Historical and Applied Perspectives on Prehistoric Land Use in Eastern North America

EVAN PEACOCK

USDA Forest Service
Tombigbee National Forest
Rt. 1, Box 98A
Ackerman, MS 39735, USA
and
The University of Sheffield
Department of Archaeology and Prehistory
Northgate House, West Street
Sheffield S1 4ET, UK

SUMMARY

Despite mounting evidence to the contrary, many scientists continue to ignore prehistoric human impact as a factor in the development of ecosystems in eastern North America. One result is the promulgation of an 'Indian as natural conservationist' mythos in the popular media. Archaeological evidence demonstrates that prehistoric human activities caused significant environmental alteration in many parts of the region. The location, timing, and severity of such alteration varied greatly, suggesting that scientists must become familiar with the archaeological record on human/land interaction at the local level. Misinformation can lead to naive justifications for conservation or other land management activities. It is argued that archaeological data pertain to current theoretical concerns in ecology, such as establishing greater temporal depth in ecosystem studies and investigating the evolution of mosaic-type landscapes. Archaeology can also be used in raising the public environmental consciousness.

INTRODUCTION

In the last two decades, debate on a global scale has emerged concerning the degree to which non-industrialised native societies brought about environmental change through so-called 'traditional' land-use practices (e.g., Alvard 1993; Boyd 1990; Butzer 1982: 347; Head 1990, 1992, 1994; Kay 1994; Patterson and Sassaman 1988: 110). Considerations of the magnitude of anthropogenic impact engendered by prehistoric or ethnographically-known groups can be found in

Environment and History **4** (1998): 1-29

many sources, including the scientific literature of several disciplines, popular accounts of pre-European landscapes, and political dogma. Despite the contemporary nature of the debate, many ecologists, cultural geographers, biogeographers and other scientists working in eastern North America persist in the view that native American groups had no impact on the landscape, or worse, that they were somehow 'natural ecologists' whose mental templates precluded cultural activities that would be destructive to the environment. Such views tend to be uncritically adopted by non-scientific audiences with a conservationist agenda, while evidence to the contrary may be uncritically used by parties interested in obtaining commercial access to protected natural resources (Ingerson 1994: 54; cf. Head 1989, 1990).

The purpose of this paper is to examine the question of aboriginal land-use and its impacts in prehistoric and early Historic period eastern North America. The history of the debate as it has unfolded in the study area and elsewhere will be briefly reviewed, followed by examples of the scale at which prehistoric environmental impact took place in the Eastern Woodlands. The variable nature of such impact through space and time, as seen in the archaeological record, will be stressed, and the implications of such variability for environmental reconstructions will be discussed. The theoretical, applied, and ethical implications of archaeological and historical data pertaining to the subject will also be briefly explored.

'NATURAL CONSERVATIONISTS' OR 'JUST PEOPLE LIKE US?' THE DEVELOPMENT OF A CONTINUING GLOBAL DEBATE IN ECOLOGY, GEOGRAPHY, HISTORY AND ANTHROPOLOGY

Following the unprecedented mobilisation of people and resources and the physical devastation caused by World War II, geographers and other scientists began to become interested in humans as active participants in landscape alteration (e.g., Tivy 1990: 243; the papers in Thomas 1956). From the beginning, prehistoric peoples tended to be treated as non-factors in environmental degradation, due to two common misconceptions: that their technologies and/or population densities were insufficient to bring about significant environmental change and that, for 'primitive' people, 'all aspects of life are harmonised into a whole' (Ammal 1956: 327), i.e., that non-Western 'traditional' societies were culturally attuned to their environments in such a way that destructive practices did not occur (Kay 1994: 377-381; Simmons 1989: 113-114). Sauer was more perceptive, noting that with the advent of domestication, 'the natural land became deformed, as to biota, surface, and soil, into unstable cultural landscapes' (1956: 56). However, he then went on to downplay the destructive potential of slash-and-burn (swidden) agriculture by comparing it to modern plowing (1956: 57), a kind of comparison that became common for researchers

wishing to highlight the rampant destruction caused by modern agricultural methods.

The image of American Indians as natural conservationists became more widespread as ecological concepts were adopted into the popular culture of the 1970s and as conservation groups began to search for management alternatives to the destructive exploitation of natural resources (Kay 1994: 377). Fertig (1970), for example, wrote of a 'well-nigh perfect symbiosis' between Indians and the biotic environment, a symbiosis made possible by the Indians' 'nearly forgotten land wisdom,' their 'ecological sense' (Fertig 1970: 4-7). Responses to this idealistic view of native American land-use practices came immediately; for example, Guthrie's article entitled 'Primitive Man's Relationship to Nature' (Guthrie 1971), which pointed out apparent discrepancies between a supposed Indian land-use ideal and actual practice (cf. Kay 1994: 379). These included driving buffalo herds over cliffs, setting prairie fires to drive game, removal of only choice cuts of meat from animals killed in mass drives, and local depletion of game and fuelwood as a factor contributing to nomadism. In denouncing the idea of an aboriginal mind-set that precluded harmful environmental acts, Guthrie went so far as to point out 'the litter of bottles and junked cars to be found on Indian reservations today' (1971: 722), an argument described by a later writer as 'scurrilous' and a 'cheap shot' (Callicott 1982: 311). The subjective nature of some of Guthrie's observations and the vituperativeness of Callicott's response highlight an emotionalism that has tended to characterise the debate over native land-use practices, a phenomenon especially prevalent in non-scientific circles.

In central and eastern Europe, landscape ecology had been emerging as a discipline that expressly considered humans as integral components of ecosystems, a viewpoint that included a consideration of non-industrialised societies' land-use practices and their effects on the landscape (Naveh 1982: 189; Jacobs 1975: 195; Woebse 1975). Land management was at the heart of such considerations, anticipating a movement that would later emerge in English-speaking countries (Crumley 1994a: 240; Kay 1994; Nassauer 1995: 229; O'Neill et al. 1993; Robbins and Myers 1992: 9; Vankat 1977: 22). For example, van der Maarel stated that:

> in Europe – and...in most of the inhabited world – the natural ecosystems we are said to study and to consider the aim of nature conservation are not natural, except for a very few places with hardly any life at all; they are man-made natural ecosystems. Either man has changed the structure, if he exerts some form of exploitation, or a natural development is taking place on a former non-natural site. So man-made natural systems are in the very focus of environmental management (1975: 265).

Although appreciation of native societies' roles in shaping landscapes was growing in Europe (e.g., Delcourt 1987: 39; Edwards 1991: 61), the New World was still generally looked upon as a place where 'pre-European' could be

equated with 'natural', and indeed a place where European naturalists could turn to find pristine, natural systems for study (Ellenberg 1979: 401; Marquardt 1994: 206; Moore, In Press: 63). There were some exceptions to this on both sides of the Atlantic, including Vankat's (1977) study of ancient fire use in California and its contemporary management implications, Ellenberg's (1979) recognition that vegetation mosaics in Andean countries had begun to originate in prehistoric times, and a growing body of studies that recognised the scale at which prehistoric urban societies in Mesoamerica had affected the landscape (e.g., Abrams and Rue 1988; Binford et al. 1987; Brenner 1983; Deevey et al. 1979; Parsons and Denevan 1967; Rice 1976, 1978; Rice et al. 1985; Rue 1986; Siemens and Puleston 1972; Turner 1974). It was still commonly held, however, that prehistoric farming techniques probably had relatively little impact on soil structure (e.g., Ellenberg 1979: 411; Goudie 1981: 39; Orme 1981: 73-74), even though sedimentological studies (e.g., Oldfield et al. 1980) and ethnographic evidence (Orme 1981: 70) were demonstrating that land clearance could take place on a massive scale using 'primitive' techniques. In eastern North America, 'presettlement' was being commonly used as a synonym for 'pre-European' (e.g., Anderson and Anderson 1975).

Gradually, human ecologists and other scientists began to realise that the 'semantic polarity between natural-unspoiled-wilderness-climax on the one hand, and man-made-spoiled-artificial, on the other' (Naveh 1982: 190) was a mental construct of Western thinking that inhibited research into natural systems (Crumley 1994a: 239; Gómez-Pompa and Kaus 1992; McGlade 1995: 115; Naveh 1982: 190). The importance of interdisciplinary input into the field of human ecology was recognised (e.g., Naveh 1982: 191) and this included a recognition of the importance of archaeological data to the field (Butzer 1982). The relevance of such data still tended to be underplayed, however. While a few detailed archaeological studies were appearing that documented unequivocal prehistoric human impact in the Eastern Woodlands (e.g., Chapman et al. 1982), other studies dealing with archaeological remains in the region emphasised the 'harmonious' relationship between pre-Columbian native American groups and the environment (e.g., Taylor and Spurlock 1982: 49). Apparent digressions from this harmonious ideal as evidenced in the archaeological or historical literature were either ignored or explained away as being due to stressful circumstances brought about by contact with the Europeans. Certainly the Western 'bad' vs. native 'good' ways of perceiving nature were still being emphasised, as the following quote from Callicott (1982: 293) illustrates:

> ...the world view typical of American Indian peoples has included and supported an environmental ethic, while that of the Europeans has encouraged human alienation from the natural environment and an exploitative, practical relationship with it. I thus represent a romantic point of view; I argue that the North American 'savages' were indeed more noble than 'civilised' Europeans, at least in their outlook toward nature.

In 1983, an important work by William Cronon, *Changes in the Land: Indians, Colonists, and the Ecology of New England*, was published. Cronon noted the fallacy of attributing all significant past environmental change to European land-use practices in the absence of supporting data (1983: 9), pointing out that the 'Indians had lived on the continent for thousands of years, and had to a significant extent modified its environment to their purposes' (1983: 12). While he did not delve into the archaeological literature on prehistoric anthropogenic impact, he made extensive use of documentary sources to illustrate the changes that had taken place in New England landscapes both prior to and after arrival of the European colonists (cf. Baron 1988; Patterson and Sassaman 1988). Importantly, Cronon realised and made explicit the limitations of relying solely on historical sources for exploring past environmental changes (1983: 6; cf. Patterson and Sassaman 1988). On a scientific front, meanwhile, evidence continued to accumulate in the eastern United States and other parts of the world that prehistoric and contemporary 'primitive' land-use practices could, and did, affect local environments to a significant degree (e.g., Abrams and Rue 1988; Anderson 1987; Burrin and Scaife 1988; Corlett 1984; Delcourt 1987; Delcourt and Delcourt 1987: 167; Kay 1994; Newsom 1993; Redman 1992; Schmidt 1994; Toky and Ramakrishnan 1983; Whitehead and Sheehan 1985; Worsley and Oldfield 1988). Despite this mounting evidence, many researchers in the eastern United States continued to argue, based on historical sources, that Indians had had little impact on the landscape or that their impacts were largely confined to actual habitation areas (e.g., Russell 1983: 86). Others, especially geomorphologists and paleoecologists, continued to ignore the possibilities of prehistoric anthropogenic impact in the region (see discussion in Joyce 1988), instead explicitly equating 'pre-European' with 'natural' (e.g., Baker 1989: 24-25; Taylor 1989: 188). For example, Platts et al. (1987) state that:

> While a certain amount of information may be gained by studying riparian areas as they exist at this time, a complete understanding cannot be obtained without considering their *historical condition* – their *pristine state* and the ways that humans have altered it. Because many of these alterations took place when an area was *first settled*, it becomes necessary to consult the *historic record* for information on *original conditions* (1987: 93; emphasis added).

