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Resource abundance constraints on the early post-contact Cherokee population

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Abstract

We present the combination of an analysis of resource demand by the early post-contact (1721) Cherokee population with spatially explicit estimates of production for five key resources: architectural land, agricultural land, firewood, hard mast, and white-tailed deer (*Odocoileus virginianus*). We combine a recent synthesis of village location and population, a map of recognized Cherokee territory, digital terrain data, estimates of per capita demand, and productive capacity for each resource. Average, high, and low demands were estimated for each resource and assigned based on a weighted function of terrain and distance from each village. We conclude that Cherokee demands for architectural and agricultural land, hard mast, and fuelwood were easily met within a short proximity to each town under all combinations of production and demand. These resources were likely not limiting, and were satisfied for the entire Cherokee population by less than 1% of the entire recognized Cherokee territory in 1721. These resources likely exceeded demand even when sources were restricted to the convex hull of the Cherokee territory, or to near stream, flat regions. Deer resources were likely harvested over a much larger area and to a much greater extent. Our best estimate of deer resource demand was 32% of annual sustainable production in the Cherokee territory, with from 16 to 48% of estimated sustainable production harvested for low and high demand estimates, respectively. Our estimates vary in response to uncertainties in deer production, harvest proportion, deer density, and sustainable harvest rates. Deer demand was substantially higher under all combinations of conditions than that available within the convex hull of Cherokee villages, indicating significant travel was needed to furnish deer requirements. Spatially explicit models that consider terrain- and distance-related tradeoffs suggest that Cherokee demand for deer drove harvest over areas consisting of over half the recognized Cherokee territory.

Keywords: Cherokee; Resource; Use; Population; Deer; Geography

1. Introduction

There is a general paucity of information on the Cherokee during the early contact period, which makes it difficult to evaluate the trajectory and substance of the economic and political transformations they underwent over the course of the 18th century. We contend that our present analysis of the town-specific demand for five resources identified as significant to the Cherokee ca. 1721 provides a critical benchmark for such an evaluation. In this article we model the constraints and trade-offs to satisfying town-specific demands for architectural land, agricultural land, firewood, hard mast, and white-tailed deer. The analysis was possible because of a new synthesis of the location and population of early contact Cherokee towns (Gragson and Bolstad, 2007) and our collation of previously unused information on household size and resource consumption suitable for estimating per capita and aggregate demand for each resource.

Our analysis centers on the Cherokee ca. 1721—the first date after the earliest Cherokee contact with the British for which there is substantial eye-witness evidence, yet prior to the major social, economic and political changes the Cherokee underwent over the course of the next half century (Corkran, 1962; Goodwin, 1977; Hatley, 1993). In 1721 the total

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Cherokee population was approximately 12,000 distributed in 62 towns with populations from 100 to 600 individuals each (Gragson and Bolstad 2007). The Cherokee at this time are believed to have controlled or used near-exclusively some 322,600 km^2 of southern Appalachia (Fig. 1), while the convex hull defined by Cherokee town locations in 1721 encompasses 13,801 km^2 or approximately 4.3% of the total Cherokee territory. The convex hull is the minimum exterior polygon that contains all points and for which all exterior angles are convex (Bolstad, 2005). It provides a conservative estimate of resource availability and has the advantage of providing a relative base against which local resource limitations can be compared.

The Cherokee remained the dominant native group in the region until their final removal in 1838. During the early 18th century, there is neither archaeological nor ethnohistoric evidence for major socioeconomic differences between Cherokee households nor evidence for pronounced wealth or power distinctions within towns (Hatley, 1993; Reid, 1970; Reid, 1976; Schroedl, 2000).

For the present analysis we determined the town-specific demand for each of the five noted resources using the estimated per capita requirement based on the population of each town. We developed the demand values for each resource using historical and contemporary measurements, reported summaries and syntheses, and modeled values. We then used weighted proximity functions to parsimoniously allocate the land required to satisfy the demand for each resource. Village demand is satisfied using a GIS and village-centered measurements that account for the clustering of Cherokee population relative to the distribution and travel requirements of each resource.

In the final step we determined ‘‘demand footprints’’ for each resource. These footprints reflect the aggregate demand for a given resource by all simultaneously occupied towns in the territory controlled or used near-exclusively by the Cherokee. The demand footprint is a useful and spatially explicit way to quantify the dependence of each Cherokee town on the ecosystems beyond its borders. It indexes the amount of land required to produce the quantity of resource needed to sustain a given population for a specific town. Calculating Cherokee resource demand at a single point in time rather than for the entire 18th century may seem counterintuitive by comparison to traditional historical studies among the Cherokee. However, as addressed in more detail below, the approach is required to develop dynamic, time-sensitive explanations about the social transformation of the Cherokee and the ecological transformation of southern Appalachia.

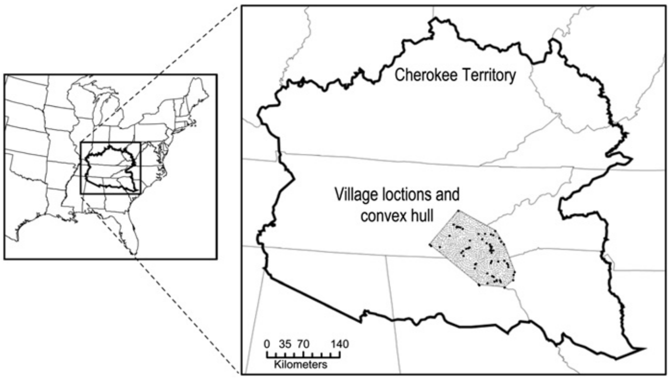

Fig. 1. The location of the Cherokee territory and villages circa 1721. The convex hull of the Cherokee villages is shown in the expansion at right.

We see our analysis as complementing rather than substituting for the largely qualitative discussion about the transformation of the Cherokee and southern Appalachia carried out to date (e.g., Goodwin, 1977; Hatley, 1993; Schroedl, 2000; Rodning, 2002). Our results derive from an empirical and mechanistic evaluation of the interaction between location and resource availability rather than an aspatial, net-effects model (Gragson and Bolstad, 2007; Johnson et al., 2005). Our approach allows us to synthesize contributions from multiple disciplines that have not often been used together to better understand the forces that ‘‘shaped the Indians of the eighteenth-century South’’ (Hudson, 2002).Our goal is to understand how the legacies of Cherokee activities affected subsequent inhabitants of southern Appalachia (Gaddis, 2002; White and Pickett, 1985; Cronon, 1983; Foster et al., 1997; Little et al., 1997).

2. Methods

2.1. Town location and population

Cherokee town location and town population data are based on a new synthesis of multiple historical documents from the early 18th century. The two most significant documents used were Varnod’s 1721 enumeration (Varnod, 1724) and Barnwell’s ca. 1721 map of the Southeast showing the location of individual Cherokee towns (Barnwell, 1721). We discuss the procedures we used in detail elsewhere (Gragson and Bolstad, 2007). While both the enumeration and the map have been independently used by previous authors to estimate total Cherokee population (e.g., Thornton, 1990) or produce lists of town names (e.g., Smith, 1979), to the best of our knowledge they have never been used together nor combined with complementary information from other period sources.

