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PALEOCLIMATE AND THE POTENTIAL FOOD RESERVES OF MISSISSIPPIAN SOCIETIES: A CASE STUDY FROM THE SAVANNAH RIVER VALLEY

David G. Anderson, David W. Stahle, and Malcolm K. Cleaveland

Precipitation reconstructions based on bald cypress (Taxodium distichum L. Rich) annual growth ring data collected from locations near the Savannah River valley, coupled with a series of simple models of storage capability, are used to calculate the agricultural food reserves potentially available each year from A.D. 1005 to 1600 to local prehistoric Mississippian populations. The resulting food reserve estimates suggest that interannual variation in rainfall during the growing season may have resulted in both extended periods of food surplus and food shortfall. We hypothesize that prolonged episodes of agricultural food surplus and shortfall had a pronounced impact on the historical trajectories of these chiefdom societies. This argument is supported by historical accounts describing the impact of drought during the period of Spanish settlement at Santa Elena (A.D. 1565–1587), and offers a possible explanation for some of the major changes observed in the late prehistoric archaeological record in the Savannah River valley, including the emergence, expansion, and decline of several mound centers and the eventual abandonment of a large portion of the basin. The study indicates the value, and potential, of analyses linking archaeological, historical, and dendrochronological data in the southeastern United States.

Reconstrucciones de precipitación basadas en muestras de anillos de crecimiento anual del ciprés pelado (Taxodium distichum L. Rich) recolectadas en lugares cerca del Valle del Río Savannah, junto con una serie de modelos simples de capacidad de almacenamiento, se utilizan en el cálculo de las reservas de productos agrícolas potencialmente disponibles anualmente, desde 1005 hasta 1600 DC. para las poblaciones prehistóricas Misisipianas locales. Los estimados de reserva de alimento resultantes sugieren que la variación en la precipitación interanual durante la estación de crecimiento habría producido tanto periodos de abundancia como de escasez de alimentos. Nosotros proponemos que episodios prolongados de abundancia y escasez de alimentos tuvieron un impacto pronunciado en las trayectorias históricas de estos cacicazgos. Este argumento está reforzado con documentos históricos que describen el impacto de la sequía durante el periodo de asentamiento hispánico en Santa Elena (A.D. 1565–1587), y ofrece una posible explicación para los cambios mayores observados en el registro arqueológico del periodo prehistórico tardío en el Valle del Río Savannah, incluyendo la emergencia, expansión, y deterioro de algunos centros con montículos y el eventual abandono de una gran porción de la cuenca. Este estudio ilustra el valor y potencial de análisis que integran datos arqueológicos, históricos y dendrocronológicos en el sureste de los Estados Unidos.

The emergence, expansion, and collapse or relocation of Mississippian chiefdoms in and near the Savannah River basin have been the subject of appreciable research in recent years (Anderson 1990a, 1994; Anderson and Schuldenrein 1985; Anderson et al. 1986; DePratter 1989; Hally 1986; Hally and Rudolph 1986; Rudolph and Hally 1985). Within the past decade long tree-ring chronologies have also been developed in a num-

ber of parts of the southeastern United States (Stahle et al. 1985a, 1985b, 1985c, 1988), and two of them, from in or near the lower Savannah basin, have been used to reconstruct growing season rainfall for each year since A.D. 1005 (Stahle and Cleaveland 1992). These rainfall reconstructions provide for the first time the precisely dated environmental data necessary to assess the possible impact of climate variations on local late prehistoric

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and early historic societies. The rainfall reconstruction for South Carolina, and estimates of the food storage capabilities of Mississippian chiefdoms, are used to develop quantitative reconstructions of the agricultural food reserves potentially available to these societies each year from A.D. 1005 to 1600. This reconstruction of potential agricultural food reserves is then compared with the extant archaeological and historic record, in a preliminary test of the hypothesis that Mississippian occupations in the Savannah River basin were influenced, in part, by interannual fluctuation in growing season rainfall.

The political stability of the agricultural chiefdoms in and near the Savannah River valley, we argue, was related in part to their ability to accommodate multiyear periods of agricultural shortfall or surplus, something in turn shaped by both short- and long-term fluctuations in climate. To assess the impact of climate on cultural systems, however, explicit models must first be developed detailing how the two are interrelated (Ingram et al. 1981a:19). Simply demonstrating a co-occurrence between a climatic episode and a cultural change is not sufficient; coincidence or correlation does not demonstrate causation, and may lead to incorrect, misleading, or overly simplistic interpretations (Anderson 1981:339; DeVries 1980:606; Parry 1981:321). Explicit linking arguments are necessary to document specifically how changes in climate may affect cultural systems.

Modeling relationships between climate and culture, furthermore, should be guided by a few simple premises (after Ingram et al. 1981a:24–25): (1) simple models, examining relationships between climate and one or a few economic and social variables, are more feasible and amenable to solution than models directed to a wide range of cultural phenomena; (2) immediate climatic effects are more easily examined than more remote effects; (3) the smaller the geographic scale of the investigation, the greater the probability of success; (4) the effects of short-term climatic fluctuations are more direct and easier

to detect and examine than the effects of long-term climatic fluctuations; and (5) the effects of climatic change are likely to be most pronounced on societies heavily dependent on agriculture. Given these premises, agricultural chiefdoms, which are typically small in population size, geographic scale, and organizational complexity, would appear to be ideal test cases for studying the effects of climate change on human society.

Also critical to model development is understanding why societies adapted or failed to adapt to climate change. The way a society copes with short-term climatic fluctuations may be unrelated to their response to long-term fluctuations. Most long-term patterns of change, in fact, are unlikely to be directly perceived, since the pattern of change is gradual and small when compared with year-to-year fluctuations (Ingram et al. 1981b:206; O'Shea 1989:57–58). Solutions to long-term fluctuations may not exist, or may be maintained in less obvious parts of culture, such as in myths and legends, whose value are best understood only in times of crisis (Minc and Smith 1989). What it is about a society that causes it to fail to adapt to change should be as much a focus for research as successful responses. The late medieval abandonment of the Norse Greenland settlements, for example, is popularly thought to have been "caused" by the climatic deterioration characteristic of the onset of the Little Ice Age (Lamb 1984:233–234). The Norse populations could have survived, however, had they adopted the technology of their Inuit neighbors—something they were unwilling to do.

Climate and the Political Organization of Chiefdoms

The production of crop surpluses and their mobilization as tribute is a crucial foundation of political structures in agriculturally based chiefdoms (Cordy 1981:30–44; Ford 1974, 1977; Orans 1966; Sahlins 1958:107–135, 201–217). Agricultural surpluses had to occur at levels necessary to maintain elite agendas and prerogatives or, in the event of production shortfalls, resources had to be present in

storage in sufficient quantity to maintain the system until restocking could occur (Burns 1983:186–187). Short- and long-term fluctuations in variables such as spring rainfall, sunlight, or the length of the growing season are particularly important factors to consider when examining the stability of chiefdom societies, because they play a major role in shaping agricultural food production. Crop failures brought about by droughts, flooding, or other catastrophes would have threatened the stability of agricultural chiefdoms by reducing the production surplus the elites needed to maintain their authority.

Stability is here taken to mean the maintenance of a given level of organizational or administrative complexity, as measured by the number of decision-making levels in operation. Instability, in contrast, is characterized by fluctuations in decision-making levels and, hence, concerns the emergence and collapse of simple and complex chiefdoms, which have one and two levels of authority above the local community, respectively (Steponaitis 1978:420; Wright 1984:42–43). Periods of repeated crop surplus could promote an expansion of organizational complexity primarily by providing elites the resources needed to pursue personal agendas, which in societies such as these traditionally centered on achieving or extending control over other elites (e.g., Brumfiel and Fox 1994). Repeated crop failures, alternatively, could lead to a weakening or collapse of chiefly authority by posing direct questions about the sacred position and intermediary role of the elite. It might have led also to a reduction in support population as people (subsidiary elites and commoners alike) physically relocated to more favored areas or polities or, in extreme cases, if population decline occurred due to famine or warfare triggered by subsistence stress.

In simple agricultural societies, organizational change can occur rapidly, on the order of a few years or decades. Various authors have suggested that short-term climate extremes, through their effect on harvests, have a greater and more immediate economic im-

pact on agriculturally dependent societies than longer-term but weaker trends (e.g., Flohn 1981:310–311; Wigley 1985). Successive years of crop shortfall or total failure are likely to have a far greater impact than isolated shortfalls or failures, especially since these conditions could quickly lead to a total loss of seed grain, precluding any farming until new seed could be obtained (Anderson 1981:352; Ingram et al. 1981a:13; Jones 1964; Parry 1981:327; Post 1980). Longer-term but weaker trends could also lead to marked change, however, since a long series of even minor production shortfalls or surpluses would likely necessitate some kind of cultural response, either to deal with the problem of dwindling reserves or repeated production beyond storage capacity.

Relationships between climate, crop yields, and social and political conditions have been widely studied. Unrest leading to organizational collapse or restructuring is a common response to harvest failure, and not merely in chiefdoms, as any reading of history will testify. The two terrible years of A.D. 1315 and A.D. 1316, when crops failed over wide areas of western Europe, for example, were characterized by “panic and frustration, famine and widespread death” (Le Roy Ladurie 1971:47). The French Revolution of 1789 was preceded by a disastrous harvest in 1788, “the historic consequences of which—scarcity, high prices, food riots—were so important in 1789” (Le Roy Ladurie 1971:74–77). MacKay (1981:367–371) demonstrated that periods of extensive social unrest in late medieval Castile could be attributed, in part, to climatic downturns that led to poor harvests. He was quick to dismiss, however, a “crass economic reductionism” that attributed this unrest solely to climatic conditions, noting that many other factors were also operating, such as demographic stress, monetary debasement, and antipathy between social and religious factions. Climate change might, indeed, merely “aggravate, rather than initiate, problems the origins of which lay in the demographic, technological, and political conditions of these periods” (Anderson 1981:345).

Merely noting an association between a climatic stimulus and a cultural response is not particularly difficult; what is hard is explaining why the response took the form it did. In this regard, it must be emphasized that, although the present analysis deals with the effects of climate, the causes of organizational change in chiefdoms are in reality complex and multivariate, requiring evaluation of a wide range of data. How agricultural chiefdoms responded to climatic change, however, unquestionably shaped their subsequent history. Specific strategies to ensure continued access to surplus may have included changing the number and diversity of plant species in cultivation or the number of harvests per year, scattering fields over fairly large areas and in a number of microenvironmental zones, increasing storage capacity, or placing storage facilities in a number of communities (Chmurny 1973; DeBoer 1988; DeVries 1980:625–626). The development of larger or more complex organizational networks, capable of appropriating and storing increased quantities of food, may have permitted the alleviation of resource shortages in one area by redistributing stored surpluses from other localities. Such a strategy may have helped rationalize or legitimize the growth of chiefdoms and, concomitantly, powerful elite authority structures and, as we shall see, may partially explain the emergence of complex chiefdoms in the Savannah River basin. Alternatively, faced with repeated production shortfalls, populations might abandon intensive agriculture altogether, and perhaps even a chiefdom form of sociopolitical organization.

The Paleoclimatic Record:

Dendrochronology and Dendroclimatology

Tree-ring chronologies providing excellent proxy measures of climate have been completed or are currently under development from locations throughout the southeastern United States (Stahle et al. 1985a, 1985b, 1985c, 1988, 1991) (Figure 1). Many tree species in this region produce annual growth rings and are suitable for dendrochronology. Some

of the best species thus far investigated include bald cypress (*Taxodium distichum*), eastern red cedar (*Juniperus virginiana*), eastern hemlock (*Tsuga canadensis*), shortleaf pine (*Pinus echinata*) and possibly other southern yellow pines, eastern white pine (*P. strobus*), red spruce (*Picea rubens*), northern white cedar (*Thuja occidentalis*), and the deciduous oaks, especially white oak (*Quercus alba*), post oak (*Q. stellata*), chestnut oak (*Q. prinus*), and overcup oak (*Q. lyrata*). Bald cypress is particularly important because cypress chronologies can be very sensitive to climate variations, and individual trees can exceed 1,500 years in age (e.g., Stahle et al. 1988). Well-preserved subfossil cypress logs recovered from submerged and buried deposits of Holocene age also hold considerable potential for long chronology development, perhaps covering the past 5,000 years (Stahle et al. 1985b). Old-growth stands with living cypress trees can still be found in many parts of the Southeast, despite intensive logging across the region. A primary reason many old trees have survived is simply because they tend to be relatively small and produce lower quality lumber, and therefore were sometimes not worth the expense of logging. Blackwater (i.e., acidic, nutrient-poor, and typically dark-colored) river systems, in particular, seem to produce lower grade cypress, but fortunately these often also favor slow growth, advanced age, and climate sensitivity in these trees. A number of intact old stands of bald cypress have been found in blackwater streams and lakes in the Southeast (Stahle et al. 1988).

