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PART I

Panarchy as an integrative paradigm

OVERVIEW

Whether or not prehistoric Native Americans were a significant ecological factor has been the subject of intense debate among generations of ecologists. During the latter half of the twentieth century, the pendulum of opinion has swung from the belief that American Indians had no influence on the composition and structure of plant and animal communities to the assertion that they were responsible for destruction of native habitats through over-exploitation of natural resources and widespread use of fire.

Quaternary paleoecology and archaeology are inherently multidisciplinary fields, drawing upon proxy information from data sets representing past states of climate, soils and geomorphology, biota, and material culture to make interpretations of changes in natural and cultural landscapes over millennial time scales. Time series of paleoecological and archaeological data yield chronologies of changes in both ecosystems and social systems. Before 1980, however, relatively few studies combined archaeological and paleoecological methods to determine objectively the kinds, extent, and duration of ecological influences by prehistoric Native Americans. Although a number of exemplary studies have been conducted since that time, the challenge remains to integrate available information effectively from paleoecology and archaeology in order to understand the linkages and dynamic feedbacks of processes underlying the documented patterns of change in prehistoric human ecosystems.

Panarchy theory has been developed recently by C. S. Holling and colleagues (Gunderson and Holling, 2001; Holling 2001) as an extension of hierarchy theory that includes cycles of adaptation in ecological and cultural processes. Panarchy theory is a heuristic explanatory model that views the development of human ecosystems as holistic, self-organizing, complex adaptive systems. Panarchy theory views the complex interactions between humans and their environment as adaptive responses that result in

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self-organized, hierarchical systems. In this book, we adopt panarchy theory as a contemporary paradigm for integrating paleoecological and archaeological data concerning the evolution of human ecosystems in North America during the Holocene interglacial interval.

In Chapter 1, *The need for a new synthesis*, we discuss the debate over the "myth of the natural man." We explain why a disparity of viewpoints has arisen concerning the role of prehistoric Native Americans as agents of ecological change, and we suggest why a new kind of synthesis is needed.

In Chapter 2, *Panarchy theory and Quaternary ecosystems*, we adopt a panarchical view of the development of Quaternary ecosystems as self-organizing, complex adaptive systems. We illustrate the utility of panarchy theory by applying it on a Quaternary time scale, where glacial–interglacial cycles represent macro-scale adaptive cycles of organization, disruption, and reorganization of ecosystems.

In Chapter 3, *Holocene human ecosystems*, we explain why the Holocene interglacial interval is unique, with the arrival of humans in North America and the development of a several-tiered panarchy of human ecosystems. We explore the implications of this new viewpoint of human ecosystems as self-organized, complex adaptive systems for reinterpreting the classic cultural periods identified in the archaeological record.

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1

The need for a new synthesis

THE MYTH OF THE NATURAL MAN

The concept of the Native American as "noble savage," living in harmony with nature, stems largely from the writings of the French philosopher, Rousseau, who lived from AD 1712 to 1778. Rousseau contrasted the "natural man," who lived in the unspoiled wilderness, with the "civilized man," who lived in society and sought to conquer the wilderness (Dolph, 1993). The concept of the noble savage was used in describing Native Americans by European American colonists of the eighteenth and nineteenth centuries, and those early descriptions became the basis for subsequent interpretations of the "presettlement" North American landscape by environmental historians and historical ecologists (Cronon, 1983; Crosby, 1986; Russell, 1997; Krech, 1999). The prevailing viewpoint of early twentieth-century ecologists was that human interference with natural succession began with European American settlement, and that in prehistoric times the vegetation was in equilibrium with climate and other environmental factors, including aboriginal human presence (Clements, 1936).