We used several subsidiary documentary sources to support or expand the information from our two primary sources. Col. George Chicken led an expedition to the Cherokee accompanied by Col. John Herbert between November 1715 and February 1716 and recorded the details of his trip in a journal (Chicken, 1894). Col. Chicken made a subsequent trip in June–October 1725 as Commissioner of Indian Trade for the South Carolina Colony that he again recorded in a diary (Chicken, 1916). Col. John Herbert produced a map after the trip he accompanied Col. Chicken on in 1715–1716 that records the location of Cherokee towns (Herbert and Hunter, 1744). From a diary kept by Col. Herbert during a trip to the Cherokee between 1727 and March 1728 we derived travel time and distance between towns (Herbert, 1936). Finally, we used a photostatic reproduction of the 1730 map by George Hunter (Hunter, 1730) made while accompanying Col. John

Herbert on one of his annual visits to the Cherokee as Commissioner of Indian Trade (Crane, 1981).

2.2. Resource requirements and availability

Our research into the early 18th century Cherokee builds from a long tradition in anthropology of asking the question 'why groups settle where they do?' (e.g., Carneiro, 1970; Gross, 1975; Gramly, 1977). In his search for the mechanisms underlying the political integration of towns and the formation of the state, Carneiro (1970) discussed the insufficiency of war as a motive force and brought into the discussion three additional mechanisms: environmental circumscription, particularly of agricultural land, social circumscription resulting from increased population density, and resource concentration in space. Gross (1975) expanded on Carneiro's work by discussing how environments consist of distinct habitats that set the limits and possibilities for human extraction of protein, the amount of which determined the size, density and permanence of settlements. Gramly (1977) did for North America what Carneiro and Gross had done for South America by examining the conflict between and defense needs among the Huron in response to competition for deer.

While foundational, these articles were premised on then-current equilibrium concepts of succession and competition that did not consider the structural details or the process characteristics of dynamic, open systems. Existing explanations of Cherokee settlement, of which there are at least four grand theories (Gragson and Bolstad, 2007), also derive from a homeostatic premise and inherently ignore both environmental heterogeneity and ecosystem processes. Production theories emphasize the properties of the physical environment related to agriculture or hunting (e.g., Corkran, 1962; Adair, 1974). Force-in-numbers theories emphasize the need for Cherokee towns to be militarily strong by having many able warriors and/or being close to another town that had many able warriors (e.g., Thornton, 1990). Origin theories invoke abstract or indeterminate forces such as mythology, clan and parentage, or language (e.g., Reid, 1976; McLoughlin, 1984; Oliphant, 2001). Imperial theories emphasize Cherokee attraction to or involvement in trade with the British, the French, or the Spanish or the imperial rivalries that originated in Europe and played out in America (e.g., Corkran, 1962; Hatley, 1993). The resulting explanations tend toward essentialism and frequently hinge on whether a particular resource is limiting; they are not formulated in recognition of the lability of human behavioral responses to environmental variation in light of the historical contingency of prior decisions (Hart, 1999; Sayer, 2000).

Setting aside *a priori* assumptions about particular resources identified as limiting to Cherokee town establishment and maintenance in the early 18th century, our mining of the Cherokee literature suggests that town location represents an optimal tradeoff between access to architectural land, agricultural land, hard mast, fuelwood, and deer. To spatially operationalize this hypothesis, we calculated the mean per person requirement for each resource and the net productivity per hectare of the resource, along with an upper and lower bound for each measurement. Following is a brief summary about the state of knowledge and how we parameterized each of the five resources.

2.2.1. Architectural land

Based on excavations at a limited number of Overhill Cherokee sites occupied during the colonial period, each Cherokee town minimally comprised public and private spaces (Schroedl, 1989, 2000; Williams, 1928). We set public space, consisting of a plaza area sometimes covered in pea gravel and typically containing a council or town house and a summer pavilion, to cover approximately 0.625 ha. The range on this value is derived from the only reported measurement in the literature for public space, 0.25 ha at Chota-Tanasse (Schroedl, 1989) and a statement by the same author that public space in Cherokee towns covered ''not more than about 1 hecatare'' (Schroedl, 2000).

Colonial period Cherokee towns covered 10–80 ha depending on population and topography (Schroedl, 2000). Domestic structures tied to individual households included a winter house some 7 m in diameter, a summer pavilion that from the available evidence was 5 by 9 m in dimension, and corn cribs and storage pits (Schroedl, 1989). The domestic structures associated with a household were surrounded by small gardens of unknown size (Williams, 1928; Herndon, 1967), although the surface area was not significant. Subsistence agriculture was carried out in large fields on the periphery of towns. The cluster of structures and associated features of an individual household within a town were spaced 10–50 m from other household areas (Schroedl, 1989, 2000). Based on an average aboriginal family size of 5.3 individuals (Baden, 1987), we estimate the private area of Cherokee towns at 0.04 ha p^{-1} with a range of 0.01–0.15 ha p^{-1}.

2.2.2. Agricultural land

Direct evidence on Colonial period Cherokee field sizes and yield is limited so we relied on comparative historical and nutritional sources. Baden (1987) used an 1835 enumeration of 35 families to derive an average field size per person of 0.51 ha, with a standard deviation of 0.84 ha. Schroeder (1999) used Schoolcraft's 1847 Indian census to estimate an average field size of 0.24 ha and a standard deviation of 0.18 ha $family^{-1}$ for 10 native North American groups that were not using plows. Noting that the mean family size for groups without plows is 5.2 individuals, Schroeder then derived a per-person area of 0.05 ha. There is strong evidence that the Cherokee did not use the plow during the Colonial period, and based on Schoolcraft's census and other information they probably did not use a plow until the first quarter of the 19th century. From this information we set agricultural field size at 0.37 ha p^{-1} with a range of 0.13–0.61 ha p^{-1}. This agrees with Baden's (2005) rough value of 0.4 ha p^{-1} derived from an examination of diverse ethnohistorical sources on Native American maize agriculture in Eastern North America.

We cross-checked our agricultural area per person estimate using estimated yields and caloric demand. Schroeder (1999) calculates the average corn yield of Cherokee families in North Carolina in 1847 as 677.4 kg ha^{-1} while Baden

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(1987) calculated an average of 766.6 kg ha^{-1} of corn for the Cherokee in 1835. The mean of these two values is 722 kg ha^{-1}. Agricultural fields were intercropped (i.e., maize, beans, and squash) rather than monocropped and post-harvest loss of maize due to insect damage and rot is between 10 and 30% so Schroeder suggests a ''reasonable'' estimate of prehistoric and early contact yields was one-half the historic yield. We thus arrive at a corn yield of 361 kg ha^{-1}.

Maize has a caloric content of 3600 kcal kg^{-1} (Schroeder, 1999) while the estimated per capita caloric requirement (kcal p^{-1} day^{-1}) for an indigenous population of adults, juveniles and children is approximately 2000 (Leslie et al., 1984). Combining our estimates for surface area, yield, calories and demand under the conditions most likely prevailing among the Cherokee in the early 18th century indicates that corn provided them with food energy sufficient for some 240 days or nearly 66% of annual demand. According to Baden (1987), maize consumption for the late historic Cherokee represented 75% of their diet. Among the historic Overhill Cherokee, archaeobotanical evidence (Chapman and Shea, 1981) indicates that maize represented 62% of the total plant food by weight. Isotopic analysis of human skeletal remains from Mississippian Period populations indicates a 35–72% caloric dependence on maize (Baden, 2005). Therefore, in the absence of further direct evidence on contact-period Cherokee agriculture we believe our estimate of 0.37 ha p^{-1} of agricultural field area is the best currently available.