By crossdating and merging the tree-ring records from living trees with those from subfossil logs, a dozen bald cypress chronologies greater than 800 years long have been completed thus far in the Southeast. Seven of these chronologies are located on the Atlantic coastal plain (Figure 1). These long cypress chronologies exhibit a very strong warm season climate signal and can provide a quantitative measurement of paleoclimate over long intervals. Bald cypress radial growth is positively correlated with rainfall and in-

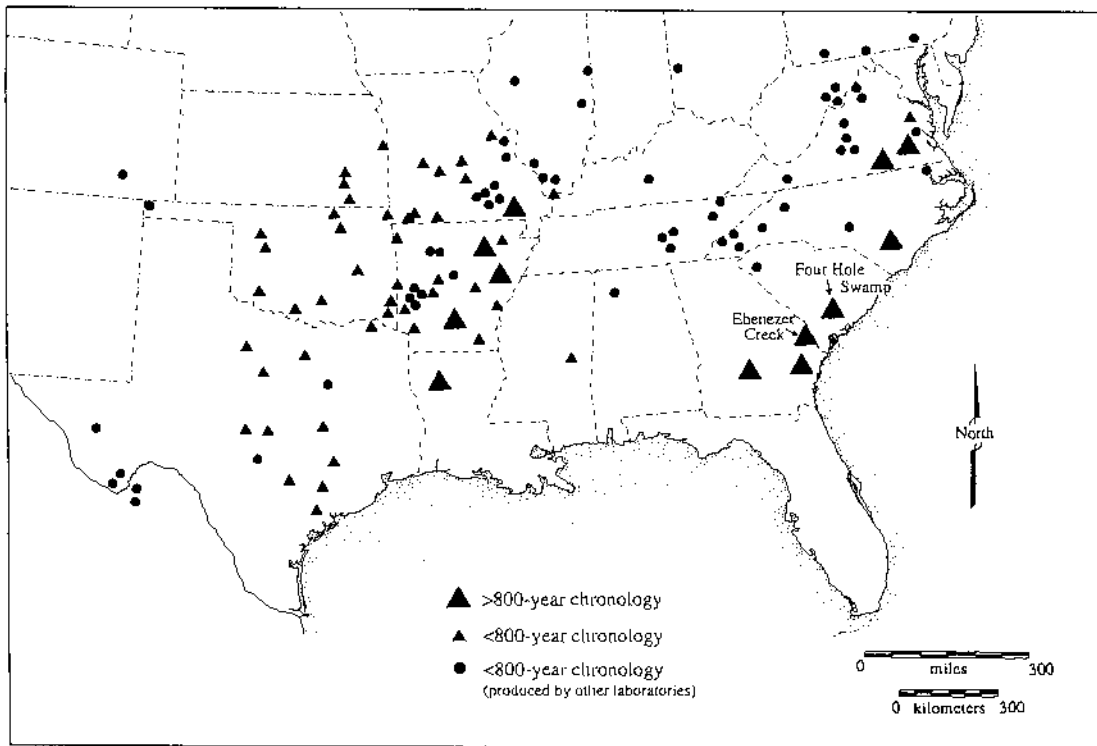


Figure 1. Tree-ring chronologies in the southeastern United States. (All chronologies developed by the Tree-Ring Laboratory, University of Arkansas, unless otherwise noted.) From *The Savannah River Chiefdoms* by David G. Anderson (©1994, University of Alabama Press). Used by permission.

versely correlated with temperature during the spring and summer, and cypress chronologies have been successfully used to reconstruct indices of drought severity (Stahle et al. 1985a, 1988), percent of possible sunshine (Stahle et al. 1991), and growing season rainfall amounts (Stahle and Cleaveland 1992, 1994). All of the tree-ring chronologies were crossdated using standard skeleton plot procedures (e.g., Douglass 1941; Fritts 1976; Stokes and Smiley 1968), and based on ring-width measurements with a precision of .01 mm on multiple cores from 20 to more than 80 trees and logs per site.

The reconstruction of potential agricultural crop reserves reported in the next section is based on a tree-ring reconstruction of growing season rainfall totals for South Carolina (Stahle and Cleaveland 1992). This rainfall estimate was based on two 1,000-year-long bald cypress chronologies from the central coastal plain, one from Four Hole Swamp,

South Carolina (33°20' N, 80°25' W), about 50 km east of the Savannah basin, and the other from Ebenezer Creek, Georgia (32°22' N, 81°15' W), a tributary of the Savannah River. The tree-ring chronologies were calibrated with state average March–June rainfall for South Carolina over the period 1887 to 1936 (Karl et al. 1983) using a multiple regression model. This regression model accounts for an appreciable amount of the variance (i.e., $R^2 = .58$) in South Carolina, March to June rainfall, from 1887 to 1936.

The accuracy of this regression model and the precipitation estimates it produces have been evaluated with several verification tests (Stahle and Cleaveland 1992). Because the calibration was based on the period from 1887 to 1936, we can compare the tree-ring-based estimates of South Carolina rainfall from 1937 to 1982 with the actual instrumentally recorded amounts available for the same time period. These instrumental records from 1937

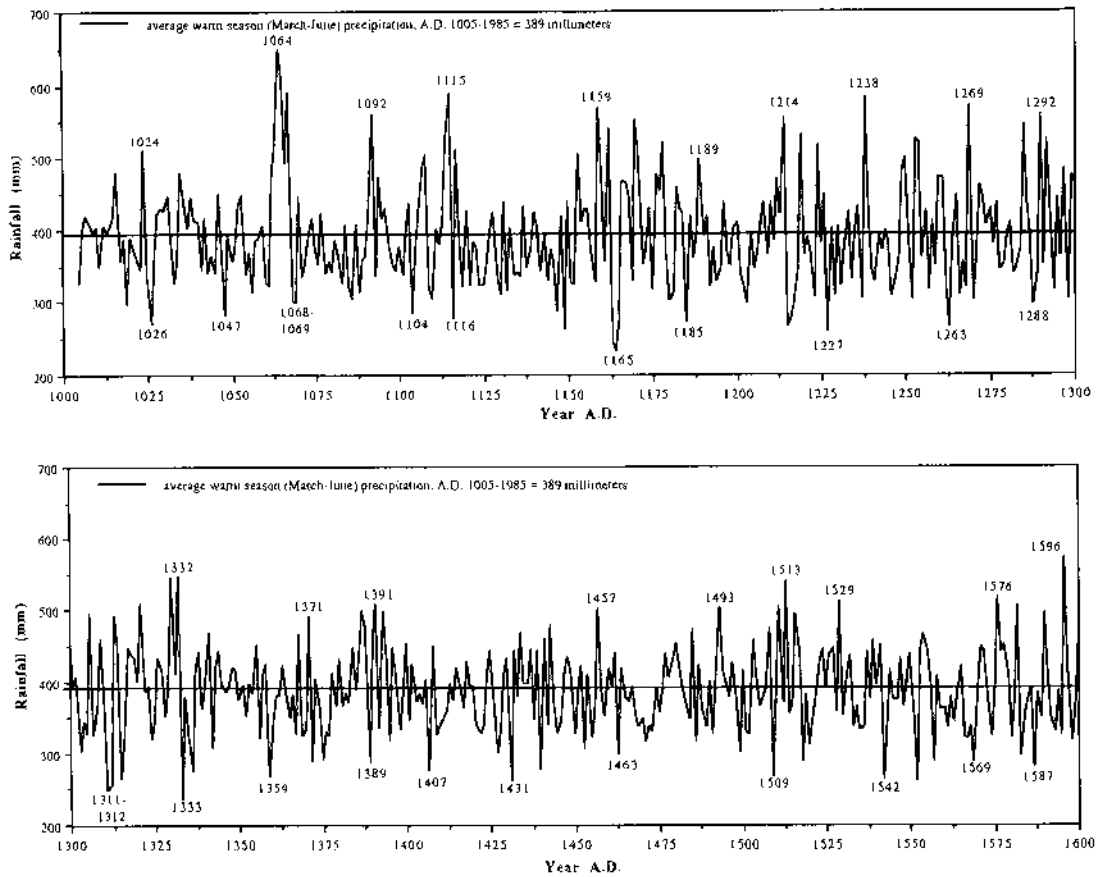


Figure 2. South Carolina reconstructed spring precipitation (March through June) A.D. 1005-1600, based on annual data developed by the Tree-Ring Laboratory, University of Arkansas. From *The Savannah River Chiefdoms* by David G. Anderson (©1994, University of Alabama Press). Used by permission.

to 1982 are statistically independent from the calibration period, and the tree-ring-reconstructed rainfall values are well correlated with the actual rainfall values during the verification subperiod (i.e., $r = .76$, $p < .001$). The regression results were also compared with similar regression-based estimates of state-averaged rainfall based on rain gauge records from actual weather stations near the two tree-ring sites. The South Carolina state-averaged rainfall variance explained by the rain gauge records was only 12 percent higher than the variance explained by the two tree-ring chronologies (Stahle and Cleaveland 1992). We believe that these results provide convincing demonstration of the accuracy of the rainfall reconstructions, which we argue perform almost as well as a small number of mechanical

rain gauges might in estimating regionally averaged (i.e., statewide) rainfall on a seasonal basis. Figure 2 presents a portion of the South Carolina rainfall reconstruction from A.D. 1005, the first year for which dendroclimatology data is available, to A.D. 1600, after which few chiefdom societies are believed to have been present in the South Carolina area (DePratter 1989). This interval completely spans the Mississippian occupation of the Savannah River valley.

A Reconstruction of Potential Agricultural Food Reserves

The tree-ring-derived reconstruction of growing season rainfall was used in conjunction with a series of simple assumptions about crop yield and food storage capability to de-

velop quantitative estimates of the agricultural food reserves potentially available to the Savannah River chiefdoms each year from A.D. 1005 to 1600. These reconstructions are called "potential food reserves" because a number of factors other than growing season rainfall and storage technology undoubtedly influenced the food reserves actually available to these chiefdoms, including growing season temperature extremes, severe weather, flooding of agricultural fields, crop disease, or insect infestations, and a host of sociocultural conditions such as tribute requirements, patterns of warfare, and cropping strategies. Nevertheless, examining potential food reserves provides a useful starting point for investigating the sensitivity of Mississippian chiefdoms to growing season climate variation. Comparable research undertaken in the American Southwest has offered valuable insight about prehistoric adaptations in that region (e.g., Burns 1983; Van West 1990).

The potential food reserve/shortfall estimates that form the primary analysis reported here were derived assuming a two-year storage capacity (one year's reserves), that is, the current year's harvest plus the storage of one previous harvest (Figure 3). Ethnohistoric accounts detailing crop reserves are rare in the Southeast, but the available references, when coupled with the direct archaeological evidence for storage facilities (i.e., Judge 1991; Kelly 1988; Polhemus 1987), are sufficient to suggest that at least one year of food reserves could have been maintained by the complex chiefdoms of the Southeast; somewhat lesser amounts appear to have been maintained by simple chiefdoms. This is suggested particularly by the amounts of corn described or actually appropriated from societies across the region by the 1539–1543 de Soto expedition (e.g., DePratter 1983:165). Although several historic accounts suggest southeastern harvests rarely lasted even a single year (e.g., Swanton 1946:256–265), almost all of these records date to the seventeenth or eighteenth centuries, well after the disappearance of the region's complex chiefdoms, whose tributary economies were based on the pro-

duction, collection, storage, and use of agricultural surplus. While it is possible that food reserves were maintained longer than two years, in the absence of direct evidence for such long-term storage, and given the humid climate of the Southeast, a two-year storage assumption seems a reasonable first approximation.

Potential food reserves and shortfalls are expressed in terms of deviations from an estimate of average annual consumption. Positive values in Figure 3, which range up to +1, reflect food surpluses above average annual consumption, while negative values, which range to -1, indicate food shortfalls that must be made up from other sources. The value for a given year represents the sum of the crops remaining in storage from the preceding year together with the yield from the current harvest, minus normal consumption. Wild plant and animal resources are not included in this analysis, although they would have been used to make up agricultural shortfalls.

Annual crop yields and the estimate of average annual consumption are computed directly from the South Carolina rainfall reconstruction. The average (reconstructed) growing season rainfall for the period from A.D. 1005 to 1985 was 389 mm, with a standard deviation of 65.6 mm. This (389 mm) is assumed to represent the amount of spring rainfall needed to produce an average harvest, which is also assumed to represent average annual consumption. Annual crop yield values are a direct transformation from this average rainfall value, with departures above and below it (i.e., the amount to which annual rainfall was above or below average), reflecting agricultural production above and below average, or surpluses and shortfalls, respectively. Years in which growing season rainfall was >2 standard deviations or more below normal, or periods of severe to extreme drought, are assumed to reflect years of total crop failure, and were assigned a value of -1. Growing season rainfall values between 0 and 2 standard deviations below average, with mild to intensive drought conditions, were

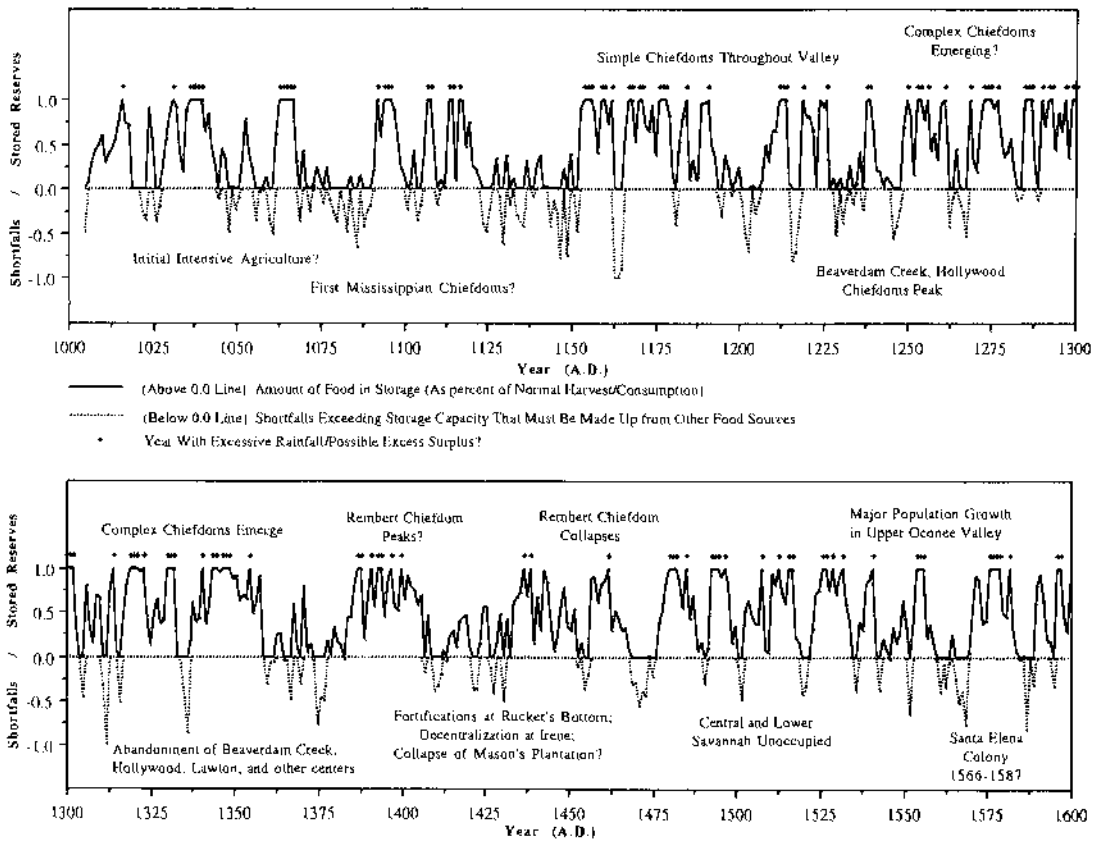


Figure 3. Reconstructed potential agricultural food reserves for the South Carolina area A.D. 1005 to 1600, calculated using the South Carolina spring rainfall reconstruction, and assuming a storage capacity equivalent to 1.0 year's reserves above normal consumption. From *The Savannah River Chiefdoms* by David G. Anderson (© 1994, University of Alabama Press). Used by permission.

assumed to reflect years when crop production was below average; the shortfall values derived from them were standardized to range between 0 and -1 . The shortfall ranges only go to -1 because numbers lower than this would imply that more crops failed than were planted, an obvious impossibility (although years with reconstructed rainfall > 2 standard deviations below average did sometimes occur).

