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RESOURCE RESILIENCE, HUMAN NICHE CONSTRUCTION, AND THE LONG-TERM SUSTAINABILITY OF PRE-COLUMBIAN SUBSISTENCE ECONOMIES IN THE MISSISSIPPI RIVER VALLEY CORRIDOR

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In small-scale human societies, a variety of factors contribute to the sustainability of subsistence economies, including premeditated conservation measures, low human population levels and predation pressure, and limited technological capacity to adversely impact environments. Here I suggest that it is worthwhile to look beyond simple characterizations of small-scale societies as being ''low impact'' in terms of their limited population, predation, and technology. Instead, we should look more closely both at the degree to which primary prey species are resilient to human predation and at the extent to which the niche construction efforts of small-scale human societies may modify vegetation communities in ways that result in their capture of a larger percentage of an ecosystem's total biotic energy. The small-scale Pre-Columbian societies occupying the Mississippi River Valley provide a case study. Throughout the Middle and Late Holocene, indigenous groups in this major north-south environmental corridor relied for protein to a substantial degree on a set of animal species/species groups (white-tailed deer, fish, migratory waterfowl) that combined both a high biotic potential and relative immunity from over-exploitation. At the same time, they practiced an integrated overall strategy of restructuring vegetation communities in ways that enhanced and expanded the habitats of many important food sources.

Key words: *archaeology, Mississippi Valley, niche construction, resource resilience.*

Un gran número de factores influyen en la sostenibilidad de la economía de subsistencia en las sociedades ''de pequeña escala''. Entre ellos están las medidas premeditadas de conservación, los bajos niveles de población, y de presión depredadora y una capacidad tecnológica limitada de influir de modo adverso en el ambiente. Es necesario no restringir el motivo del ''bajo impacto'' de estas sociedades a su pequeña población, su limitada depredación y su escasa tecnología. Hace falta estudiar detenidamente la capacidad de recuperación frente a la explotación humana de las especies alimentarias principales. También es imprescindible investigar cómo los esfuerzos de construcción de sus nichos pueden modificar las comunidades vegetales para lograr maximizar la obtención de un mayor porcentaje de la energía biótica total del ecosistema. Las sociedades precolombinas de pequeña escala asentadas en el Valle del Río Mississippi son un buen ejemplo. Los grupos indígenas que ocuparon este enorme corredor norte-sur durante el Holoceno medio y tardío, dependían fundamentalmente de las proteínas provenientes de determinadas especies y de algunos grupos animales (venado de cola blanca, peces, aves acuáticas migratorias). Estos animales combinan un alto potencial biótico con una alta inmunidad a la sobreexplotación. A su vez tenían una estrategia general integrada de reestructuración de las comunidades vegetales para aumentar y expandir los hábitats de muchas de sus fuentes principales de alimento.

Introduction

The deciduous woodlands of eastern North America encompass a rich diversity of environments, and this diversity is reflected in the temporal and

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spatial mosaic of subsistence economies that were employed by the small-scale[1] indigenous societies of the region prior to European contact (see Crawford 2010; Gremillion 2010; Lapham 2010; and Styles 2010 for overviews and extensive references). Along with exhibiting well-documented regional and temporal patterns of variation, these indigenous eastern woodland economies also appear to have shared substantial sustainability. Based on the analysis of plant and animal remains recovered from archaeological sites across the region, the Native American societies of the eastern woodlands maintained and adjusted their utilization of biotic communities over thousands of years in ways that, with a few possible exceptions (e.g. Cahokia, see Lopinot and Woods 1993; Tainter 2006), do not appear to have either degraded their environment or overexploited their resource base.

In large measure, the sustainable nature of Pre-Columbian economies in the eastern woodlands can be attributed to low human population levels, limited human predation of prey species, and the limited technological capacity of Native Americans to adversely impact plant communities and ecosystems (Smith and Wishine 2000). I argue here, however, that it is worthwhile to look beyond the ''low impact'' profile of these small-scale indigenous societies and to view their limited predation pressure and limited potential for environmental damage from a different perspective. On the one hand, rather than characterizing human impact on wild animal populations simply in terms of low predation pressure, it is worthwhile to consider the extent to which a number of the primary prey species they relied upon may have been resilient under human predation. The term ''reslience'' as used here refers to the capacity of the species in question to sustain high annual harvest yield levels over long periods of time. On the other hand, rather than focusing on the limited technological potential of these small-scale societies to adversely impact eastern forest communities, I suggest that it is more interesting and informative to look at their positive patterns of traditional management of plant communities. Through a range of active and sustained patterns of human niche construction, they were able to modify and enhance vegetation communities in coherent and systematic ways in order ''to capture a larger proportion of total biotic energy'' (Smith and Wishnie 2000). Humans are, after all, recognized as ''the ultimate niche constructors'' (Odling-Smee et al. 2003). When considered in concert, these two general aspects of indigenous subsistence economies in the eastern woodlands–the resilience of primary animal prey species to human predation and the systematic management of vegetation communities through human niche construction efforts–offer a new perspective on Pre-Columbian sustainability in the eastern woodlands.

The Mississippi River Valley case study provides a good opportunity to address the role of resource reslience and human niche construction in the sustainability of subsistence economies of the East. Forming a north-south environmental corridor that extends through 15 degrees of latitude, from the upper Midwest to the Gulf of Mexico, the Mississippi River Valley and its lower tributaries were occupied by indigenous societies that exhibited substantial north-south variation both in sociocultural organization and structure, and in the range of different plant and animal species that contributed to their economies (Emerson et al. 2000; Sassaman and Anderson 1996; Smith 1986; Springer 1980;

Styles 1981). Against this backdrop of considerable sociocultural and subsistence economic diversity, however, it is possible to identify broad-scale regional similarities in both human reliance on sets of animal species that were resilient to predation, and shared general patterns of human niche construction that targeted particular sets of wild plant species.

Resource Conservation and Resource Resilience

Small-scale societies are often found to practice premeditated conservation measures. This entails, ''keeping something, especially an important environmental or cultural resource, or an entire habitat, from harm, loss, or change, using a resource sparingly so as not to exhaust supplies, and/or using specific measures to maintain and enhance a resource, a suite of resources or entire habitats'' (Turner and Berkes 2006:497). It is likely that such conscious conservation practices have a deep time depth and played an integral and important role in the long-term economic sustainability of indigenous societies in the eastern woodlands prior to European contact. A number of early historical accounts document the existence of such trans-generational systems of traditional ecological knowledge (Hudson 1970, 1976). Unfortunately, the existence of deliberate intent at resource protection remains largely impossible to document in the archaeological record of the region.