2.2.3. Hard mast

Despite common references to the preparation and consumption of mast (e.g., Hally, 1989; Swanton, 1946), Bartram (1947) appears to be the only eye-witness providing some idea on quantity (i.e., a passing comment that one family had collected 100 bu of nuts). We began by assuming that the average proportion of nuts in the Cherokee diet was 24.4% based on archaeobotanical information on plant food by weight recovered from several Cherokee sites (Chapman and Shea, 1981). We then converted the estimated dietary proportion of nuts to an annual requirement based on a per capita consumption of 2000 kcal day^{-1} for an indigenous population of adults, juveniles and children (Leslie et al., 1984) and an average food energy value of 709 kcal per 100 g of nut meat (Talalay et al., 1984). This results in an expected annual requirement of 25.1 kg of nut meat per individual.

To determine the area required to meet this demand we relied on reconstruction as well as accounts by contemporary eye-witnesses about natural constraints on hard mast production (Goodwin, 1977; Williams, 1928; Bartram, 1947; Newman, 1979). Mast production varies substantially in space and time although spatial variability is partially accounted for by predictable changes in forest tree species composition (Bolstad et al., 2001; Whittaker, 1956). Contemporary mast production exhibits substantial interannual variation at 3–8 year intervals due to within-genera synchrony in the two dominant producers: oak (*Quercus* sp.) and hickory (*Carya* sp.). However, contemporary production is a poor indicator of historic production since forest composition in southern Appalachia changed substantially at the beginning of the 20th century as a result of the blight that eliminated American chestnut (*Castanea dentata* L.). This species was a dominant across a range of eastern deciduous forest types and often comprised more than 30% of forest basal area (Illick, 1921; Keever, 1953; Mackey and Sivec, 1973; Williams, 1989).

American chestnut was a stable, prolific mast source compared to oak (*Quercus* sp.) and hickory (*Carya* sp.) (Diamond et al., 2000; Forrester and Runkle, 2000). We estimated from Diamond et al. (2000) the pre-blight average hard mast production in southern Appalachian forests as 414 kg ha^{-1} $year^{-1}$ (chestnut, oaks and hickories combined). The interannual variability would have been small due to reliable production by chestnut and asynchrony in peak masting among the oak and hickory species; however, a large proportion of annual mast production is lost to animals. According to Petruso and Wickens (Petruso and Wickens, 1984), animals consume on average 66% of the mast crop of four species of oak while Shaw (in Diamond et al., 2000) states that wildlife require 112 kg ha^{-1} of mast (given a carrying capacity dependent on many factors not specifically identified). Finally, human nut harvesters are not perfectly efficient so in the absence of direct evidence suggesting a different value we assume that humans were 10% efficient in harvesting mast. Given a mean annual production of 414 kg ha^{-1}, only 37.8% useful by edible weight (i.e., meat minus shell), the expected return for nut meat alone is 15.6 kg ha^{-1}. To obtain the expected annual requirement of 25.1 kg of nut meat, a human would need to harvest 1.6 ha of forest. With a range on mast production of 184–738 kg ha^{-1} we further estimate the range on the required per capita harvest area as 0.9 ha and 3.6 ha.

2.2.4. Fuelwood

Boiling water to prepare food—cooking meat and vegetables, boiling nut meat for oil and parboiling corn for storage—is reported as the most important use of fuelwood among the Cherokee (Swanton, 1946; Hally, 1986). For example, acorns, beans, and whole kernel corn were boiled for 10–12 h prior to processing and consumption (Swanton, 1946). The other significant use of fuelwood reported among the Cherokee was the heating of homes during the winter months (Timberlake, 1948). Ready access to significant quantities of fuelwood are implied by the cooking and heating demands of the Cherokee, but there is no direct evidence for the rate of fuelwood consumption by the Cherokee during the Colonial period. We consequently used circumstantial evidence available from the archaeological and ethnohistoric literature for the region and comparative information on fuelwood consumption in developing countries (Hall et al., 1982). In addition, we used direct evidence on fuelwood consumption from a traditional, environmentally analogous contemporary situation: mid-elevation (900–2000 m) Nepali villages (Mahat et al., 1987). From these sources we conclude that a reasonable starting value for the consumption of fuelwood by the early contact Cherokee was 1.20 mt p^{-1} $year^{-1}$ with a standard deviation of 0.77 mt.

The rate of fuelwood consumption must be related to the rate of fuelwood production in order to determine landscape

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harvest potential. Colonial Cherokee as well as many contemporary populations in developing areas lack the technologies to effectively harvest green wood. They therefore relied on natural woody detritus—branchfall, stemfall from stand self-thinning and mortality, and disturbance-related mortality. Woody detritus production reaches substantial levels a few years after canopy closure and although detritus production is variable in space and episodic in time, it eventually balances aboveground woody production when averaged over multiple stands at scales of tens to hundreds of hectares. Woody detritus may last from one to several years after mortality before becoming useless as fuelwood due to decomposition. While larger pieces have a longer effective life, they would also be less useful because humans alone had to transport the wood.

We estimated wood production in southern Appalachia from contemporary production measurements and an estimate of use efficiency. Results from numerous studies carried out across a range of stand ages have established that aboveground woody production after canopy closure typically varies between 2 and 6 mt ha^{-1} $year^{-1}$ (Bolstad et al., 2001; Whittaker, 1956). Production is lower in young forests, peaks in many communities under different site conditions between 60 and 120 years, and declines slightly as stands age further. Productivity is higher in near-stream and floodplain areas at lower elevations, and lowest on high elevation ridges (Bolstad et al., 2001; Whittaker, 1956). The proportion of stemwood and branchwood biomass less than 30 cm in diameter declines from 100% in the first 20 years to less than 20% at 80 years for most forest types and sites in southern Appalachia. We estimate that 25% (range 9–40%) on average of all deadfall would have been useable to the Colonial Cherokee under the technology conditions they faced, and that their fuelwood harvest efficiency was 50% of suitable deadfall.

2.2.5. Deer

White-tailed deer (*Odocoileus virginianus*) was the principal source of meat and hides, historically as well as prehistorically, for native Americans over most of the eastern deciduous forest region (Gramly, 1977; Hickerson, 1974; Keene, 1981; Hodge, 1907; Snow and Lanphear, 1989; Driver, 1969). Deer are typically the first or second most abundant animal remain retrieved from non-coastal sites (Guilday, 1971; Guilday and Tanner, 1965; Guilday et al., 1962; McMichael, 1963; Parmalee, 1965; Salwen, 1970). Deer hunting is also identified by several authors as both the primary activity of Cherokee males during the Colonial period as well as the main source of meat and hides used to satisfy both subsistence and trade needs (Corkran, 1962; Goodwin, 1977; Hatley, 1993; Crane, 1981). However, neither knowing MNI counts (minimum number of individuals) nor that hunting was important are sufficient for determining deer harvest levels. We therefore used ethnohistoric evidence from the Southeast on the deer skin requirements to satisfy household needs on a yearly basis and adjusted this value for the proportion of harvest used to meet Colonial trade demand.

Braund (1999) states that the minimum household need was 25–30 deerskins with an average of 50; a household in this context consisted of one adult male, one adult female and two children. Taking 50 deer as the average value and assuming a range of 25–75 we derive a base requirement of 12.5 deer p^{-1} $year^{-1}$ with a range of 6.3–18.8 deer p^{-1} $year^{-1}$. Charlestown (the principal port of trade used by the Cherokee) records do not itemize the native source of deer skins arriving and leaving the port (Braund, 1999; Clowse, 1981). Crane (1981), however, states that the number of deerskins provided by the Cherokee was "insignificant" prior to 1715 (i.e., the end of the Yamasee War) and "took off" after 1721 when the Indian Trading Co. was formed. From information in Clowse (1981), Goodwin (1977) and Corkran (1962) we determined that the Cherokee supplied 59,259 deer hides in 1751 near the 1754 peak in their trading effort when they provisioned Charlestown with 44% of all deer hides.

