / III. However, rates did decline significantly between Moundville II / III and IV. Because intensive agriculture is associated with lower rates of osteoarthritis, these results appear to support the idea of re-intensification of agriculture during Moundville IV. Unfortunately, Schoeninger and Schurr's stable carbon isotope results indicate a significant decrease in maize consumption during this period. Unless there is some other behavioral factor during the Moundville IV subphase that accounts for decreased rates of physical wear-and-tear, I am unable to account satisfactorily for this trend.

My data yielded mixed results for dental disease in the Moundville population. In general, I recorded lower rates of dental caries and abscesses than I would have expected for an agricultural population and can only suggest that I grossly undercounted caries. It would be interesting to repeat my analysis using 10X or higher magnification to carefully scout out and record all possible caries, which would possibly yield a more representative result. There were no differences in rates of caries, abscesses, or dental wear between the subphases, implying that disintensification had no effect on dental health over time. Interestingly, males had a statistically higher rate of dental wear than females during the Moundville II / III subphase. This trend represents a dietary or behavioral difference from earlier and later subphases, though I have no compelling explanation for why this might be the case.

I observed general trends in my data that suggested to me that disintensification and reintensification might have truly occurred, but few of my results returned a statistically significant difference between subphases. I believe that some of these trends might be proven statistically significant should the sample of Moundville remains dated to specific subphases ever increase. Although it is unlikely that many more burials will ever be excavated at Moundville, there are 532 known gravelots bearing subphase-specific diagnostic ceramics (Steponaitis 1980:253-264, table 36). There are also nearly 1500 sets of human skeletal remains from Moundville. Where these two data sets overlap (i.e., burials with both preserved skeletal remains and diagnostic ceramics), I conservatively chose to analyze only those that were dated to a **single** subphase. It would be possible to greatly increase the sample size by including individuals dated to a range of subphases, if the **latest** subphase diagnostics are regarded as the *terminus ad quem* for the interment as a whole. Furthermore, I believe that it is only a matter of time before an intrepid ceramicist develops ceramic diagnostics for Knight and Steponaitis' (1998b) developmental stages of the Moundville chiefdom, at which point I can abandon the Moundville I, II / III and IV subphase convention, and discuss the skeletal remains in terms of actual developmental stages rather than mixed-subphase proxies.

The Test of the Model

As a test of my disintensification model, temporal patterns appear to yield few positive results of changing health across the A.D. 1300 temporal boundary marking the transition from centralized settlement at Moundville to dispersed settlement in smaller communities across the Black Warrior River Valley. My paleopathological analysis presents a mixed picture of results. If my disintensification model had been accurate, I expected diet and health to improve during the Moundville II / III subphase as population dispersed across the landscape, reducing exposure to infectious disease and parasites. Population dispersal would have also reduced pressure on first-line faunal resources, making preferred meat more available. I also expected disintensification of the agricultural economy, which would have broadened the plant subsistence base to include a greater variety of plant foods, thereby improving nutrition.

Based upon known patterns of Moundville IV settlement, I also expected diet and health to decline again during the Moundville IV subphase, as population re-aggregated into nucleated settlements. I reasoned that nucleation of population would be accompanied by more intensive agriculture in response to competition for nearby arable land. Unfortunately, my review of the subsistence literature revealed that maize consumption actually decreased by a small but statistically significant degree in Moundville IV populations, indicating that my assumption regarding the direct connection between population nucleation and agricultural intensification was wrong.

When I tested these hypotheses using paleopathological data, two temporal trends appeared. First, there appears to be no support for population dispersal or economic disintensification between the Moundville I and Moundville II / III subphases, because there appears to have been no change in diet or health status. Population dispersal would have led to decrease in infectious disease rates, which did not change during Moundville II / III, as evidenced by lack of statistically significant increases in porotic hyperostosis and cribra orbitalia, treponematosis, or periostitis. Agricultural disintensification also would have led to changes in work stress, though I found none between Moundville I and Moundville II / III, as measured by the lack of statistically significant change in rates of osteoarthritis. Disintensification would have also produced changes in diet, which I did not find, because dental health remained constant across the Moundville I to Moundville II / III boundary, with no change in rates of dental caries, abscesses, or dental wear. The only dental health indicator that did return a significant change was the rate of antemortem tooth loss, which increased from Moundville I to Moundville II / III. Because AMTL is closely correlated with caries rate, and caries rates did not change between subphases, the significance of this difference is unclear. Finally, I observed no difference in mean age at death between the Moundville I and Moundville II / III subphases, which is in line with the lack of differentiation between subphases in the other health and dietary indicators.