The same relationship was assumed on the positive side, with precipitation values above average assumed to be directly proportional to surplus crop production. A year during which growing season rainfall was two standard deviations above average was assumed to be a year in which twice the normal harvest was produced, and a direct proportional relationship for harvest surplus values was as-

sumed when rainfall values were between 0 and 2 standard deviations above average; any surplus above normal consumption would have been added to reserves. The reserve total does not exceed $+1$ in the model reported here (Figure 3), because this represents the assumed maximum storage capacity (although years with reconstructed rainfall > 2 standard deviations above average likewise did sometimes occur).

When the surplus was greater than storage capacity (i.e., $> +1$), it was declared "excess surplus" (Burns 1983:247) and excluded from the reserve totals. Years when excess surplus occurred are indicated in Figure 3, although the amounts, which varied appreciably, are not. Excess surplus occurred either in years of unusually high spring rainfall (i.e., > 2 standard deviations above average) or, more

commonly, when a crop surplus occurred when stored reserves were already at or near capacity from the previous year. In either case, excess surplus would have to have been consumed immediately, and could have been used to sponsor trade, feasting, monumental construction, or other public activities. Because too much rainfall (i.e., >2 standard deviations above average) might be as detrimental on crops as too little rainfall, by causing flooding or crops to rot in the field (e.g., Le Roy Ladurie 1971:45), the role of excess surplus is minimized in the present analysis.

Although the analysis reported here is based on an assumed capacity equivalent to one year's reserves, it must be emphasized that a number of analyses of potential food shortfalls/reserves were actually calculated, using storage capabilities ranging from .5 to 2.0, or six months to two years' reserves over normal consumption (Figure 4). Not unexpectedly, these analyses demonstrate that the larger the quantity of food that could have been in storage, the lower the magnitude and frequency of shortfalls that would have had to be made up from other sources. It is likely that local chiefly elites quickly perceived this connection, and attempted to maximize crop yields and storage capability within limits of labor organization, technology, and climate. This could have reduced subsistence risk and led to greater societal stability (unless, of course, the demands to increase surplus prompted rebellion from other elites or commoners). The region's chiefdoms may have formed and expanded, in part, to buffer subsistence uncertainties (although many other factors were also clearly involved). Whether different storage capabilities were used by differing levels of organizational complexity, such as approximately a half year's reserves for simple chiefdoms, and one or more years reserves for complex chiefdoms, is unknown at present.

Historic and Prehistoric Political Change and Potential Food Reserves

The reconstructed potential food reserves/shortfall data were examined in conjunction

with archaeological and historical evidence from in and near the Savannah River valley, in an effort to delimit long-term relationships among climate, agricultural production, storage technology, and political organization. Given the low precision and accuracy of prehistoric archaeological dating at present in this part of the Southeast, we cannot unequivocally resolve the hypothesized effects of climate on local Mississippian societies. However, the plausibility of the analysis and interpretations advanced can be demonstrated with an examination of events from the early historical period, when the chronology of reconstructed climate and historical events both are annually resolved. Valuable first-hand accounts of social and environmental conditions survive from the Spanish colony of Santa Elena, occupied from 1565 to 1587 on Parris Island, South Carolina. These archival references provide a compelling example of the suggested impact of drought and low food reserves on late Mississippian societies.

The Effect of Climate on the Santa Elena Colony

Santa Elena was established in 1566 on the South Carolina coast at Parris Island (South 1980), roughly midway between the two tree-ring collection sites used to develop the food reserve reconstruction. The rainfall reconstruction indicates that below-normal rainfall occurred during all years from 1559 to 1569, except for 1565 (Figure 2). Above-average rainfall is indicated for most of the 1570s, but drought conditions returned in the 1580s and the Santa Elena colony was abandoned in 1587 during a severe drought. The potential food reserve reconstruction indicates shortfalls occurred every year from 1560 to 1569, with the exception of 1565, when a brief surplus occurred; this was exhausted the next year (Figure 3).

Our best account of climatic conditions comes from April 1566, shortly after the initial Spanish occupation. Documentary accounts indicate that the region was undergoing a severe drought that had greatly reduced native food supplies. Descriptions of

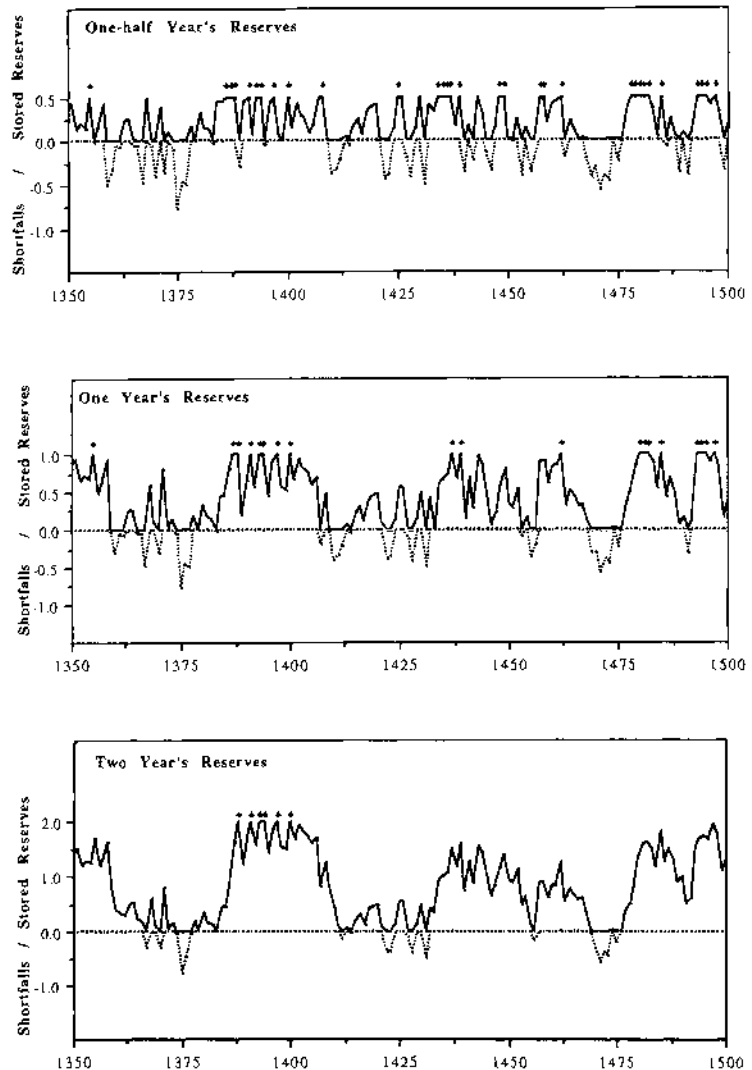


Figure 4. Reconstructed potential agricultural food reserves for the South Carolina area A.D. 1350 to 1500, calculated using the South Carolina spring rainfall reconstruction, and assuming storage capacities equivalent to half a year's, and one and two years' reserves above normal consumption. Bold line above 0.0 = amount of food in storage as percent of normal harvest/consumption. Dotted line below 0.0 = shortfalls exceeding storage capacity that must be made up. Crossmarks = years with excessive rainfall/possible excess surplus?

the native Orista, who appear to have been organized in a simple agricultural chiefdom, included the observations that "there was little food in the land, as there had been no rain for 8 months" and that "their cornfields and farming lands were dry, whereat they were all sad, on account of the little food they had" (Gonzalo Solís de Merás in Quinn 1979:492, 493; see also Connor 1928:177, 210). Although Menéndez de Avilés, the governor and founder of the colony, stationed one of his officers and some 20 men with the Orista, they were in "great fear of lack of food" since "even if the Indians had been willing to give

their food to Estéban de las Alas and his men, they had none, for it had not rained for many months" (Gonzalo Solís de Merás in Waddell 1980:147). These records support the paleoclimatic reconstruction, which indicates that the growing season for the period from 1566 to 1569 was particularly dry, and that the year 1566 was one of the driest of the decade, with only the years 1567 and 1569 drier.

The colony at Santa Elena had a precarious existence in its early years, something that was due at least in part to the poor climatic conditions. The establishment of the colony,

in fact, occurred toward the end of the driest period of the entire sixteenth century, although the Spanish could have had no idea how atypical these conditions were. Food was scarce during the first years of settlement and its acquisition preoccupied the local authorities. The Pardo expeditions were sent into the interior at this time not only for exploration, but also to relieve the colony of the necessity of feeding the men. During Pardo's second expedition from 1567 to 1568, conditions were so desperate at Santa Elena that Pardo was ordered to bring food from the interior, and food shortages in the colony were at least part of the reason why he dispersed his forces into a series of small forts along his route (Hudson 1990:45; 152ff). These forts were all destroyed and their companies massacred within a few months of their establishment. The climatic reconstruction offers independent confirmation of these conditions, and suggests reasons why the colony and its settlements in the interior ultimately failed.

Native rebellions during this period, the records indicate, were brought about by demands the Spanish placed on local populations for food and services. A minor rebellion occurred in 1570, for example, when the authorities at Santa Elena, short on food, "ordered three or four caciques, among them Escamacu, Orista, and Hoya, to bring some canoe loads of maize to Santa Elena" (Juan Rogel 1570, cited in Waddell 1980:149). Rogel, a Jesuit living with the Indians, abandoned his mission at this time, knowing the Indians would not react well to these demands. When the Indians failed to provide the corn, the Spanish sent soldiers to their village, and rebellion ensued until the caciques were appeased with gifts. Although no mention of climatic conditions or amount of food on hand is given in Rogel's account, the reaction of the natives suggests they had little to spare, which would have likely been the case if, as indicated by the paleoclimatic reconstruction, the previous four years (1566–1569) had been particularly dry. The attacks on the colony and its outposts, particularly

the destruction of the forts in the interior, may well have been prompted, if not hastened, by the demands the Spanish placed on a native agricultural system that was likely already under considerable stress.

The colony continued to endure hardships throughout its first decade, with reports of poor harvests and hunger common (e.g., Connor 1925:85, 89, 99, 155, 245). A massive native revolt in 1576, which came after many years of harvest shortfalls and Spanish demands, forced the temporary abandonment of the colony. Interestingly, the year 1576 was one of the wettest of the century, according to the reconstruction (Figure 2), and that same year one of the settlers testified "in the months of April and May, when the [grain for] bread ripens in this island, it does nothing but rain all that time, which is when we are sowing and gathering the maize" (Alonso Martin 1576, cited in Connor 1925:149). This quote, while supporting the paleoclimatic reconstruction, also suggests that too much rainfall may have been as bad as too little; hence the minimal significance assigned excess surplus in the current analysis.

Climatic conditions were generally favorable over the remainder of the century, including the years 1576 to 1582, which the reconstruction indicates were characterized by favorable climatic conditions, and when moderate to extensive food reserves could have been in storage (Figure 3). This inference is strongly supported in the documents from this period. The colony was reestablished late in the summer of 1577, and one of the first things the Spanish did was to send punitive expeditions to reassert their authority over the native populations. The Spanish commander, Pedro Menéndez Márques, nephew of Menéndez de Avilés, reported that he "burned nineteen villages" and that "great was the harm I did them in their food stores, for I burned a great quantity of maize and other supplies" (Menéndez Márques, cited in Connor 1930:225). The Spanish themselves had considerable success with their crops, and Menéndez Márques (cited in Connor 1930:227) reported in April of 1579 that "last year

Dates	Upper Piedmont	Inner Coastal Plain	Mouth of the Savannah
A.D. 1800	No Occupation	No Recognized Occupation	No Recognized Occupation
1700	Estatoe		
	Unnamed		
1600	Tugato		
1500			
1400	Rembert	Silver Bluff (Provisional)	Irene I
1300		Hollywood	Savannah III
1200	Beaverdam	Lawton (Provisional)	Savannah I/II
1100	Jarrett		St. Catherine's
1000	Woodstock	Savannah I	Wilmington
900		Interior St. Catherine's Equivalent	
800	Late Swift Creek/Napier	Interior Wilmington Equivalent	
700			

Figure 5. Mississippian cultural sequences in the Savannah River valley. From *The Savannah River Chiefdoms* by David G. Anderson (©1994, University of Alabama Press). Used by permission.