From this information we set the Cherokee contribution to the skin trade at 0% in 1699 and grew it at 0.8% per year to its 44% maximum in 1754. We then estimated the annual number of deer skins provided by the Cherokee between 1720 and 1729 as 13,652. This is equivalent to 0.9 deer killed per individual per year (range of 0.6–1.2) to satisfy the Charlestown trade. Added to the base requirement of 12.5 deer p^{-1} $year^{-1}$ (range of 6.3–18.8), we obtain a final estimated harvest rate of deer for the Cherokee of 13.4 deer p^{-1} $year^{-1}$ (range 6.8–20.0). While an increase of 0.9 deer p^{-1} $year^{-1}$ may seem insignificant, the Cherokee population in 1721 was approximately 12,000 (Gragson and Bolstad, 2007; Goodwin, 1977; Varnod, 1724), which translates to a harvest of 10,800 deer $year^{-1}$ specifically for trade.

To determine the area used by the Cherokee to harvest deer we reconstructed deer density from historical and current observations, and sustainable harvest rates from contemporary observations of deer reproductive ecology. Estimated deer density in eastern forests during the pre- and early post-European settlement period range from 7.7 to 39.0 deer km^{-2} (Bersing, 1966; Morton, 1838; Seton, 1909). We adopted a mean value of 9.4 deer km^{-2} with a range of 5.6–13.2 deer km^{-2} (Baker, 1984), which is the approximate midpoint of historical density estimates for the early Euroamerican period. This figure is within the observed density range of the population recovery following hunting for the skin market reflecting different perspectives on deer abundance due to changes in land use and predator density (Elder, 1965; Matthiessen, 1959; McCabe and McCabe, 1984). Current deer population densities in eastern forests are typically between 5 and 12 deer km^{-2} when averaged over large tracts of land that do not experience deep snow; observed differences are primarily due to vegetation structure and hunting rates.

Numerous studies have shown that deer populations in eastern deciduous forests can sustain harvest rates between 30 and 40% of the adult population without experiencing a decline (Caughley, 1977; Gross et al., 1973; Hayne, 1984; McCullogh, 1979; Whitington, 1984). Assuming deer were harvested at the maximum sustainable rate, we multiplied deer population estimates by harvest rates to derive production; production was then partitioned between humans and the two other significant predators recorded for the region: wolves (*Canis lupus*) and cougars (*Felis concolor*). Cougars exhibit low predation rates with consumption typically less than 1 deer km^{-2} $year^{-1}$ (Hornrocker, 1970; Mech, 1984); wolves consume between 1 and 2 deer per km^{-2} $year^{-1}$, although this varies considerably according to the population densities of both predator and prey (Mech, 1970, 1973, 1984; Peterson and Page, 1983; Pimlot, 1967). Wolf, cougar, and other predators combined have a yield of 1.6 deer per km^{-2} $year^{-1}$. Given a deer density of 9.4 per km^{-2} and a sustainable harvest of 34%, this results in a sustainable yield of 3.2 deer $year^{-1}$ with approximately half harvested by humans.

2.3. Spatial data and analysis

We used high-resolution digital elevation models (DEMs) and applied spatial convolution filters and summation (Bolstad, 2005; Wilson and Gallant, 2000) to calculate land requirements for each resource. Digital elevation models store elevation in a grid, with a value for elevation above sea level stored in each of the grid cells, and spatial convolution filters are weighted combinations of adjacent cells. Land requirements were expressed on an area basis and as a percentage of available land in the convex hull of Cherokee towns or in the total Cherokee territory. The procedures for how we compiled and analyzed the spatial data to achieve this objective are described in the following paragraphs.

Cherokee towns were concentrated in river valleys with large alluvial flats. In southern Appalachia these valleys have widths ranging from 0.2 to 1 km and are typically associated with primary waterways or their larger tributaries. Cherokee towns were typically located in areas with sufficient space for both town structures and agricultural fields, near water and along the most easily traveled terrain—all factors identified as important in the placement of Cherokee towns during the early Colonial period (Gragson and Bolstad, 2007; Goodwin, 1977; Adair, 1974). Cherokee towns were not evenly distributed over the entire territory but clumped in the southeast quadrat (Fig. 1). We therefore used the convex hull (13,801 km^2) to determine the demand for architectural and agricultural land, hard mast, and fuelwood, and the entire territory (322,600 km^2) for determining the land requirement for deer. Our preliminary analyses indicate that the area required to satisfy the Cherokee demand for deer was substantially larger than that required to satisfy the demand for the other four resources, but in addition the historic rationale for why the Cherokee claimed such a large area was because it was required to satisfy their demand for deer (Goodwin, 1977; Royce, 1975).

We used elevation datasets to derive slope, aspect and other landform indices after Moore (Moore and Grayson, 1991) using a third-order finite difference method (Bolstad, 2005). We obtained elevation from two sources: a fine grain source for all resources within the convex hull and a coarse grain source for deer. Fine grain, 30 m grid cell size, elevation data were derived from USGS 1:24,000 scale maps (Bolstad, 2005). Map boundaries were selected to ensure each Cherokee town was at least 12.5 km from the edge of the dataset and that all areas were within the convex hull of the elevation dataset. Coarse grain, 90 m grid size, elevation data was derived from the Shuttle Radar Topography Mission (Lillesand and Kiefer, 2000). This dataset balances faithful topographic representation with constraints on data volume and processing times, which were important considerations given the large surface area from which the Cherokee harvested deer. The required areas for all resources did not differ by more than 2% whether based on 30 m or 90 m elevation data.

We thus assembled several spatial data layers representing intrinsic and extrinsic factors related to Cherokee resource distribution and demand: elevation, slope, aspect, valley breadth, river location, distance to water, and the territory claimed by the Cherokee. Land was assigned as used or unused for each of the five resources based on a village-centered score using the following weighted function:

$$S_{i,j} = \alpha_j - \beta_j \times \text{distance to village} - \chi_j \times \text{elevation difference} - \delta_j \times \exp(\text{slope}) \quad (1)$$

where $S_{i,j}$ is the score for location i, resource j; α, β, χ, and δ are parameters that vary by resource type (Table 1).

$S_{i,j}$ is an ordinal score with a numerical value that has no objective significance since land assignment to the used or unused class is largely governed by the ratios of β, χ, and δ. These ratios do not affect the total amount of land allocated to each use; they only control the spatial distribution of the allocation. This distinction is important since our analytical goal was to determine how plausible combinations of the parameters resulted in substantial use of distant resources.

Parameter values were fixed for each resource for each model run. The parameter α serves as a positive base from which distance, elevation and slope factors reduce the quality of the site. A value for α was chosen so that location scores were always positive to reduce storage requirements in signed vs. unsigned numbers. Relative weightings were used for β, χ, and δ to reflect constraints and relative trade-offs of resource-gathering activities. For example, parameter values were assigned for agricultural land to reflect the approximate four-to-one ratio in the energetic costs of walking on steep vs. level terrain so as to penalize steep slopes, and to restrict agriculture to relatively flat areas. While the values were plausible, they were somewhat arbitrary.