There was a greater degree of change in diet and health between the Moundville II / III and Moundville IV subphases, though there is no consistent trend in support or contradiction of my hypothesis that population re-aggregated and that diet quality and health declined during this period. I had predicted that rates of infection would increase with population nucleation and greater exposure to disease vectors during Moundville IV. This trend, as well as my hypothesis that maize agriculture intensified during this period, is confirmed by the increase in porotic hyperostosis and cribra orbitalia. Unfortunately, these results contradict Schoeninger and Schurr's (1998) results which indicate a decrease in maize consumption during Moundville IV. On the other hand, if the osteological paradox is at play, these results may represent a healthier population during Moundville IV, who survived anemia and lived to manifest the stigmata of the condition, while Moundville I and II / III populations were actually less healthy and succumbed to health stress before the effects could be manifest. In this case, the trend confirms Schurr and Schoeninger's results, but contradicts the greater disease load and poorer diet I had envisioned for the nucleated, intensive agricultural population of Moundville IV.

Rates of treponematosis remained unchanged from Moundville II / III to Moundville IV, while rates of periostitis declined, again contradicting my hypothesis that rates of infectious disease would increase with population nucleation during Moundville IV. Rates of osteoarthritis also declined, suggesting Moundville IV populations were working less hard, which also contradicts my hypothesis of agricultural intensification. Furthermore, diet does not appear to have changed appreciably across this temporal boundary, as rates of dental caries, dental abscesses, and dental wear did not change between subphases, though rates of antemortem tooth loss declined. This latter change appears to mirror the statistically significant decrease in maize consumption found by Schoeninger and Schurr (1998) for the Moundville IV subphase. Since the rate of AMTL is closely associated with caries rates and diet, these results also contradict my predictions for an increase in agricultural intensity and therefore maize consumption for Moundville IV. Finally, there was no difference in mean age at death for Moundville IV populations, which suggests that any change in health status between the subphases was not severe enough to result in greater or lesser mortality.

These results are the final nail in the coffin for my disintensification model, which suggested that populations would be nucleated and practicing intensive agriculture during the Moundville I subphase, followed by population dispersal and economic disintensification during the Moundville II and III subphases. Instead, I found no paleopathological indicators of either population dispersal or economic disintensification. Later, in the Moundville IV subphase, I predicted re-intensification of agriculture in concert with known population nucleation. Although I found very limited paleopathological support for population nucleation, the results for agricultural intensification are truly contradictory of one another. Rates of porotic hyperostosis and cribra orbitalia can be interpreted in support of increased maize consumption and population nucleation during Moundville IV, in conjunction with known patterns of settlement during this period. Or, the osteological paradox can be applied to the data to infer decreased maize consumption and less population nucleation, in conjunction with known patterns of subsistence for the Moundville IV subphase. Unfortunately, both patterns cannot be true at the same time. Similarly, rates of periostitis can be interpreted as declining in the Moundville IV subphase, suggesting they were healthier, which supports the known decline in rates of maize subsistence, but contradicts known patterns of population nucleation. If the osteological paradox is applied, the opposite pattern holds true. Furthermore, rates of osteoarthritis also suggest intensification of agriculture during Moundville IV, but rates of antemortem tooth loss mirror Schurr and Schoeninger's results of decreased maize consumption during the same period. Because these results are truly contradictory, perhaps in this case the classic appeal, "clearly more research is necessary" stands true.

Moundville and the outlying communities in the chiefdom appear to have maintained close ties, and continued to act as a single entity in terms of subsistence and social connections, thereby leaving open the vectors of disease and infection at consistent low levels throughout the Moundville era. I believe this low-level exposure partially accounts for the lack of clear distinctions in health between the subphases. Overall, people appear to have maintained good health and an adequate diet across time, regardless of population movements and political change. In closing my chapters on health and disintensification at Moundville, I can only echo Mary Lucas Powell's conclusions regarding health in the Moundville population: "The overall impression gained from this study is of an aboriginal agricultural population that was generally well adapted to its natural and social environment" (Powell 1991a:46). The dispersal of Moundville's population after A.D. 1300 in no way represents "the beginning of the end" of the chiefdom, but rather an organizational improvement that maintained the social and salutary status quo to the benefit of outlying communities and the residents of Moundville alike.