An interesting phenomenon began to emerge, wherein the role of pre-modern agriculture in altering the landscape was explicitly recognised (e.g., Jackson and Piper 1989: 1591 – 'soil erosion beyond replacement levels is an agriculture-old problem...the nature that produced us...has been almost totally destroyed or seriously damaged during the 8000-10000yr of agriculture'), yet the very researchers who made these connections continued to treat prehistoric North American Indian groups (many of whom had been agricultural for hundreds of years prior to the arrival of Europeans) as having had no effect upon the 'natural' landscape:

> the few relics of *pre-Columbian* vegetation that remain must serve as our best standards by which any agriculture touted as sustainable is to be judged...the patterns and processes discernible in *natural ecosystems* still remain the most appropriate standard available to sustainable agriculture (Jackson and Piper 1989: 1591-1592; emphasis added).

In 1992, the occasion of the 500th anniversary of Columbus' initial voyage to the New World fostered several critical assessments of the state of human/nature relations in American aboriginal societies at the time of European contact. These works specifically addressed the 'pristine myth' (Denevan 1992 – a.k.a. 'la leyende verde' [Whitmore and Turner 1992: 419], 'ecoethnographic romanticism' [Ingerson 1994: 54], 'the ecologically noble savage hypothesis' [Alvard 1993]) of a natural symbiosis between nature and native human groups in the Americas, an idealistic outlook that had gained renewed credence in the popular press (e.g., Sale 1990, Shetler 1991, Weatherford 1988). Examination of historical records provided unequivocal evidence concerning the extensive nature of aboriginal modification of the landscape for agriculture (Butzer 1992; Denevan 1992; Doolittle 1992; Whitmore and Turner 1992), game management (Denevan 1992: 372; Robbins and Myers 1992: 17-18), monument and road construction (Denevan 1992: 377), and so on. Most of these authors made only passing mention of actual lines of archaeological evidence, beyond the presence of visible features such as canals, mounds, or ridged fields (e.g., Doolittle 1992: 393-397) that could be examined. Butzer was an important exception, calling for a renewed emphasis on archaeological (1992: 347), paleobotanical and geomorphological work (1992: 348-349) in order better to understand the full impact of prehistoric technologies on the biophysical environment.

These critical analyses were timely, given that in the same year other works were appearing that continued to ignore the possibility of human influence on the paleoenvironmental record. For example, Foster et al. (1992) discussed the 'post-settlement' history of human land-use and vegetation dynamics in central New England – 'post-settlement' referring to Historic period Euroamerican habitation. Baker et al. (1992) examined evidence for shifting prairie/forest boundaries in the American midwest during the period from 10,000 to 3,500 B.P. While they noted that archaeological data could, and should, be used to address the subject (Baker et al. 1992: 387-388), human influence on the landscape (e.g., the intentional setting of prairie fires to drive game or over-harvesting of the scarce timber resource for construction, fuel, and other purposes) was not considered as a factor that may have altered the prairie/forest border through time; rather, all such changes were ascribed to climatic fluctuations. Based on fossil pollen data, Grimm and Jacobson state that in eastern North America:

> Deforestation, agriculture, and other intensive land disturbance accompanying European settlement caused large changes in vegetation. However, at many sites major vegetation changes began well before European contact, and the change in the

average curve during the last millenium has both European cultural and pre-Columbian components (Grimm and Jacobson 1992: 183).

The changes in forest type noted are attributed by the authors to the onset of the Little Ice Age; they fail to note that the 1,000 B.P. time line, when such changes begin to appear in the fossil pollen record, is coincident with the widespread advent of prehistoric maize agriculture throughout the region.

While there has since been a renewed emphasis on examining the impacts of past land-clearance and agriculture in Mesoamerica (e.g., Alcala-Herrera et al. 1994; Butzer 1996; Gómez-Pompa and Kaus 1992; Lozano-García et al. 1993; O'Hara et al. 1993; Sluyter 1994) and more sophisticated efforts at understanding the land-use ideals of contemporary foragers (e.g., Gottesfeld 1994), humans as a long-term ecological factor continue to be downplayed or ignored in many parts of North America north of Mexico (see Kay 1994 for an important exception). For example, Nordt et al. (1994) examined late Quaternary vegetation changes in central Texas using organic carbon isotope compositions in alluvial soils. While they noted that 'prehistoric humans often started grassland fires as a means of manipulating wildlife populations...thereby altering fire frequency and, potentially, vegetation composition' (Nordt et al. 1994: 118), they went on to state that 'it is not possible to determine the relative importance of these potential agents of vegetation change in our study' (1994: 118) and subsequently ascribed noted vegetation changes to shifts in the climatic regime. Rhodes and Davis (1995) examined late Holocene sediment input in a small water body in Maine in order to 'study lake responses to changes in a landscape similar to today's, but prior to European settlement about 350 years ago' (1995: 734-735). They found evidence for several episodes of pronounced terrestrial erosion and postulated that 'each horizon reflects a disturbance in the terrestrial catchment...evidence presented in the charcoal section indicates that most of these episodes were initiated by forest fires' (1995: 738). There is no mention of humans as possible agents in these pre-European landscape disturbance events. Similarly, Baker (1995) displayed data on 'natural' fire regimes (pre-1900) and those affected by 'European settlement and fire suppression' (1995: Table 1). It is clear from his discussion that 'pre-European' is considered to be synonymous with 'natural' (1995: 144). Beach (1994) used 'pre-settlement' to mean pre-European when examining the history of sedimentation in southern Minnesota, and did not mention the land-use practices of the historic tribes that inhabited the area prior to and during the period under question (mid-19th century onward). Many popular works, meanwhile, have continued to stress the theme of native Americans as natural conservationists (e.g., Bierhorst 1994) despite notable attempts by some ecologists to present a more balanced picture (e.g., Botkin 1995).

A charitable view is that the evidence presented in 1992 has not yet had time to be assimilated into current thinking on the topic of how American Indians affected the environment in times past. Another possibility is that many research-

ers would prefer to continue using pre-European landscapes in North America, especially eastern North America, as natural analogues against which modern environmental impacts can be judged.

This brief overview has not begun to touch upon the literature that exists on the subject. In particular, there is a vast number of works dealing with the use of fire by American Indians (e.g., Barrett and Arno 1982; Day 1953; Denevan 1992: 372; H. Lewis 1977; Myers and Peroni 1983; Patterson and Sassaman 1988; Russell 1983). However, it should serve to illustrate that the debate continues to this day. There are several other points that can be drawn out of the existing literature: 1) those researchers who do attempt to account for the influence of American Indians on the landscape tend to rely heavily on historical documents and ethnographic accounts (e.g., Russell 1983: 78), despite the limited temporal range and subjective biases inherent within such works (Denevan 1992: 375; cf. Galloway 1995: 13-21): archaeological information, while occasionally mentioned, is seldom actually incorporated into studies of landscape evolution; 2) the reliance on historical sources tends to produce a synchronic view of native American/environment relationships: variation through time (and space) is generally ignored; 3) those researchers who do make use of archaeological data tend to concentrate on areas outside of North America, such as Mexico and the Andean countries, where prehistoric state-level societies had developed (e.g., Butzer 1996; Whitmore and Turner 1992), or on the American Southwest, where prehistoric structures, canals, and other features are still highly visible on the landscape. The lack of attention to eastern North America serves to exacerbate the perception that prehistoric impact was minimal there, despite the known presence of large prehistoric populations. The next section of this paper will describe several examples of significant prehistoric environmental alteration in eastern North America and stress the variable nature of such alteration through time and space as revealed by archaeological investigations.

ARCHAEOLOGICAL EVIDENCE FOR PREHISTORIC ANTHROPOGENIC IMPACT IN THE EASTERN UNITED STATES

According to Simmons (1989: 28), the term 'impact' refers to 'all aspects of change concomitant with human societies, but also specifically...to unplanned alterations.' In order to examine prehistoric impacts, the types of disturbance that could be expected to have happened and the resulting evidence that is retrievable from the archaeological record must be considered. The mere presence of humans can be assumed to have resulted in some disturbance, as vegetational changes can be brought about by such low-scale activities as track-trampling (Wilson and McG. King 1995) and only slight changes in vegetation cover can lead to significant erosion (Thornes 1988: 206); however, to show up as a regular pattern in the archaeological record, disturbance would necessarily had have to

have been widespread, intensive, or of appreciable duration. The regular use of fire for clearing vegetation, for example, would doubtless have increased runoff and erosion (Beaty 1994; Goudie 1981: 134; Morris and Moses 1987), especially if such burning was carried out on a broad scale, while clearance for agriculture could constitute a significant disturbance event.

The exact timing of initial human arrival into the New World is still a matter of debate; however, the bulk of radiocarbon-dated evidence from North and South America indicates occupancy by 14,000 – 12,000 years B.P. Both archaeological and environmental evidence from this early period are lacking in the detail necessary to allow accurate assessments of anthropogenic change. The extinction of numerous animal species at the end of the Pleistocene has been assigned to human hunting practices by some (e.g., Martin and Klein 1984), a scenario that has been used to suggest rapacious (or at least non-conservationist) tendencies by the earliest occupants of the Americas (Guthrie 1971). However, as Klein (1992) has recently pointed out, the Pleistocene 'overkill' debate is still too far from resolution to have any real bearing on the question of prehistoric impact.

