The Impact of Fluctuating Agricultural Potential on Coosa's Sociopolitical and Settlement Systems

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Coosa: Variation in Population Trends and Traditions
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Background

I want to shift the focus of our discussions from Coosa, in particular, to Mississippian in general. Non-coastal Mississippian Period cultures (A.D. 900 to 1700?) have traditionally been seen as ranked societies supported by intensive maize agriculture. While considerable research has produced lengthy statements on the proposed sociopolitical aspects of these precontact populations, little attention has been focused on generating models of the economic system which served to support these societies. Yet, some archaeologists associate changes in the prehistoric record with cultural adjustments precipitated by intensive agricultural practices:

Bruce Smith:

The settlement pattern of Mississippian populations in some flood-plain situations might also change through time if soil depletion necessitated shifting the location of homesteads, and perhaps even local centers [Smith 1978],

Alan Harn:

The reasons for the abandonment of hamlets were probably varied but may have centered on both the depletion of natural food resources and on soil fatigue by unrestricted crop-growing [Harn 1978].

Yet, others correlate the distribution of Mississippian centers with "inexhaustible soil resources that annually are refreshed by flooding". Both of these assumptions cannot be true. I think, minimally, we can agree that archaeologists probably would make interesting farmers. If we examine the ethnohistoric accounts dealing with aboriginal agricultural systems we get a real-world view of the impact of soil depletion and firewood exhaustion:

Sagard, ca. 1632, on the Huron states:

The chief town formerly contained two hundred large lodges, each filled with many households; but of late, on account of lack of wood and because the land began to be exhausted, it has been reduced in size, divided in two, and rebuilt in another more convenient locality . . . . There are certain districts where they move their towns and villages every ten, fifteen, or thirty years, more or less, and they do so only when they find themselves too far away from wood . . . . They move their town or village [also] when in course of time the land is so exhausted that their corn can no longer be grown on it in the usual perfection for lack of manure; because they do not understand cultivating the ground nor putting the seed anywhere else than in the usual holes [Sagard 1939:92-93].

Francois du Peron, ca. 1639, writes of the Huron:

The land, as they do not cultivate it, produces for only ten or twelve years at most; and when the ten years have expired, they are obliged to remove their village to another place [Thwaites 1896-1901:15:153].

In 1724 Lafitau, after ten years in Canada, writes:

As the Indians never manure their ground and do not even let it lie fallow, it is soon exhausted (and worn out). Then they are forced to move their villages elsewhere and make new fields in new lands. They are also reduced to this necessity, at least in North American and cold countries, by another more pressing reason for, as the women have to carry firewood to their lodges every day, the longer a village stays in the same place, the farther the distant the wood is so that, after a certain number of years, they can no longer keep up the work of carrying the wood on their shoulders from so far [1977:69-70].

William Bartram, ca. 1773, received this answer from a trader in the Creek town of Apalachucha when asked why the Indians "frequently" broke up their towns and settled new ones:

> *. . . the necessity they were under of having fresh or new strong land for their plantations, and new, convenient and extensive range or hunting ground, which unavoidably forces them into contentions and wars with their confederates and neighboring tribes; to avoid which they had rather move and seek a plentiful and peaceable retreat, even at a distance, than contend with friends and relatives or embroil themselves in destructive wars with their neighbors . . . [1928:315].*

All of this supports a model of shifting aboriginal agriculture correlated with depletion of firewood and the *necessity* of incorporating it into our definition of the Mississippian system. If we can model this process, we should be able to test a wide range of hypotheses, not the least of which would be the condition of the Coosa hegemony at the time of the Spanish intrusions.

I would like to show you the results of a study I completed about ten years ago (Baden 1987) that redefined aboriginal agriculture in terms of stability theory. Namely, I developed a measure of agricultural potential that, when plotted over time, reveals periods of stability and instability. Most of the details and proofs behind this study go beyond the time constraints (and maybe attention spans) of this session. For that reason, I have provided a handout that details useful references and a graphic representation of the study's results.

There are 3 major components to any model of agriculture: population demands, technological options, and environmental constraints. My approach involves looking through ethnohistoric accounts to define behavior and technology. Unless there was some lost art to farming known only to the Mississippian elites, contact experiences should approximate these potentials. Environmental potential can be approximated from soil surveys at the county level. When my original study was completed, I lacked climate data that, today, is available with the bald cypress studies of Stahle and Cleaveland (1994). However, my examination of this data correlated with known crop yields does not present a clear, predictable pattern. Estimates of rainfall amounts are not sufficient to predict crop yields the way we would like. Although I am continuing to examine the potential of including this information into my model, the complexities of this undertaking will not be attempted here. Botanical discussions can help define the varietal component of prehistoric maize's yield potential. Finally, I look at agronomic studies on growing maize to determine the impact of these "choices" on the sustainability of prehistoric agriculture. Again, I will have to summarize my findings and hope that you will accept the intermediate arguments as "magically derived", at least for today. I can only assure you that the magic is strong!