CHAPTER 7

CONCLUSIONS

The intellectual foundation of my research rests on Steponaitis' 1998 re-evaluation of the development and chronology of Moundville settlement pattern. In his new formulation, Steponaitis proposed that there was a previously unrecognized post-A.D. 1300 population dispersal from the central site to outlying farmsteads and single-mound sites, leaving Moundville as a locus of community mortuary ritual and elite residence. This chiefdom was once thought to have followed a classic trajectory of slow, steady, ever-increasing influence matched by burgeoning populations and self-aggrandizing moundbuilding on the part of the emerging elite, ending in sudden collapse nearly 500 years later. When Steponaitis re-wrote the chronology, he also re-wrote the history of the Moundville chiefdom. We now recognize Moundville as a small-scale ranked society slowly developing for a century or more, suddenly blossoming into a full-fledged chiefdom, mobilizing influence and labor to construct a formal complex of mounds, plaza, palisade, and elite residences over the course of fifty to one hundred years (Knight and Steponaitis 1998b:15-17). Knight (1998) interprets this complex as a sociogram, "in which the placement of mounds around the plaza reflects ranked status relationships among kin groups. If so, a fixed rank ordering had been imposed on these kin groups by incorporating that order into a sacred landscape, an act that implies considerable power at the center" (Knight and Steponaitis 1998b:17). This power was then exerted to convert the social distance between the elite and the nonelite into physical distance, as most of the Moundville population vacated the site, "presumably moving out onto dispersed farmsteads in the peripheral alluvial valley" (Knight and Steponaitis 1998b:18). Only the elite remained in residence at Moundville, and the palisade ceased to be rebuilt, perhaps because it was no longer needed as a social barrier dividing elite and nonelite precincts of the site. Moundville became a necropolis and focus of elite activity, including elaborate ceremonialism marked by elaborate burials incorporating Southeastern Ceremonial Complex iconography and symbols of rank. At the same time, the chiefs were "mainstreaming" cult symbolism on pottery manufactured and used at Moundville but also distributed in lesser quantities throughout the chiefdom (Knight and Steponaitis 1998b:19).

I took this refined sociopolitical structure as the jumping-off point for my research: what effect would population dispersal have on the social and economic functioning of the chiefdom? I interpreted population dispersal as the beginning of a process of subsistence disintensification, in which subsistence production would be decentralized along with population. Far-reaching consequences of disintensification would result in improved health and nutrition among the Moundville population. I envisioned testing the disintensification model with three lines of evidence: subsistence diversity, settlement pattern, and human health. If subsistence disintensification had truly occurred, I expected it to appear first in the faunal and floral record of Moundville subsistence. Population dispersal would relieve stress on animal communities resulting in better hunting, and would also reduce agricultural intensity to the degree that monocrop farming could be supplemented with multicrop gardening and collecting, thereby increasing dietary diversity and improving overall nutrition. Second, I needed to test settlement pattern. Steponaitis (1998) had demonstrated that population declined at Moundville after A.D. 1300, but as I note above, Knight and Steponaitis (1998b:18) could only "presume" that the departing populace had spread out into the dispersed farmsteads across the river valley. In my settlement pattern analysis, I set out to test this proposition. Finally, I reasoned that population dispersal would alleviate some of the health risks associated with nucleated settlement, particularly sanitation and disease transmission.

Subsistence, Settlement, and Health at Moundville: Disintensification Bites the Dust

When I examined reports of the archaeological record of subsistence at Moundville, I found that many of my predictions for changes in dietary diversity were either unsupported or were downright contradicted by the available data. At Moundville, there was a general trend towards agricultural intensification early in the site's history, but no significant changes in floral subsistence diversity across the population dispersal boundary around A.D. 1300. Also early in the site's history, evidence of greater floral diversity at outlying sites (in contrast with decreased floral diversity at Moundville) suggests that the Moundville population was being provisioned. Furthermore, faunal data from the single-mound sites indicate that meat was provisioned not only to Moundville, but perhaps also to the lesser elite residing at single-mound nodal sites throughout the valley. After the collapse of the Moundville chiefdom there was a small but significant decrease in maize consumption, which completely contradicts my prediction that maize agriculture would reintensify during this period. Furthermore, my predictions about faunal subsistence were not upheld, since faunal diversity remained essentially unchanged throughout time, at a level suggesting moderate stress on first-line resources.