The parameter β weighs the relative cost of travel across horizontal terrain while the parameter χ scales the cost of a net change in elevation or the cost of vertical travel. The variation in these two parameters was constrained to reflect the approximate ratio in energetic cost of horizontal vs. vertical travel and averaged 0.25 with a range from 0.1 to 6.0 (β was always less than or equal to χ). The chosen ratios of β_j/χ_j were also

Table 1
Parameter values used for resource allocation functions

	β	χ	δ
Architecture	1.0–3.0	2.0–6.0	0–10
Agriculture	1.0–3.0	2.0–6.0	0–10
Fuelwood	0.1–3.0	0.2–6.0	0–20
Hard mast	0.1–3.0	0.2–6.0	0–20
Deer	0.1–3.0	0.2–6.0	0–20

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constrained to avoid village locations at slopes greater than 10%. The parameter δ reflects the cost of traveling over steep terrain to reflect the propensity to travel along contours; the average value was 10 with a range from 0 to 20. (The parameter χ represents the cost of traveling between locations that are at different elevations, but does not factor the difference in elevation along the intervening path.) The distance vs. elevation difference ranged from approximately 1:2 to 1:8, with lower relative costs for distance vs. slope resulting in an increase in the number of unused cells near villages. We stress that changing the weights only affected the *shape* rather than the *area* used to satisfy the demand for each resource.

All cells were initially set to unused for each resource, then allocated to the used class in an iterative fashion starting from the center of each village. Because some land uses were mutually exclusive, we used the following two rules in the assignment process: (1) land was first assigned to architectural use then to agricultural use; and (2) land for fuelwood, hard mast and deer harvest was assigned to areas not already assigned to architectural or agricultural use. Rook's case neighbor cells to the cell marking the center of each Cherokee town (i.e., adjacent cells north, south, east, or west of the central cell) were assigned to a candidate set based on their values as determined by Eq. (1). The highest scoring neighbor (highest $S_{i,j}$ value) was added to the used set and rook's case neighbors for this new cell were then added to the candidate list, which was again evaluated. The highest valued cell from the candidate list was added to the used set with new candidate cells inserted to the candidate list in order of scores, effectively creating a sorted list. The highest ranking cell from the candidate list was then transferred to the used set, thereby growing the used set outward from the town center. This process was repeated until the specific resource requirement for each town was satisfied.

The distribution of towns and their associated agricultural land appears restricted to locations near streams. This suggests that the cost of satisfying the demand for architectural and agricultural land increases with distance from water, but the distance at which either becomes prohibitive regardless of the need to satisfy the demand is unknown. To set limits on this uncertainty we carried out additional land allocation runs for architectural and agricultural demand limiting the land allocation to areas within 100, 200, and 300 m of streams. The location of streams was based on contemporary USGS information under the assumption that stream course locations have not changed substantially since 1721. Floodplain widths for Strahler third-order streams are typically less than 30 m; for fourth-order streams less than 300 m; and fifth-order less than 1 km. Meanders are restricted to the floodplain, and meander displacements since 1721 are likely to have been substantially less than changes in floodplain width.

3. Results

3.1. Use of non-deer resources

Our analyses suggest the Cherokee population in the early 18th century did not approach the regional capacity for architectural, agricultural, fuelwood or hard mast production within the territory claimed (Tables 2, 3). The estimated use at the mean values for each of these four resources is approximately half their maximum values, and the total area required at the highest levels of per capita consumption was less than 741 km^2. This is a miniscule portion of the available land within the Cherokee territory claimed at this time—less than 1%. This suggests the demand for these resources was both localized and easily satisfied within relatively short distances of the center of each town, as illustrated in Fig. 2. (The situation in the case of deer is different and will be dealt with below separately.)

Suitable architectural and agricultural areas, defined as land near streams (buffers at 100–300 m), low slope ($\leq 5°$), and within the convex hull of observed Cherokee town locations, were lightly used. For our most restrictive assumption (areas within 100 m of a stream), approximately 5% of the available near-stream area in the convex hull was required to meet the demand (Table 4). The total area in the restrictive case covers approximately 4100 km^2 and more than 1100 km^2 of this amount is essentially flat. These lands are furthermore primarily in large, contiguous blocks on floodplains and in near-stream coves that typically cover several hectares to hundreds of hectares. As we relaxed the stream proximity requirement from 100 to 300 m, our estimates of the proportion of land required by the Cherokee declines. With a 300 m buffer, the amount of available, low-slope land increases to 2235 km^2 representing less than 3% of the available land within the convex hull.

The Cherokee population was clearly not limited by the availability of architectural and agricultural land, or areas suitable for harvesting hard mast and firewood either locally within the convex hull or within the entire Cherokee territory. The amount of available land required to meet demand for these four resources is typically less than 3% of the convex hull area under our best estimates (i.e., low human requirement and high per-unit-area production) and less than 10% under our worst estimates (i.e., high human requirement and low per-unit-area production). These results suggest that the Cherokee population in 1721 did not approach intrinsic landscape limits for obtaining architectural, agricultural, hard mast or fuelwood resources in their environment, which stands in sharp contrast to widely held beliefs such as Adair's (1974: 239) that Cherokee ''… towns are still scattered wide of each other, because the land will not admit any other settlement.'' Numerous suitable sites went unused, at least according to the criteria we apply sites with flat land near water

Table 2
Cumulative estimated land requirements (km^2) by resource type for the 62 Cherokee villages in 1721

	Low-requirement	Mid-requirement	High-requirement
Architecture	1.2	4.9	18.4
Agriculture	16.0	45.5	74.9
Fuelwood	105.6	294.8	484.0
Hard mast	110.6	19.5	442.2
Deer	52300	103000	153700

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Table 3
Estimated land requirements as a percentage of the 322,600 km^2 Cherokee territory

	Mean	High	Low
Architecture	0.00	0.01	0.00
Agriculture	0.01	0.02	0.00
Fuelwood	0.10	0.15	0.03
Hard mast	0.09	0.14	0.03
Deer	31.9	47.6	16.2

suitable for towns and agricultural fields as well as proximate to areas capable of producing ample quantities of fuelwood and hard mast. Unused sites were common both within the convex hull as well as the Cherokee territory at large. A substantially larger Cherokee population than actually recorded could have been supported by hearth, agricultural, hard mast, and firewood resources by the territory in 1721, but the fact that the population was not larger suggests that some other resource, activity, or set of conditions limited the Cherokee.

3.2. Use of deer resources

Our analysis suggests that the demand for deer was part of the limitation. Demand for deer ca. 1721 was substantial and at times may have approached its sustainable maximum within the Cherokee territory (Table 2). Satisfying the demand for deer required using approximately 30% of the total available territory (at the mean consumption of 13.4 deer p^{-1} $year^{-1}$ and average deer density of 9.4 deer km^{-2}). Territory use ranged from 16% to 48% of the total available land when using the lower (6.8 deer p^{-1} $year^{-1}$) and upper (20.0 deer p^{-1} $year^{-1}$) demand values.

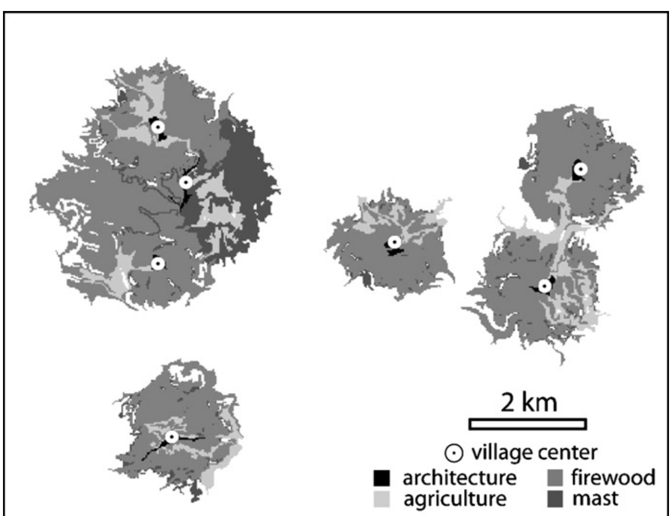

Fig. 2. An example of land required for architecture, agriculture, firewood, and mast harvest in the proximity of a group of Cherokee villages. This allocation is under the "best" assumptions for per capita requirements described in the text. Architectural and agricultural requirements were assigned first in order and exclusive of other uses, while firewood and mast harvest could be coincident on the remaining land. Allocation was with equation 1 values of $\beta_j = 1$, $\chi_j = 4$, and $\delta_j = 1$.