Parameters

Summarizing the behavioral component, the Eastern North American Indian's agricultural tradition involved the following generalized practices:

1. Fields were cleared using fire one or more years in advance of the first planting;
2. Fire was also used to clear old fields prior to planting;
3. Planting was undertaken after the first sufficient thaw;
4. Three to ten kernels were placed in hills spaced two to three feet apart in rows up to six feet apart;
5. No recognized soil fertilization procedure was practiced;
6. Cultivation involved two minimal hoeings when the plants were roughly six inches and two feet high, respectively;
7. Harvesting was undertaken in two phases: the first in middle-to-late summer when the kernels were in the milky stage and the last in the fall after the grain had completely ripened;
8. Yield estimates ranged between 10 and 20 bu/acre;
9. Field sizes ranged between 0.3 and 1.5 acres/person.

Population dynamics include some estimate of initial, Emergent Mississippian size and a rate of increase over time. Both are difficult to calculate. For rate of increase, the Coale-Demeny life table models (Coale et al. 1983) provide long term analysis of worldwide populations over the last century. Using their population classification scheme and burial population summaries, I would assume an annual rate of increase (r) lying between [3 to 17 per 10,000] (0.003 and 0.017), which agrees with their West Level 1 tables. Applying this value of r to:

$$P_t = P_0 e^{rt}$$

creates an exponentially increasing population function. Defining P_0 becomes problematic. How many people does it take to “start” a Mississippian social structure? I don’t think we have this answer, but we can make estimates and test them against the rest of the model. We can also assume a fixed population size that, by definition, can be set to the largest, most stable value possible (under the other constraints of the model). That is what will be done here, pending better estimates of Mississippian population sizes.

Population demand for maize can be estimated using isotopic assays of skeletal remains. It has been reported that a cline between 35% and 72% caloric dependence existed for Mississippian populations (Lynott et al. 1986:61). Using 3600 calories/kg of maize (Minnis 1985:11), each person would require 6.47 bu/year or 1.64 quintals/year for a 65% dependence (that’s 0.025 quintals/percentage dependence). Most demand curves take the form of a sigmoid and this can be used to estimate dependence across time with strong correlation with skeletal data. **[SLIDE 1: DEPENDENCE CURVE]**

Turning to the maize varieties or races, we can assume that early Mississippian populations grew a form of Basketmaker maize. This variety would be capable of producing yields in the range of 7.5 bu/acre (4.7 quintals/ha). Later races of Northern Flints would have achieved maximum yields between 18 and 30 bu/acre (11.3 to 18.8 quintals/ha). These yields are consistent with early 19th century farming records (it wasn’t until the mid 19th century that hybridization practices developed more productive varieties like today’s southern dents). Turning yield potential into field size requires matching varietal capabilities with dependence. A 35% dependence on Basketmaker maize would require 0.47 acres/person (0.19 ha/person). A 65% dependence on Northern Flints would require closer to 0.9 acres/person (0.4 ha/person). It is unlikely that more than an acre of ground would have been planted per person under any circumstances.

The potential environment for aboriginal agriculture consisted of rich, easily tilled bottomlands. Proximity to a lower water table enhances survival during drought years and the friable soils would be encourage root growth and be the easiest to work with wood, bone, shell, and lithic tools. To estimate the maximum field potential in any area, I use the Capability Class I soils as the most likely candidates for prehistoric fields. Capability IIw class soils might also be useful, although by today's standards they would be considered prone to flooding and waterlogging. Tabulating these soils and adjusting modern yield potentials to estimate prehistoric yields, gives us an initial reservoir of agricultural soils for any region. This "reservoir" will be used to define stability. Here the reservoir of soils is defined at the county level. This is a macroscopic approach. As soils become mapped at the field level, a more specific geographically defined reservoir will be possible.

Finally we need to examine the critical and least understood component of this model: the nitrogen cycle. Without belittling the importance of other nutrients, like potassium and phosphorus, we must recognize that prehistoricly as well as today, nitrogen is the key nutrient for maize production. Its incorporation into useable, mineralized inorganic forms (i.e. nitrate and ammonium) depends on a number of conditions including the presence of organic matter and nitrogen-fixing microbes. Only about 1-3% of the predominant organic N is mineralized each year. Studies in the late 19th century (Hall 1917), designed to encourage the use of fertilizers, can be used to demonstrate the effects of not supplementing nitrogen in maize fields as well as generate curves for predicting nitrogen loss over time. **[SLIDE 2: DEPLETED YIELDS]** Nitrogen is further depleted each year when fields were burned prior to planting (killing microbes and releasing 95% of available N). Fields that have become depleted have been shown to require as much as 100 to 150 years to naturally replenish their organic nitrification potentials (Russell 1973:324).