Ultimately, however, the subsistence data at Moundville may not be adequate for answering questions of intensification and disintensification over time. First, the evidence of provisioning from the farmsteads to Moundville and perhaps the single-mound outlying sites suggests that the subsistence pattern may be skewed in directions we may never be able to reconstruct. Knight and Solis (1983:7) suggested the members of the Moundville chiefdom were practicing a bimodal subsistence strategy in which they planted a diverse range of plants in family gardens and maize crops in community farm fields. This would result in a simultaneously intensive and disintensive floral signature at the outlying sites, with a continuously intensive signature at Moundville as long as provisioning was going on. Therefore the question remains: is the subsistence pattern a unified, monolithic entity, or do different sub-patterns reflect different social strata, and if so how did they impact one another? Beyond the effect of provisioning, the Moundville subsistence data also suffer from inadequate sampling, despite the best efforts of two decades of research. The scope and breadth of the Moundville chiefdom are such that representative sampling will require many more years of collective effort.

In contrast, my general predictions about settlement pattern and disintensification were upheld. I found fewer sites when I predicted that the population was nucleated and a greater number of sites when I predicted that the population was dispersed. The results of my remaining three hypotheses regarding changes in site size and distance between sites were inconclusive. They did not support the contention that population had dispersed across the Black Warrior River valley during the early

Moundville II subphase, but they also did not disprove it. Because Steponaitis' (1998) analysis of ceramics from midden contexts at Moundville indicates a strong decline in population after A.D. 1300, and my settlement analysis suggests that the sheer number of sites in the valley increased after A.D. 1300, it is clear that population dispersal occurred.

In my investigation of health and nutrition at Moundville I found no evidence that disintensification occurred after A.D. 1300. There were no statistically significant changes in health between the Moundville I and Moundville II / III subphases. Despite population dispersal, I found that the economic, social, and political systems continued functioning much as they had during the Moundville I subphase. Furthermore, my predictions concerning population nucleation and subsistence re-intensification during the Moundville IV subphase had mixed results. It is unclear what social and political processes were at work during Moundville IV, but it is clear that they were qualitatively distinct from preceding subphases.

Data Redeemed

In all, though the data are complicated and my conclusions even more so, my results indicate that the post-A.D. 1300 population dispersal within the Moundville chiefdom was not associated with economic disintensification, and had few subsequent impacts to settlement pattern and no effect on human health. But what does this say about the structure of what was going on in the Moundville chiefdom? Does this point to greater centralization or less? Were the people at the outlying sites closely and fervently allied to the elite at Moundville, planting and harvesting communal cornfields for the chief's granaries and giving up the best meat for the chief and his family? Or did they maintain a vestigial allegiance to the Moundville elite, working mostly for themselves and their families and saving (still the best, but smallest) part of their produce for a barely known and barely thought-of chiefly anachronism living in mound-top solitude at the necropolis by the river? Who and where were *their* chiefs, and what were their relationships to Moundville?

At Moundville, the arrangement of mounds around the plaza follows a pattern of alternating residential and mortuary mounds (Peebles 1971, Walthall 1981), which decrease in size as they are located increasingly greater distances south of Mounds A and B, located on the northern periphery of the plaza. As the largest and tallest mounds around the plaza, Mounds A and B are generally interpreted as representing the social and political pinnacle of Moundville society held by the individuals associated with these mounds in prehistory (Peebles 1971, 1978; Scarry 1998). The physical distance between these largest mounds and their smaller counterparts farther south along the plaza is thought to echo the social distance between their denizens (Peebles 1971). Knight (1998) terms this a "diagrammatic ceremonial center" in which the "layout of public architecture or monuments calls deliberate attention to key social and cosmological distinctions, in a maplike manner" (Knight 1998:45). He suggests that this indeed confirms an earlier suspicion that the arrangement of mounds reflects the social and political status quo, with a bilaterally symmetrical arrangement of paired burial and residential mounds that decrease in size as well as physical and social distance from the paramount Mounds A and B. This probably reflects a kin-based, dualistic hierarchical social and political structure.