Even in the absence of available evidence for deliberate conservation efforts, however, Smith and Wishnie (2000:501) also identify a number of factors, including low human population density, low human demand for resources, and limited technology, as potential default explanations for the sustainability of small-scale economies and resource management systems over long periods of time. Yet, if one of these default causal factors–low human demand for resources–is considered not in terms of low predation pressure but rather in terms of the capacity of prey species to sustain high harvest yields, such resource resilience can be seen to have played an important role in the long-term sustainability of human hunting and fishing systems in the eastern woodlands.

Two of the most obvious and most important aspects of the relative reslience of different prey animals to human predation are the biotic potential (reproductive rates) of target fauna and the inability of human hunters to access and draw down the breeding population ''capital'' accounts of prey species. Here I argue that throughout the Middle and Late Holocene (i.e., after ca. 8,000 B.P.), the three species and species groups that provided a substantial percentage of the meat protein for Mississippi Valley societies (bottom feeding fish species, migratory waterfowl, and the white-tailed deer), were all very resilient to human predation. The reslience of these species/species groups in turn contributed in a significant way to the long-term sustainability of human subsistence economies in the region.

White-tailed Deer

With the extinction of megafauna in the late Pleistocene, highly competitive ecological specialists disappeared from the woodlands of eastern North America, opening the way for the rapid proliferation or ''competitive release'' of mobile rstrategist ungulates–''species with high reproductive rates, short individual life expectancies, and excellent mechanisms of juvenile dispersal'' (Geist 1999:84). Premier among the r-selected generalists that came to dominate the simplified Holocene ungulate guild of the eastern woodlands was the white-tailed deer (*Odocoileus virginianus*), which became *the prey* for human hunters in the region (Wolverton et al. 2008). In addition to their relatively large body size and predictable seasonal patterns of spatial aggregation (Smith 1975), three aspects of the white-tailed deer made them the consummate prey for human hunters in the East, as reflected in their universal high ranking in Middle and Late Holocene archaeofaunal assemblages (Lapham 2010; Styles 2010): high reproductive or biotic potential, rapid dispersal of young, and ''resistance'' to predation. White-tailed deer have a theoretical maximum reproductive rate or biotic potential of about sixty percent per year (Brohn and Robb 1955; Robertson 1969). Along with being able to survive the loss through predation or other factors of more than half of their population on an annual basis, white-tailed deer populations also have the capacity to rapidly expand back into and repopulate areas hard hit by human harvesting (Wolverton et al. 2008). In addition to being able to sustain heavy human predation over the long term, white-tailed deer populations in the eastern woodlands can also be considered, in large measure, as having been invulnerable to overexploitation. Inhabiting brushy or wooded edge areas during most of the year, deer respond to increased hunting pressure with highly effective avoidance behavior, which includes prolonged hiding and a shift to nighttime feeding. As a result, white-tailed deer are considered a ''resistant species'' (Smith 1975:22). Given suitable habitat, it is almost impossible to drive a white-tailed deer population below a ''security density'' level (Smith 1974). Given the excellent cover conditions that existed in the pre-contact eastern woodlands, it would have been highly unlikely that human hunting pressure would have threatened the survival of deer populations. It was not until the intensive deer drives of the post-contact period that human predation substantially impacted deer herds in some regions of the East (Lapham 2005).

In addition, white-tailed deer would not have been impacted by a loss of habitat due to the alteration of vegetation communities by the indigenous small-scale societies of the region. On the contrary, since an important part of the diet of white-tailed deer consists of the twigs, shoots, and leaves of low growing shrubs and bushes, their population densities are low in climax forest situations where a closed canopy has been established. Highest population densities occur in early successional situations that have small areas of varying types, producing maximum edge areas between habitat zones. As a result, medium levels of human clearance of vegetation, far from having a negative impact on deer populations, would actually have improved their habitat and increased carrying capacity levels. Richard Yerkes (2005:248-249) provides a compelling argument in this regard in his consideration of human utilization of white-tailed deer in the American Bottom region of the Mississippi River Valley during the Middle Mississippi Period. After A.D. 1000, this portion of the Mississippi Valley witnessed the highest recorded level of Pre-Columbian human modification of vegetation communities anywhere in the East; yet Yerkes (2005:248) argues that forest clearance resulted in an enhanced habitat for deer:

> It is more likely that the Mississippians improved the habitat of many of the animals they hunted by burning and clearing forests and planting crops… Deer may have been more abundant during the heyday of Cahokia that they were before agriculture was established… There is little evidence that Mississippian hunting ''pressure'' had an adverse effect on American Bottom deer populations.

Benefiting from human clearance of vegetation, able to repeatedly rebound from high harvest levels and resist overexploitation, the white-tailed deer played a central role in contributing to the long-term sustainability of subsistence economies in the Mississippi Valley. Of comparable significance to deer, the single most important prey species throughout the eastern woodlands was a group of fish species that shared a number of key characteristics including, most importantly, ease of harvest in specific habitat and seasonal settings, and reslience to overharvesting.

Fish

Fish were a major source of protein for Native American societies in the Mississippi River Valley throughout the Middle and Late Holocene, contributing 25 percent or more of the annual protein budget of some groups (Yerkes 2005). In the 19th and 20th centuries, before extensive pollution drastically reduced their populations, the Mississippi River and its tributaries yielded impressively large annual fish harvests (e.g., 10.9 million kg from a 483 km section of the Illinois River in 1908; Limp and Reidhead 1979:70). Given their lack of modern fishing technology (e.g., mechanized trawlers, large nets, etc.), however, comparably high harvests from major river channels in the East were obviously beyond the reach of Pre-Columbian societies. With the high and moderate energy input techniques available to them (attended pole fishing, spear fishing, unattended multiple hook lines, and weirs and traps), Pre-Columbian groups were able to catch fish in the deep waters of main channels and channel remnant oxbow lakes, but such efforts would have required high labor input for any given output (Limp and Reidhead 1979).