I made them sow much maize [and] at this fort alone over 1,000 *fanegas* [1550 U.S. bushels] were collected." In 1578, according to the reconstructions, growing season rainfall was about one standard deviation over normal (.973), and crops equivalent to a year's reserves could have been in storage (Figures 2, 3). The historic records thus support the hypothesis that the rainfall reconstructions are accurate and may additionally provide an accurate method of estimating food reserves.

The Santa Elena colony was abandoned in late 1587, and climate may have played a role in the Spanish decision to terminate the enterprise in South Carolina. The year 1587, the paleoclimatic reconstruction indicates, was the driest year during the entire 20-year period of Spanish settlement (as well as the third driest year of the entire sixteenth century), and three of the four years before this (1583–1585) were characterized by below-average rainfall (Figure 2). Consolidation of Spanish settlement in La Florida at St. Augustine rather than Santa Elena at this time

was facilitated, in part, by perceptions that the former area was more fit for settlement (Lyon 1984:15). The role climate played in this decision is unknown but the precipitation reconstruction suggests that it may have been more important than previously recognized.

The Possible Effect of Climate on Prehistoric Mississippian Occupations

Fourteen mound centers and over 500 village, hamlet, and special activity sites are currently known from the Savannah River basin and immediately adjoining areas, and significant changes are observed in the Mississippian archaeological record during the interval from A.D. 1000 to 1600. Excavations have revealed approximate periods of occupation as well as individual construction episodes at many of the centers and at a number of smaller nonmound sites (Anderson 1990a:250–464, 1994:157–259) (Table 1). A detailed cultural chronology for the late prehistoric and early historic era has been developed based

Table 1. Major Mississippian Excavation Assemblages from the Savannah River Basin.

Site No.	Site Name	Year Excavated	Site Type	Phases of Primary Occupation	Period of Primary Occupations	References
—	Mason's Plantation	—	platform mounds? (n = 6)	Lawton/Hollywood?	ca. A.D. 1200-1350?	Jones 1873:148-157; Moore 1898:167-168
9Eb86	Tate	—	platform mound (n = 1)	Beaverdam?	ca. A.D. 1200-1300?	Hutto 1970:23-25
9Eb1	Rember	1883, 1948	platform mounds? (n = 5)	Beaverdam, Rember	A.D. 1200-1450	Thomas 1894:315-317; Caldwell 1953; Rudolph and Hally 1985:453-459; Anderson et al. 1994
9Ri1	Hollywood	1891, 1965	platform mound (n = 2)	Hollywood	A.D. 1250-1350	Thomas 1894:317-326; DeBaillon 1965
9Ch15	Haven Home	1897-1898	burial mound (n = 1)	Savannah I/II	A.D. 1150-1200	Waring 1968
9Sn3	Hudson's Ferry	1897-1898	burial mound (n = 1)	Lawton/Hollywood	A.D. 1200-1250	Moore 1898:169-171
38A111	Lawton	1897-1898	platform mound (n = 2)	Lawton	A.D. 1200-1250	Moore 1898:171-172; Anderson 1990a:662-68
9Ch1	Irene	1939-1941	platform and burial mound (n = 2)	Savannah I/I, III, Irene I	A.D. 1200-1400	Moore 1898:168; Caldwell and McCann 1941
9St1	Tugalo	1956-1957	platform mound (n = 1)	Jarret, Rember, Tugalo	A.D. 1100-1600	Thomas 1894:314-315; Caldwell 1956; Williams and Branch 1978
38Oc47	Chauga	1958	platform mound (n = 1)	Jarret, Tugalo, Estate	A.D. 1100-1200; >A.D. 1500	Kelly and Neitzel 1959, 1961
9St3	Estate	1959-1960	platform mound (n = 1)	Tugalo, Estate	>A.D. 1500	Kelly and DeBaillon 1960
38Pn2	I. C. Few	1967	burial mound? (n = 3)	Beaverdam, Rember, Estate	A.D. 1200-1600; >A.D. 1700	Grange 1972

Table 1. Continued.

Site No.	Site Name	Year Excavated	Site Type	Phases of Primary Occupation	Period of Primary Occupations	References
9Eb92	Beaverdam site group	1980	hamlet?	Beaverdam, Rember	ca. A.D. 1200-1450	Campbell and Weed 1984
9Eb207	Beaverdam site group	1980	hamlet?	Beaverdam	ca. A.D. 1200-1300	Campbell and Weed 1984
9Eb208	Beaverdam site group	1980	hamlet?	Beaverdam	ca. A.D. 1200-1300	Campbell and Weed 1984
9Eb219	Beaverdam site group	1980	hamlet?	Jarrett, Beaverdam	ca. A.D. 1100-1300	Campbell and Weed 1984
38An126	Big Genorostee Creek	1980	hamlet?	Rember	ca. A.D. 1300-1450	Wood et al. 1986
9Eb382	Van Creek	1980	hunting camp?	Rember	ca. A.D. 1300-1450	Wood et al. 1986
9Eb357	Clyde Gulley	1980-1981	village	Jarrett	ca. A.D. 1100-1200	Tippitt and Marquardt 1984
38An8	Simpson's Field	1980-1981	hamlet?	Beaverdam/Rember	ca. A.D. 1200-1450	Wood et al. 1986
9Eb76	Rufus Bullard	1980-1981	village?	Beaverdam, Rember	ca. A.D. 1200-1450	Anderson and Schuidenrein 1985
9Eb85	Beaverdam Creek	1980-1981	platform mound (n = 1)	Beaverdam	ca. A.D. 1200-1300	Rudolph and Hally 1985
9Eb91	Rucker's Bottom	1980-1982	village	Beaverdam, Rember	ca. A.D. 1200-1450	Anderson and Schuidenrein 1985
38Oc186	Tomassee	1986	village	Estate	ca. A.D. 1700-1750	Smith et al. 1988
9Sn4	Red Lake	1988	platform mound (n = 1)	Lawton	A.D. 1200-1250	Espenshade et al. 1993; M. Williams; personal communication
38Oc18	Chattooga	1989-1993	village	Estate	ca. A.D. 1700-1750	Schroedl and Riggs 1989

Modified from Anderson 1994:172; courtesy University of Alabama Press.

on a cultural stratigraphy, ceramic seriation, radiocarbon dating, and archival references from the Spanish and English colonial period. Variations in ceramic design motif, rim treatment, and other incidental decoration have proven to be highly sensitive chronological markers, and fine-grained late prehistoric cultural sequences have been developed in three parts of the basin, with temporal resolution on the order of 100–150 years currently possible (Anderson 1994:362–377) (Figure 5).

Before discussing associations between the paleoclimatic and archaeological records, it must be emphasized that the absolute timescale for the archaeological sites, occupations, and assemblages from the Savannah River valley, although quite detailed by archaeological standards, is far less precise than the annual timescale available from the dendrochronological record. Accordingly, the following inferences advanced here linking specific aspects of the archaeological and paleoclimatic record should be viewed as hypothetical, and may be accepted or rejected given future investigation and improved archaeological dating. It must also be stressed, however, that the Mississippian political history that follows, specifically the general dating of events at individual sites, although subject to some debate (c.f., Anderson 1990b; Eubanks 1989), was developed and published independently of and well *before* the dendrochronological and paleoclimatic record described here was produced (c.f., Anderson et al. 1986, Stahle and Cleaveland 1992). Finally, in the discussion that follows, smaller mound sites (i.e., with one or two platform mounds) are assumed to represent the centers of simple chiefdoms, or else subsidiary communities in complex chiefdoms, while larger centers (i.e., with more than two mounds, at least one of which is a platform mound) are assumed to represent the administrative and ceremonial centers of complex chiefdoms. Some archaeological and ethnohistoric evidence supports such an assumption, although it will, of course, require further testing (Anderson 1994; Hally 1993; Hally et al. 1990;

Steponaitis 1978). Only two large, multi-mound centers existed in the basin during the Mississippian era, at Mason's Plantation and Rembert (Table 1).

Mississippian populations practicing intensive agriculture may have been present in the Savannah River basin as early as ca. A.D. 1000. Small numbers of Woodstock- and Etowah-like ceramics have been found at the Chauga and Rembert sites in the northern part of the basin, suggesting that occupation of these centers may have begun sometime in the eleventh century (Figure 6). It is not until ca. A.D. 1150 or shortly thereafter, however, that unequivocal evidence for occupied Mississippian mound centers appears, when sites with single or at best two mounds, presumably the administrative centers of simple chiefdoms, emerge in several parts of the basin. Ethnobotanical evidence for intensive maize agriculture likewise appears only after this time (Anderson 1994:316–318), an inference supported by stable carbon isotope analyses of human skeletal remains from the mouth of the basin, which indicate that appreciable maize use in that area postdates the St. Catherine's phase (Larsen et al. 1992).

The paleoclimate data may help us partially understand why Mississippian chiefdoms emerged when they did in the basin. Although the reconstruction of food reserves indicates the interval from ca. A.D. 1005 to 1055 was favorable for agriculturalists, the period from ca. A.D. 1056 to 1152 would have been a very difficult time, with food supplies severely stressed during the years from A.D. 1056 to 1061, A.D. 1076 to 1090, and A.D. 1124 to 1152; only during the years around A.D. 1100 were conditions favorable for agricultural food production. Production of agricultural surpluses and their mobilization as tribute, essential to fueling the tributary economies of both simple and complex chiefdoms, would have been difficult during this interval. During the second half of the twelfth century, from ca. A.D. 1154 to 1200, however, climatic conditions were quite good, with surpluses predicted most years, and only a few years where shortfalls exhausted re-

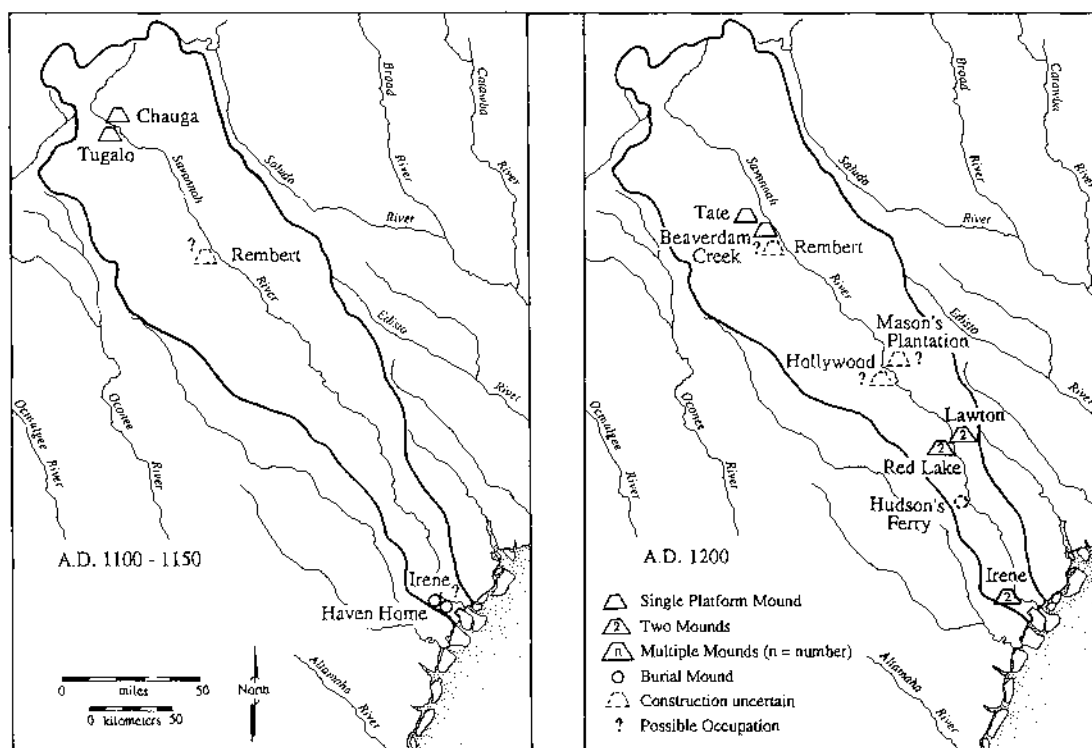


Figure 6. Mississippian centers in the Savannah River valley at ca. A.D. 1100-1150 and 1200.

serves ($n = 7$, although the shortfalls from A.D. 1162 to 1164 were quite severe). The extended period of favorable climate that characterized the latter half of the twelfth century thus may have favored the emergence of Mississippian centers, while the generally unfavorable interval before this time may have hindered their development.

The two single-mound centers near the headwaters of the basin—at Chauga and Tugalo, which were perhaps the earliest occupied Mississippian centers in the drainage—were abandoned around A.D. 1200. Whether and where their populations might have relocated is unknown, although they could have moved downstream, given the number of centers that appear in the lower reaches of the basin about this time. The extended period of increased spring rainfall that is indicated for the late twelfth century may have helped encourage down-river settlement, since favorable harvests would have been common and stored reserves plentiful, reducing the stresses associated with reloca-

tion. If the increased rainfall translated into an increase in flooding, furthermore, this may have attracted Mississippian agriculturalists, since it would have facilitated small-scale irrigation as well as have led to soil renewal in floodplain areas (Larson 1971, 1972; Murphy and Hudson 1968; Smith 1978; Ward 1965).