Furthermore, if this plan is correct, it differs in one key element from a Southeastern ethnohistoric model cited by Knight (1998). The sociogram at Moundville is structurally analogous to the historic Chickasaw "camp square", in which the camp houses of subclans are arranged around the camp square, bilaterally divided between clans and decreasing in relative rank from north to south along both sides of a central plaza and council fire. However, among the Chickasaw, the symmetrical division is complete – there is no corporate group whose house falls along the center line of the sociogram. At Moundville, the plan deviates from the ethnohistoric model in that Mound B, hypothesized to be the house mound of the Moundville paramount chief, **does** fall along the center line of the sociogram. Mound B does not occupy one side or the other of the sociogram, but instead occupies a unique, separate context, suggesting the denizens of Mound B had unique, separate status in the community. "This shift to a central position is in effect a statement setting up a diametric relationship between the paramount and the rest of the community" (Knight 1998:59). Knight interprets this as a "subtle strategy" for inserting a new status into a traditional, "culturally familiar order" (Knight 1998:59), thereby co-opting the kin-based system into a political, rank-based system.

Thus, the social space was deliberately manipulated by those in the power-wielding segment of society in order to perpetuate and legitimate both their claims to power and those of their successors (Knight 1998). Furthermore, the paramount chiefs who superimposed this social order upon the physical landscape at Moundville may have been not merely reflecting the relative rank and status of corporate groups in the Moundville sociogram, but actually codifying the social order to suit their needs. Knight

(1998:60) envisions that "Moundville's planners effectively legislated the relative rank of kin segments (which formerly may well have been negotiable) by monumentalizing that ranking in a ceremonial space. It was an attempt by an emergent nobility to make a newly transformed social order tangible, inviolable, immovable, sacred". In this manner, "...architecture, and particularly in this case earthen mounds, became powerful levers of social inequality, expanding the divisions between supernaturally sanctioned elites and commoners" (Wesson 1998:119).

Having firmly established authority within the hierarchy, the Moundville paramountcy next reinforced their unique and separate status with a large-scale population movement around A.D. 1300. At this time, the population dispersed across the landscape, settling in small farmsteads centered in "neighborhoods" around single mound centers. The only remaining residents of Moundville were the elite and their retainers. By this population movement, the paramount elite became both socially and spatially segregated from the remainder of Moundville society. The palisade ceased to be renewed during this period, suggesting that it was no longer necessary as a social barrier, and the only nonelite tie to Moundville was the continued mortuary tradition, as the site became a necropolis for the chiefdom.

Beck (2003) suggests that during this time period between A.D. 1200 and 1300, when the social order was fixed by the chiefly aristocracy, and the general populace was dispersed from Moundville, the site of chiefly authority, the Moundville chiefdom changed its essential character. It went from being a constituent hierarchy, in which power was negotiated and chiefs used persuasive aggregation to attract and keep followers, to an apical hierarchy in which chiefly power was unquestioned and the nonelite were physically, socially, and ideologically segregated from the paramount chiefs at Moundville. Instead, I envision that Moundville was perhaps both a constituent and an apical hierarchy; one in which authority was structurally invested in a particular aristocratic class, who had ascribed rank and power, but who constantly had to negotiate their position against challenges to their hegemony within an inherently unstable system.

During the 150 years following initial population dispersal, the Moundville site underwent a gradual transformation as the elite residential mounds were gradually abandoned and former burial mounds ceased to have interments. We know that the mounds at Moundville were abandoned from south to north, i.e., from lowest ranked to highest ranked. Analysis of new excavations and existing collections from CCC-era profile trench excavations of mounds along the southern periphery of the plaza revealed a pattern of early and intensive construction and occupation of the mounds during the Moundville I and early Moundville II stages. These mounds were in minimal use or abandoned by the Moundville III subphase (Knight 1995, 1998). Similar analysis of mounds along the northern edge and central axis of the site indicated a comparable pattern of construction and occupation during the later Moundville I and Moundville II subphases, but also a strong indication of occupation throughout the Moundville III subphase (Knight 1995). Three of these mounds, P, B, and E even show scant evidence of occupation during the Moundville IV subphase (Knight 1995). This pattern of abandonment may suggest that the more northerly mound dwellers were more directly associated with the success and survival of the chiefdom, long after the less directly connected kin groups of the southern plaza periphery mounds had splintered away.