The earliest sure evidence we have for widescale anthropogenic environmental alteration in the Eastern Woodlands dates from about 5,000 B.P., when various forms of squash (*Cucurbita* spp.) began to be cultivated in 'incipient garden plots' on floodplains (Asch and Asch 1985; Chapman and Watson 1993; Delcourt 1987: 40; Fritz and Smith 1988; King 1985: 96; Watson 1985; Yarnell 1993). Plant husbandry activities intensified as a host of native cultigens came under domestic control by around 3,500 B.P.: this 'eastern agricultural complex' (see Smith 1987 for a history of research on this topic) included sumpweed (*Iva annua*), sunflower (*Helianthus annuus*), *Chenopodium* spp., bottle gourd (*Lagenaria siceraria*), knotweed (*Polygonum erectum*), maygrass (*Phalaris caroliniana*), little barley (*Hordeum pusillum*), and tobacco, *Nicotiana* sp. (Asch and Asch 1985; Chapman and Shea 1981; Chapman and Watson 1993; Cowan 1985; Delcourt 1987; Ford 1985; Fritz 1993; Fritz and Smith 1988; Smith 1987; Watson 1985; Yarnell 1993) and was well-established in numerous areas by 2,000 B.P. or somewhat later (e.g., Arzigan 1987; Fritz and Smith 1988: 4; Johannessen 1993: 60-61; McBride and Dewar 1987; Pulliam 1987; Wymer 1987).

It is difficult to characterise the exact nature of the farming practices associated with this native seed complex, as the actual field systems are no longer extant. It is generally assumed to have entailed fairly long-term clearance of substantial areas of floodplain (Delcourt 1987: 43) with a reliance on annual floods for fertility renewal (Smith 1987: 28); monocropping is also suggested, since 'the practical necessities of sowing and harvesting small-grain plants would make them difficult to grow in a mixed garden' (Johannessen 1993: 68). The disturbance patches resulting from this type of activity would qualify as agroecosystems:

> ...an agroecosystem [is] an interactive group of biotic and abiotic components, some of which are under human control, that forms a unified whole (ecosystem) for the purpose of producing food or fiber. Agroecosystems are intentionally disturbed ecosystems that, through human influences, are being forced into states different than the natural systems from which they are derived (Elliott and Cole 1989: 1598; cf. Green 1988: 248).

Wood and seed charcoal and pollen retrieved from archaeological sites and lake cores show that the disturbances associated with this type of subsistence activity were significant. Begining by about 4,000 B.P., and seen commonly by 2,000 B.P., there is a dramatic increase in the proportions of disturbance-favored plant species such as ragweed (*Ambrosia artemisiifolia*), pokeweed (*Phytolacca americana*), bluestem (*Andropogon scoparius*), goldenrods (*Solidago* spp.), sumac (*Rhus typhina*), pine (*Pinus* spp.), eastern redcedar (*Juniperus virginiana*), persimmon (*Diospyros virginiana*), tulip tree (*Liriodendron tulipfera*) and American cane, *Arundinaria* sp. (Chapman et al. 1982; Chapman and Shea 1981; Chapman and Watson 1993: 35; Cowan 1985: 237-238; Crites 1987: 13; Delcourt 1987: 42; Delcourt and Delcourt 1987: 167; Delcourt et al. 1986; Fritz 1990, 1993: 50-51). The land clearance implied by the charcoal and pollen evidence undoubtedly led to increased erosion, a process that would have contributed to land degradation and resultant water pollution (Beach 1994: 7; Butzer 1982; Goudie 1981: 84, 127-129; Webster and Waide 1982). As Cowan (1985: 240) puts it, 'the natural landscape was being transformed on a new scale during this period as a result of increasing clearance of canopy level trees for...garden plots.'

Beginning at about 1,000 B.P., intensive agriculture based on maize, beans and squash became a widespread phenomenon in the eastern Woodlands. This subsistence strategy involved a heavy focus on floodplain and terrace soils that could be worked with hoes of stone and bone (scapulae). The amount of land clearance must have increased dramatically as maize was produced for consumption, storage and exchange. It was this intensive agricultural system that so impressed the first European travelers in eastern North America, who spoke of 'leagues of fields' of maize and other crops (e.g., T. Lewis 1907; Varner and Varner 1951). The historical sources have been examined by many authors (e.g., Ceci 1979; Doolittle 1992; Woods 1987) and will not be further discussed here. For the purposes of this paper, what is important to remember is that such extensive field systems had been in place for hundreds of years prior to European contact, implying that wide-scale land clearance and accelerated erosion were long-term processes in the eastern Woodlands. What is the archaeological evidence pertaining to those processes?

Physical evidence of the actual field systems themselves still remains in some areas, most notably Wisconsin, where large prehistoric ridge-and-furrow fields have been investigated (e.g., Boszhardt et al. 1985; Brown 1909; Gallagher and Stevenson 1983; Gallagher et al. 1985; King 1993: 235; Moffat 1979; Riley

1987; Riley and Freimuth 1977; cf. Delabarre and Wilder 1920; Denevan 1970; Doolittle 1992; Dimmick 1994; Fowler 1969; and Heidenreich 1974 for discussions of other areas). These features consist of alternating ridges and furrows, the ridges having been made by heaping alluvium from the furrows; they are often superimposed and tend to be oriented in different directions within the same field (Riley 1987: 298), implying long-term reuse of areas of good soil. The sample of such features thus far recorded is small and doubtless much evidence has been destroyed by modern agriculture; nonetheless, it can be shown that these ancient fields reached sizes of 100 acres or more (Riley 1987: 300). Parallel rows of heaped hills were used in some areas, such as the Assonet Neck 'Indian cornhills' in Massachusetts (Delabarre and Wilder 1920), where approximately 80,000 hills, each separated by about three feet of space that was presumably kept clear during the time of use (Dimmick 1994: 240), were noted.

These sorts of features, coupled with historical accounts and the commonplace presence of maize in archaeological deposits, give some idea of the scale of landscape alteration that was taking place due to prehistoric agriculture in eastern North America. That such alteration was leading to significant environmental changes is evidenced by further increases in disturbance-favored charcoal and pollen from archaeological sites and lake cores (e.g., Chapman and Shea 1981). For example, Chapman et al. (1982: 118) noted that by late prehistoric times the wood-charcoal spectra from sites in the Little Tennessee River drainage were dominated by early successional species (51 percent of the total). Increases in lacustrine sedimentation and ragweed pollen noted at Tuskegee Pond, a small water body located on a stream terrace in the Little Tennessee River valley, were coincident with the time of transition to maize agriculture in the area (Delcourt 1987: 43-44). According to Delcourt (1987: 44), this indicated 'progressive intensification of land use and soil erosion accompanying the increasing human populations in the valley.' Whitehead and Sheehan (1985) noted a marked increase of pine pollen in a core from the Tombigbee River valley in eastern Mississippi: they attribute this increase to the clearance of bottomlands related to the beginnings of maize agriculture in the area (1985: 134). Based on such evidence, archaeologists tend to see the beginning of intensive maize agriculture as a time when 'humans systematically modified the composition of the ecosystem. The intensity of human use of the bottomlands was considerably increased [and] ...large areas of the bottomlands were converted...into nearly monocultural cropland' (Muller 1987: 258; cf. Newsom 1993: 133; Reidhead 1980: 152).

It can be seen, then, that over the course of millenia native Americans significantly altered their environments for the purposes of crop production. This was by no means the only major source of land disturbance, however. Another practice that must have had considerable impact was the felling of trees for the construction of dwellings, for firewood, and for other purposes. The most thoroughly considered example of this phenomenon in eastern North America comes from the Cahokia site in Illinois, an enormous, sprawling, prehistoric

agricultural settlement that supported a population of tens of thousands of people and covered several square miles. Based on current demographic estimates and data on postholes excavated in archaeological contexts, Lopinot and Woods (1993: 220) estimate that the number of wall posts used to construct dwellings in the Cahokia area during the height of site use (A.D. 1050-1150) was approximately 800,000. This does not even include wood used for other parts of houses, such as roof beams. To this must be added an estimated 15,000 logs the size of telephone poles that were used to construct a 3 km palisade around the main site (Lopinot and Woods 1993: 209; Pfeiffer 1974), a palisade that was rebuilt several times. Add to this the wood needed for other public and private construction, fuel, etc. (Lopinot and Woods 1993: 210), and it becomes clear why the over-exploitation of forest resources is commonly cited as a prime reason why the Cahokia polity eventually collapsed (Lopinot and Woods 1993; Newsom 1993).

While Cahokia is at one end of a scale where size and prehistoric population density are concerned, it is by no means the only large archaeological site in eastern North America. Prehistoric sites several acres in size are common and excavation at a habitation site typically reveals thousands of postholes, pits, and other features indicative of site-specific environmental alteration and implying past exploitation of the surrounding areas. Where many sites of the same time period are known (i.e., many sites that were roughly contemporaneous, implying large prehistoric populations), significant environmental alteration can often be detected. In Arkansas, for example, Williams (1993) has detected an unexpectedly high occurrence of pine in the original General Land Office (GLO) land survey notes for an area near to several salt brines. Investigation of a complex of 15th – 17th century aboriginal sites indicated a high level of past salt production in the area (Early 1993), a process that required large amounts of fuel wood for boiling off the briny water. Williams has suggested that the over-abundance of pine represented in the GLO notes represents the aboriginal clearance of the hardwood-dominated forest for fuel. In the central Mississippi and lower Illinois river valleys, charcoal evidence suggests that bald cypress (*Taxodium distichum*) was a preferred wood for house construction between about 2,000 to 1,000 B.P., and that heavy exploitation of this species evidently led to a truncation of its natural range:

> As human populations increased, this wood resource diminished as the species became locally extinct at its northern range limits. The 'presettlement' range of *Taxodium* as mapped by biogeographers is thus not representative of its potential range based upon its climatic and hydrologic tolerance limits (Delcourt 1987: 40).

It is important to remember that, even though tens of thousands of archaeological sites have been recorded in eastern North America, only a fraction of the ones that actually exist have thus far been recorded and of that fraction only a small number have been explored through excavation. The point is that archaeological sites are not scattered, isolated phenomena; they are a ubiquitous

component of the physical landscape. Investigations in previously unexplored uplands between major river valleys are yielding thousands of new sites each year (e.g., Kowalewski and Hatch 1991; Peacock 1994), while the numbers of known habitation sites in the valleys continues to increase as well. The sites were not all occupied or used at the same time; rather, they contain the material remnants of at least 12,000 years of the human presence. It is their very ubiquity in space and time, however, that implies a constant anthropogenic pressure upon the environment. Besides habitation sites with their structures, pits, hearths, etc., there are also mounds, other earthworks, borrow pits, quarries, fish weirs, and a host of other site types that represent environmental alteration of one sort or another.