By around A.D. 1200, up to nine mound centers were occupied in the basin, with all but the Irene site on the coast falling in three apparent clusters located in the central piedmont and in the inner and central coastal plain (Figure 6). These sites appear to represent groups of simple chiefdoms, although the close proximity of the centers in the three interior clusters may indicate more complex chiefdoms were beginning to form. The first half of the thirteenth century was a period of moderate climatic deterioration, with food shortfalls occurring in 16 of the years from A.D. 1201 to 1250. The increased subsistence uncertainty, at least when compared to the preceding half century from ca. A.D. 1150 to 1200, when these centers apparently

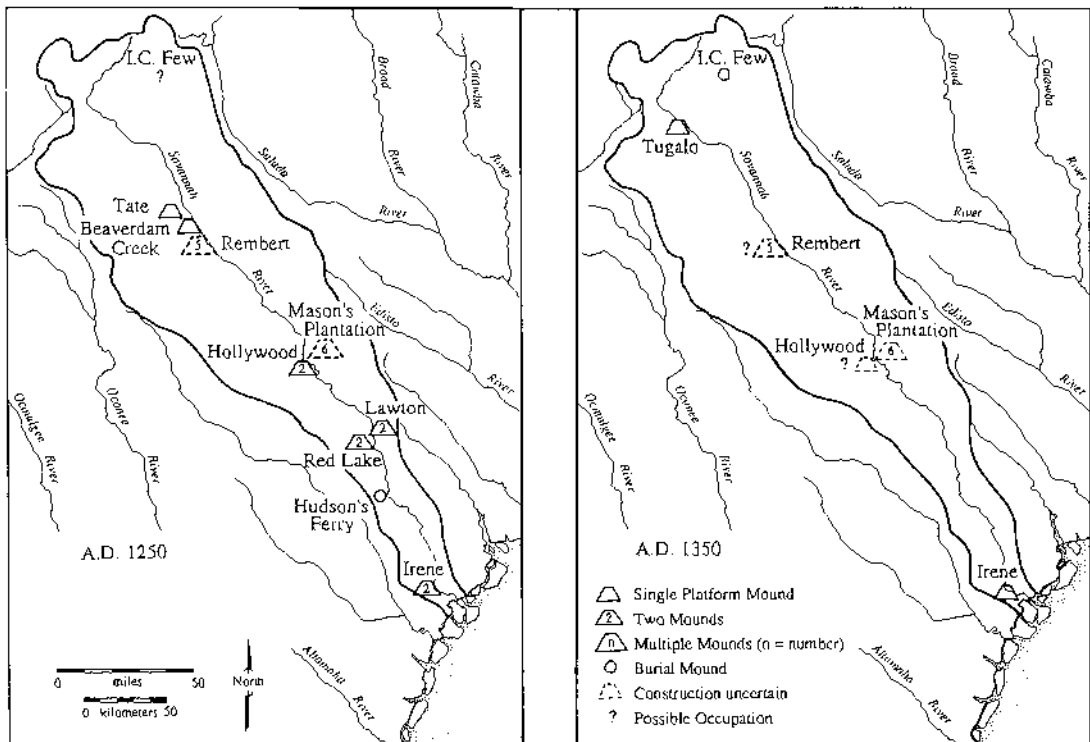


Figure 7. Mississippian centers in the Savannah River valley at ca. A.D. 1250 and 1350.

emerged, may have led to greater cooperation or competition between these societies, as their elites attempted to overcome increased food shortages.

Between ca. A.D. 1250 and 1350 the nature of Mississippian occupation changed dramatically in the Savannah River basin, although unfortunately our chronological controls are not precise enough to determine when and in what order specific events occurred. At the beginning of this interval, as many as 10 small centers were scattered throughout the basin, while by the end of it, around A.D. 1350, over half of these had been abandoned, and two major multimound centers had apparently emerged, at Rembert and Mason's Plantation (Figure 7). By or shortly after ca. A.D. 1300 the small mound centers at Hollywood, Lawton, and Red Lake in the coastal plain, and Beaverdam Creek and Tate in the central piedmont had been abandoned, while at the mouth of the river platform mound construction had ceased at Irene. In the central piedmont, in contrast, occupations at the

multimound Rembert site were particularly extensive from ca. A.D. 1300–1450, the interval to which most of the Mississippian materials from the site are dated (Anderson 1994: 193–194; Anderson et al. 1986:41–42; Caldwell 1953; Rudolph and Hally 1985:456–459). The fourteenth century is also thought to have been the period of primary occupation at the multimound Mason's Plantation site in the inner coastal plain, although our dating of this site, which had washed away by the end of the last century, is based purely on circumstantial evidence, notably that extant collections from the immediately surrounding area date to this approximate time period (Anderson 1994:193–194).

These events are thought to represent the collapse or incorporation of several of the valley's simple chiefdoms into one or two complex chiefdoms, centered at Mason's Plantation and Rembert. Climatic conditions were generally quite favorable throughout this interval, with only 16 years of shortfall indicated in our reconstruction between A.D.

1251 and 1358. While the process leading to the emergence of complex chiefdoms, assuming our interpretation of events is correct, may have been initiated during the period of subsistence uncertainty that characterized the early thirteenth century, the culmination of this trend occurred during an extended period of favorable conditions. The extensive agricultural surpluses potentially present could have been used by particularly competent elites to further their political agendas, which appear to have included absorbing or eliminating less successful elites in outlying centers. In the Savannah River basin, the growth of complex chiefdoms took place at the expense of surrounding simple chiefdoms, a process that has also been observed in a number of other southeastern Mississippian societies (e.g., Blitz 1993; Steponaitis 1978:440–449, 1991; Welch 1991). The elites at Rembert thus likely hastened the abandonment of the centers at Tate and Beavercreek, while those at Mason's Plantation likely stifled the political ambitions of populations in the lower drainage, where abandonments are indicated at the Irene, Lawton, and Red Lake centers, and possibly at Hollywood as well; exactly how these processes unfolded is unknown.

The third quarter of the fourteenth century was likely a time of great environmental stress on the basin's chiefdoms. Below-average rainfall conditions occurred most years, with harvest shortfalls exceeding reserves 12 of the 19 years from A.D. 1359 to 1377. Unfortunately, our archaeological dating is not sufficiently precise at present to resolve what happened during these years, although some suggestions, subject to further evaluation as our chronological resolution improves, can be made. It is possible, for example, that the abandonment of some of the valley's single-mound centers, inferred to have happened before A.D. 1350 (and likely did for several of them, given current understanding of their dating, as indicated in Table 1), may have actually occurred during this later period. This is possible at Hollywood and Irene, where platform mound construction is thought to

have ceased sometime between A.D. 1300 and 1350; that our dating of these events may be off by 20 or 30 years is not at all inconceivable.

The absence of late Mississippian artifacts in the Mason's Plantation area indicates this center was probably abandoned sometime between ca. A.D. 1350 and 1450. During this same interval there is unequivocal evidence for the appearance or expansion of fortifications at Irene, which underwent a renewal of sorts, and at Rucker's Bottom, a small agricultural village in the piedmont (Anderson 1994:184, 219–223, Anderson and Schuldenrein 1985:523–531). Since there is no evidence for occupation at any of these three sites after ca. A.D. 1450, it is tempting to place the start of these events in the early part of this range, during a period of great subsistence uncertainty. It is equally plausible, as we shall see, however, that they could have occurred somewhat later, in the early fifteenth century.

After A.D. 1377 climate improved for a generation, and crop surpluses are predicted almost every year until A.D. 1407. A moderate deterioration in climate lasting almost three-quarters of a century immediately followed, however, with shortfalls occurring in 21 of the 70 years from A.D. 1407 to 1476. Sometime during this roughly century-long interval, both the Mason's Plantation and Rembert complex chiefdoms collapsed; the dating of assemblages attributed to the two complexes suggests the former declined before the latter (Figure 8). Sometime after ca. A.D. 1350–1375, a rounded burial mound was built over the abandoned and eroded platform mound at Irene, a council house and mortuary complex appeared, and the associated buildings and fortifications were enlarged appreciably. Although a more egalitarian form of political organization is suggested by the presence of a council house, the populations using the Irene site appear to have dominated the lower drainage for a time, with evidence for their interments, in the form of urn burials, noted as far inland as Hollywood and Stallings Island.

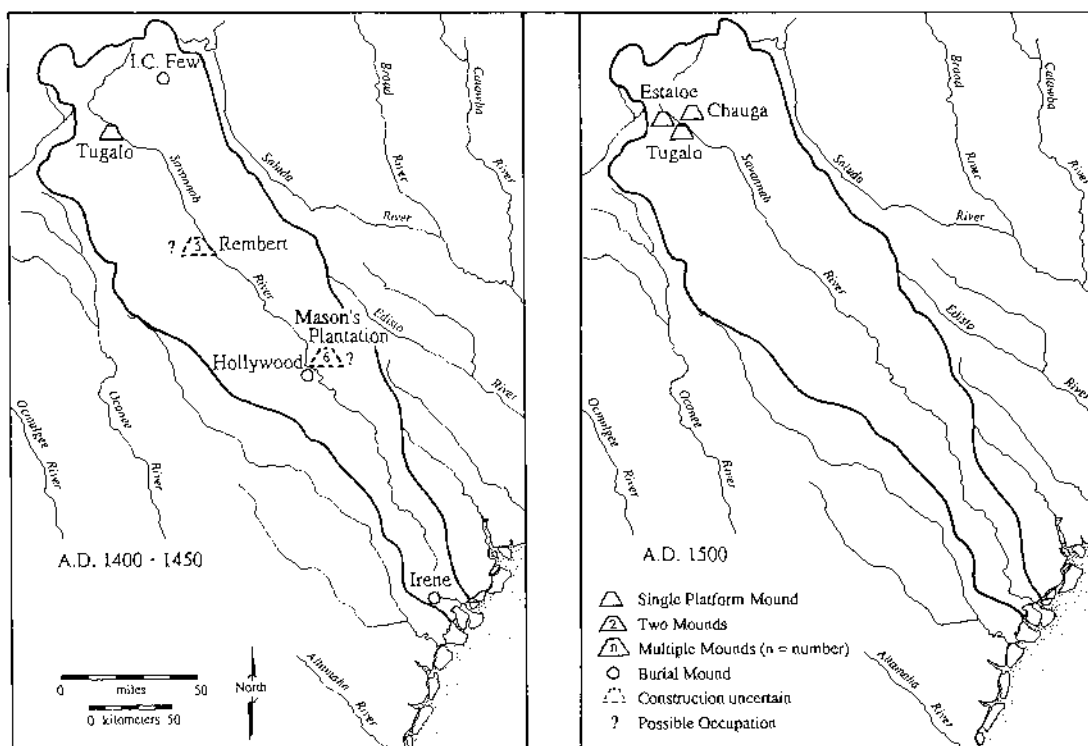


Figure 8. Mississippian centers in the Savannah River valley at ca. A.D. 1400-1450 and 1500.

Irene was finally abandoned around A.D. 1450, and by the late fifteenth century the entire lower two-thirds of the basin was depopulated, with no evidence for reoccupation until late in the seventeenth century (Anderson 1994:249-250). Interestingly, stable carbon/nitrogen isotope analyses conducted at Irene indicate maize use was appreciably lower during the final period of occupation than when the platform mound was in use, a pattern that may reflect the greater climatic uncertainty or, given the absence of evidence for elites, reduced demands for surpluses to further chiefly political agendas (Larsen et al. 1992).

The fourteenth and fifteenth centuries also saw the reoccupation of long-abandoned centers in the upper part of the basin, at Tugalo and Chauga, as well as the emergence of a new center at Estatoe. That this happened more or less contemporaneously with the depopulation of the lower basin raises the possibility that a movement of people upriver may have occurred. The appearance and

expansion of fortifications at both Rucker's Bottom and Irene just prior to their abandonment suggests warfare or raiding was on the increase, perhaps as groups sought to obtain food (or control food-producing hunting territories) to overcome the agricultural shortfalls characteristic of this period. Other evidence for increased warfare has also been noted at this time, including multiple burials, weapons trauma, and the presence of isolated skulls, although the samples are small (Anderson 1994:293-294, 300). Finally, during the fifteenth century a number of mound centers in the drainages to the east of the Savannah were also apparently abandoned, including Scott's Lake along the lower Santee and Blair and McDowell along the Broad (DePratter 1989). All of these centers are in South Carolina, and may have been subject to the same or similar climatic conditions inferred for the Savannah basin, since the rainfall and derivative crop yield/storage reconstructions were produced and verified using statewide precipitation data.

The food reserve reconstruction indicates that the years from A.D. 1469 to 1476 were particularly bad, the longest near-continuous period of shortfalls of the entire century (in A.D. 1474, following five years of shortfall, a slightly above average harvest occurred, which was followed by two more bad years). The fifteenth-century climate downturn may not have delivered the coup de grâce to the agricultural populations in the lower basin, but it likely played a role. A long interval of decreased rainfall would have had a marked effect on crop yields and hence surplus production, affecting in turn the ability of local chiefly elites to finance their political systems. The changes in Mississippian settlement observed in the Savannah River basin in the fifteenth century may thus reflect, in part, drought-induced migrations of peoples from the lower to the upper portion of the basin, or to other, more favored polities in adjoining drainages. If true, population relocation analogous to the abandonment of the Colorado Plateau (Dean et al. 1985) and the Virgin Branch Anasazi (Larson and Michaelson 1990) may have occurred, if not entirely for the same reasons.