A Partnership in Power

Throughout Moundville's historical trajectory, what were the structural relationships that produced these population movements and mitigated the power and social position of the high elite, mid-elite, and nonelite of the Moundville chiefdom? Beck (2003) envisions the social structure of the Moundville chiefdom as an apical hierarchy, in which chiefs held the power to separate themselves from the people, to mark their status with chiefly cult paraphernalia, and control the growth of the outlying lesser elite to keep them from becoming a challenge to the hegemony of Moundville. Wesson (1998) describes the post-A.D. 1300 population dispersal as a possible outgrowth of the increasing elite power, in which the elite made a "conscious decision" to "enhance the sanctity of the center" by making it available only to the elite and powerful, thereby further increasing their social and physical distance from the nonelite. These interpretations place the power of population removal in the hands of the chiefs.

I propose instead that the chiefs and the people of Moundville were actually engaged in a partnership in power. The chiefdom centered at Moundville clearly became quite complex over a short period of time: the great mound center was constructed in less than fifty years between A.D. 1200 and 1250. A mere fifty years later a great population movement reinforced the sanctity of the mound center and dispersed the people across the valley in a highly productive relationship with the land, as well as an efficient spatial relationship of farmsteads to single mound centers, and single mound centers to Moundville. In this resulting heterarchy, the nonelite were the breadbox of the chiefdom, growing food for themselves and provisioning the single mound centers and Moundville. In return, chiefs controlled the manufacture and importation of prestige goods (Knight and Steponaitis 1998b). Chiefs also maintained internal order and mediated external relationships with other Mississippian polities. Most importantly, chiefs may have been responsible for maintaining relationships with the supernatural (Cobb 2003:74), thereby ensuring survival of the entire polity.

Within this classic rendition of the chiefdom model, I propose that all parties were engaged in a negotiation for power that involved active agency on the part of each segment of the population, not simply the elite. For example, I asked whether the subsistence system was a unified, monolithic entity, or do different patterns reflect different social strata, and if so how did they impact one another? Knight and Solis (1983) suggest that the farmstead-dwellers were engaged in a dual subsistence pattern: generalized gardening at the household level, plus intensive maize agriculture aimed at providing surplus for the chiefdom. The farmsteaders were provisioning both maize and meat to both the mid-elite of the single mound centers and the high elite at Moundville. Rather than a mindless meeting of tribute demands, provisioning can be interpreted as the nonelite manipulating the system in order to create dependence upon them by the elite stratum. Beck (2003) points out that in a chiefdom structure characterized by instability and competition between regional and local chiefs, the chiefs become dependent upon the agricultural producers for surplus to fund the necessary feasting and gifting required to maintain the balance of power in a constantly shifting system.

Negotiation for power becomes more intense at the mid-elite level, in which lesser chiefs resident at the single mound centers were simultaneously receiving provisions from the farmsteads and possibly channeling provisions to Moundville

(Knight and Steponaitis 1998b:16). They were engaged in local ritual, gifting, and feasting to maintain allegiance among the farmsteaders (Maxham 2000), and may have been aggrandizing their own status in relation to the paramount at Moundville by building larger mounds at more distant single mound centers (Steponaitis 1978). If these lesser chiefs were heads of cadet lines of the paramount chiefdom, as suggested by Welch (1998), then they were both dependent upon the paramount chief for their status within the chiefdom, yet in a structural position to challenge the paramount by virtue of their genealogical proximity.

The greatest intensity of negotiation for power clearly took place within the highest elite stratum at Moundville, among the paramount, who had the greatest to lose in a shake-up of the chiefdom structure. In the early stages of Moundville's development, these chiefs exercised their power and enhanced their status through use of public labor in leveling the plaza, building mounds, and constructing the palisade surrounding Moundville. In their implementation of the diagrammatic ceremonial center envisioned by Knight (1998), they co-opted public space for elite ceremonial use, and literally changed not just the structure of the site but even the visual space, creating sight lines emphasizing the grandeur of the mound-plaza arrangement, while hiding from view the private mound-top domain of the elite (Cobb 2003:69). In the ultimate seizure of public space, the Moundville elite initiated the removal of much of the population to outlying communities, claiming not just the elite precinct but the entire site for their own domain. Moundville's high elite received provisions from outlying sites, though their nourishment was never so great as to create status distinctions in health (Powell 1985, 1988). Some of their provisions were then redistributed in the form of public feasting and gifting. After population dispersal, Moundville elites invested greater energy in prestige goods production: greenstone, pottery, stone tools (Knight and Steponaitis 1998b:17), and shell (Welch 1991), and imported exotic materials such as copper and marine shell (Knight and Steponaitis 1998b:17). Distribution of such goods bearing Southeastern Ceremonial Complex symbolism increased dramatically after A.D. 1300 (Knight and Steponaitis 1998b), particularly in mortuary contexts, suggesting the Moundville elite were investing their chiefly regalia in the ingratiation of their constituency, doling out symbols of chiefly power to keep local chiefs loyal. Perhaps this is symbolic of changing power relations between the high elite and lesser elite in the Moundville chiefdom.