It should be clear by this point that the activities of prehistoric aboriginal societies could, and often did, constitute 'impacts' on past environments, impacts which may be discernible to this day. What is very important to note, however, and something that is often masked by sole reliance on historical records, is that there was a great deal of variability in these impacts through space and time (Fritz 1990; Watson 1985: 99). For example, the eastern agricultural complex discussed previously is known to have been present in western Arkansas and Missouri, Kentucky, central and eastern Tennessee, and central Ohio and Illinois, but apparently it was never adopted in other places with large prehistoric populations such as the Tombigbee River valley of eastern Mississippi and western Alabama (Fritz 1990, 1993: 41; Johannessen 1993: 63-66; Scarry 1993a: 85; Yarnell 1993: Fig. 2-1). In some areas the native starchy seed complex continued in use alongside maize agriculture, while in others it disappeared from the suite of crops being cultivated (Fritz 1990). Not all aboriginal groups adopted maize agriculture, either. In Florida, for example, some groups were dependent on farming at the time of historic contact while others practiced little or no agriculture (Ruhl 1993). Variability is often seen in areas that do yield evidence for either one or both of the two systems, with differences in the scale of farming activity (and concomitant disturbance) being noted between uplands and lowlands or between drainages or even between individual sites (e.g., Johannessen 1988; 1993: 62).

This variability has important implications for environmental reconstruction. It should be apparent that there was no one Indian 'way' of land-use, any more than there was one Indian 'way' of thinking about and relating to the environment. Based upon the information that is currently available, it can never be assumed for any particular area that prehistoric native Americans did not bring about environmental alteration, nor can it be assumed that they did constitute a significant disturbance factor. Ecologists, historical geographers and other researchers interested in reconstructing past environments or exploring long-term human/land relationships in eastern North America must make themselves aware of the archaeological data that exist pertaining to their area of investigation. To do less forces one to make assumptions that may fly in the face of existing empirical data.

IMPLICATIONS FOR THEORETICAL AND APPLIED ECOLOGY

In the last several years ecology has begun to redefine itself as a discipline, moving away from a functional, essentially ahistorical, orientation that focused on the homeostatic regulation of natural systems (e.g., Reichle et al. 1975: 27-29, who stress the 'temporal continuity and functional properties' of ecosystems) to a more dynamic viewpoint that emphasises the processes of change at a variety of scales (see Zimmerer 1994 for a discussion of the 'new ecology'). This can be seen in the emergence of subdisciplines such as landscape ecology (e.g., Forman and Godron 1986; Naveh 1982) and historical ecology (e.g., Crumley 1994b). Central to these approaches are an appreciation of the long-term role of humans in shaping biophysical landscapes (e.g., Barber 1991: 14; Butzer 1982: 172; Crumley 1994c; Goudie 1987: 11; Green 1980, 1988; Küster 1991: 24; Nassauer 1995; Naveh 1982: 191; Nicholas 1988; Oldfield et al. 1980; Simmons 1989; Sluyter 1994; Whitmore and Turner 1992) and a stress on providing greater temporal depth in ecological and geographical studies (e.g., Forman 1995; Wilbanks 1994: 547; Winterhalder 1994; Schmidt 1994: 100; Zimmerer 1994: 117), something that has been called for for many years (e.g., Forman 1995: 133; Goudie 1981: 127, 1987; Harris and Thomas 1991: 96; Moran 1990: 8; Naveh 1982: 230; Ovington 1975). Archaeology, coupled with paleoecology, can address these needs. More careful consideration of past human activities is also warranted in terms of the growing emphasis in ecology and geography on 'mosaic'-type landscapes and 'patch'-type disturbances (Baker 1989, 1995; Ellenberg 1979: 402; Winterhalder 1994: 33; Zimmerer 1994: 110), features that were likely commonplace in pre-industrial times. The systemic approach has not been abandoned; rather, ecologists and other scientists are struggling to mesh systems theory with a multi-scalar approach (e.g., Grossman 1977; Levin 1992; McGlade 1995: 121-123; Moran 1990: 20; Nicholas 1988). The processes involved with biotic community dynamics and geoevolutionary development may be most accurately addressed at time scales appropriate to archaeological and palaeoecological research (Crumley 1994c: 6; Gee and Giller 1991; Holliday et al. 1993; Linse 1993; Nicholas 1988: 264; Rhodes and Davis 1995: 734; Schmidt 1994: 100; Stein 1993; Winterhalder 1994).

One characteristic of these emerging fields of study is an orientation towards application (e.g., Baker 1989; Paul and Robertson 1989: 1595; Salwasser and Tappeiner 1981). In particular, it has been suggested by many researchers that 'primitive' or 'traditional' land-use practices might be reinstated as models of sustainable-yield agriculture and other types of land management (Alvard 1993: 355-356; Bebbington and Carney 1990; Crumley 1994a: 240, 1994c: 7; Doolittle 1992: 386, 398; Hassan 1994: 154; Lambert and Arnason 1984; Schmidt 1994: 99-100; Sluyter 1994: 576; Gómez-Pompa 1978; cf. Chandler 1994), especially in developing countries. Such reinstatement schemes have actually been tried in some countries (e.g., Gómez-Pompa 1978; Ingerson 1994: 54-55; Naveh 1982:

223-228; O'Neill et al. 1993), with varying degrees of success. Laying aside the problems associated with 'sustainable development' as a management concept (Bebbington and Carney 1990; Redclift 1991: 36-37; Wilbanks 1994) , what can we learn from the prehistoric land-use strategies of eastern North America in these terms?

The answer can be summed up in one word: diversity. The incredible variety of food crops grown by the aboriginal inhabitants of the Americas has long been remarked upon (e.g., Harlan 1992; Whitmore and Turner 1992; Zimmerer 1994: 114-115); that variety represented an invaluable store of germplasm which provided a buffer against plant disease outbreaks (Harlan 1992) and it also allowed a great deal of flexibility in responding to short-term environmental fluctuations (Scarry 1993b). Such diversity is seen as 'an essential strength of most small-scale societies' (Redman 1992: 40) and is the key element that scientists of various disciplines see as worthy of emulation (e.g., Harper 1987: 41; Medley et al. 1995: 172; Moran 1990: 26-27; Redman 1992; Wilbanks 1994: 545-546; Winterhalder 1994). The aboriginal inhabitants of eastern North America were no exception where subsistence diversity was concerned: not only did they manage the many native seed crops mentioned earlier but they also had several varieties of maize favored by different microhabitats (e.g., Dimmick 1994; Scarry 1993b; see Zimmerer 1994: 114-115 for an alternative view on 'niche specialisation'). The use of such variety as a buffering mechanism may indeed be worthy of emulation and the cultivation of ruderal species now considered to be 'weeds' bears renewed investigation by applied ecologists, plant geneticists, and other scientists.

A more immediately applicable product of archaeological research into past human/land interactions is the potential for public education. What should be avoided in the public arena is the stereotypical comparison of pre-European 'pristine' landscapes to modern, disturbed ones. Arguments for fuller ecological considerations of human actions will have greater impact if accurate historical data can be marshalled to show how people have affected the environment in a given area over the long-term. As Marquardt (1994: 203) says, 'archaeologists are in a position to provide a long-term, broad-scale perspective on culture and environment and...this perspective can be translated to the lay public with salutary effects on environmental problems.' He gives an excellent example of this sort of educational process, describing a multi-year archaeological project in Florida that involved heavy public participation and that delivered a detailed message about human/land relationships through time in the area (Marquardt 1994). Archaeology is a popular science which interfaces with the public in numerous ways, including museums, magazines, television, and so on. If ecologists are willing to incorporate archaeological data into their work, it can serve as a vehicle for heightening environmental consciousness in the public-at-large.

POLITICAL PERCEPTIONS AND ENVIRONMENTAL ETHICS

The focus on change, rather than stasis, in environmental systems poses potential problems for ecology and other disciplines dealing with the question of human/land interaction. When prehistoric landscapes could be viewed as 'natural,' a return to those landscapes – a return to 'wilderness' conditions (Gómez-Pompa and Kaus 1992) – could be promoted as a political agenda for conservationists (Head 1990: 450) and environmental policies tended to reflect an 'equilibrium' view of natural systems (Winterhalder 1994: 40). This sometimes has had unforeseen consequences (Zimmerer 1994: 117), such as the unintended suppression of fire-dependent plant species. With the growing realisation that humans have played an ecological role in the New World since the end of the Pleistocene, the debate has become more complex. How can land managers restore 'natural' conditions if such conditions haven't existed since the last Ice Age? What is meant by 'natural' and what is meant by 'wilderness' (Gómez-Pompa and Kaus 1992; Kay 1994: 384-385; Robbins and Myers 1992: 9)? If change is the norm, then management, rather than conservation – action, rather than non-action – might be historically justifiable (Head 1989; Zimmerer 1994: 115). There is a legitimate fear that such justification might lead to short-sighted management policies: 'The proponents of a contingent or historical science have acknowledged that too celebratory an attitude toward change in nature could justify destructive human behavior' (Ingerson 1994: 61). This problem has been recognised in other parts of the globe as well. The following lengthy quote from Head (1989) outlines the debate as it has developed in Australia; the similarities to the unfolding situation in North America are remarkable:

> The long-term perspective on vegetation change is increasingly given weight in debates over contemporary management issues. It is important when we consider what we are trying to conserve – the vegetation and fire patterns we have now, those that existed 200 years ago, or perhaps even earlier? In Victoria there has been discussion over the relative impacts on East Gippsland rainforests of the Ice Age and the woodchippers, conservationists arguing that the latter are more profound. Several years ago, in Queensland, the Forestry Department used Kershaw's data to argue that it was acceptable to log the rainforests because they had recovered from adverse climatic conditions in the past, so could survive a further onslaught. Our environmental history is no less susceptible to myth-making than our economic or political history.
>
> The same can be said of non-Aboriginal Australia's view of Aborigines. In 1982 Horton suggested that people were interpreting the evidence over 'fire-stick farming' according to what they wanted to believe about Aborigines. The idea of Aborigines as being 'in harmony with nature', and thus having absolutely no impact on the environment, suited a naive view of 'wilderness' that was prevalent in the sixties and early seventies. Archaeological and palaeocological work in the seventies demonstrated that virtually no corner of Australia was wilderness in the sense of being uninhabited by people.