Misconceptions

Before I provide examples of this model, I need to address some commonly held misconceptions about the sustainability of Mississippian agriculture (indeed, these same points apply to all agriculture). First, *flooding supplies needed nutrients to refresh fields*. Not true when it comes to nitrogen, the critical element. Flood waters do not hold nitrogen (that is, not until 20th century synthetic nitrates entered the environment!). Flood waters create denitrifying environments and leach nitrates out of the upper soil horizons. Waterlooging can rapidly release iron and magnesium cations that are highly toxic to *rhizobia* bacteria & plants (like *Phaseolus vulgaris*). Floods are detrimental to the nitrogen capacity of soils.

Second, *beans planted with maize add nitrogen to the soil.* Again, not true unless the beans are plowed in as a green manure. Studies have shown that seldom is there a direct transfer of nitrogen between legumes and maize. In the few experiments where a transfer was measured it never exceeded 5% and then it was more a result of drought conditions causing the legume to produce a surplus of nitrogen which it released to the surrounding soil (Giller and Wilson 1991:118-136). Of all the grain legumes, *Phaseolus vulgaris* has been shown to be the worst nitrogen-fixing plant (due to poor nodulation); in fact even with inoculation it generally fails to fix nitrogen into the soil.

Lastly, *maize can be stored indefinitely*. Naturally, this is not true and although surpluses could be used to minimize subsequent crop failures, the long term storage potential of maize, in the southeast, would probably not exceed one year. Beyond that, the nutritional viability would be diminished and the planting potential of the stored grain would be equally jeopardized.

A summary of the models parameters would now be appropriate:

1. Population will be expected to increase at a rate between 0.003 and 0.017 per year.
2. Individual maize consumption per year is expected to be on the order of 0.025 quintals (0.1 bu) per percent dependence, e.g. an average 65% dependence implies a 1.63 quintals/year (6.5 bu/year) requirement per person. As a function of time, consumption for the Mississippian Period will approximately follow a sigmoidal trend.

3. Maximum potential yield under optimal conditions is not expected to greatly exceed 18.8 quintals/ha (30 bu/acre) during the period. Emergent Mississippian yields would not be expected to exceed 4.7 quintals/ha (7.5 bu/acre).
4. Maximum labor output will not exceed 0.4 ha (1.0 acre) per person.
5. The expected non-depleted average yield will be 9.99 quintals/ha (sd = 3.31) (15.92/5.28 bu/acre). Fluctuations will follow a normal distribution based on observed, crop yields.
6. Yields are expected to be annually reduced and, allowing for depletion, maximum potential yield follows. **[SLIDE 2].**
7. To account for heavy weed growth, all yield equations will use 2t for t (i.e. twice the consumption of maize alone).
8. The recovery or fallow period will be on the order of 100 to 150 years.

[5 SLIDES of MY EXPERIMENTAL PLOT]

The Application

Let's go through a quick 300 year simulation using the above parameters on an example in the literature. Jon Muller, in 1978 (1978:287-288), briefly described the agricultural conditions for the Kincaid site in southern Illinois. At the time, he concluded that Kincaid was composed of 400 individuals supported by 621ha. The population was seen as requiring 0.4 ha/person. He concluded that Kincaid could have supported 1500 people. Strictly as an example application, if we define demand to be 1.64 quintals/person (65% dependence) minimal required yield would be 4.1 quintals/ha (6.5 bu/acre). Let's arbitrarily say that 3 sequential failures will result in field abandonment. (In reality, an aboriginal farmer would know when certain weeds begin to appear that the field should be abandoned). Let's further use a value of 0.01 for r, the rate of population increase. The results follow from the **[SLIDE 3: POPULATION CURVE] [SLIDE 4: HARVESTS] [SLIDE 5: AVAILABLE LAND]**.

After 51 years all available land would be in a depleted state. At t = 176 the site could be repopulated (in this case by 400 people). Because of the periodic nature of site repopulation, total depletion would again occur at t = 227. Population adjustments occurred at t = 41 and 215. During the 300 year period the average planting duration was 12.6 years per field. The average surplus per person was 0.72 quintals. Although highly generalized, this example demonstrates that soil depletion could seriously inhibit growth at Kincaid. Such a level of population density could not be supported for more than a few generations without major adjustments.

Carneiro (1960:82) would argue that the maximum sustainable population (carrying capacity) of such a site should be :

$$\frac{\dfrac{621\text{ ha}}{(125 + 12.6)\text{ yr}}\ 12.6\text{ yr}}{0.4\text{ ha/person}} = 142.2\text{ people}$$

If we re-simulate the above conditions, maintaining a zero population growth at P_0 = 142, the fluctuating amount of available land (R) is shown in **[SLIDE 6: AVAILABLE LAND USING CARNEIRO]**. Because of soil depletion, population reductions would occur at t = 126 (P_t drops to 133). Total abandonment would occur at t = 134. Failure to recognize the negative environmental impact of agriculture invalidates the usefulness of carrying capacity, so defined.