Table 4
Amount and proportion of suitable area estimated available for Cherokee villages

Distance to stream threshold (m)	Suitable area (km^2)	Unsuitable area (km^2)	Proportion suitable (%)	Area required as proportion of suitable (%)
100	1142	3038	37.6	4.4
200	1711	5616	30.5	2.9
300	2235	8180	27.3	2.3

Suitable areas were defined as flat (<4% slope) within the convex hull of 1721 Cherokee villages and near streams (100, 200, or 300 m to nearest 2nd order or larger stream). Area required is based on mean per capita requirement of architectural and agricultural lands applied to the entire Cherokee population.

The area required to satisfy the Cherokee demand for deer depends on the following period factors, listed in order of increasing uncertainty about their values: sustainable harvest rates, deer population densities, Cherokee per capita annual demand, and harvest proportion by humans vs. other predators (see Table 5). We discuss each in turn.

3.2.1. Deer sustainable harvest rate

Estimates for sustainable harvest rates are based on numerous studies of the biology of the white-tailed deer over a broad range of habitats, populations, and regions. There is remarkable similarity in the results from studies conducted in forested and forest-agricultural mosaics in eastern North America, which indicate sustainable harvest rates clustered near 25–38% (Gross et al., 1973; Hayne, 1984; McCullogh, 1979). Harvest rates below ~25% are characterized by population increases to densities that elicit control via other mechanisms, primarily disease and parasitism. Harvest rates above ~38% often lead to notable shifts in the population demography toward younger ages that eventually result in population decline as a consequence of increased early mortality due to increased predation pressure.

These studies are corroborated by current management of white-tailed deer at a range of densities in eastern North America. While harvest goals vary by state and province, most states maintain stable populations through target harvest rates of approximately 15–20% for does, and 30–40% overall. Substantially higher harvest rates would reduce the area required for deer at least in the short term. In the case of the early contact Cherokee, increasing the harvest rate of deer from 34% to 50% per year without changing other parameter values leads to a reduction in area from 103,000 km^2 to 73,000 km^2. However, a 50% harvest rate would drive deer population levels down under most environmental conditions. This in turn would lead to either a net reduction in the deer harvested or an increase in the area required to meet demand.

3.2.2. Deer population density

Deer densities in eastern North America show plateaus that are strongly influenced by vegetation mosaic, which can be used as a proxy for past densities. Deer densities across all counties in the eastern United States range from 0 to over 50 deer km^{-2}. These extremes are rare, however, and primarily occur in heavily disturbed or managed habitats such as urban areas

Table 5
Land required by the Cherokee to meet deer demand at various per person levels based on harvest proportion and density

Requirement (deer person^{-1} year^{-1})	Harvest proportion	Area required (km^2)		
		Deer density 5.6 (no./sq km)	Deer density 9.4 (no./sq km)	Deer density 13.2 (no./sq km)
13.4	0.2	432000	257500	183400
13.4	0.5	172900	103000	73400
13.4	0.8	108000	64400	45800
20.0	0.2	645200	384400	273700
20.0	0.5	258100	153700	109500
20.0	0.8	161300	96100	68400
6.8	0.2	219400	130700	93100
6.8	0.5	87700	52300	37200
6.8	0.8	54800	32700	23300

Our compilation of sources suggests 13.4 deer were required per person, with an average density of 9.4 deer km^{-2}, a harvest proportion of 0.5, and a sustainable annual deer harvest rate of 34%.

and game refuges which lack major predators and prohibit hunting (Baker, 1984). Deer densities in predominantly forested, rural areas of eastern North America vary from 4 to over 15 deer km^{-2} and are unimodally related to vegetation. The highest densities are associated with a mix of forest (at least 40%) and cropland (30–40%), with deer density decreasing as either crop area or forest portion decreases. The lowest deer densities in vegetated habitats occur in large areas of continuous forest cover.

Our analyses suggest the territory occupied by the Cherokee in 1721 did not have a well-developed forest-cropland structure so deer densities were unlikely to be near the higher contemporary levels. Agricultural production was lower than contemporary production, and agricultural areas were also widely scattered. They covered no more than 10% of first-order watersheds, and decreased in surface area as watershed size increased. The landscape mosaic was thus very different than the approximately equal mix of forest and agriculture that supports high contemporary deer densities. Even if an optimum agricultural/forest mix were present, deer density in the vicinity of agricultural fields was most likely similar to the deer densities observed today in predominantly forested areas of southern Appalachia—between 5 and 10 deer km^{-2}.

The estimated area required to support the aggregate deer demand for the Cherokee population in 1721 varies from approximately one-quarter (73,400 km^2) to one-half (172,900 km^2) of the total territory as deer density varies from 5.6 to 13.2 deer km^{-2} (Table 5, row 2). The 73,400 km^2 required under the highest deer density is approximately seven times the area in the convex hull of the towns. Even under the most favorable density conditions, substantial travel would have been required to meet the Cherokee demand for deer ca. 1721. Both period and contemporary authors (Goodwin, 1977; Hatley, 1993; Adair, 1974; Gipson, 1939) state that the Cherokee traveled significantly to ensure success in harvesting deer.

3.2.3. Cherokee per capita annual deer demand

Figures for per capita deer consumption drawn from period journals and contemporary analyses vary approximately threefold from 6.8 to 20.0 deer p^{-1} year^{-1} (Driver, 1969; McCabe and McCabe, 1984; Carroll, 1836; Evans, 1981; O'Callaghan, 1863). Because the uncertainty in per capita consumption affects our estimates of the area needed to meet demand, we determined several estimates (Table 5). Rows 1–3 show estimated land requirements at a median consumption of 13.4 deer p^{-1} year^{-1}; rows 4–6 show land requirements at the high consumption of 20.0 deer p^{-1} year^{-1}; and rows 7–9 show land requirements at the low consumption of 6.8 deer p^{-1} year^{-1}.

Under our most well-founded deer density and harvest proportion estimate, 13.4 deer km^{-2} and 50%, the estimated land requirement ranges from 52,300 to 153,700 km^2 or from 16 to 48% of the total Cherokee territory ca. 1721. Not surprisingly, lower per capita demand leads to lower aggregate demand and an estimated harvest area of ~23,300 to ~219,000 km^2 over all combinations of other variables. Even under our lowest estimated demand, however, the harvest area required to meet the estimated demand is more than 1.7 times the area of the convex hull of Cherokee towns. Our estimates pertain to Cherokee demand at the historic transition between harvesting deer for subsistence vs. harvesting deer for trade (McDowell, 1992), and at this particular point in time they probably had few incentives to over-harvest deer. Transportation of hides and meat was by humans as the Cherokee did not acquire and use horses until later (Goodwin, 1977; Newman, 1979). In addition, hides could not be effectively stored in large quantities for long time periods and meat, even processed as jerky or pemmican, had a useful life measured in months rather than years (Corkran, 1962; Swanton, 1946).