> There followed increasing recognition of the variety of ways in which Aborigines manipulated their environment in order to survive. It seemed that in order for land rights to be widely recognised by non-Aboriginal society, Aboriginal ways of 'using' the land had to appear as much like farming and as little like hunting and gathering as possible. It was also perceived to be useful for land rights arguments for the period of Aboriginal occupation of Australia to be as long as possible, so Singh's suggestion of a 130,000 BP arrival data was enthusiastically greeted in some quarters.
>
> Today, when the obstacles facing both the conservation and lands rights causes seem to be growing, we need to be particularly careful about which ideas we use and how we use them. It can be argued that the conservation movement, in its broadest sense, has been guilty of using certain Aboriginal themes for its own purposes, and has then found itself backed into a corner when these ideas collapse before continued scientific scrutiny. The same, of course, can be said for mining companies and other anti-land rights interests who attempt to use suggestions of significant Aboriginal impacts as a justification for the denial of land rights (Head 1989: 43-44).

In North America and elsewhere this debate, which is increasingly cast in terms of 'sustainable development,' is fundamentally political (Head 1989, 1992; Rappaport 1990: 46; Redclift 1991; Wilbanks 1994: 544) but its resolution ultimately will rest on scientific data (Butzer 1996; Hassan 1994: 154; Head 1994: 85; Schmidt 1994: 100). In this regard, the key word quoted above is 'naive.' As ecologists put forward models of landscape 'design,' it is taken for granted that accurate knowledge of ecological processes is essential (Nassauer 1995: 235-236); it must be remembered that wherever and whenever humans have existed, they have been an integral part of those processes. Environmental studies that ignore or downplay the historical element in landscape development are inherently faulty (Kay 1994: 384-385; Zimmerer 1994: 117). It is no longer acceptable for scientists to assume that prehistoric ecosystems were 'pristine,' nor is it acceptable to assume that, if humans were present in the past, they necessarily brought about significant environmental alterations. It is not necessary to *assume* anything; rather, it is essential that existing archaeological and historical data be incorporated into environmental studies, especially those that seek to characterise the long-term development of biophysical landscapes. If archaeological and palaeoecological data do not exist for a particular area, those data can be retrieved through integrated research programs designed to explore the nature of human impact over the long-term. In this light, ecologists have a legitimate stake in giving input to, as well as seeking input from, their colleagues in archaeology.

DISCUSSION

It has been shown that, despite much scientific evidence to the contrary, many ecologists, geomorphologists, geographers, and other scientists persist in viewing prehistoric and historic period native Americans as having been a 'non-

factor' in environmental change in eastern North America. One possible explanation for this phenomenon is that archaeological data are often viewed as being too 'soft' to yield real input into the questions of landscape development (Crumley 1994c: 4-5). While it is true that archaeological data suffer from interpretive problems related to cultural and depositional biases and post-depositional alterations (Butzer 1982: 178; Evans 1978; Gee and Giller 1991; Jochim 1990: 84-85), such factors can be understood and dealt with in a variety of manners. Archaeological sites represent the points of interface between prehistoric humans and the environment; any inquiry into the nature of human/land relationships in past times must not therefore exclude those points or it will inherently be incomplete. In the interest of emphasising this, it is recommended that the term 'pre-settlement' be dropped from any study of Holocene environmental systems in the Americas.

In the move towards a unified approach to sustainability, the need for interdisciplinary input and integration is imperative (Butzer 1996; Elliott and Cole 1989: 1601; Paul and Robertson 1989: 1595; Salwasser and Tappeiner 1981). Archaeology has been considered to be a partner in this integration only in rare instances (e.g., Goudie 1987). The efforts towards obtaining interdisciplinary input have heightened a sense of impending synthesis in human/land studies and several approaches are being put forward as the ideal conjoiner of disparate scientific practices. These include landscape ecology (Naveh 1982: 197, 230), historical ecology (Crumley 1994b), human geography (Wilbanks 1994), geoarchaeology (Stein 1993: 1) and human ecodynamics (McGlade 1995). The approach that eventually establishes primacy will necessarily incorporate archaeological and historical data as standard constituents of a holistic format. It will then be in a better position to make accurate environmental reconstructions, understand the role of humans in landscape development, and influence public opinion and official policy concerning contemporary and future land-management practices in eastern North America and elsewhere in the world.

ACKNOWLEDGMENTS

This paper was written while the author was on leave from the USDA Forest Service, National Forests in Mississippi and a graduate student in the Department of Archaeology and Prehistory, University of Sheffield, England. I would like to thank Ian Brown and James Hardin for sending me materials from the United States, and Lesley Head for kindly allowing me to use an unusually long quote from her work. I would also like to thank Janet Rafferty and Paul Halstead for providing editorial comments on a draft version of the paper. I owe a particular debt of thanks to Thomas McGovern for his encouragement and his suggestion of *Environment and History* as an appropriate outlet for this work.

REFERENCES

Abrams, E. M., and D. J. Rue. 1988. The causes and consequences of deforestation among the prehistoric Maya. *Human Ecology* **16**: 377-395.

Alcala-Herrera, J. A., J. S. Jacob, M. L. Machain Castillo, and R. W. Neck . 1994. Holocene palaeosalinity in a Maya wetland, Belize, inferred from the microfaunal assemblage. *Quaternary Research* **41**: 121-130.

Alvard, M. S. 1993. Testing the 'ecologically noble savage' hypothesis: interspecific prey choice by Piro hunters of Amazonian Peru. *Human Ecology* **21**: 355-387.

Ammal, E. K. J. 1956. Introduction to the subsistence economy of India. In W. L. Thomas, Jr. (ed.), *Man's Role in Changing the Face of the Earth*, Vol. 1, pp. 324-335. The University of Chicago Press.

Anderson, A. 1987 Supertramp science: some thoughts on archaeometry and archaeology in Oceania. In W. R. Ambrose and J. M. J. Mummery (eds.), *Archaeometry: Further Australasian Studies*, pp. 3-18. Canberra: The Australian National University.

Anderson, R. C., and M. R. Anderson. 1975. The presettlement vegetation of Williamson County, Illinois. *Castanea* **40**: 345-363.

Arzigan, C. 1987. The emergence of horticultural economies in southwestern Wisconsin. In W. F. Keegan (ed.), *Emergent Horticultural Economies of the Eastern Woodlands*. Southern Illinois University at Carbondale, Center for Archaeological Investigations, Occasional Paper No. 7: 217-242.

Asch, D. L., and N. B. Asch. 1985. Prehistoric plant cultivation in west-central Illinois. In R. I. Ford (ed.), *Prehistoric Food Production in North America*. The University of Michigan, Museum of Anthropology, Anthropological Papers No. 75: 149-203.

Baker, R. G., L. J. Maher, C. A. Chumbley, and K. L. van Zant. 1992. Patterns of Holocene environmental change in the midwestern United States. *Quaternary Research* **37**: 379-389.

Baker, W. L. 1989. Landscape ecology and nature reserve design in the Boundary Waters Canoe Area, Minnesota. *Ecology* **70**: 23-35.

Baker, W. L. 1995. Longterm response of disturbance landscapes to human intervention and global change. *Landscape Ecology* **10**: 143-159.

Barber, K. 1991. On the relationship between palaeoecology and neoecology. In D. R. Harris and K. D. Thomas (eds.), *Modelling Ecological Change*, pp. 13-16. London: University College Institute of Archaeology.

Baron, W. R. 1988. Historical climates of the northeastern United States: seventeenth through nineteenth centuries. In G. P. Nicholas (ed.), *Holocene Human Ecology in Northeastern North America*, pp. 29-46. New York: Plenum Press.

Barrett, S. W., and S. F. Arno. 1982. Indian fires as an ecological influence in the northern Rockies. *Journal of Forestry* **80**: 647-651.

Beach, T. 1994. The fate of eroded soil: sediment sinks and sediment budgets of agrarian landscapes in southern Minnesota, 1851-1988. *Annals of the Association of American Geographers* **84**: 5-28.

Beaty, K. G. 1994. Sediment transport in a small stream following two successive forest fires. *Canadian Journal of Fisheries and Aquatic Sciences* **51**: 2723-2733.

Bebbington, A., and J. Carney. 1990. Geography in the International Agricultural Research Centers: theoretical and practical concerns. *Annals of the Association of American Geographers* **80**: 34-48.

Bierhorst, J. 1994. *The Way of the Earth: Native America and the Environment.* New York: William Morrow and Company, Inc.

Binford, M. W., M. Brenner, T. J. Whitmore, A. Higuera-Gundy, E. S. Deevey, and B. W. Leyden. 1987. Ecosystems, paleoecology and human disturbance in subtropical and tropical America. *Quaternary Science Reviews* **6**: 115-128.

Boszhardt, R. F., T. W. Bailey, and J. P. Gallahger. 1985. Oneota ridged fields at the Sand Lake Site (47Lc44), La Crosse County, Wisconsin. *The Wisconsin Archaeologist* **66**: 47-67.

Botkin, D. 1995. *Our Natural History: The Lessons of Lewis and Clark*. New York: Gosset/Putnam.

Boyd, W. E. 1990. Australian environmental archaeology – a review of some main themes. In D. E. Robinson (ed.), *Experimentation and Reconstruction in Environmental Archaeology*, pp. 249-262. Symposia of the Association for Environmental Archaeology No. 9, Roskilde, Denmark, 1988.

Brenner, M. 1983. Paleolimnology of the Peten Lake District, Guatemala, II. Mayan population density and sediment and nutrient loading of Lake Quexil. *Hydrobiologia* **103**: 205-210.

Brown, C. E. 1909. Wisconsin garden beds. *The Wisconsin Archaeologist* **8**: 97-105.

Burrin, P. J., and R. G. Scaife. 1988. Environmental thresholds, catastrophe theory and landscape sensitivity: their relevance to the impact of man on valley alluviations. In J. Bintliff, D. A. Davidson, and E. G. Grant (eds.), *Conceptual Issues in Environmental Archaeology*, pp. 211-232. Edinburgh University Press.

Butzer, K. W. 1982. *Archaeology as Human Ecology*. Cambridge University Press.

Butzer, K. W. 1992. The Americas before and after 1492: an introduction to current geographical research. *Annals of the Association of American Geographers* **82**: 345-368.

Butzer, K. W. 1996. Ecology in the long view: settlement histories, agrosystemic strategies, and ecological performance. *Journal of Field Archaeology* **23**: 141-150.

Callicott, J. B. 1982. Traditional American Indian and western European attitudes toward nature: an overview. *Environmental Ethics* **4**: 293-318.

Ceci, L. 1979. Maize cultivation in coastal New York: the archaeological, agrinomical and documentary evidence. *North American Archaeologist* **1**: 45-74.

Chandler, P. 1994. Adaptive ecology of traditionally derived agroforestry in China. *Human Ecology* **22**(4): 415-442.

Chapman, J., and A. B. Shea. 1981. The archaeobotanical record: Early Archaic period to contact in the lower Little Tennessee River valley. *Tennessee Anthropologist* **6**: 61-84.