Fish populations of the Mississippi Valley corridor, however, did not always remain in the deep-water habitats of active and remnant river channels. During spring floods, great numbers of a variety of species of fish moved from active and remnant channel (oxbow lake) deep-water habitats into adjacent seasonal, shallow water areas to spawn. In these shallow water settings they were vulnerable to simple drive-line methods of fish capture that combined low human effort with potentially high harvest returns (Limp and Reidhead 1979; Smith 1975:58; Styles et al. 1983; Yerkes 2005:250). Such shallow-water fish harvesting that required minimal technology and energy input would have been particularly efficient once the floodwaters of spring had receded back below the level of the main channel and channel remnant oxbow lakes, isolating large numbers of fish in slowly shrinking backwater pools and lakes.

Seasonality studies of archaeological fish assemblages indicate that although fishing, not surprisingly, was not restricted to a particular season of the year, strong reliance on such spring-summer harvesting of impounded shallow water bottom feeding species (e.g., bowfin, suckers, bullheads, catfish) had been incorporated into indigenous subsistence economies in the Mississippi Valley Corridor by 7,300 B.P. (Styles et al. 1983:288-289), and remained a ''vital component of the Mississippian [post A.D. 1000] seasonal subsistence system'' (Yerkes 2005:250). Based on delta 15N values of between 7.0 and 9.0 percent (Schoeninger and Schurr 1998:128), Yerkes suggests that fish comprised perhaps 25 percent of the total protein intake for human societies in the American Bottom region of the Mississippi Valley after A.D. 1000. Other studies (e.g., Smith 1975; Springer 1980) document a comparably high level of reliance on fish by Pre-Columbian indigenous societies in the lower Mississippi Valley.

Two important points can be made regarding this harvesting of impounded bottom feeding fish species from seasonal shallow water settings by the small-scale societies of the Mississippi Valley Corridor. First, by the time the floodwaters had receded to a level that isolated the seasonal shallow water lakes and ponds from deep-water habitats, many of the adult fish that comprised breeding populations had already returned to the relative safety of the main channel and oxbow lakes. Here, human predation would have occurred at a much lower level and at a much higher cost. Second, even though a substantial percentage of the breeding populations of different species had in large measure returned to the safety of deep water, a large quantity and variety of fish were also now cut off and trapped in seasonally inundated shallow water settings. Even if left unharvested by humans, these fish would not survive to contribute to the reproductive cycle of the following year. As the volume of water in these seasonal pools decreased, the fish trapped in them would either fall prey to predators, human or otherwise, or would die of suffocation when the pools dried up completely (Paloumpis 1957). When placed in this context, the Pre-Columbian human harvesting of fish in the Mississippi Valley Corridor can be recognized, in large measure, as having very little impact on the breeding populations of the species involved because the indigenous small-scale societies of the region placed an understandable emphasis on the seasonal, low energy collection of impounded fish and the trapped fish, targeted for collection, had already been partitioned off from any contribution to future generations of their species. As was the case with the white-tailed deer, the fish populations of the Mississippi Valley corridor were thus able to sustain very substantial human harvests on an annual basis and, at the same time, were to a considerable degree immune to over-exploitation by human predation.

Migratory Waterfowl

Migratory waterfowl, a third species group of considerable importance in the diet of Mississippi Valley groups, also combined the two key characteristics of high potential annual yield on a sustained basis, with relative immunity to overexploitation by human hunters. They were utilized in large numbers during spring and fall migration seasons (as well as through the winter months in the central and lower valley) as they traversed the Mississippi Flyway. Forming an enormous funnel, the Mississippi Flyway has a northern mouth that stretches across the arctic tundra from Baffin Island to northeastern Alaska, and a southern spout formed by the floodplain of the lower Mississippi Valley, starting at Cape Girardeau Missouri and extending downstream to the Gulf of Mexico.

Throughout the Holocene, two dozen different species of ducks, geese, and swans have followed this flyway corridor on an annual basis as they moved between their continent-wide northern breeding grounds and their principal southern wintering grounds located in the lower Mississippi Valley and the coastal marshes of Louisiana (Smith 1975:64-76). The timing of the movement of waterfowl through the flyway each spring and fall is relatively well documented, and the migration patterns of different species, including first arrivals, peaks of movement, and total period of migration, vary little from year to year (Smith 1975:71).

Given the extent of historical habitat destruction along the flyway in the last hundred years, it is difficult to accurately estimate the number of birds that both wintered in the lower Mississippi Valley portion of the flyway and followed it back and forth from their breeding grounds prior to European contact. Twentieth-century migration census information collected on the significantly depleted waterfowl populations, however, provide a solid modern baseline for comparison. Only a dozen species are bagged within the flyway today with any regularity, and of the 10 species that make up 95 percent of the modern day sport-hunting harvest, 70 percent are mallard ducks (*Anas rubripes*). Each fall, usually in the first week of November, the Mississippi Flyway witnesses the ''Grand Passage'' of mallards, as *two to three million* birds flood the flyway on their way to occupying wintering grounds in the central and lower sections of the valley and along the coastal marshes of Louisiana. Numerous historical accounts attest to the ubiquitous rich abundance of waterfowl along the flyway in the spring and fall, and throughout the winter in the central and lower valley. As mallards and other species of waterfowl both move through the flyway and overwinter in the central and lower Mississippi Valley, they occupy the vast remnant channel aquatic habitats, which provide abundant food for both shallow water dabblers and deeper diving species. Mallards and other dabblers are also known to frequent harvested fields in search of overlooked grain and may have similarly exploited pre-Columbian fields and gardens.

Like deer and fish, migratory waterfowl would have been an almost inexhaustible prey species through the fall, winter, and spring along much of the central and lower valley. On the one hand, their northern tundra nesting grounds are located far from the reach of Mississippi Valley hunters, ensuring the integrity of breeding populations once they traverse the flyway. This isolation of ''capital account'' nesting areas would be moot, of course, if breeding populations were decimated by hunting as they move through the flyway. Modern hunting statistics, however, underscore the substantial number of birds that can be harvested in the flyway on a sustained basis without impacting the reproductive potential of breeding populations. According to US Fish and Wildlife Service statistics, for example, the sustainable waterfowl harvest in 2003 in Arkansas alone involved 72,000 registered duck hunters who shot 510,000 mallard ducks and more than 1.1 million total ducks (U.S. Fish and Wildlife Service nd). Both in terms of isolated breeding grounds and the sheer volume of birds involved, migratory waterfowl prior to European contact were immune to overharvesting during their spring and fall migrations.