In the late fifteenth century an extended period of favorable climate began, lasting until A.D. 1559, with shortfalls indicated during only 10 years. Unfortunately, Mississippian populations were no longer present in the lower Savannah River basin, nor did they return, suggesting that social or political factors rather than environmental conditions were dictating local settlement patterns. Archaeological research in nearby areas has given us some clues about what these factors were, since the chiefdoms in the major drainages on either side of the Savannah not only survived, but apparently expanded appreciably during this period. The fifteenth and sixteenth centuries witnessed substantial population growth in the upper Oconee River basin to the west of the Savannah (Kowalewski and Hatch 1991); some of this included population dispersal throughout the uplands, which may represent a successful attempt to deal with increased subsistence un-

certainty and perhaps warfare through the scattering of people, storage facilities, and fields.

During this same period the chiefdom of Cofitachequi in central South Carolina achieved regional prominence, although population nucleation in central towns, rather than a dispersal into numerous small hamlets, seems to have occurred in this case. The abandonment of nearby centers like Scott's Lake, Blair, and McDowell appears to have been part of this process, suggesting the political subordination of potential rivals (DePratter 1989; Hudson 1990) (Figure 9). (When de Soto arrived at Cofitachequi in the spring of 1540, he was received with great hospitality and given appreciable quantities of food [Garcilaso de la Vega in Varner and Varner 1951:300-301]. Extensive food reserves are predicted from the reconstruction, offering a partial explanation for the courteous reception the expedition received; it would be interesting to see what food reserves might have been potentially available in other parts of the region, where the expedition was not always so readily welcomed.)

As noted in the discussion of the records from Santa Elena, the reconstruction indicates that crop yields during the period from 1559 to 1569 were disastrous, representing a period of near-continuous harvest shortfalls equaled or exceeded in severity only twice before during the preceding five centuries—during the late eleventh and late fifteenth centuries, from 1076 to 1090 and 1469 to 1476. These conditions, which, as we have seen, placed a great hardship on both the Spanish and Indian populations, may additionally offer a cautionary tale on the effect of climatic variability on ethnographic or ethnohistoric interpretation. A local Indian group is reported to have spent much of the year since "time immemorial" wandering in search of wild plants and animals (Juan Rogel 1570 in Waddell 1980:147-153); this mobility may have been an effort to locate alternate food resources in direct response to the extended drought conditions of the past decade, and not the natural order of things.

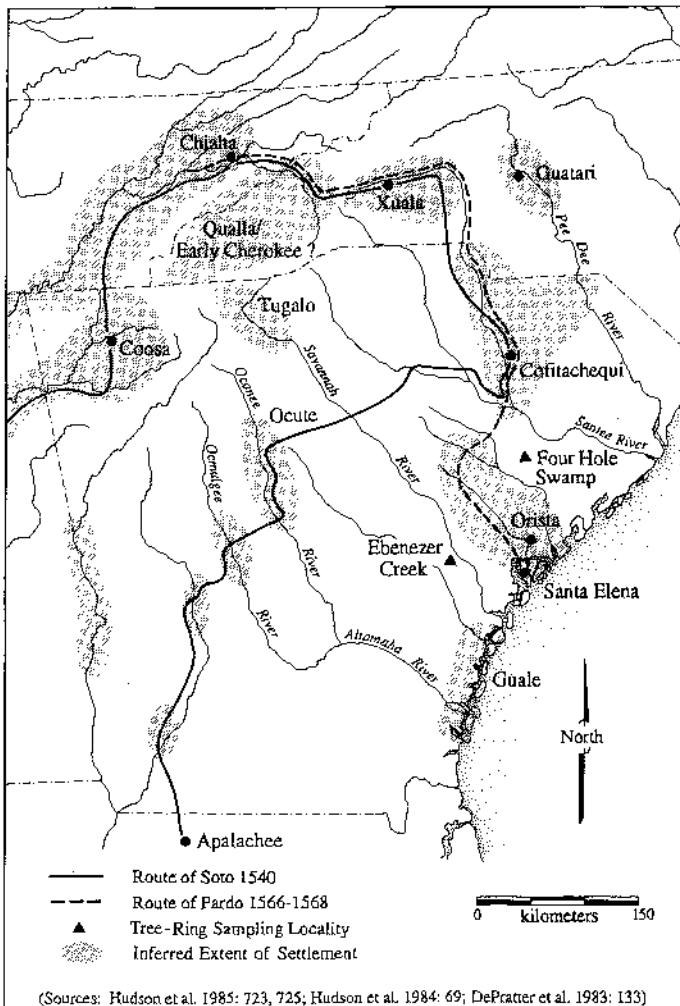


Figure 9. Mississippian polities in and near the Savannah River basin in the sixteenth century.

Political Change in Mississippian Chiefdoms: Lessons from the Savannah River Valley

Our examination of paleoclimatic data for the period of Mississippian and early historic settlement in the Savannah River area revealed several extended periods of above- or below-average warm season rainfall and probable crop surpluses and deficits from A.D. 1100 to 1600. A number of approximately dated episodes of prehistoric social change, we have seen, appear to have occurred during these extended periods of surplus or deficit food reserves. Growing season rainfall, through its effect on crop yields, we have argued, likely played an important caus-

al role in many of these observed changes, a hypothesis that can be further tested on a site and regional basis given improved dating of relevant archaeological manifestations. Given our current level of chronological resolution, though, century-scale associations, such as the apparent emergence of complex chiefdoms during an extended favorable climatic interval, or the abandonment of the lower basin during a long downturn, must be viewed as more likely than decade-scale associations, such as the dating of the appearance of fortifications at Rucker's Bottom and Irene to a comparatively brief period of climatic deterioration in the late fourteenth century.

The analysis clearly indicates the impor-

tance of stored food reserves on the stability of chiefdoms in an area like the Southeast, where appreciable interannual climatic variability affecting agricultural food production occurs. Reserves would have enabled local Mississippian populations to buffer shortfalls in production, enabling them to overcome with minimal dislocation both isolated crop failures as well as a number of consecutive years of slightly to moderately below-average harvests. Our reconstruction indicates, in fact, that maintaining one year's reserves would have ensured adequate or better food supplies three-quarters of the years from A.D. 1005 to 1600 ($n = 449$, or 75.3 percent). When extended periods of drought did happen, furthermore, reserves could have ensured that the effects of declining harvests were spread out, giving local populations more time to switch to other sources of food. This same analysis shows, however, that no reasonable or feasible storage strategy could have enabled local Mississippian populations to avoid stress during major periods of extended drought (e.g., see Figure 4).

Finally, our analysis also highlights the fact that climatic conditions alone cannot explain all of the changes observed in the Savannah River chiefdoms. A prime example is the depopulation of the lower basin in the mid-fifteenth century. Although this abandonment occurred during an extended downturn in climate, and might be comprehensible in these terms, this does not explain why the area remained unoccupied for almost two centuries afterward even though favorable rainfall conditions reappeared in the late fifteenth century. The reasons for the continuing depopulation are complex and appear deeply rooted in political geography and history, notably the locations of and rivalries between a number of chiefdoms over the larger region (Anderson 1994:326–329).

In brief, at the time of the de Soto expedition in 1540, the complex chiefdoms of Ocute and Cofitachequi occupied the central parts of Georgia and South Carolina, respectively, and were reported to be bitter rivals; the Spanish army passed through an exten-

sive unoccupied buffer zone when traveling between them, that included the area occupied by the Savannah River chiefdoms the century before (Rodrigo Ranjel in Bourne 1904:89–102, 140; Fidalgo de Elvas in Bourne 1904:55–69; Hudson et al. 1985, 1987, 1990) (Figure 9). The Mississippian populations along the Savannah thus appear to have been caught between two powerful, expanding chiefdoms, and the increased political and likely military competition they faced came about at a time when climatic deterioration was creating appreciable stress both locally and perhaps over a much larger area. Forced to make up harvest shortfalls by obtaining wild plant and animal resources from surrounding areas, the Savannah Mississippian populations likely came into increased contact with rivals from nearby drainages, who may have also been concerned with finding alternate sources of food. If hostilities resulted, the Savannah, which is appreciably smaller than the major drainages to either side, may have had an appreciably lower base population, giving elites in the basin a numerical disadvantage in such conflicts. Over time, the chiefdoms along the Savannah collapsed and their populations either died out or relocated; once the basin was abandoned, the continuing hostilities within the region precluded its reoccupation.

Although the Savannah chiefdoms had survived periods of prolonged drought during earlier centuries, they had not, apparently, previously been threatened by external rivals, since the political landscape of eastern Georgia and South Carolina was largely characterized by simple chiefdoms prior to the fourteenth century (DePratter 1989; Williams and Shapiro 1987). Extended harvest shortfalls, when coupled with increasing losses in warfare or hunting activity, would likely have severely challenged the sacred authority of the Savannah River elites, in turn affecting their ability to mobilize tribute. The gradual circumscription of the Savannah River chiefdoms likely led to a relocation of the valley's population to other areas, and to more successful leaders. For these reasons, strict en-

vironmental determinism cannot explain the events observed in the archaeological record of the Savannah River basin. Environment and climate likely played an important role, but so too did the political conditions that existed between the region's chiefdoms.

Conclusions

The paleoclimatic data used in this analysis were achieved through dendrochronological and dendroclimatological research. Although analyses of this kind have a long history in the Southeast, dating back to Gordon R. Willey's (1937) pioneering efforts to derive a central Georgia chronology while working at Macon Plateau in the 1930s (see also Bell 1951 and Hawley 1941), only now is their full potential being realized. We have seen that a number of major changes in the prehistoric archaeological record of the Savannah River basin, including the emergence and collapse of a series of simple and complex chiefdoms, may have occurred during extended periods of reconstructed food surplus or shortfall. A great deal of additional research will be required, however, to bring a high level of confidence to our hypothesis that these events are directly related.

Refinement of the archaeological timescale is a prerequisite to further research, since our placement of components in the South Appalachian area is, at best, no more than ± 50 years. Many more accurate and precise dates will be needed in order to rigorously test the hypothesized influence of past climate variation on the food reserves and political changes in Mississippian chiefdoms. Dendrochronology is now a feasible dating method for the late prehistoric period in many parts of the Southeast. Bald cypress chronologies 800 to 1,600 years long are available from several locations on the Atlantic coastal plain and in the lower Mississippi Valley, and an 850-year-long red cedar chronology developed in the Missouri Ozarks (Guyette 1981) has recently been confirmed and updated. If suitably preserved cypress or red cedar wood or charcoal can be recovered in proximity to these available master chronologies, then exact tree-ring dates might be ob-

tained for specimens with as few as 100 growth rings. Archaeological wood could also contribute to substantial extension of the master tree-ring chronologies. The many dugout canoes of various ages from the Southeast are one excellent source of ancient wood that could contribute to these chronological goals.

If tree-ring dates cannot be obtained, at least two other dating methods might provide the level of precision and accuracy needed to test climate hypotheses. Prehistoric timbers with more than 100 annual growth rings could provide radiocarbon specimens from fixed time intervals (for example, 101 growth rings could provide six radiocarbon specimens, each exactly 20 years apart). These specimens could be submitted for high-precision ^{14}C dating, and the derived dates used to reproduce a segment of the radiocarbon secular variation curve. If the prehistoric timber happens to date from a period when the radiocarbon curve was quite variable, then the "wiggles" evident in the curve could be matched against the wiggles in the secular variation curve. Under these most favorable conditions, an accurate date within ± 10 years could then be determined for the terminal ring, because the secular variation curve has been calibrated against the exact tree-ring timescale (Clark and Renfrew 1972; Clark and Sowray 1973; Pearson 1986; Stuiver and Becker 1986).

Archaeomagnetic dating provides a second method of obtaining reasonably accurate dates with a precision of ± 15 to ± 60 years at the 95 percent confidence level (Wolfman 1984:396). The polar curve available for the southwestern United States appears valid for the lower Mississippi Valley, but it may be necessary to develop a separate polar curve for the remainder of the Southeast (Wolfman 1984:408-410). Needless to say, increased temporal precision would be valuable in the exploration of a host of questions facing Southeastern archaeology.

Other topics that need to be explored in greater detail are the geographic scale of the dendroclimatological reconstructions, temporal patterns of past rainfall anomalies, and links between growing season rainfall, tree

growth, and crop yields. For example, are extended periods of above- and below-average precipitation synchronous over large areas, and if so, how does this impact cultural systems, in particular activities like warfare, alliance formation, settlement and field distributions, and hunting and storage strategies?

Research will need to be directed to verifying relationships between reconstructed rainfall values and crop yields, factoring out the effects of modern agricultural practices. Our reconstruction of potential food reserves presumes, for example, that "growing season" rainfall amounts averaged from March through June are directly related to Mississippian crop yields. For the most part, this seems to be a reasonable presumption for long-maturing crops such as maize, but is it likely that complete crop failure would occur if a dry March to June was followed by a favorably moist July to September? An excessively wet March to June might also fail to provide even the surplus harvests our simple crop-rainfall model predicts, much less the "excess surpluses" downplayed in this analysis. Therefore, the degree to which March-June rainfall was associated with Mississippian agricultural production needs to be explored in detail. This might be accomplished by experimental crop production using Mississippian agricultural technology, or by comparing March to June rainfall with twentieth-century crop yield data for crops grown without irrigation and with trend from technological intervention (e.g., fertilizer and pesticide [Burns 1983]), presuming such data can be located for the southeastern United States.

Finally, additional archaeological, archival, and ethnographic information concerning Mississippian storage technology and capacity, and the exchange of foodstuffs, will be needed.