Chapman, J., and P. J. Watson. 1993. The Archaic period and the flotation revolution. In C. M. Scarry (ed.), *Foraging and Farming in the Eastern Woodlands*, pp. 27-38. Gainesville: The University Press of Florida.

Chapman, J., P. A. Delcourt, P. A. Cridlebaugh, A. B. Shea, and H. R. Delcourt. 1982. Man-land interaction: 10,000 years of American Indian impact on native ecosystems in the lower Little Tennessee River valley, eastern Tennessee. *Southeastern Archaeology* **1**: 115-121.

Corlett, R. T. 1984. Human impact on the subalpine vegetation of Mt. Wilhelm, Papua, New Guinea. *Journal of Ecology* **72**: 841-854.

Cowan, C. W. 1985. Understanding the evolution of plant husbandry in eastern North America: lessons from botany, ethnography and archaeology. In R. I Ford (ed.), *Prehistoric Food Production in North America*. The University of Michigan, Museum of Anthropology, Anthropological Papers No. 75: 205-243.

Crites, G. D. 1987. Middle and Late Holocene ethnobotany of the Hayes Site (40ML139): evidence from Unit 990N918E. *Midcontinental Journal of Archaeology* **12**: 3-32.

Cronon, W. 1983. *Changes in the Land: Indians, Colonists, and the Ecology of New Englan*d. New York: Hill and Wang.

Crumley, C. L. 1994a. Epilogue. In C. L. Crumley (ed.), *Historical Ecology: Cultural Knowledge and Changing Landscapes*, pp. 239-241. Santa Fe: School of American Research Press.

Crumley, C. L. 1994b (ed.). *Historical Ecology: Cultural Knowledge and Changing Landscapes*. Santa Fe: School of American Research Press.

Crumley, C. L. 1994c. Historical ecology: a multidimensional ecological orientation. In C. L. Crumley (ed.), *Historical Ecology: Cultural Knowledge and Changing Landscapes*, pp. 1-16. Santa Fe: School of American Research Press.

Day, G. 1953. The Indian as an ecological factor in the northeastern forests. *Ecology* **34**: 329-346.

Deevey, E. S., D. S. Rice, P. M. Rice, H. H. Vaughan, M. Brenner, and M. S. Flannery. 1979. Mayan urbanism: impact on a tropical karst environment. *Science* **206**: 298-305.

Delabarre, E. B., and H. H. Wilder. 1920. Indian corn hills in Massachusetts. *American Anthropologist* **22**: 203-225.

Delcourt, H. R. 1987. The impact of prehistoric agriculture and land occupation on natural vegetation. *Trends in Ecology and Evolution* **2**: 39-44.

Delcourt, P. A., and H. R. Delcourt. 1987. *Long-Term Forest Dynamics of the Temperate Zone*. New York: Springer-Verlag.

Delcourt, P. A., H. R. Delcourt, P. A. Cridlebaugh, and J. Chapman. 1986. Holocene ethnobotanical and paleoecological record of human impact in the Little Tennessee River valley, Tennessee. *Quaternary Research* **25**: 330-349.

Denevan, W. M. 1970. Aboriginal drained-field cultivation in the Americas. *Science* **169**: 647-654.

Denevan, W. M. 1992. The pristine myth: the landscape of the Americas in 1492. *Annals of the Association of American Geographers* **82**: 369-385.

Dimmick, F. R. 1994. Creative farmers of the Northeast: a new view of Indian maize horticulture. *North American Archaeologist* **15**: 235-252.

Doolittle, W. E. 1992. Agriculture in North America on the eve of contact: a reassessment. *Annals of the Association of American Geographers* **82**: 386-401.

Early, A.M. (ed.) 1993. *Caddoan Saltmakers in the Ouachita Valley: The Hardaman Site.* Fayetteville: The Arkansas Archeological Survey Research Series, No. 43.

Edwards, K. J. 1991. Using space in cultural palynology: the value of the off-site pollen record. In D. R. Harris and K. D. Thomas (eds.), *Modelling Ecological Change*, pp. 53-59. London: University College Institute of Archaeology.

Ellenberg, H. 1979. Man's influence on tropical mountain ecosystems in South America. *Journal of Ecology* **67**: 401-416.

Elliott, E. T., and C. V. Cole. 1989. A perspective on agroecosystem science. *Ecology* **70**: 1597-1602.

Evans, J. G. 1978. *An Introduction to Environmental Archaeology*. Ithaca, New York: Cornell University Press.

Fertig, F. 1970. Child of nature, the American Indian as an ecologist. *Sierra Club Bulletin* **55**: 4-7.

Ford, R. I. 1985. Patterns of prehistoric food production in North America. In R. I. Ford (ed.), *Prehistoric Food Production in North America*. The University of Michigan, Museum of Anthropology, Anthropological Papers No. 75: 341-364.

Forman, R. T. T. 1995. Some general principles of landscape and regional ecology. *Landscape Ecology* **10**: 133-142.

Forman, R. T. T., and M. Godron. 1986. *Landscape Ecology*. New York: John Wiley and Sons, Inc.

Foster, D. R., T. Zebryk, P. Schoonmaker, and A. Lezberg. 1992. Post-settlement history of human land-use and vegetation dynamics of a *Tsuga canadensis* (hemlock) woodlot in central New England. *Journal of Ecology* **80**: 773-786.

Fowler, M. L. 1969 Middle Mississippian agricultural fields. *American Antiquity* **34**: 365-375.

Fritz, G. J. 1990. Multiple pathways to farming in precontact eastern North America. *Journal of World Prehistory* **4**: 387-435.

Fritz, G. J. 1993. Early and Middle Woodland period paleoethnobotany. In C. M. Scarry (ed.), *Foraging and Farming in the Eastern Woodlands*, pp. 39-56. Gainesville: The University Press of Florida.

Fritz, G. J., and B. D. Smith. 1988. Old collections and new technology: documenting the domestication of *Chenopodium* in eastern North America. *Midcontinental Journal of Archaeology* **13**: 3-27.

Gallagher, J. P., and K. Stevenson. 1983. Oneota subsistence and settlement in southwestern Wisconsin. In G. E. Gibbon (ed.), *Oneota Studies*. The University of Minnesota, Publications in Anthropology 1: 15-27.

Gallagher, J. P., R. F. Boszhardt, R. F. Sassa, and K. Stevenson. 1985. Oneota ridged field agriculture in southwestern Wisconsin. *American Antiquity* **50**: 605-612.

Galloway, P. 1995. *Choctaw Genesis: 1500-1700*. Lincoln and London: University of Nebraska Press.

Gee, J. H. R., and P. S. Giller. 1991. Contemporary community ecology and environmental archaeology. In D. R. Harris and K. D. Thomas (eds.), *Modelling Ecological Change*, pp. 1-12. London: University College Institute of Archaeology.

Gómez-Pompa, A. 1978. An old answer to the future. *Mazingira* **5**: 50-55.

Gómez-Pompa, A., and A. Kaus. 1992. Taming the wilderness myth. *Bioscience* **42**: 271-279.

Gottesfeld, L. M. J. 1994. Conservation, territory, and traditional beliefs: an analysis of Gitksan and Wet'suwet'en subsistence, northwest British Columbia, Canada. *Human Ecology* **22**(4): 443-465.

Goudie, A. 1981. *The Human Impact*. Oxford: Basil Blackwell.

Goudie, A. S. 1987. Geography and archaeology: the growth of a relationship. In J. M. Wagstaff (ed.), *Landscape and Culture*, pp. 11-25. London: Basil Blackwell.

Green, S. W. 1980. Broadening least-cost models for expanding agricultural systems. In T. K. Earle and A. L. Christenson (eds.), *Modeling Change in Prehistoric Subsistence Economies*, pp. 209-241. Academic Press.

Green, S. W. 1988. Palynology and human ecology: theory and method for the study of prehistoric agriculture. In J. Bintliff, D. A. Davidson, and E. C. Grant (eds.), *Conceptual Issues in Environmental Archaeology*, pp. 246-272. Edinburgh University Press.

Grimm, E. C., and G. L. Jacobson, Jr. 1992. Fossil-pollen evidence for abrupt climate changes during the past 18 000 years in eastern North America. *Climate Dynamics* **6**: 179-184.

Grossman, L. 1977. Man-environment relationships in anthropology and geography. *Annals of the Association of American Geographers* **67**: 126-144.

Guthrie, D. A. 1971. Primitive man's relationship to nature. *Bioscience* **21**: 721-723.

Harlan, J. R. 1992. *Crops and Man*, 2nd edition. Madison, Wisconsin: American Society of Agronomy, Crop Science Society of America.

Harper, J. L. 1987. The heuristic value of ecological restoration. In W. R. Jordan III, M. E. Gilpin, and J. D. Aber (eds.), *Restoration Ecology: A Synthetic Approach to Ecological Restoration*, pp. 35-45. Cambridge University Press.

Harris, D. R., and K. D. Thomas. 1991. Modelling ecological change in environmental archaeology. In D. R. Harris and K. D. Thomas (eds.), *Modelling Ecological Change*, pp. 91-102. London: University College Institute of Archaeology.

Hassan, F. A. 1994. Population ecology and civilization in ancient Egypt. In C. L. Crumley (ed.), *Historical Ecology: Cultural Knowledge and Changing Landscapes*, pp. 155-181. Santa Fe: School of American Research Press.

Head, L. 1989. Prehistoric aboriginal impacts on Australian vegetation: an assessment of the evidence. *Australian Geographer* **20**: 37-46.

Head, L. 1990. Conservation and aboriginal land rights: when green is not black. *Australian Natural History* **23**(6): 448-454.

Head, L. 1992. Australian aborigines and a changing environment – views of the past and implications for the future. In J. Birckhead, T. De Lacy, and L. Smith (eds.), *Aboriginal Involvement in Parks and Protected Areas*, pp. 47-56. Canberra: Aboriginal Studies Press.

Head, L. 1994. Both ends of the candle? Discerning human impact on the vegetation. *Australian Archaeology* **39**: 82-86.

Heidenreich, C. E. 1974. A relict Indian corn field near Greenmore, Ontario. *Canadian Geographer* **18**: 379-394.

Holliday, Vance T., C. R. Ferring, and P. Goldberg. 1993. The scale of soil investigations in archaeology. In J. K. Stein and A. R. Linse (eds.), *Effects of Scale on Archaeological and Geoscientific Perspectives*. The Geological Society of America Special Paper 283: 29-37.