It is clear that the power of the Moundville paramount elite waned in relation to the lesser elite and nonelite following population dispersal around A.D. 1300. "Resistance to authority may have increased during the next century and a half (ca. A.D. 1300-1450), hence the need to continually reinforce the social order through the abstract political symbolism of cosmological referents" (Rees 2001:135). In a model contrasting the idea of entrenchment of elite power following population dispersal, Wesson (1998:119) suggests that "as elite control of sacred space increased, an increasing number of individuals opted out of the system and either established individual farmsteads or moved to other communities". If the Moundville compound was indeed viewed as the physical manifestation of the sacred, and if the nonelite were being deliberately alienated from it, they may have chosen to move elsewhere and create their own sacred landscape (Wesson 1998:119). Indeed, as power was centralized on the mounds at the northern end of the plaza, construction ceased on the mounds at the southern end of the plaza, those with the greatest physical and spiritual distance from the paramount. These people had the least to gain from sticking with the Moundville paramount, and the most to gain by splitting away – which is exactly what they appear to have done (Wesson 1998:120).

As I discussed in Chapter 3, in addressing the question of chiefly cycling Blitz (1999) offers a model based upon a "fission-fusion process in which small and large chiefdoms [are] formed by the aggregation and dispersal of minimal or basic political units" (Blitz 1999:583). This basic political unit is defined as a single platform mound (whether it be the single-mound on a site, or one of many on a single site) representing a bounded social or political group, implying that single-mound sites represent weak and decentralized power in a small chiefdom, and multi-mound sites represent strong and centralized power in a large chiefdom. Single-mound centers were created either independently, or by a fissioning process from multi-mound centers, while multi-mound centers were created by fusion of autonomous populations from two or more single-mound centers. In such a situation, multiple mounds were necessary within the same community, because the individual populations would maintain separate civic-ceremonial facilities from one another. The maintenance of separate corporate groups within the same community would provide natural boundaries along which the population could split in times of stress or conflict (Blitz 1999). Blitz further suggests that population dispersal does not represent the aggressive political expansion of a successful chiefdom, but instead the decentralization of a weak and dissolving chiefdom (1999:589-590).

The population movement around A.D. 1300 may have been implemented by lesser nobles who were feeling pressure to mobilize their kin to move away from the chiefly center, while perhaps the lesser elite were themselves equally anxious to weaken their ties with the Moundville paramountcy. If Moundville was indeed a multi-mound center created by attracting lesser chiefs who then built a lineage-specific pair of burial and residential mounds according to the Moundville sociogram, then perhaps this lesser elite maintained their separate corporate identity as codified in the site arrangement, while also maintaining strong connections to their ancestral lands and people. The pattern this creates is of a west-central Alabama "Oaxaca barrio" in which noble representatives of a lesser chiefdom would establish and maintain a presence at the chiefly center, while maintaining social, political, and economic ties back home. When pressure came to reduce the population at the center, these minor chiefs and their people returned home. There may also have been lesser chiefs or nobles who had no ancestral home elsewhere in the valley, having established their high-ranked lineage from within the Moundville chiefly center. Welch (1998:165) refers to these as "cadet lines," descended from the paramount chief, and suggests that the proliferation of single-mound sites in the valley over time was associated with the generational increase of these lineages. Lacking a presence at the main center, such lesser chiefs (long-established or new) may have then grown more autonomous over several chiefly generations, resulting in ultimate severance of connections with the Moundville elite.