The debate among ecologists

Day (1953) was among the first academic ecologists to question this assumption. He argued that at the time of first European contact, the landscape of Eastern North America was not an unbroken virgin forest that had not been disturbed significantly by activities of Native Americans. Rather, settlers often described large tracts of open forest with little understory. Day cited ethnographic accounts (e.g., Densmore, 1927) to infer that prehistoric and historic Indians of New England drew upon the forest for a large variety of products. Historical accounts documented that Indians lived in villages that were sometimes stockaded and more than 100 acres in extent, and grew maize, tobacco, beans, and squash in extensive fields that were

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abandoned only as white settlements encroached and disease eliminated Indians. Day cited a number of anecdotal accounts of the use of fire, for example by the Iroquois of central New York, for hunting, improving growth of grass, and clearing of fields. He suggested that Indians may have taken advantage of blowdowns of forest canopy trees, keeping the forest canopy gaps clear by burning. Day further speculated that selective hunting and use of fire to promote browse would have increased the populations of heath hen, passenger pigeon, wild turkey, and white-tailed deer, and that the cultural practice of favoring nut trees and other food plants would have had long-term effects on forest composition. He stated, however, that there was no evidence in the writings of early authorities for wholesale annual burning across southern New England, and that fire was important only in places inhabited by Indians. Day (1953) concluded that "Indians of the Northeast cleared land for villages and fields, cut fuelwood and set fires beyond the clearings, exercised a wide indirect influence on vegetation through their hunting, and may have favored or even transplanted food and medicinal plants."

Later researchers (Cronon, 1983; Russell, 1997) questioned the extent to which anecdotal evidence in the form of early travelers' accounts and diaries can be used to substantiate conclusions about the importance of Indians as an ecological factor. In a re-evaluation of the historical evidence for burning by Native Americans within the forested coastal region extending from the Carolinas to Maine, Russell (1983) found that only half of the thirty-five documents she read that described vegetation or Indian life in the sixteenth and seventeenth centuries mentioned the use of fire, except for cooking. Only six credible accounts referred to purposeful burning near camps or villages, with fires escaping only accidentally; the most frequently described fires were scattered and of limited extent. Russell cited an earlier study by Raup (1937) suggesting that early settlers may have attributed open woods to Indian-set fires because they were unable to imagine natural openings in the forest.

Although historical accounts can provide direct evidence linking human activities with ecological effects, such documents must be screened carefully to ensure objectivity of the witness (Forman and Russell, 1983). From analysis of such documents, the extent of the ecological effects of limited use of fire and other human activities remains unclear, with several alternative explanations for the described openness of precolonial forests: (1) descriptive accounts were written by land speculators to attract colonists, and emphasized how easily open woodland could be converted to farms; (2) settlements of European Americans were established on the sites of

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abandoned Indian villages, and travel routes followed long-established Indian trails, leading to a perception of widespread disturbance from a biased, localized view that may not have been representative of the vegetation across the whole landscape; and (3) shading by large, old canopy trees may have created an open understory in the forest through natural plant succession. Frequent Indian-set fires may have had deleterious effects on the environment, including destruction of necessary firewood and edible mast as well as replacement of predominant oak forests by fire-adapted pines (Russell, 1983).

Other authors have attempted to debunk what they called the "environmentalist myth" stemming from the romanticized concept of Rousseau's "noble savage" living in harmony with nature (Diamond, 1986; Dolph, 1993; Krech, 1999). Rather than revering nature and practicing a conservation ethic, prehistoric hunter-gatherers and primitive agriculturalists may have had widespread destructive influences on the environment, for example causing the extermination of large animals, whose extinctions occurred soon after first arrival of humans on the islands of New Zealand, Madagascar, and Hawaii. This "Overkill hypothesis" has been proposed to account for extinction of large mammals across North America at the end of the Pleistocene (Martin, 1984). Examples of irreversible environmental damage through habitat destruction associated with prehistoric human cultures include deforestation of Easter Island by Polynesian colonists that led to soil erosion, lower crop yields, loss of material for building canoes that were used for fishing, and loss of wood levers for erecting stone statues (Diamond, 1986). When the carrying capacity of the island for humans was exceeded, cannibalism and warfare resulted. In the American Southwest, a combination of prolonged drought, failure of irrigation systems, and over-exploitation of wood resources by the Anasazi led to a similar demise of their culture nearly 1000 years ago (Kohler, 1992; Redman, 1999).