Ingerson, A. E. 1994. Tracking and testing the nature-culture dichotomy. In C. L. Crumley (ed.), *Historical Ecology: Cultural Knowledge and Changing Landscapes*, pp. 43-66. Santa Fe: School of American Research Press.

Jackson, W., and J. Piper. 1989. The necessary marriage between ecology and agriculture. *Ecology* **70**: 1591-1593.

Jacobs, J. 1975. Diversity, stability and maturity in ecosystems influenced by human activities. In W. H. van Dobben and R. H. Lowe-McConnell (eds.), *Unifying Concepts in Ecology*, pp. 187-207. The Hague: Dr W. Junk B. V. Publishers.

Jochim, M. 1990. The ecosystem concept in archaeology. In E. F. Moran (ed.), *The Ecosystem Approach in Anthropology*, pp. 75-90. Ann Arbor: The University of Michigan Press.

Johannessen, S. 1988. Plant remains and culture change: are paleoethnobotanical data better than we think? In C. A. Hastorf and V. S. Popper (eds.), *Current Paleoethnobotany*, pp. 145-166. The University of Chicago Press.

Johannessen, S. 1993. Farmers of the Late Woodland. In C. M. Scarry (ed.), *Foraging and Farming in the Eastern Woodlands*, pp. 57-77. Gainesville: The University Press of Florida.

Joyce, A. A. 1988. Early/Middle Holocene environments in the Middle Atlantic region: a revised reconstruction. In G. P. Nicholas (ed.), *Holocene Human Ecology in Northeastern North America*, pp.185-214. New York: Plenum Press.

Kay, C. E. 1994. Aboriginal overkill: the role of Native Americans in structuring western ecosystems. *Human Nature* **5**: 359-398.

King, F. B. 1985. Early cultivated cucurbits in eastern North America. In R. I. Ford (ed.), *Prehistoric Food Production in North America*. The University of Michigan, Museum of Anthropology, Anthropological Papers No. 75: 73-97.

King, F. B. 1993. Climate, culture, and Oneota subsistence in central Illinois. In C. M. Scarry (ed.), *Foraging and Farming in the Eastern Woodlands*, pp. 232-254. Gainesville: The University Press of Florida.

Klein, R. G. 1992. The impact of early people on the environment: the case of large mammal extinctions. In J. E. Jacobson and J. Firor (eds.), *Human Impact on the Environment: Ancient Roots, Current Challenges*, pp. 13-34. Boulder, Colorado: Westview Press.

Kowalewski, S. A., and J. W. Hatch. 1991. The sixteenth-century expansion of settlement in the Upper Oconee watershed, Georgia. *Southeastern Archaeology* **10**: 1-17.

Küster, H. 1991. Phytosociology and archaeobotany. In D. R. Harris and K. D. Thomas (eds.), *Modelling Ecological Change*, pp. 17-26. London: University College Institute of Archaeology.

Lambert, J. D. H., and J. T. Arnason. 1984. Ancient Maya drained field agriculture: its possible application today in the New River Floodplain, Belize, C. A. *Agriculture, Ecosystems and Environment* **11**: 67-84.

Levin, S. A. 1992. The problem of pattern and scale in ecology. *Ecology* **73**: 1943-1967.

Lewis, T. H. (ed.). 1907. The narrative of the expedition of Hernando de Soto, by the Gentleman of Elvas. In J. F. Jameson (ed.), *Spanish Explorers in the Southern United States 1528-1543*, pp. 127-272. New York: Charles Scribner's Sons.

Lewis, H. T. 1977. Maskuta: the ecology of Indian fires in northern Alberta. *Western Canadian Journal of Anthropology* **7**: 15-52.

Linse, A. R. 1993. Geoarchaeological scale and archaeological interpretation: examples from the Central Jornada Mogollon. In J. K. Stein and A. R. Linse (eds.), *Effects of Scale on Archaeological and Geoscientific Perspectives*. The Geological Society of America Special Paper 283: 11-28.

Lopinot, N. H., and W. I. Woods. 1993. Wood overexploitation and the collapse of Cahokia. In C. M. Scarry (ed.), *Foraging and Farming in the Eastern Woodlands*, pp. 206-231. Gainesville: The University Press of Florida.

Lozano-García, M. S., B. Ortega-Guerrero, M. Caballero-Miranda, and J. Urrutia-Fucugauchi. 1993. Late Pleistocene and Holocene paleoenvironments of Chalco Lake, central Mexico. *Quaternary Research* **40**: 332-342.

Martin, P. S., and R. G. Klein (eds.). 1984. *Quaternary Extinctions: A Prehistoric Revolution*. Tuscon: University of Arizona Press.

Marquardt, W. H. 1994. The role of archaeology in raising environmental consciousness. In C. L. Crumley (ed.), *Historical Ecology: Cultural Knowledge and Changing Landscapes*, pp. 203-221. Santa Fe: School of American Research Press.

McBride, K. A., and R. E. Dewar. 1987. Agriculture and cultural evolution: causes and effects in the lower Connecticut River valley. In W. F. Keegan (ed.), *Emergent Horticultural Economies of the Eastern Woodlands*. Southern Illinois University at Carbondale, Center for Archaeological Investigations, Occasional Paper No. 7: 305-327.

McGlade, J. 1995. Archaeology and the ecodynamics of human-modified landscapes. *Antiquity* **69**: 113-132.

Medley, K., B. W. Okey, G. W. Barrett, M. F. Lucas, and W. H. Renwick. 1995. Landscape change with agricultural intensification in a rural watershed, southwestern Ohio, U.S.A. *Landscape Ecology* **10**: 161-176.

Moffat, C. R. 1979. Some observations on the distribution and significance of the garden beds in Wisconsin. *The Wisconsin Archaeologist* **60**: 222-248.

Moore, J. In Press. How to fire a major deciduous forest in an inclement climate. In A. Morrison and T. Pollard (eds.), *Stone Age in Scotland – 40 Years On*. Edinburgh University Press.

Moran, E. F. 1990. Ecosystem ecology in biology and anthropology: a critical assessment. In E. F. Moran (ed.), *The Ecosystem Approach in Anthropology: From Concept to Practice*, pp. 3-40. Ann Arbor: The University of Michigan Press.

Morris, S. E., and T. A. Moses. 1987. Forest fire and the natural soil erosion regime in the Colorado Front Range. *Annals of the Association of American Geographers* **77**: 245-254.

Muller, J. 1987. Lower Ohio Valley emergent horticulture and Mississippian. In W. F. Keegan (ed.), *Emergent Horticultural Economies of the Eastern Woodlands*. Southern Illinois University at Carbondale, Center for Archaeological Investigations, Occasional Paper No. 7: 243-273.

Myers, R. L., and P. A. Peroni. 1983. Approaches to determining aboriginal fire use and its impact on vegetation. *Bulletin of the Ecological Society of America* **64**: 217-218.

Nassauer, J. I. 1995. Culture and changing landscape structure. *Landscape Ecology* **10**: 229-237.

Naveh, Z. 1982. Landscape ecology as an emerging branch of human ecosystem science. In A. MacFadyen and E. D. Ford (eds.), *Advances in Ecological Research* 12: 189-237. Academic Press.

Newsom, L. A. 1993. Plants and people: cultural, biological, and ecological responses to wood exploitation. In C. M. Scarry (ed.), *Foraging and Farming in the Eastern Woodlands*, pp. 115-137. Gainesville: The University Press of Florida.

Nicholas, G. P. 1988. Human behavior and Holocene ecology. In G. P. Nicholas (ed.), *Holocene Human Ecology in Northeastern North America*, pp. 1-7. New York: Plenum Press.

Nordt, L. C., T. W. Boutton, C. T. Hallmark, and M. R. Waters. 1994. Late Quaternary vegetation and climate changes in central Texas based on the isotopic composition of organic carbon. *Quaternary Research* **41**: 109-120.

O'Hara, S. L., F. A. Street-Perrott, and T. P. Burt. 1993. Accelerated soil erosion around a Mexican highland lake caused by prehispanic agriculture. *Nature* **362**: 48-51.

Oldfield, F., P. G. Appleby, and R. Thompson. 1980. Palaeoecological studies of lakes in the highlands of Papua New Guinea. I. The chronology of sedimentation. *Journal of Ecology* **68**: 457-477.

O'Neill, A. L., L. M. Head, and J. K. Marthick. 1993. Integrating remote sensing and spatial analysis techniques to compare Aboriginal and pastoral fire patterns in the East Kimberley, Australia. *Applied Geography* **13**: 67-85.

Orme, B. 1981. *Anthropology for Archaeologists*. London: Duckworth.

Ovington, J. D. 1975. Strategies for the management of natural and man-made ecosystems. In W. H. van Dobben and R. H. Lowe-McConnell (eds.), *Unifying Concepts in Ecology*, pp. 239-246. The Hague: Dr W. Junk B. V. Publishers.

Parsons, J. J., and W. M. Denevan. 1967. Pre-Columbian ridged fields. *Scientific American* **217**(1): 93-100.

Patterson, W. A., III, and K. E. Sassaman. 1988. Indian fires in the prehistory of New England. In G. P. Nicholas (ed.), *Holocene Human Ecology in Northeastern North America*, pp. 107-135. New York: Plenum Press.

Paul, E. A., and G. P. Robertson. 1989. Ecology and the agricultural sciences: a false dichotomy? *Ecology* **70**: 1594-1597.

Peacock, E. 1994. Twenty-five years of cultural resource management on the National Forests of Mississippi. *Mississippi Archaeology* **29**: 72-81.

Pfeiffer, J. E. 1974. Indian City on the Mississippi. New York: Time-Life Nature/Science Annual.

Platts, W. W., C. Armour, G. D. Booth, M. Bryant, J. L. Bufford, P. Cuplin, S. Jensen, G. W. Lienkaemper, G. W. Minshall, S. B. Monsen, R. L. Nelson, J. R. Sedell, and J. S. Tuhy. 1987. Methods for Evaluating Riparian Habitats with Applications to Management. USDA Forest Service Intermountain Research Station General Technical Report INT-221.

Pulliam, C. B. 1987. Middle and Late Woodland horticultural practices in the western margin of the Mississippi River valley. In W. F. Keegan (ed.), Emergent Horticultural Economies of the Eastern Woodlands. Southern Illinois University at Carbondale, Center for Archaeological Investigations, Occasional Paper No. 7: 185-199.

Rappaport, R. A. 1990. Ecosystems, populations and people. In E. F. Moran (ed.), *The Ecosystem Approach in Anthropology: From Concept to Practice*, pp. 41-72. Ann Arbor: The University of Michigan Press.

Redclift, M. 1991. The multiple dimensions of sustainable development. *Geography* **76**: 36-42.