3.2.4. Harvest proportion by humans and other predators

We set the mean estimated harvest proportion due to humans at 50% with a range from 20% to 80%. This was based on a sustainable harvest rate of 3.2 deer km^{-2}, and harvest rates by wolves of 1.3 deer km^{-2} and by mountain lion of 0.3 deer km^{-2}. Wolf and lion densities in eastern forests are not quantified although both species were reported in period accounts as present in high densities (Laliberte and Ripple, 2003). Our only recourse is to substitute our best estimates from contemporary observations where wolves or lions are present so that given the limits imposed by predator territoriality, harvest rates by non-human predators are unlikely to be lower than 0.6 or higher than 2.5 deer km^{-2}year^{-1}.

Changes in the proportion of deer harvest by the Cherokee over this range, holding other parameters constant, results in an approximate four fold change in the area required to obtain deer. When harvest proportion varies from 0.8 to 0.2 (mid values for other parameters; deer density of 9.4 km^{-2} and a consumption requirement of 13.4 deer p^{-1} $year^{-1}$), the area required ranges from 64,400 km^2 to 257,500 km^2. Similar changes are observed at all other combinations of density and per capita consumption. Only under the most favorable combination of high deer density, high harvest proportion, and low per capita requirements is demand satisfied by an area immediately surrounding the convex hull of Cherokee villages.

3.3. Deer harvest footprints and trade-offs

Our analysis is a model-based approach to inferring cause from observed patterns (Johnson et al., 2005) rather than a narrative interpretation that verges on possibilism. There are few explicit records about prehistoric or historic native motivations for village placement, how resource scarcity was perceived, or even the patterns and areas of resource use although certainly such factors were important in structuring native resource procurement activities. The value of a model-based approach lies in setting bounds on the plausible range of values for how and where resources were used and the extent to which they were influenced by human action. In the case of the early contact Cherokee, it is an important means for going beyond description and the limitations of negative evidence to test competing hypotheses about the factors structuring the distribution of resources and their resource-demand activities. In this final section we examine the footprint on the landscape of deer hunting along with its inherent tradeoffs for the early-contact Cherokee.

We assumed in the results we present above that all areas were equally suitable for deer harvest irrespective of slope, distance, or elevation difference from a town center. These are naïve assumptions as current observation and period journal entries indicate local physiography is an important determinant of deer density and hence hunting success. For example, deer and particularly pregnant does need ready access to water and consume 1–2 liters day^{-1} (Marchinton and Hirth, 1984). Rainfall frequency in southern Appalachia means that water is widely available in puddles and vegetation during spring and summer (Downing and McGinnes, 1976), but the drying and/or freezing of ephemeral water sources and less succulent vegetation results in more variable deer densities in fall and winter. The highest deer densities are expected near watercourses and in cove and flat, low slope positions where vegetative productivity is generally higher and the energetic cost of movement generally lower; altitudinal migration of deer is commonly reported for both period and contemporary herds. The energetic cost of human movement is also lower in flat terrain with somewhere between a 2 to 1 and 6 to 1 ratio in traveling on steep vs. level terrain.

Using mean parameter values results in a land surface to meet deer demand that is more than three times what would be sustainable in the convex hull of Cherokee towns. Local depletion of deer in such a situation would have been likely. While depletion could have been offset by recruitment of deer from peripheral areas, deer diffuse at rates of one to a few kilometers per year which is not sufficient to compensate for overharvesting except possibly at the margins of the Cherokee territory. The alternative to intensifying harvest is to extensify harvest, and this implies increasing travel distances from Cherokee towns for which there is some ethnohistoric evidence (Gipson, 1939).

There is nothing to suggest how increased travel from Cherokee towns would affect the pattern of land use. Nevertheless, under the increased travel scenario the optimum harvest area may have been larger than the strict area requirements summarized in Table 5. The Cherokee likely bypassed steep or mountaintop areas in traveling to more distant valleys and coves where deer would more readily be encountered. The tradeoff was thus between increasing the likelihood of a successful hunt while minimizing the effort to reach the hunting area. This tradeoff would increase the area over which deer harvests took place since by-passed lands were "embedded" in the matrix of hunted or huntable lands resulting in a patchy use surface.

Fig. 3 illustrates the outcome of Eq. (1) with parameter values $\alpha = 100{,}000$, $\beta = 1$, $\chi = 4$ and $\delta = 1$ with distance and height units expressed in kilometers. All deer and human requirements were set to the estimated central value (i.e., 13.4 deer p^{-1} $year^{-1}$, 9.6 deer km^{-2}, and 50% harvest proportion). The total land requirement in this situation is 103,000 km^2 as

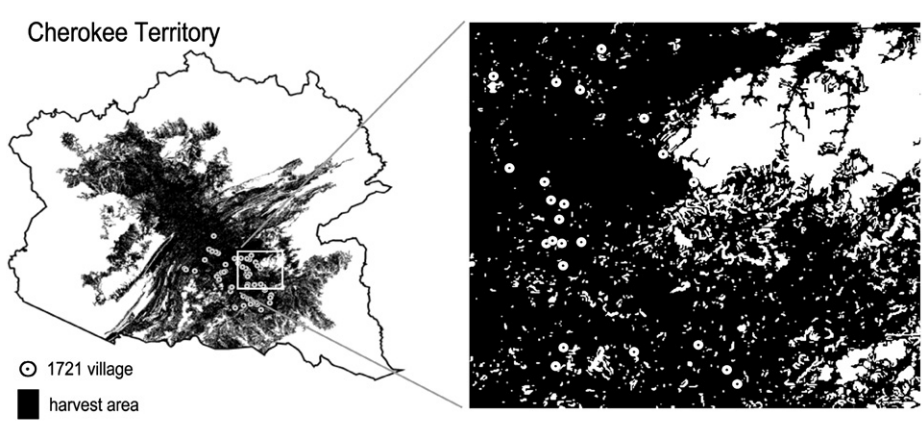

Fig. 3. An example of land allocation for deer harvest using a plausible range of resource production and consumption requirements. Note there is substantial bypassed areas within the initial allocation of flat, valley bottom areas.

shown in Table 5. Eq. (1) furthermore indicates that approximately 28,400 km^2 were "bypassed" (i.e., unharvested) because they were either too steep or at large elevation differences from the originating villages. Bypassed areas were unhunted in the simulation, and ranged from approximately 900 km^2 with $\beta = 1$, $\chi = 2$, and $\delta = 0$, to more than 71,400 km^2 with $\beta = 1$, $\chi = 6$, and $\delta = 2$. Fig. 4 illustrates changes in the amount of bypassed land with changes in the ratios of β, χ, and δ, with the light gray showing a ratio of 1, 4, and 5, respectively, and dark areas a ratio of 1, 2, and 2. This latter set substantially reduces the relative cost of harvesting on steep or higher elevation slopes, resulting in less bypassed land and a more compact allocation. We do not attempt to identify particular parameter values that provide a correct accounting of the bypassed lands, nor that this ratio of bypassed to used lands is anything more than plausible. Rather, we argue that there was a potentially large proportion of land that was less intensively used that provided a matrix in which hunted land was embedded. Further refining this quantity is left to future research.

Eq. (1) indicates substantially larger areas could be utilized than those indicated in Table 5, given the large amounts of "bypassed" land. Eq. (1) is admittedly a crude approximation of the tradeoffs made by the Cherokee when selecting areas to hunt and is best viewed as a proxy for multiple factors. Deer populations have been observed to vary in space and time in response to infectious disease, local to regional weather, hunting pressure, changes in predator densities, and large-scale synchrony in vegetation condition. The Cherokee likely employed multiple strategies to respond to variations in deer populations as reflected in the hunting practices of contemporary indigenous groups (Alvard, 2000; Vickers, 1988). The value of the model is to set bounds on the plausible range of values rather than invoke possibilities without the benefit of evidence pertinent to the practices that are most likely to prevail in a particular setting.