Human Niche Construction

Along with relying on prey species/species groups that had high reproductive potential and were resistant to over-harvesting (thus ensuring a reliable and sustainable source of meat protein), the small-scale societies of the Mississippi Valley Corridor also played a very active role in ''improving'' their natural world in ways that contributed to the stability and sustainability of the both the animal and food plant portions of their subsistence economies. The focus of discussion here is their management of non-domesticated plants, and I begin with a general consideration of human niche construction and the basic goal of shifting of vegetation communities toward early successional stages.

Efforts by human societies to shape their natural landscapes, in particular their efforts to selectively manipulate non-domesticated plant components of biotic communities, have been classed under a number of terms over the past seven decades, including ''environmental manipulation,'' ''indigenous management,'' ''domesticated landscapes,'' ''indigenous resource management,'' and ''traditional resource management'' (Smith 2007). All of these overlapping terms and characterizations can be comfortably included under the more general heading of ''niche construction.'' Niche construction is defined as ''organism-driven environmental modification'' (Odling-Smee et al. 2003), and through niche construction or ''ecosystem engineering,'' many organisms reshape both their own environments and those of other organisms and in so doing modify the natural selection pressures acting on a range of other components of the biotic community (Jones et al. 1997). Not surprisingly, humans are recognized as ''the ultimate niche constructors'' (Odling-Smee et al. 2003).

Just as it is difficult to establish the extent to which the indigenous Pre-Columbian societies of the eastern woodlands employed premeditated conservation measures, it is similarly challenging to measure on an overall regional scale and with any degree of accuracy, the extent to which they actively modified their environments. While pollen and charcoal records do document human clearance efforts at the local level (e.g., Delcourt 1993; Delcourt and Delcourt 2004; Delcourt et al. 1986), extrapolating these data points into overall regional assessments of long-term landscape modification is more problematic. Human alteration of eastern North American ecosystems certainly occurred prior to European contact, but quantifying the overall scale of impact–how different the landscapes would have looked in 1491 in the absence of 10,000 years of human presence–is a complex problem, leaving considerable room for alternative speculative scenarios (e.g., Mann 2006; Smith 2010).

While it may be difficult to either recognize deliberate resource conservation or accurately measure the overall regional impact these groups actually had in shaping the ecosystems of eastern North America, it is possible to look in the archaeological and ethnohistoric records for indications of the ways in which they modified and enhanced their surroundings throughout the Holocene. The major form of ecosystem modification carried out by the Pre-Columbian inhabitants of the region was of course the creation and expansion of agricultural landscapes–the replacing of natural biotic communities with fields and gardens of domesticated plants (Doolittle 2000). This began at about 5,000 years ago with the independent domestication of four indigenous species of seed plants (Smith 2006c). The importance of low-level food production economies then intensified at around 500 to 200 B.C., and a subsequent broad-scale shift to maize-centered agriculture occurred at around A.D. 800 to 1000 (Smith 2006d).

The efforts by small-scale societies to shape Mississippi Valley landscapes in ways that improved their food supply were not, however, restricted to growing crops. Even before the initial domestication of local seed plants in the East and continuing well into the historic period, indigenous societies of many areas of the eastern woodlands also actively and systematically modified their environments in ways that increased and enhanced the reliability and ease of acquisition of non-domesticated species of plants and animals (e.g., the white-tailed deer). These efforts contributed substantially to the sustainability of human subsistence economies in the region.

An obvious initial observation to be made regarding efforts by the indigenous societies of the eastern woodlands to modify their surroundings is that their general goal in altering ecosystems was to ''enhance'' the environment in ways that enabled them ''to capture a larger proportion of total biotic energy'' (Smith and Wishnie 2000: 497). A significant percentage of all such human activities that could be designated as niche construction, and which increase the potential human share of an ecosystem's total energy budget, can be generally recognized as involving some form of disturbance of plant communities, both incidental (e.g., establishing settlements, pathways, etc.), and deliberate (controlled burning or manual clearance of vegetation for cultivation of crops, or to selectively encourage wild species of plants and animals).

Comparable in many respects to natural events (e.g., fires, the seasonal reshaping of river valleys such as the Mississippi and its tributaries due to floods, and the openings in forests resulting from tree falls), human disturbance of vegetation, when occurring at intermediate levels of frequency and intensity, is acknowledged as increasing species diversity within ecological communities (Anderson 2003, 2005; Blondel and Aronson 1999; Johnson Gottesfeld 1994; Lewis 1982; Lewis and Ferguson 1988; Perry and Amaranthus 1997; Smith and Wishnie 2000). Importantly, the increase in biodiversity caused by vegetation disturbance occurs among those species of both plants and animals that occupy the early successional habitats of open edge areas. This is, in turn, of clear benefit to human societies, since many of the wild species of plants and animals they rely upon as food sources fall into this early successional category.

Although creation of agricultural landscapes–the controlled burning and manual clearance of vegetation for agricultural fields–is the most obvious human activity that shifts vegetation communities toward earlier successional habitats, evidence of vegetation modification in non-agricultural settings in eastern North America, particularly through the use of fire, is widespread (Black et al. 2006; Clark and Royall 1995; Day 1953; Delcourt et al. 1998; Dorney and Dorney 1989; Patterson and Sassaman 1988; Russell 1983).

Transplanting of fruit-bearing and other perennial species

In addition to shifting local vegetation communities toward earlier successional composition through the general practice of manual clearance and controlled burning of vegetation, indigenous societies in different regions of the East also sometimes altered the close-in environment of their settlements by a much more focused form of environmental engineering. Seeking out a limited number of desirable species of long-lived (perennial) food plants that were scattered across the landscape, they would relocate them closer to their habitation sites. As Doolittle (2000:43) notes, this general practice of transplanting long-lived species adjacent to settlements allowed for easier harvesting and shorter travel time. It would also have strengthened perceptions of ownership of the resources, reduced unwanted harvesting of crops by human and non-human interlopers, and have facilitated the monitoring and harvesting of fruits, berries, and other plant parts as they matured.