Southeastern Mississippian and earlier exchange networks are usually posited by archaeologists as risk-minimization systems established, in part, to ensure that food shortages in one area could be made up from other areas. The transfer of food, sometimes in ex-

change for valuables, is typically inferred, although exchange could also reinforce social ties that would allow populations to relocate at least temporarily in times of hardship (e.g., Braun and Plog 1982, Brose 1989; see also Halstead and O'Shea 1989 and O'Shea 1981). Given the logistical difficulties inherent in moving bulk goods, particularly between societies located in differing drainages, however, it is unlikely that major interpolity exchange systems predicated on the movement of massive amounts of food ever existed in the region (although the possibility of extensive *intrapolity* bulk goods movements along river systems should not be discounted). Given the frequency and rapidity with which stored reserves could have been exhausted, the analysis here suggests that seed grain, rather than bulk foodstuffs, may have been an important component of Mississippian exchange systems.

Analyses of paleoclimate are likely to prove valuable to the study of southeastern archaeology and history. The South Appalachian area alone offers many fruitful avenues for future research. The occupation and abandonment of Macon Plateau, for example, can be explored in conjunction with the recently developed tree-ring chronology from the Altamaha River (Stahle and Cleaveland 1992). The early to mid-twelfth century, when the chiefdom at Macon is thought to have collapsed, for example, was a period of unusual drought in central Georgia that may have been a source of stress on the inhabitants of this society. Many of the major historic Indian revolts during the colonial period, such as the Guale revolt of 1597, the Yamassee War of 1715, and the Cherokee War of 1760, occurred during or just following periods of reconstructed drought, although the possible role of reduced harvests is not known. Long-term climate trends during the historic period may have played a role in shaping settlement expansion or agricultural practices, as the Santa Elena example suggests (see also Burns 1983:12-13; Hawley 1941:66).

Compelling evidence for political change is apparent in the late prehistoric archaeological record of the southeastern United

States. Mississippian chiefdoms varied appreciably in size and organizational complexity, and scores of these societies emerged, expanded, and then collapsed within the region during the period from ca. 800 to 1600. The investigation of climatic factors, we have seen, must be considered if we are to fully understand organizational change in these societies. In recent years some scholars have tended to downplay the role of natural forces in the shaping of human events, and to stress the determinative role of individual actors and their cultural and ideological environment. These are fully appropriate and informative areas for study. It is difficult to argue that climatic effects were unimportant to the Mississippian chiefdoms of the Southeast, however, given the impact climatic variability has had on modern American society, as witnessed by the great droughts of 1986 and 1988, and the floods of 1993 and 1994. A perspective emphasizing natural as well as social forces, this example from the Savannah River basin indicates deeper insight about the causes of prehistoric cultural change.

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References Cited

- Anderson, D. G.
 1990a *Political Evolution in Chiefdom Societies: Cycling in the Late Prehistoric Southeastern United States*. Ph.D. dissertation, Department of Anthropology, University of Michigan. University Microfilms, Ann Arbor.
 1990b The Mississippian Occupation and Abandonment of the Savannah River Valley. *The Florida Anthropologist* 43(1):13-35.
 1994 *The Savannah River Chiefdoms: Political Change in the Late Prehistoric Southeast*. University of Alabama Press, Tuscaloosa.
- Anderson, D. G., and J. Schuldenrein
 1985 *Prehistoric Human Ecology Along the Upper Savannah River: Excavations at the Rucker's Bottom, Abbeville, and Bullard Site Groups*. Russell Papers, Interagency Archeological Services Division, National Park Service. Atlanta, Georgia.
- Anderson, D. G., D. J. Hally, and J. L. Rudolph
 1986 The Mississippian Occupation of the Savannah River Valley. *Southeastern Archaeology* 5(1): 32-51.
- Anderson, D. G., C. Amer, and R. F. Elliott
 1994 *Archaeological Survey Along the Upper Savannah River, 1990, Including Underwater Investigations at the Rembert Mound Group*. Technical Papers 1, Interagency Archeological Services Division, National Park Service. Atlanta, Georgia.
- Anderson, J. L.
 1981 History and Climate: Some Economic Models. In *Climate and History: Studies in Past Climates and their Impact on Man*, edited by T. M. L. Wigley, M. J. Ingram, and G. Farmer, pp. 337-355. Cambridge University Press, Cambridge.
- Bell, R. E.
 1951 Dendrochronology at the Kincaid Site. In *Kincaid: A Prehistoric Illinois Metropolis*, by F. Cooper-Cole. University of Chicago Press, Chicago.
- Blitz, John
 1993 *Ancient Chiefdoms of the Tombigbee*. University of Alabama Press, Tuscaloosa.
- Bourne, E. G. (editor)
 1904 *Narratives of the Career of Hernando De Soto in the Conquest of Florida as Told by a Knight of Elvas and in a Relation by Luys Hernandez de Biedma. Factor of the Expedition. Translated by Buckingham Smith, Together with an Account of De Soto's Expedition Based on the Diary of Rodrigo Rangel, His Probate Secretary, Translated from Ovide's Historia General y Natural de las Indias*. 2 volumes. A. S. Barnes and Company, New York.

- Braun, D., and S. Plog
1982 Evolution of "Tribal" Social Networks: Theory and Prehistoric North American Evidence. *American Antiquity* 47:504-525.
- Brose, D. S.
1989 From the Southeastern Ceremonial Complex to the Southern Cult: "You Can't Tell the Players without a Program." In *The Southeastern Ceremonial Complex: Artifacts and Analysis The Cottonlandia Conference*, edited by P. Galloway, pp. 27-37. University of Nebraska Press, Lincoln.
- Brumfiel, Elizabeth M., and John W. Fox (editors)
1994 *Factional Competition in the New World*. Cambridge University Press, Cambridge.
- Burns, B. T.
1983 *Simulated Anasazi Storage Behavior Using Crop Yields Reconstructed from Tree Rings: A.D. 652-1968*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Arizona. University Microfilms, Ann Arbor.
- Caldwell, J. R.
1953 The Rembert Mounds, Elbert County, Georgia. *Bureau of American Ethnology Bulletin* 154: 303-320. Washington, D.C.
1956 Progress Report on Excavation at Tugalo (9St1-Georgia). Manuscript on file at the Laboratory of Archaeology, University of Georgia, Athens.
- Caldwell, J. R., and C. McCann (editors)
1941 *Irene Mound Site, Chatham County, Georgia*. University of Georgia Press, Athens.
- Campbell, J. L., and C. S. Weed
1984 *The Beaverdam Group Archaeological Investigations at 9Eb92, 9Eb207, 9Eb208, and 9Eb219 Richard B. Russell Multiple Resource Area, Elbert County, Georgia*. Russell Papers, Interagency Archaeological Services Division, National Park Service. Atlanta, Georgia.
- Chumrny, W. W.
1973 *The Ecology of the Middle Mississippian Occupation of the American Bottom*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Illinois at Urbana-Champaign. University Microfilms, Ann Arbor.
- Clark, R. M., and C. Renfrew
1972 A Statistical Approach to the Calibration of Floating Tree-Ring Chronologies Using Radiocarbon Dates. *Archaeometry* 14:5-19.
- Clark, R. M., and A. Sowray
1973 Further Statistical Methods for the Calibration of Floating Tree-Ring Chronologies. *Archaeometry* 15:255-266.
- Connor, J. T.
1925 *Colonial Records of Spanish Florida Letters and Reports of Governors and Secular Persons. Volume I A.D. 1570-1577*. Publications of the Florida State Historical Society. Deland, Florida.
1928 *Pedro Menéndez de Avilés: Adelantado, Governor and Captain-General of Florida; Memorial by Gonzalo Soltaais de Merás; First Published in La Florida su Conquista y Colonizacion por Pedro Menéndez de Avilés by Eugenio Ruidiaz y Caravia*. Publications of the Florida State Historical Society, Number 3. Deland, Florida.
1930 *Colonial Records of Spanish Florida Letters and Reports of Governors, Deliberations of the Council of the Indies, Royal Decrees, and Other Documents. Volume II A.D. 1577-1580*. Publications of the Florida State Historical Society. Deland, Florida.
- Cook, E. R., D. W. Stahle, and M. K. Cleaveland
1992 Dendroclimatic Evidence from Eastern North America. In *Climate Since 1500*, edited by R. S. Bradley and P. D. Jones, pp. 331-348. Routledge, London.
- Cordy, R. H.
1981 *A Study of Prehistoric Social Change: The Development of Complex Societies in the Hawaiian Islands*. Academic Press, New York.
- Dean, J. S., R. C. Euler, G. J. Gummerman, F. Plog, R. H. Hevly, and T. N. V. Karlstrom
1985 Human Behavior, Demography, and Paleoenvironment on the Colorado Plateau. *American Antiquity* 50:537-554.
- DeBaillou, C.
1965 A Test Excavation of the Hollywood Mound (9R11), Georgia. *Southern Indian Studies* 17:3-11.
- DeBoer, W. R.
1988 Subterranean Storage and the Organization of Surplus: The View from Eastern North America. *Southeastern Archaeology* 7:1-20.
- DePratter, C. B.
1983 *Late Prehistoric and Early Historic Chiefdoms in the Southeastern United States*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Georgia, Athens. University Microfilms, Ann Arbor.
1989 The Archaeology of Coftachequi. In *Studies in South Carolina Archaeology: Papers in Honor of Robert L. Stephenson*, edited by A. C. Goodyear III and G. T. Hanson. Anthropological Studies. South Carolina Institute of Archaeology and Anthropology, University of South Carolina, Columbia.
- DePratter, C. B., C. M. Hudson, and M. T. Smith
1983 The Route of Juan Pardo's Explorations in the Interior Southeast, 1566-1568. *Florida Historical Quarterly* 62:125-158.
- DeVries, J.
1980 Measuring the Impact of Climate on History: The Search for Appropriate Methodologies. *Journal of Interdisciplinary History* 10:599-630.
- Douglass, A. E.
1941 Crossdating in Dendrochronology. *Journal of Forestry* 39:825-831.
- Espenshade, C. T., T. Pluckhahn, M. Roberts, D. C. Jones, and E. C. Poplin
1993 *Cultural Resources Survey and Testing of the Georgia Pacific (Thompson-Towns) Tract Screven County, Georgia*. Brockington and Associates. Atlanta, Georgia.
- Eubanks, W. S., Jr.
1989 Studying deSoto's Route: A Georgian House of Cards. *The Florida Anthropologist* 42(4):369-380.
- Flohn, H.
1981 Short-term Climatic Fluctuations and Their Economic Role. In *Climate and History: Studies in Past Climates and Their Impact on Man*, edited by T. M. L. Wigley, M. J. Ingram, and G. Farmer, pp. 310-318. Cambridge University Press, Cambridge.
- Ford, R. I.
1974 Northeastern Archaeology: Past and Future

- Directions. *Annual Review of Anthropology* 3:385-413.
- 1977 Evolutionary Ecology and the Evolution of Human Ecosystems: A Case Study from the Midwestern United States of America. In *Explanation of Prehistoric Change*, edited by J. N. Hill, pp. 153-184. University of New Mexico Press, Albuquerque.
- Fritts, H. C.
1976 *Tree-Rings and Climate*. Academic Press, London.
- Grange, R. D.
1972 *The I. C. Few Site (38PN2)*. Manuscript on file at the South Carolina Institute of Archaeology and Anthropology, University of South Carolina, Columbia.
- Guyette, R.
1981 *Climatic Patterns of the Ozarks as Reconstructed from Tree-Rings*. Unpublished Master's thesis, University of Missouri, Columbia.
- Hally, D. J.
1986 The Cherokee Archaeology of Georgia. In *The Conference on Cherokee Prehistory*, assembled by D. G. Moore, pp. 95-121. Warren Wilson College, Swannanoa, North Carolina.
1993 The Territorial Size of Mississippian Chiefdoms. In *Archaeology of Eastern North America Papers in Honor of Stephen Williams*, edited by J. B. Stoltman, pp. 143-168. Archaeological Report No. 25. Mississippi Department of Archives and History, Jackson.
- Hally, D. J., and J. L. Rudolph
1986 *Mississippi Period Archaeology of the Georgia Piedmont*. Laboratory of Archaeology Series Report No. 24. University of Georgia, Athens.
- Hally, D. J., M. T. Smith, and J. B. Langford, Jr.
1990 The Archaeological Reality of DeSoto's Coosa. In *Archaeological and Historical Perspectives on the Spanish Borderlands East*, edited by D. H. Thomas, pp. 121-138. *Columbian Consequences*, vol. 2. Smithsonian Institution Press, Washington, D.C.
- Halstead, P., and J. O'Shea (editors)
1989 *Bad Year Economics: Cultural Responses to Risk and Uncertainty*. Cambridge University Press, Cambridge.
- Hawley, F.
1941 *Tree Ring Analysis and Dating in the Mississippi Drainage*. University of Chicago Press, Chicago.
- Hudson, C. M.
1990 *The Juan Pardo Expeditions: Exploration of the Carolinas and Tennessee, 1566-1568*. Smithsonian Institution Press, Washington, D.C.
- Hudson, C. M., M. T. Smith, and C. B. DePratter
1984 The Hernando DeSoto Expedition: From Apalachee to Chiaha. *Southeastern Archaeology* 3:65-77.
- Hudson, C. M., J. E. Worth, and C. B. DePratter
1990 Refinements in Hernando DeSoto's Route through Georgia and South Carolina. In *Archaeological and Historical Perspectives on the Spanish Borderlands East*, edited by D. H. Thomas, pp. 107-119. *Columbian Consequences*, vol. 2. Smithsonian Institution Press, Washington, D.C.
- Hudson, C. M., M. T. Smith, D. J. Hally, R. Polhemus, and C. B. DePratter
1985 Coosa: A Chiefdom in the Sixteenth Century United States. *American Antiquity* 50:723-737.
- 1987 In Search of Coosa: Reply to Schroedl and Boyd. *American Antiquity* 52:840-857.
- Hutto, B.
1970 *Archaeological Survey of the Elbert County, Georgia, Portion of the Proposed Trotter's Shoals Reservoir, Savannah River*. Laboratory of Archaeology Series No. 7. University of Georgia, Athens.
- Ingram, M. J., G. Farmer, and T. M. L. Wigley
1981a Past Climates and Their Impact on Man: A Review. In *Climate and History: Studies in Past Climates and Their Impact on Man*, edited by T. M. L. Wigley, M. J. Ingram, and G. Farmer, pp. 3-50. Cambridge University Press, Cambridge.
- Ingram, M. J., D. J. Underhill, and G. Farmer
1981b The Use of Documentary Sources for the Study of Past Climates. In *Climate and History: Studies in Past Climates and Their Impact on Man*, edited by T. M. L. Wigley, M. J. Ingram, and G. Farmer, pp. 180-213. Cambridge University Press, Cambridge.
- Jones, C. C.
1873 *Antiquities of the Southern Indians, Particularly of the Georgia Tribes*. D. Appleton and Company, New York.
- Jones, E. L.
1964 *Seasons and Prices: The Role of Weather in English Agricultural History*. George Allen & Unwin, London.
- Judge, C.
1991 Some Preliminary Thoughts on Barbacoas and the Importance of Food and Tribute Storage in Late Mississippian Times. *South Carolina Antiquities* 23: 19-29.
- Karl, T. R., L. K. Metcalf, M. L. Nicodemus, and R. G. Quayle
1983 *Statewide Average Climatic History, South Carolina*. National Climate Data Center Historical Climatology Series 6-1. Asheville, North Carolina.
- Kelly, P.
1988 *The Architecture of the King Site*. Unpublished Master's thesis, Department of Anthropology, University of Georgia, Athens.
- Kelly, A. R., and C. De Baillou
1960 Excavation of the Presumptive Site of Estatoe. *Southern Indian Studies* 12:3-30.
- Kelly, A. R., and R. S. Neitzel
1959 *Chauga Mound and Village (38OC1) and Other Sites in the Hartwell Basin*. Manuscript on file at the Interagency Archaeological Services Division, National Park Service, Atlanta, Georgia.
- 1961 *The Chauga Site in Oconee County, South Carolina*. Laboratory of Archaeology Series No. 3. University of Georgia, Athens.
- Kowalewski, S. A., and J. W. Hatch
1991 The Sixteenth-Century Expansion of Settlement in the Upper Oconee Watershed, Georgia. *Southeastern Archaeology* 10:1-17.
- Kronberg, N., and J. C. Purvis
1959 *Climate of the States—South Carolina*. Weather Bureau Climatograph of the United States No. 60-38. U.S. Department of Commerce, Washington, D.C.