Tellico Example

Moving to a larger example, I want to examine the expected results of Mississippian agriculture in east Tennessee's Little Tennessee River Valley. The study area includes three counties: Monroe, Blount, and Loudon. **[SLIDE 7: STUDY AREA SLIDE]** Total Class I soils acreage equals 19,559.2 ha. The expected maximum yield for Northern Flint varieties is 17.2 quintals/ha. Using this example we can further examine the impact of behavioral choices. First we can examine the selection of field size **[SLIDE 8: 13 0.1ha/person]**. Larger field sizes serve to minimize failures by assuring sufficient maize can be harvested each year. **[SLIDE 9: 0.4ha/person]** A population of 1000 with an r value of 0.008 produces the following dynamic fluctuations in population levels **[SLIDE 10: POPULATION GROWTH]**. To remove the population constraints, we can consider stationary population levels and use the rest of the model's constraints to provide us with estimates of the maximum population size that never requires fissioning or totally depletes the valley's land reservoir **[SLIDE 11: ZERO GROWTH CURVES]**. Further, we can allow for adjusted field sizes over time **[SLIDE 12: ADJUSTED FIELD SIZES] [SLIDE 13: HARVESTS WITH ADJUSTED FIELD SIZES]**. Note the relatively large field size increases in A.D. 950, 1200, 1325, and 1550. These dates suggest times of strategic decision making shifts (critical points?). Using these adjustments, we can calculate a stationary population size of 4010 (twice that of the historic Overhill Cherokee in 1760). We now can produce one last simulation for 4010 people with an r of 0.0 between A.D. 900 and 1700. The field statistics for this run reveal a mean harvest of 5.8 quintals/ha, mean surplus of 0.431 quintals/ha, and mean field life of 9.87 years.

Now, returning to the original purpose of all this: stability measures. If we can define a potential variable (here it is available land), we can examine the graph of its fluctuations over time and see clear areas of rapid change, stability, and instabilities **[SLIDE 14: Stability Curve]**. Note the rapid decrease in land potential between A.D. 900-1000 (Emergent Mississippian); this is an unstable time. This occurs again between A.D. 1300-1400. Each instability is separated by a fairly stable period (A.D. 1000-1300). The points of change (discontinuities) mark transition points (phase shifts) that correlate well with Martin Farm, Hiwassee Island, Dallas, and Historic Cherokee.

Coosa

Now back to Coosa. If we look at the Coosa River drainage in northwest Georgia **[SLIDE 15: COUNTIES SLIDE]** and apply the same techniques to its 25,981.4 ha of Class I soils, we can produce a similar curve. The stationary population size for this area would be 5668. The maximum yield potential would be 17.89 quintals/ha. **[SLIDE 16: COOSA STABILITY CURVE]** What are the implications?

Certainly the concept of "permanent village" needs to be re-examined.

"Contemporaneous" villages may also be questioned. Social organization and information processing structures, on a wide geographical scale, would have been encouraged. Stress induced by reduced agricultural potential would force cultural changes and ultimately, for the archaeological record, create recognizable phase changes. This study presents an alternative perception of cultural change. Change is here seen as the inevitable result of a system, far from equilibrium, adapting to fluctuating conditions. Such a system displays a dissipative structure (Nicolis and Prigogine 1977) in that, while maintaining local stability at some material/energy cost, it eventually reaches a threshold where it evolves into an unstable order in response to fluctuations. It is under these conditions that new cultural phases are produced (morphogenesis).

The Spanish arrived at the second critical period in Mississippian morphogenesis and it is difficult to say whether their impact pushed a marginally stable population beyond the edge or, through disease, reduced the population demands to levels capable of being supported with smaller land reservoirs. We will never know what transition would have occurred had the Spanish never appeared, but using model building techniques like this, with the addition of other cultural components, we may someday be able to extrapolate Mississippian trajectories. With better spatial control of soils, we should be able to simulate the entire shifting settlement system. At least we should now have a better appreciation for the impact of nitrogen depletion on settlement systems.

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Units of Measure

1 bu = 2150.42 cu in = 32 qt

1 bu = 56 lb shelled corn = 68 to 72 lb ear corn (Myrick 1903:368)

1 qt = 1988.2 kernals of maize (approximately) (U.S. Commissioner of Patents 1848:130)

1 quintal (US) = 100 kg = 220.46 lb = 3.937 bu shelled corn

1 acre = 43,560 sq ft

1 ha = 2.471 acres

1 quintal/ha = 1.593 bu/acre