In the eastern woodlands of North America, a variety of fruit-bearing trees that flourish in open, sunny forest edges and clearings were a primary focus of such transplanting efforts. Kris Gremillion (2010) lists a number of species that were likely candidates for relocation, including honeylocust, gum, elderberry, mulberry, hackberry, sugarberry, hawthorn, plum, cherry, and persimmon. After its introduction, peach also became a widespread addition to these ''orchards'' of the Southeast (Newsom and Trieu Gahr 2010). William Bartram and other early travelers through the region mention plums, peaches, persimmons, beautyberry, and red mulberry, among other species, growing adjacent to old Indian settlements (Bartram 1791; Hammett 1997:201). Although it is difficult to establish the size, frequency, and species composition of these ''orchards'' prior to European contact, there is a long record of the use of fleshy fruits in the eastern woodlands throughout the Holocene and a clear increase in the quantity and variety of fleshy fruit seeds occurring in archaeological contexts over time (Gremillion 2010).

Many early historical accounts of the eastern woodlands of North America also describe a variety of different berry crops growing in ''old fields'' around Indian settlements (Doolittle 2000; Gremillion 2010; Hammett 1997). Wild strawberry, groundcherry, and *Rubus* species (dewberry and blackberry) were often observed thriving in open areas adjacent to settlements, and understory shrubs that produced edible fruits such as raspberry, blueberry, cranberry, serviceberry, and huckleberry were recorded as commonly present in overgrown fields (Gremillion 1998; Swanton 1946:281; Yarnell and Black 1985).

Given that these fruit-bearing species required open, sunny forest edge and clearings habitat, they would have been shaded out relatively quickly following the abandonment of pre-Columbian settlements and the return of overstory canopy vegetation. The signature of their presence, however, has occasionally been recorded when early 19th-century land surveys and witness tree records were obtained within a decade or two after settlements ceased to exist (Foster et al. 2004). In addition, on-site pollen assemblages hold the potential of documenting the presence of fruit-bearing species in close proximity to Pre-Columbian settlements (Hebda et al. 2005).

Broadcast sowing of new stands of annual seed-bearing plants

Another important niche construction activity of indigenous societies in eastern North America involved the creation of new stands of seed-bearing annuals through the simple practice of broadcast sowing of harvested seed. In the early 18th century, Le Page du Pratz described Natchez women and children scattering the seeds of a plant he called ***choupichoul*** along the exposed sandbanks of the lower Mississippi River (Smith 2006a). The species involved, *Chenopodium berlandieri* Moq., is today a common pioneering species of river valley settings in the eastern woodlands, where it colonizes a variety of open and disturbed soil environments, both anthropogenic and natural. It particularly favors open sand bank settings exposed by the receding floodwaters of spring (Smith 2006b). Given the preferred habitat of *C. berlandieri* and its aggressive pioneering of sandy river valley soils, along with du Pratz's description of it being sowed on exposed sand banks of the Mississippi river in the 1720s, it is clear that the Natchez were establishing new stands of an indigenous seed plant in appropriate habitats as they were exposed by receding floodwaters each spring.

Dependant upon a variety of vectors of seed dispersal in river valley settings, including spring floodwaters, *C. berlandieri* today is usually found only in small patches or as isolated plants, rather than in extensive stands. In full sun settings, individual free-living *C. berlandieri* plants can grow to six feet in height and produce up to 50,000 small seeds, and once planted, would have required very little, if any, attention from humans during the growing season (Smith 2006b). In contrast to the small patches and isolated individual plants of today, the Natchez could have created large and very productive stands of this economically important annual seed plant with an investment of relatively little effort.

It is not possible to establish if the seeds scattered by the Natchez had been harvested from local wild stands of chenopod the preceding fall, or if they represented the seed stock of the domesticated *C. berlandieri* that had been grown in eastern North America for more than 3,000 years (Smith 2007). In either case, the sowing of chenopod seeds on exposed sand bank settings represents a niche construction activity deliberately designed to ''enhance'' the environment in ways that enabled human societies to capture a larger proportion of an ecosystem's total biotic energy. Similar sowing of the seed of wild species has been described in a number of other areas of North America (Bonnicksen et al. 1999:452). Although this form of ecosystem engineering could have taken place along many of the river valleys of the eastern woodlands and could have had considerable time depth, such efforts would not have occurred in exactly the same locations from year to year. Spring floodwaters would have reshaped river valley topography, shifting the location of prime sandbank real estate on an annual basis and necessitating the relocation of anthropogenic chenopod stands each year. Broadcast sowing of chenopod, then, provides an interesting contrast to the transplanting of perennial fruit crops. In both cases human effort was directed toward encouraging early succession species, and involved the deliberate placement of resources on the landscape. In the case of the transplanting of wild perennial crop plants, however, human effort was directed toward relocating the target species to relatively stable habitats created and maintained by humans close to their settlements. In the case of chenopod, on the other hand, human niche construction efforts focused on facilitating the dispersal of seed to naturally created habitats that shifted in location from year to year.

In situ enhancement and expansion of nut and mast-bearing trees

The small-scale societies of eastern North America also increased the reliability and potential harvest yield of existing stands of nut and mast bearing trees through in-place expansion and enrichment of their habitats. Although larger and later-successional-stage nut and mast-bearing trees, such as oaks, hickories, and walnut, are sometimes mentioned as occurring among the fruit and berry producing species of close-in transplanted ''orchards'' (Bartram 1791; Gremillion 2010), they are more often described as being scattered both within abandoned fields and beyond, where they would have been selectively encouraged *in situ*. Hammett (1997:197), for example, outlines a general abstract pattern of landscape management by pre-European societies of eastern North America that is comparable to that documented in many areas of the world, with settlements and their adjacent small gardens encircled by two resource catchment zones–a close-in area of actively cultivated and fallow fields, and surrounding it, a wooded zone which served as an extremely valuable combination of orchard, hunting park, and woodlot, as well as a gradual territory margin. Selective retention of overstory nut and mast-bearing trees during field clearance could have resulted in their scattered distribution in the close-in zone of active and fallow fields (Black et al. 2006; Foster et al. 2004; Wykoff 1991). In outlying forest areas, the relative abundance of these taxa would have been increased by a lower level of selective encouragement. Controlled burning along with other methods of thinning both understory and canopy species could have encouraged larger and higher yielding nut and mast-bearing trees (Gremillion 2010; Hammett 1997; Munson 1986; Yarnell 1964, 1982). Such a broad-scale niche construction practice has been suggested as having a deep time depth in eastern North America based on pollen records (Delcourt et al. 1998) and a shift from closed to open canopy squirrel species (Munson 1986). As settlements and their concentric resource catchment zones were periodically relocated throughout forest zones of eastern North America, they would have left behind a legacy of fallow-cycle vegetation communities that were substantially enriched in forest species of economic value in comparison to their composition prior to clearing. Following settlement abandonment, as overstory canopies encroached on and reduced the habitat of early successional species, the larger, later successional trees of economic value that had been previously encouraged would continue to dominate the forest structure.