- Lamb, H. H.
1984 Climate and History in Northern Europe and Elsewhere. In *Climatic Changes on a Yearly to Millennial Basis: Geological, Historical, and Instrumental Records*, edited by N. A. Morner and W. Karlen, pp. 225–240. D. Reidel Publishing, Dordrecht, The Netherlands.
- Larsen, C. S., M. J. Schoeninger, N. J. van der Merwe, K. M. Moore, and J. A. Lee-Thorp
1992 Carbon and Nitrogen Stable Isotope Signatures of Human Dietary Change in the Georgia Bight. *American Journal of Physical Anthropology* 89:197–214.
- Larson, D. O., and J. Michaelson
1990 Impacts of Climatic Variability and Population Growth on Virgin Branch Anasazi Cultural Developments. *American Antiquity* 55:227–249.
- Larson, L. H., Jr.
1971 Settlement Distribution during the Mississippi Period. *Southeastern Archaeological Conference Bulletin* 13:19–25.
1972 Functional Considerations of Warfare in the Southeast During the Mississippian Period. *American Antiquity* 37:383–392.
- Le Roy Ladurie, E.
1971 *Times of Feast, Times of Famine: A History of Climate Since the Year 1000*. Doubleday, New York.
- Lyon, E.
1984 *Santa Elena: A Brief History of the Colony, 1566–1587*. South Carolina Institute of Archaeology and Anthropology, Research Manuscript Series No. 193. University of South Carolina, Columbia.
- MacKay, A.
1981 Climate and Popular Unrest in Late Medieval Castile. In *Climate and History: Studies in Past Climates and Their Impact on Man*, edited by T. M. L. Wigley, M. J. Ingram, and G. Farmer, pp. 356–376. Cambridge University Press, Cambridge.
- McGhee, R.
1981 Archaeological Evidence for Climatic Change During the Last 5000 Years. In *Climate and History: Studies in Past Climates and their Impact on Man*, edited by T. M. L. Wigley, M. J. Ingram, and G. Farmer, pp. 162–179. Cambridge University Press, Cambridge.
- Minc, L. D., and K. P. Smith
1989 The Spirit of Survival: Cultural Responses to Resource Variability in North Alaska. In *Bad Year Economics: Cultural Responses to Risk and Uncertainty*, edited by P. Halstead and J. O'Shea, pp. 8–39. Cambridge University Press, Cambridge.
- Moore, C. B.
1898 Certain Aboriginal Mounds of the Savannah River. *Journal of the Academy of Natural Sciences of Philadelphia* 2(2)(2nd series):162–172.
- Murphy, C., and C. M. Hudson
1968 *On the Problem of Intensive Agriculture in the Aboriginal Southeastern United States*. Working Papers vol. 2, no. 1, pp. 24–34. University of Georgia, Department of Sociology and Anthropology, Athens.
- Orans, M.
1966 Surplus. *Human Organization* 25:24–32.
- O'Shea, J.
1981 Coping With Scarcity: Exchange and Social Storage. *British Archaeological Reports International Series* 96:167–183.
1989 The Role of Wild Resources in Small Scale Agricultural Systems: Tales from the Lakes and Plains. In *Bad Year Economics: Cultural Responses to Risk and Uncertainty*, edited by P. Halstead and J. O'Shea, pp. 57–67. Cambridge University Press, Cambridge.
- Parry, M. L.
1981 Climatic Change and the Agricultural Frontier: A Research Strategy. In *Climate and History: Studies in Past Climates and their Impact on Man*, edited by T. M. L. Wigley, M. J. Ingram, and G. Farmer, pp. 319–336. Cambridge University Press, Cambridge.
- Pearson, G. W.
1986 Precise Calendrical Dating of Known Growth-Period Samples using a "Curve Fitting" Technique. *Radiocarbon* 28:292–299.
- Polhemus, R. B.
1987 *The Toqua Site: A Late Mississippian Dallas Phase Town*. Publications in Anthropology 44. Tennessee Valley Authority, Knoxville.
- Post, J. D.
1980 The Impact of Climate on Political, Social, and Economic Change: A Comment. *Journal of Economic History* 10:719–723.
- Quinn, D. B. (editor)
1979 *The Extension of Settlement in Florida, Virginia, and the Spanish Southwest*. New American World: A Documentary History of North America to 1612, vol. 5. Arno Press, New York.
- Rudolph, J. L., and D. J. Hally
1985 *Archaeological Investigation of the Beaverdam Creek Site (9EB85), Elbert County, Georgia*. Russell Papers, Interagency Archeological Services Division, National Park Service. Atlanta, Georgia.
- Sahlins, M. D.
1958 *Social Stratification in Polynesia*. University of Washington Press, Seattle.
- Schroedl, G. F., and B. Riggs
1989 Cherokee Lower Town Archaeology at the Chattooga Site (38Oc18). Paper presented at the 46th Annual Southeastern Archaeological Conference, Tampa, Florida.
- Smith, B. D.
1978 Variation in Mississippian Settlement Patterns. In *Mississippian Settlement Patterns*, edited by B. D. Smith, pp. 479–503. Academic Press, New York.
- Smith, M. T., J. M. Williams, C. B. DePratter, M. Williams, and M. Harmon
1988 *Archaeological Investigations at Tomassee (38Oc186), A Lower Cherokee Town*. South Carolina Institute of Archaeology and Anthropology, Research Manuscript Series No. 206. University of South Carolina, Columbia.
- South, S. A.
1980 *The Discovery of Santa Elena*. South Carolina Institute of Archaeology and Anthropology, Research Manuscript Series No. 150. University of South Carolina, Columbia.

- Stahle, D. W., and M. K. Cleaveland
1992 Reconstruction and Analysis of Spring Rainfall Over the Southeastern U.S. for the Past 1000 Years. *Bulletin of the American Meteorological Society* 73: 1947-1961.
- 1994 Tree-Ring Reconstructed Rainfall over the Southeastern U.S.A. During the Medieval Warm Period and Little Ice Age. *Climatic Change* 26:199-212.
- Stahle, D. W., M. K. Cleaveland, and J. G. Hehr
1985a A 450-year Drought Reconstruction for Arkansas, United States. *Nature* 316:530-532.
- 1988 North Carolina Climate Changes Reconstructed from Tree Rings: 372 to 1985. *Science* 240:1517-1520.
- Stahle, D. W., E. R. Cook, and J. W. C. White
1985b Tree-Ring Dating of Bald Cypress and the Potential for Millennia-Long Chronologies in the Southeast. *American Antiquity* 50:796-802.
- Stahle, D. W., J. G. Hehr, G. G. Hawks, Jr., M. K. Cleaveland, and J. R. Baldwin
1985c *Tree-Ring Chronologies for the Southcentral United States*. Tree Ring Laboratory and Office of the State Climatologist, Department of Geography, University of Arkansas, Fayetteville.
- Stahle, D. W., M. K. Cleaveland, and R. S. Cerveny
1991 Tree-ring Reconstructed Sunshine Duration over Central USA. *International Journal of Climatology* 11:285-295.
- Steponaitis, Vincas P.
1978 Location Theory and Complex Chiefdoms: A Mississippian Example. In *Mississippian Settlement Patterns*, edited by B. D. Smith, pp. 417-453. Academic Press, New York.
- 1991 Contrasting Patterns of Mississippian Development. In *Chiefdoms: Power, Economy, and Ideology*, edited by T. K. Earle, pp. 193-228. Cambridge University Press, Cambridge.
- Stockton, C. W., W. R. Boggess, and D. M. Meko
1985 Climate and Tree Rings. In *Paleoclimate Analysis and Modeling*, edited by A. D. Hecht, pp. 71-148. John Wiley and Sons, New York.
- Stokes, M. A., and T. L. Smiley
1968 *An Introduction to Tree-Ring Dating*. University of Chicago Press, Chicago.
- Stuiver, M., and B. Becker
1986 High-precision Decadal Calibration of the Radiocarbon Time Scale, 1950-2500 B.C. *Radiocarbon* 28:863-901.
- Swanton, J. R.
1946 Indians of the Southeastern United States. *Bureau of American Ethnology Bulletin* 137:1-943. Washington, D.C.
- Thomas, C.
1894 *Report of the Mound Explorations of the Bureau of Ethnology*. Bureau of American Ethnology, Annual Report 12. Washington, D.C.
- Tippitt, V. A., and W. H. Marquardt
1984 *Archaeological Investigations at Gregg Shoals, a Deeply Stratified Site on the Savannah River*. Russell Papers, Interagency Archeological Services Division, National Park Service. Atlanta, Georgia.
- Van West, C. R.
1990 *Modeling Prehistoric Climatic Variability and Agricultural Production in Southwestern Colorado: A GIS Approach*. Ph.D. dissertation, Department of Anthropology, Washington State University. University Microfilms, Ann Arbor.
- Varner, J. G., and J. J. Varner
1951 *The Florida of the Inca by Garcilaso de la Vega*. University of Texas Press, Austin.
- Waddell, E.
1980 *Indians of the South Carolina Lowcountry 1562-1751*. Reprint Company, Spartanburg, South Carolina.
- Ward, T.
1965 Correlation of Mississippian Soil Types. *Southeastern Archaeological Conference Bulletin* 3: 42-48.
- Waring, A. J., Jr.
1968 The Indian King's Tomb. In *The Waring Papers: The Collected Papers of Antonio J. Waring, Jr.*, edited by S. Williams, pp. 209-215. Papers of the Peabody Museum of American Archaeology and Ethnology, no. 58. Harvard University, Cambridge, Massachusetts.
- Welch, P. D.
1991 *Moundville's Economy*. The University of Alabama Press, Tuscaloosa.
- Wigley, T. M. L.
1985 Impact of Extreme Events. *Nature* 316:106-107.
- Wigley, T. M. L., M. J. Ingram, and G. Farmer (editors)
1981 *Climate and History: Studies in Past Climates and Their Impact on Man*. Cambridge University Press, Cambridge.
- Wiley, G. R.
1937 Notes on Central Georgia Dendrochronology. *Tree-Ring Bulletin* 4(2):6-8.
- Williams, J. M., and G. Shapiro
1987 The Changing Contexts of Oconee Valley Political Power. Paper presented at the 44th Annual Southeastern Archaeological Conference, Charleston, South Carolina.
- Williams, W., and C. Branch
1978 The Tugaloo Site, 9St1. *Early Georgia* 6:32-37.
- Wolfman, D.
1984 Geomagnetic Dating Methods in Archaeology. In *Advances in Archaeological Method and Theory* Vol. 7, edited by M. B. Schiffer, pp. 363-458. Academic Press, New York.
- Wood, W. D., D. T. Elliott, T. P. Rudolph, and D. B. Blanton
1986 *Archaeological Data Recovery in the Richard B. Russell Multiple Resource Area. The Anderson and Elbert County Groups: 38An8, 38An29, 38An126, 9Eb17, 9EN19 and 9Eb21*. Russell Papers, Interagency Archeological Services Division, National Park Service. Atlanta, Georgia.
- Wright, H. T.
1984 Prestate Political Formations. In *On the Evolution of Complex Societies Essays in Honor of Harry Hoijer 1982*, edited by T. K. Earle, pp. 43-77. Undena Publications, Malibu, California.