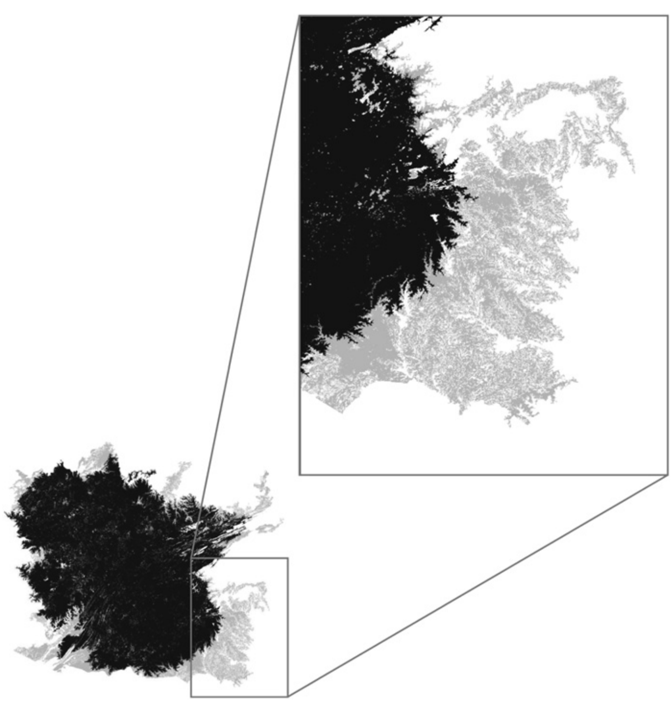

Fig. 4. An example of varying the relative ratios of β, χ, and δ, with the light gray showing a ratio of 1, 4, and 5, respectively, and dark areas with a ratio of 1, 2, and 2. Changing these ratios changes the relative cost of horizontal vs. "vertical" travel, and results in less (grey) or more (black) compact allocations. We do not argue that we may identify one set of values within our plausible range, only that all values in this plausible range contain substantial, unhunted areas embedded within the hunted area, thereby reflecting tradeoffs between energy spent and harvested.

4. Conclusions

We estimated land requirements to satisfy the demand for architectural, agricultural, fuelwood, hard mast, and deer resources by the Cherokee population in 1721. These estimates are based on a new synthesis of village location and population data, historical accounts of resource requirements and their use by the Cherokee, and historic and contemporary measurements of resource availability and production in southern Appalachia. Our analysis suggests the demand for all resources except deer was easily met within the convex hull defined by the observed Cherokee town locations ca. 1721. Our analysis further suggests that deer harvests within the convex hull would have been unsustainable although demand ca. 1721 could have been met within the total Cherokee territory.

The predominantly qualitative studies of the 18th century Cherokee provide general insight on their subsistence, but our analysis provides boundary conditions on harvesting resources identified as critical to the long-term viability of Cherokee towns. Our intent was not to address this long-term viability of the Cherokee per se, but to lay the foundation to a substantive analysis of this issue in future work by ourselves (that is currently in progress) and others. Our results on Cherokee deer harvest ca. 1721 provide a benchmark for evaluating the common inference (Goodwin, 1977; Hatley, 1993) that Cherokee deer hunting was ever less sustainable up through the American Revolution with hunters spending more time going farther afield to locate ever scarcer deer. There is limited proof for the idea of local depletion advanced to date in the Cherokee literature. In addition, evidence for game depletion by indigenous hunters remains equivocal when the appropriate parameters for judging harvest sustainability have been measured (e.g., Alvard, 2000; Vickers, 1988).

While Cherokee trade with the British has been used as a global explanation for the depletion of deer, such an explanation blurs the resource-specific harvesting processes consequentially associated with such a final outcome. Much like Carneiro's (1970) comments about the role of warfare in the formation of states, "trade with the British" is a necessary element, but not sufficient in itself to explain Cherokee settlement. Our modeling approach to the Cherokee ca. 1721 transcends speculation about the resource potential of southern Appalachia or the consequences of Cherokee over-harvesting of particular resources reached in the absence of detailed information about the location, population or place-specific demand for such resources. There are several possible Cherokee responses to the progressive reduction in the availability of deer. These include more complete use of the available territory, increasing harvest levels, longer hunts, and resource substitution, which we leave for future research.

The broader question addressed by our research is how relatively discrete events in time by the Cherokee between 1690–1794 could result in changes to the availability of certain resources or the physical environment to leave a legacy on the landscape affecting the opportunities of subsequent generations (White and Pickett, 1985; Cronon, 1983; Foster et al., 1997; Little et al., 1997; Vogt et al., 1997). There is a strong suggestion that the physical re-arrangement of Cherokee towns over the course of the 18th century reflects a reorganization of Cherokee activities to participate in an export economy (Goodwin, 1977; Dunaway, 1996), of which deerskins were by far the most important commodity. These qualitative insights, however, lack the details necessary to evaluate the tradeoffs, turning points or mechanisms for such a transition. The present analysis is the first time step in our development of an operational model that builds from statements of fact and belief in the literature about the relationship between landscape structure, forest productivity, and Cherokee settlement.

The Cherokee became official allies of the British in 1715 and Cherokee trade came under monopoly control of the South Carolina government in 1716. The first government trading posts were established at this time in several of the larger Cherokee towns (Goodwin, 1977; Williams, 1928; McDowell, 1992; Gearing, 1974) with the result that from 1716 forward there was a steady increase in the flow of European goods into Cherokee country in exchange for deerskins (Goodwin, 1977; Dunaway, 1996). By the mid-1750s, the supply of deerskins at the port of Charles Town was noticeably smaller than it had been during the preceding two decades (Clowse, 1981). In addition, the deer population in the source area was said to be so reduced that many Cherokee abandoned long-occupied towns and moved north in search of new hunting grounds (Gipson, 1939). By the time Bartram traveled through Cherokee country in the 1770s, he found it almost depopulated of large animals—buffalo, elk and deer—the only reminder of their existence being heaps of white bones (Bartram, 1947).

It is not surprising that the encroachment of a powerful territorial state such as Britain had striking effects on the Cherokee, perhaps leading them to exceed the capacity of the land to meet their demand for subsistence or commoditized resources. Without explicit recognition of how environmental variability and behavioral response relate to satisfying demand, there is little basis for resolving between the four monolithic, but largely unsubstantiated, grand theories of Cherokee settlement (Gragson and Bolstad, 2007). For example, Braund (1999) notes that a hunter could kill 400 deer in a winter while the Varnod enumeration (Varnod, 1724) indicates there were at least 3500 Cherokee adult males in the early 18th century, which translates to a potential annual harvest of 1,400,000 deer. There are several reasons to question this level of harvest even though the Cherokee are described as "… employees of a trading system built around faraway demands of European society" (Corkran, 1962: 6). The largest reported annual provision of skins at the port of Charles Town during the Colonial period was 100,000 lbs or approximately 60,000 skins (Clowse, 1981).

As we have demonstrated in this article, geospatial analyses can be used to incorporate diverse sources of evidence to test competing hypotheses about the factors structuring the distribution and activities of the Cherokee. By testing competing hypotheses it becomes possible to resolve between distinct historical scenarios of the rise and fall of the Cherokee nation over the course of the 18th century (e.g., Corkran, 1962; Reid, 1976; Gipson, 1939). The testing of competing hypotheses can also help place the Cherokee into their environmental context making possible comparisons with other native groups with long-term data without blurring resource-level processes (Alvard, 2000; Vickers, 1988; Marks, 1976). This will help move southern history and ethnohistory beyond its longstanding parochialism (Kolchin, 2003).

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