The settlement pattern data seem to support this scenario. Moundville originated with the development of at least two small single-mound sites during the early Moundville I subphase, surrounded by small settlements throughout the Black Warrior

River Valley. During the late Moundville I subphase, the paramount center at Moundville was constructed and the mounds were built (Knight and Steponaitis 1998b). Peebles (1974, 1991) believes that the social divisions graphed by the Moundville sociogram were in place well before the mounds were built, in the form of kindred-specific burial plots from the Moundville I subphase (Wesson 1998:118). I wonder if there were also lineage-ranked domestic structures now obscured by the mounds. As Moundville arose, the second mound center in the valley was abandoned, while three new single-mound centers arose (Knight and Steponaitis 1998b). By late Moundville II and early Moundville III, coincident with the Moundville population dispersal, there were seven single-mound centers active in the Black Warrior River Valley. Also during this period, the first Mississippian cemeteries outside of Moundville appeared, while the population at Moundville proper continued to dwindle (Welch 1998). By late Moundville III, burials at Moundville declined while the secondary mound centers increased in size, suggesting population nucleation (Welch 1998). This trajectory of chiefdom development appears to support the model I have described: early consolidation of power among an incipient elite social stratum and development of town-mound connections, followed by population dispersal and declining influence among the paramounts at Moundville simultaneous with increasing autonomy among the lesser elite at single-mound sites.

When I reexamined some of the earlier Black Warrior River Valley settlement pattern studies, I realized that there is additional evidence in favor of this model. For example, Steponaitis (1978) developed a complex model for measuring the efficiency of the locations of major and minor centers within a chiefdom, based upon calculations of the efficiency of transporting tribute. Over time, the placement of these minor centers became increasingly efficient (Steponaitis 1978) for transporting tribute to Moundville. Bozeman retested this phenomenon (1982:291-300) using new survey data. He also found that over time the spatial relationships between minor centers and Moundville became increasingly more efficient.

Bozeman concluded that this result indicates that the Moundville chiefdom represented a politically unified entity with a hierarchy of site sizes and functions. However, this notion can be questioned in light of the new Moundville chronology (Knight and Steponaitis 1998b). Perhaps instead of representing political unity, efficient travel between minor centers and Moundville became more important as lesser chiefs moved away to live within their own site clusters. "This analysis indicates that changes in the spatial configuration of Moundville and its subordinate centers were directed toward the minimization of movement cost between Moundville and the minor centers" (Bozeman 1982:300). Bozeman takes this as evidence of the "political unification" of the Moundville chiefdom, but I suggest the opposite: political splintering of the chiefdom, accompanied by vestigial faithfulness to the external trappings of the old order in the form of continued ties with the remnant elite and an enduring spiritual tie to mortuary ritual practiced at Moundville. As Rees (2001:139) suggests, perhaps "even after it was virtually abandoned, Moundville may have continued to serve as a referent for legitimate authority in a decentralized polity".

Steponaitis (1978) also addressed the question of minor centers in his location theory analysis. In it, he noted that mounds on sites farther away from Moundville are larger than mounds on sites nearer the main site. He suggests that minor centers closer to Moundville might have felt the greater brunt of tribute obligation and would therefore have had fewer resources to enlarge and elaborate their own mounds (Steponaitis 1978, Bozeman 1982). In light of more recent discussion of the relationships among social factions at and around Moundville (Knight 1998), it seems equally likely that the more remote minor centers had larger mounds because their leaders were less dependent upon and less controlled by Moundville, and therefore free to symbolically aggrandize themselves to a greater extent than those more closely tied to Moundville. If the residents of the outlying mound centers were more tenuously connected to the paramount chief, they may have built larger mounds as a symbol of their greater independence and autonomy.

Pauketat (2003) discusses population movements in terms of agency on the part of the individuals doing the moving: i.e., they are taking part in the cultural process. In the case of the Moundville population movement, the lesser elite and their kinsmen who changed their place of residence were actively constructing a new set of relationships between themselves and the paramount chiefs at Moundville, which eventually led to the dissolution of the chiefdom as a whole. Not only that, but the paramount chiefs at Moundville also exercised agency in their drive to push population out of Moundville to the hinterlands, increasing their social and political distance, but at the ultimate cost of their hegemony. Pauketat would describe this process as a "two-way negotiation" (2003:43) between the resettled farmers and Moundville elite which completely reorganized the Moundville culture. Ultimately, this reorganization appears to have been beneficial for the individual humans who occupied the Moundville sphere, who enjoyed good health and quality of life, at least for a short time. Unfortunately, it was not equally beneficial to the Moundville chiefdom structure, which was unable to stave off the increasing autonomy of the single-mound site clusters.

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