Discussion

As noted in the introduction to this article, the deciduous woodlands of eastern North America include a great variety of different environments, and the Pre-Columbian societies of the region developed, across space and time, very successful and quite diverse subsistence economy solutions to their spatially constrained resource catchments (e.g., Styles 1981). Unraveling and gaining a better understanding of the evolution of these local-scale adaptive solutions represents both a central and complex future challenge for archaeobiologists and archaeologists.

While acknowledging these broad temporal and geographical patterns of variation in subsistence economies across the eastern United States, I also think that it is worthwhile to acknowledge that in the Mississippi Valley Corridor, it is possible to recognize the existence of an underlying set of common foundational elements which together comprise a basic adaptive structure or *Bauplan* (Zeder 2009). I have briefly presented here what I believe to be the two core aspects of the underlying *Bauplan* that supported the long-term sustainability of human subsistence economies during the Middle and Late Holocene: 1) a primary reliance for protein on a set of animal species and species groups (deer, fish, migratory waterfowl) that combined both a high biotic potential and relative immunity from over-exploitation; and 2) a coherent and integrated overall strategy of restructuring vegetation communities in ways that enhanced and expanded the habitats of many plant (and some animal) species that were important sources of food and raw materials.

Both premeditated conservation measures and the default factors (low population, low demand, limited technology) identified by Smith and Wishnie (2000) certainly contributed to the sustainable nature of the subsistence economies of the indigenous small-scale Pre-Columbian societies of the region. In terms of the analysis and understanding of sustainability in a broader context, however, it is also worthwhile to view the subsistence economies of small-scale societies in general from a different vantage point and to take a closer look both at the relevant characteristics of the primary species targeted for utilization and the manner in which groups selectively reshaped their environments to their benefit. This analysis of the core foundation of sustainability of subsistence economies of the indigenous Pre-Columbian societies of the Mississippi Valley does not provide any amazing discoveries or ''silver bullet'' solutions for the present-day challenges that face us. Lessons of sustainability learned from small-scale societies rarely translate into solutions within the context of present-day globalized economies. It is, nonetheless, interesting to note that the two basic ''secrets'' to the long-term success and sustainability of Pre-Columbian subsistence economies in the Mississippi Valley were: 1) not drawing down or otherwise impacting ''capital account'' breeding populations of resource species; and 2) carrying out only moderate levels of vegetation modification ''niche construction'' activities designed to ''enhance'' the environment for human benefit. It is also perhaps obvious, but still interesting, to note the extent to which human subsistence economies in the Pre-Columbian Mississippi Valley fit comfortably within the overall structure of the ecosystem. Predation on deer, fish, and migratory waterfowl did not alter or impact the overall general health of the prey species, and in the absence of human predation, other predators or mortality factors likely would have shaped the species in question in similar ways. Similarly, many of the specific methods of human ecosystem engineering described above also represent anthropogenic analogs to events, processes and landforms that occur in nature, such as fire clearance of trees and grasslands, forest clearings due to windfalls, flood scoured sand banks, and seasonal stranding of fish in oxbow lakes. This mimicking of natural processes represents another obvious hallmark of sustainability in small-scale societies.

Note

[1] Small-scale societies are defined as ones ''that maintain political autonomy at the level of one or a few local communities and, hence, number a few hundred to a few thousand inhabitants'' (Smith and Wishnie 2000:493).

References Cited

Anderson, M. Kat.
2003 Native Californians as Ancient and Contemporary Cultivators. In *Before the Wilderness: Environmental Management by Native Californians*, eds. T.C. Blackurn and M.K. Anderson, pp. 151–174. Ballena, Menlo Park.
2005 *Tending the Wild*. University of California Press, Berkeley.

Bartram, William.
1791 *Travels Through North & South Carolina, Georgia, East & West Florida, the Cherokee Country, The Extensive Territories of the Muscogulges, or Creek Confederacy, and the Country of the Chactaws; Containing an Account of the Soil and Natural Productions of Those Regions, Together with Observations on the Manners of the Indians*. James and Johnson, Philadelphia.

Black, Bryan A., Charles M. Ruffner, and Marc D. Abrams.
2006 Native American Influences on the Forest Composition of the Allegheny Plateau, Northwest Pennsylvania. *Canadian Journal of Forest Research* 36:1266–1275.

Blondel, Jacques and James Aronson.
1999 *Biology and Wildlife of the Mediterranean Region*. Oxford University Press, Oxford.

Bonnicksen, Thomas M., M. Kat Anderson, Henry T. Lewis, Charles E. Kay, and Ruthann Knudsen.
1999 Native American Influences on the Development of Forest Ecosystems. In *Ecological Stewardship: A Common Reference for Ecosystem Management*, Vol II, eds. C. Johnson, A.J. Malk, R. Szaro and W.Y. Sexton, pp. 439–470. Elsevier Science Ltd., Oxford.

Brohn, A. and D. Robb.
1955 Age Composition, Weights, and Physical Characteristics of Missouri Deer 1944-1951. Pittman-Robertson Series, No. 3, Missouri Conservation Commission, Columbia.

Clark, J.S. and P.D. Royall.
1995 Transformation of a Northern Hardwood Forest by Aboriginal (Iroquois) Fire: Charcoal Evidence from Crawford Lake, Ontario, Canada. *The Holocene* 5:1–9.