Redman, C. L. 1992. The impact of food production: short-term strategies and long-term consequences. In J. E. Jacobson and J. Firor (eds.), *Human Impact on the Environment: Ancient Roots, Current Challenges*, pp. 35-49. Boulder, Colorado: Westview Press.

Reichle, D. E., R. V. O'Neill, and W. F. Harris. 1975. Principles of energy and material exchange in ecosystems. In W. H. van Dobben and R. H. Lowe-McConnell (eds.), *Unifying Concepts in Ecology*, pp. 27-43. The Hague: Dr W. Junk B. V. Publishers.

Reidhead, V. A. 1980. The economics of subsistence change: test of an optimization model. In T. K. Earle and A. L. Christenson (eds.), *Modeling Change in Prehistoric Subsistence Economies*, pp. 141-186. Academic Press.

Rhodes, T. E., and R. B. Davis. 1995. Effects of late Holocene forest disturbance and vegetation change on acidic Mud Pond, Maine, USA. *Ecology* **76**: 734-746.

Rice, D. S. 1976. The Historical Ecology of Lakes Yaxha and Sacnab, El Peten, Guatemala. Ph.D. dissertation, Pennsylvania State University, State College. Ann Arbor: University Microfilms.

Rice, D. S. 1978. Population growth and subsistence alternatives in a tropical lacustrine environment. In P. D. Harrison and B. L. Turner II (eds.), *Pre-Hispanic Maya Agriculture*, pp. 35-62. Albuquerque: University of New Mexico Press.

Rice, D. S., P. M. Rice, and E. S. Deevey, Jr. 1985. Paradise lost: Classic Maya impact on a lacustrine environment. In M. D. Pohl (ed.), *Prehistoric Lowland Maya Environment and Subsistence Economy*, pp. 91-105. Cambridge: Harvard University, Papers of the Peabody Museum of Archaeology and Ethnology, vol. 77.

Riley, T. J. 1987. Ridged-field agriculture and the Mississippian economic pattern. In W. F. Keegan (ed.), *Emergent Horticultural Economies of the Eastern Woodlands*. Southern Illinois University at Carbondale, Center for Archaeological Investigations, Occasional Paper No. 7: 295-304.

Riley, T. J., and G. Freimuth. 1977. Prehistoric agriculture in the upper Midwest. *Field Museum of Natural History Bulletin* **48**(6): 4-8.

Robbins, L. E., and R. L. Myers. 1992. Seasonal Effects of Prescribed Burning in Florida: A Review. Tallahassee: Tall Timbers Research, Inc. Miscellaneous Publications No. 8.

Rue, D. J. 1986. A Palynological Analysis of Pre-Hispanic Human Impact in the Copan Valley, Honduras. Ph.D. dissertation, Pennsylvania State University, State College. Ann Arbor: University Microfilms.

Ruhl, D. L. 1993. Old customs and traditions in new terrain: sixteenth- and seventeenth-century archaeobotanical data from *La Florida*. In C. M. Scarry (ed.), *Foraging and Farming in the Eastern Woodlands*, pp. 255-283. Gainesville: The University Press of Florida.

Russell, E. W. B. 1983. Indian-set fires in the forests of the northeastern United States. *Ecology* **64**: 78-88.

Sale, K. 1990. *The Conquest of Paradise: Christopher Columbus and the Columbian Legacy*. New York: Alfred A. Knopf.

Salwasser, H., and J. C. Tappeiner II. 1981. An ecosystem approach to integrated timber and wildlife habitat management. Transactions of the 46th North American Wildlife and Natural Resources Conference, 1981: 473-487. Washington, D.C.: Wildlife Management Institute.

Sauer, C. O. 1956. The agency of Man on the earth. In W. L. Thomas, Jr. (ed.), *Man's Role in Changing the Face of the Earth*, Vol. 1, pp. 49-69. The University of Chicago Press.

Scarry, C. M. 1993a. Variability in Mississippian crop production strategies. In C. M. Scarry (ed.), *Foraging and Farming in the Eastern Woodlands*, pp. 78-90. Gainesville: University Press of Florida.

Scarry, C. M. 1993b. Agricultural risk and the development of the Moundville chiefdom. In C. M. Scarry (ed.), *Foraging and Farming in the Eastern Woodlands*, pp. 157-181. Gainseville: The University Press of Florida.

Schmidt, P. R. 1994. Historical ecology and landscape transformation in eastern equatorial Africa. In C. L. Crumley (ed.), *Historical Ecology: Cultural Knowledge and Changing Landscapes*, pp. 99-125. Santa Fe: School of American Research Press.

Shetler, S. 1991. Three faces of Eden. In H. J. Viola and C. Margolis (eds.), *Seeds of Change: A Quincentennial Commemoration*, pp. 225-247. Washington: Smithsonian Institution Press.

Siemens, A. H., and D. E. Puleston. 1972. Ridged fields and associated features in southern Campeche: new perspectives on the Lowland Maya. *American Antiquity* **37**: 228-239.

Simmons, I. G. 1989. *Changing the Face of the Earth*. Oxford: Basil Blackwell.

Sluyter, A. 1994. Intensive wetland agriculture in Mesoamerica: space, time, and form. *Annals of the Association of American Geographers* **84**: 557-584.

Smith, B. D. 1987. The independent domestication of indigenous seed-bearing plants in eastern North America. In W. F. Keegan (ed.), *Emergent Horticultural Economies of the Eastern Woodlands*. Southern Illinois University at Carbondale, Center for Archaeological Investigation, Occasional Paper No. 7: 3-47.

Stein, J. K. 1993. Scale in archaeology, geosciences, and geoarchaeology. In J. K. Stein and A. R. Linse (eds.), *Effects of Scale on Archaeological and Geoscientific Perspectives*. The Geological Society of America Special Paper 283: 1-10.

Taylor, R. W. 1989. Changes in freshwater mussel populations of the Ohio River: 1,000 BP to recent times. *Ohio Journal of Science* **89**: 188-191.

Taylor, R. W., and B. D. Spurlock. 1982. The changing Ohio River naiad fauna: a comparison of early Indian middens with today. *The Nautilus* **96**: 49-51.

Thomas, W. L., Jr. (ed.). 1956. *Man's Role in Changing the Face of the Earth*, Vols. 1 and 2. The University of Chicago Press.

Thornes, J. B. 1988. Erosional equilibria under grazing. In J. Bintliff, D. A. Davidson, and E. G. Grant (eds.), *Conceptual Issues in Environmental Archaeology*, pp. 193-210. Edinburgh University Press.

Tivy, J. 1990. *Agricultural Ecology*. New York: Longman Scientific and Technical.

Toky, O. P., and P. S. Ramakrishnan. 1983. Secondary succession following slash and burn agriculture in north-eastern India. II. Nutrient cycling. *Journal of Ecology* **71**: 747-757.

Turner, B. L. II. 1974. Prehistoric Intensive Agriculture in the Mayan Lowlands. *Science* **185**: 118-124.

van der Maarel, E. 1975. Man-made natural ecosystems in environmental management and planning. In W. H. van Dobben and R. H. Lowe-McConnell (eds.), *Unifying Concepts in Ecology*, pp. 263-274. The Hague: Dr W. Junk B. V. Publishers.

Vankat, J. L. 1977. Fire and man in Sequoia National Park. *Annals of the Association of American Geographers* **67**: 17-27.

Varner, J., and J. Varner (trans.). 1951. *The Florida of the Inca*. Austin: University of Texas Press.

Watson, P. J. 1985. The impact of early agriculture in the upland drainages of the Midwest and Midsouth. In R. I. Ford (ed.), *Prehistoric Food Production in North America*. The University of Michigan, Museum of Anthropology, Anthropological Papers No. 75: 99-147.

Weatherford, J. 1988. *Indian Givers: How the Indians of the Americas Transformed the World*. New York: Fawcett Columbine.

Webster, J. R., and J. B. Waide. 1982. Effects of forest clearcutting on leaf breakdown in a southern Appalachian stream. *Freshwater Biology* **12**: 331-344.

Whitehead, D. R., and M. C. Sheehan. 1985. Holocene vegetational changes in the Tombigbee River valley, eastern Mississippi. *American Midland Naturalist* **113**: 122-137.

Whitmore, T. M., and B. L. Turner II. 1992. Landscapes of cultivation in Mesoamerica on the eve of the Conquest. *Annals of the Association of American Geographers* **82**: 402-425.

Wilbanks, T. J. 1994. 'Sustainable development' in geographic perspective. *Annals of the Association of American Geographers* **84**: 541-556.

Williams, G. I., Jr. 1993. Environmental setting. In A. M. Early (ed.), *Caddoan Saltmakers in the Ouachita Valley: The Hardman Site*, pp. 15-28. Arkansas Archeological Survey Research Series No. 43.

Wilson, J. B., and W. McG.King. 1995. Human-mediated vegetation switches as processes in landscape ecology. *Landscape Ecology* **10**: 191-196.

Winterhalder, B. 1994. Concepts in historical ecology: the view from evolutionary ecology. In Carole L. Crumley (ed.), *Historical Ecology: Cultural Knowledge and Changing Landscapes*, pp. 17-41. Santa Fe: School of American Research Press.

Woebse, H. H. 1975. *Landschaftökologie und Landschaftsplanung*. R. M. Verlag, Graz.

Woods, W. I. 1987. Maize agriculture and the late prehistoric: a characterization of settlement location strategies. In W. F. Keegan (ed.), *Emergent Horticultural Economies of the Eastern Woodlands*. Southern Illinois University at Carbondale, Center for Archaeological Investigations, Occasional Paper No. 7: 275-294.

Worsley, A. T., and F. Oldfield. 1988. Palaeoecological studies of three lakes in the highlands of Papua New Guinea. II. Vegetational history over the last 1600 years. *Journal of Ecology* **76**: 1-18.

Wymer, D. A. 1987. The Middle Woodland-Late Woodland interface in central Ohio: subsistence continuity amid cultural change. In W. F. Keegan (ed.), *Emergent Horticultural Economies of the Eastern Woodlands*. Southern Illinois University at Carbondale, Center for Archeological Investigations, Occasional Paper No. **7**: 201-216.

Yarnell, R. A. 1993. The importance of native crops during the Late Archaic and Woodland periods. In C. M. Scarry (ed.), *Foraging and Farming in the Eastern Woodlands*, pp. 13-26. Gainesville: The University Press of Florida.

Zimmerer, K. S. 1994. Human geography and the 'New Ecology': the prospect and promise of integration. *Annals of the Association of American Geographers* **84**: 108-125.