Crawford, Gary W.
2010 People and Plant Interactions in the Northeast. In *The Subsistence Economies of Indigenous North American Societies*, ed. B.D. Smith. Smithsonian Institution Scholarly Press, Washington D.C. (in press).

Day, Gordon M.
1953 The Indian as an Ecological Factor in the Northeastern Forest. *Ecology* 24: 329–346.

Delcourt, Hazel R.
1993 The Impact of Prehistoric Agriculture and Land Occupation on Natural Vegetation. *Trends in Ecology and Evolution* 2:39–44.

Delcourt, Paul A. and Hazel Delcourt.
2004 *Prehistoric Native Americans and Ecological Change*. Cambridge University Press, Cambridge.

Delcourt, Paul H., Hazel Delcourt, Pat Cridlebaugh, and Jefferson Chapman.
1986 Holocene Ethnobotanical and Paleoecological Record of Human Impact on Vegetation in the Little Tennessee River Valley, Tennessee. *Quaternary Research* 25:330–349.

Delcourt, Paul A., Hazel R. Delcourt, Cecil R. Ison, William E. Sharp, and Kristen J. Gremillion.
1998 Prehistoric Human Use of Fire, the Eastern Agricultural Complex, and Appalachian Oak-Chestnut Forests: Paleoecology of Cliff Palace Pond, Kentucky. *American Antiquity* 63:263–278.

Doolittle, William E.
2000 *Cultivated Landscapes of Native North America*. Oxford University Press, Oxford.

Dorney, Cheryl H. and John R. Dorney.
1989 An Unusual Oak Savanna in Northeastern Wisconsin: The Effect of Indian-caused Fire. *American Midland Naturalist* 122:103–113.

Emerson, Thomas E., Dale L. McElrath, and Andrew C. Fortier.
2000 *Late Woodland Societies: Tradition and Transformation across the Midcontinent*. University of Nebraska Press, Lincoln.

Foster, H. Thomas II, Brian Black, and Marc D. Abrams.
2004 A witness tree analysis of the effects of Native American Indians on the Pre-European Settlement Forests in East-Central Alabama. *Human Ecology* 32:27–41.

Gremillion, Kristen J.
1998 Prehistoric Human Use of Fire, the Eastern Agricultural Complex, and Appalachian Oak-Chestnut Forests: Paleoecology of Cliff Palace Pond, Kentucky. *American Antiquity* 63:263–278.
2010 The Role of Plants in Southeastern Subsistence Economies. In *The Subsistence Economies of Indigenous North American Societies*, ed. B.D. Smith. Smithsonian Institution Scholarly Press, Washington (in press).

Geist, V.
1999 Periglacial ecology, large mammals, and their significance to human biology. In *Ice age peoples of North America: environments, origins, and adaptations of the first Americans*, eds. R. Bonnischsen and K.L. Turnmire, pp. 78–94. Oregon State University Press, Corvallis.

Hammett, Julia.
1997 Interregional Patterns of Land Use and Plant Management in Native North America. In *People, Plants and Landscapes: Studies in Paleoethnobotany*, ed. K.J. Gremillion, pp. 195–216. University of Alabama Press, Tuscaloosa.

Hebda, Richard J., Marlow G. Pellatt, Rolf W. Mathewes, Daryl W. Fedje, and Steven Acheson.
2005 Vegetation History of Anthony Island, Haida Gwaii, and its relationship to Climate Change and Human Settlement. In *Haida Gwaii: Human History and Environment from the Time of Loon to the Time of the Iron People*, eds. D.W. Fedje and R.W. Mathewes, pp. 59–76. University of British Columbia Press, Vancouver.

Hudson, Charles.
1970 The Cherokee Concept of Natural Balance. *The Indian Historian* 3:51–54.
1976 *The Southeastern Indians*. University of Tennessee Press, Knoxville.

Johnson Gottesfeld and Leslie, M.
1994 Conservation, Territory and Traditional Beliefs: An Analysis of Gitksan and Wet'suwet'en Subsistence, Northwest British Columbia, Canada. *Human Ecology* 22:443–465.

Jones, C.G., J.H. Lawton, and M. Shachak.
1997 Positive and Negative Effects of Organisms as Physical Ecosystem Engineers. *Ecology* 78:1946–1957.

Lapham, Heather A.
2005 *Hunting for Hides*. University of Alabama Press, Tuscaloosa.
2010 Animals in Southeastern Native American Subsistence Economies. In *The Subsistence Economies of Indigenous North American Societies*, ed. B.D. Smith. Smithsonian Institution Scholarly Press, Washington, D.C. (in press).

Lewis, Henry T.
1982 A Time for Burning. Boreal Institute for Northern Studies. Occasional Publication, No. 17, University of Alberta, Edmonton.

Lewis, Henry T. and T.A. Ferguson.
1988 Yards, Corridors, and Mosaics: How to Burn a Boreal Forest. *Human Ecology* 16:57–77.

Limp, W. Frederick and Van A. Reidhead.
1979 An Economic Evaluation of the Potential of Fish Utilization in Riverine Environments. *American Antiquity* 44: 70–78.

Lopinot, Neal and William I. Woods.
1993 Wood Overexploitation and the Collapse of Cahokia. In *Foraging and Farming in the Eastern Woodlands*, ed. M. Scarry, pp. 206–231. University Press of Florida, Gainesville.

Mann, Charles C.
2006 *1491: New Revelations of the Americas Before Columbus*. Knopf, New York.

Munson, Patrick.
1986 Hickory Silviculture: a Subsistence Revolution in the Prehistory of

Eastern North America. Paper presented at the Conference on Emergent Horticultural Economies of the Eastern Woodlands, Carbondale, Illinois.

Newsom, Lee A. and D. Ann Trieu Gahr.
2010 Fusion Gardens: Native North America and the Columbian Exchange. In *The Subsistence Economies of Indigenous North American Societies*, ed. B.D. Smith. Smithsonian Institution Scholarly Press, Washington, D.C. (in press).

Odling-Smee, F.J., K.N. Laland, and W. Feldman.
2003 Niche construction. *Monographs in Population Biology, No. 37*. Princeton University Press, Princeton.

Paloumpis, Andreas.
1957 The Effects of Drought Conditions on the Fish and Bottom Organisms of Two Small Oxbow Ponds. *Transactions of the Illinois State Academy of Science* 50:60–64.

Patterson, William A. and Kenneth Sassaman.
1988 Indian Fires in the Prehistory of New England. In *Holocene Human Ecology in Northeastern North America*, ed. G.P. Nicholas, pp. 107–135. Plenum Publishing, New York.

Perry, D.A. and M.P. Amaranthus.
1997 Disturbance, Recovery, and Stability. In *Creating a Forestry for the 21st Century: The Science of Ecosystem Management*, eds. K.A. Kohm and J.F. Franklin, pp. 31–56. Island Press, Washington, D.C.

Robertson, Walter V.
1969 Population Dynamics of White-tailed Deer. In *White-tailed Deer in the Southern Forest Habitat*. Southern Forest Experiment Station, Forest Service, U.S. Department of Agriculture, Nacogooches.

Russell, Emily W.B.
1983 Indian-set fires in the Forests of the Northeastern United States. *Ecology* 64:78–88.

Sassaman, Kenneth and David Anderson, editors.
1996 *Archaeology of the Mid-Holocene Southeast*. University Press of Florida, Gainesville.

Schoeninger, M. and M. Schurr.
1998 Human Subsistence at Moundville: The Stable Isotope Data. In *Archaeology of the Moundville Chiefdom*, eds. V.J. Knight and V. Steponaitis, pp. 120–132. Smithsonian Institution Press, Washington, D.C.

Smith, Bruce D.
1974 Predator-Prey Relationships in the Southeastern Ozarks- A.D. 1300. *Human Ecology* 2:31–43.
1975 Middle Mississippian Exploitation of Animal Populations. Anthropological Papers, No. 57, Museum of Anthropology, University of Michigan, Ann Arbor.
1986 The Archaeology of the Southeastern United States: From Dalton to de Soto, 10,500-500 B.P. In *Advances in World Archaeology, Vol. 5*, eds. F. Wendorf and A. Close. Academic Press, New York.
2006a In search of *Choupichoul*, the Mystery Grain of the Natchez. In *Rivers of Change*. University of Alabama Press, Tuscaloosa.
2006b The Economic Potential of *Chenopodium berlandieri* in Prehistoric Eastern North America. In *Rivers of Change*. University of Alabama Press, Tuscaloosa.
2006c Eastern North America as an Independent Center of Plant Domestication. *Proceedings of the National Academy of Sciences* 103:12223–12228.
2006d *Rivers of Change*. University of Alabama Press, Tuscaloosa.
2007 Niche Construction and the Behavioral Context of Plant and Animal Domestication. *Evolutionary Anthropology* 16:188–199.
2010 Shaping the Natural World: Patterns of Human Niche Construction by Indigenous Small-Scale Societies in North America. In *The Subsistence Economies of Indigenous North American Societies*, ed. B.D. Smith. Smithsonian Institution Scholarly Press, Washington, D.C. (in press).

Smith, Eric A. and Mark Wishnie.
2000 Conservation and Subsistence in Small-Scale Societies. *Annual Review of Anthropology* 29:493–524.

Springer, J.W.
1980 An analysis of prehistoric food remains from the Bruly St. Martin site, Louisiana, with a comparative discussion of Mississippi Valley faunal studies. *Mid-Continental Journal of Archaeology* 5:193–223.

Styles, Bonnie W.
1981 Faunal Exploitation and Resource Selection: Early Late Woodland Subsistence in the Lower Illinois Valley. *Scientific Papers, No. 3*. Northwestern University Archaeology Program, Evanston.
2010 Animal Use by Holocene Aboriginal Societies of the Northeast. In *The Subsistence Economies of Indigenous North American Societies*, ed. B.D. Smith. Smithsonian Institution Scholarly Press, Washington, D.C. (in press).

Styles, Bonnie W., Steven R. Ahler, and Melvin L. Fowler.
1983 Modoc Rock Shelter Revisited. In *Archaic Hunters and Gatherers in the American Midwest*, eds. J.L. Phillips and J.A. Brown, pp. 261–297. Academic Press, New York.

Swanton, John R.
1946 The Indians of the Southeastern United States. *Bureau of American Ethnology Bulletin, No. 137*. U.S. Government Printing Office, Smithsonian Institution, Washington, D.C. (Reprinted: Classics in Smithsonian Anthropology 2; Smithsonian Institution Press, Washington, 1979.).

Tainter, Joseph.
2006 Archaeology of Overshoot and Collapse. *Annual Review of Anthropology* 35:59–74.

Turner, Nancy J. and Fikret Berkes.
2006 Coming to Understanding: Developing Conservation through Incremental Learning in the Pacific Northwest. *Human Ecology* 34:495–513.

United States Fish and Wildlife Service.
n.d. Available at: http://www.flyways.us/regulations-and-harvest/harvest-trends (verified 18 September 2009).

Wolverton, S., L. Nagaoka, J. Densmore, and B. Fullerton.
2008 White-tailed deer harvest pressure & within-bone nutrient exploitation during the mid to late Holocene in southeast Texas, USA. *Before Farming* 2008(2):article 3.

Wykoff, William.
1991 Black Walnut on Iroquoian Landscapes. *Northeast Indian Quarterly* 4: 4–17.

Yarnell, Richard A.
1964 Aboriginal Relationships Between Culture and Plant Life in the Upper Great Lakes Region. *Anthropological Papers, No. 23*. Museum of Anthropology, University of Michigan, Ann Arbor.
1982 Problems of Interpretation of Archaeological Plant Remains of the Eastern Woodlands. *Southeastern Archaeology* 1(1):1–7.

Yarnell, Richard A. and M. Jean Black.
1985 Temporal Trends Indicated by a Survey of Archaic and Woodland Plant Food Remains from Southeastern North America. *Southeastern Archaeology*. 93–106.

Yerkes, Richard W.
2005 Bone Chemistry, Body Parts, and Growth Marks: Evaluating Ohio Hopewell and Cahokia Mississippian Seasonality, Subsistence, Ritual, and Feasting. *American Antiquity* 70:241–265.

Zeder, Melinda A.
2009 The Neolithic Macro-(Rev)olution: Macroevolutionary theory and the study of culture change. *Journal of Anthropological Archaeology* 17:1–63.