Day (1953) called for increased documentation of the extent and intensity of effect of prehistoric Native American impacts on their natural environment. He advocated that to understand the ecology of a given study area, ecologists should collaborate with archaeologists to determine (1) the duration of Indian occupation; (2) prehistoric human population density; (3) population concentration and movements; and (4) the local pattern of settlement. He concluded "that an area which was wooded when first seen by white men was not necessarily primeval; that an area for which there is no record of cutting is not necessarily virgin; and that a knowledge of local archeology and history should be part of the ecologist's equipment." Despite Day's encouragement for interdisciplinary collaboration, until the

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1980s and 1990s relatively few studies combined ecological, archaeological, and paleoecological methods to determine objectively the kinds, extent, and duration of prehistoric Native American ecological influences.

Divergent viewpoints

The continuing debate over the extent to which Native Americans have been an ecological factor through time has in part resulted from a lack of communication across disciplinary lines. This lack of coordination of interdisciplinary evidence has resulted from a long history of independent development of these academic disciplines. Across the North American continent, the fields of ecology, archaeology, and Quaternary paleoecology have developed parallel but distinctively different traditions of investigation based upon their respective long-established methods. During much of the twentieth century, ecological research concentrated on understanding the relationships of plants and animals to their natural environment, independent of human intervention (McIntosh, 1985). Archaeologists focused on interpreting the evolution of human cultures based primarily upon field collections of durable artifacts such as stone projectile points and ceramic pottery (Griffin, 1952). Quaternary paleoecologists have been preoccupied with deciphering long-term changes in climate from pollen records preserved in lake sediments (Wright *et al.*, 1993).

With these several divergent objectives, relatively little research has been designed to develop and test explicit hypotheses about the interrelationships of human populations, plant and animal communities, climate change, and landscape evolution. As a result, widely differing points of view have developed concerning the importance of prehistoric humans as agents of ecological change. Archaeologists, working with tangible evidence of human presence from numerous specific sites, argue for the pervasive impacts of Native Americans on North American landscapes throughout at least the past 15 000 years (Driver and Massey, 1957; Morse and Morse, 1983). Ecologists, selecting study sites located away from known centers of prehistoric human influence, view that in preColumbian times the North American continent was a vast, largely untouched wilderness (Braun, 1950; Williams, 1989; Whitney, 1994). Quaternary paleoecologists, using large lakes as study sites, strive to resolve regional climate change and broad-scale vegetation dynamics (Webb *et al.*, 1993), but tend to overlook ecological pattern and process on the more local scales at which humans may have interacted with their environment in prehistoric times (Delcourt *et al.*, 1986). Many paleoecologists thus view climate change as the ultimate forcing

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function for both ecological and cultural change (Wright, 1984, 1993), whereas many archaeologists argue for human cultural and technological adaptation as an overriding factor in social organization and population growth through time (Johnson and Earle, 2000; Kohler *et al.*, 2000).

EFFECTIVE LAND MANAGEMENT REQUIRES A NEW SYNTHESIS

Differences in techniques, focus, and objectives have resulted in a polarization of viewpoints, leading to confusion about the ecological role of prehistoric Native Americans. Resolving this conflict of opinions is important not only because it influences how we view the heritage of Native Americans but also because it is an important element in determining how we will manage our natural resources into the future (Peacock, 1998). The United States federal government mandates that wilderness areas and old-growth forests be restored and maintained in their "natural condition," defined as that which existed in preColumbian times (before European American contact in the late 1400s), and therefore supposedly in a condition that was previously unaffected by human activities (Henderson and Hedrick, 1991; Hamel and Buckner, 1998). This land management policy reflects the widely held notion that activities of prehistoric Native Americans were an insignificant ecological factor, and it is furthered by the general rejection by ecologists of "soft" data from archaeological investigations and historic ethnographic accounts (Russell, 1983, 1997).

Intermeshing of viewpoints

Integrating interdisciplinary data first requires intermeshing of viewpoints. Butzer (1982) was among the first to call for such a synthesis of viewpoints, with a general goal of understanding the human ecosystem. Stoltman and Baerreis (1983, p. 252) defined the human ecosystem as "a discrete human population that has a shared cultural inventory of technologic, social–organizational, and subsistence practices and is in interactive association with a specified environment." The human ecosystem thus defined includes subsistence, technology, social organization, population, and environment (Figure 1.1), all five of which potentially leave interpretable physical traces in the archaeological record (Stoltman and Baerreis, 1983). Butzer (1982) defined "contextual archaeology" as "a realistic appreciation of the environmental matrix and of its potential spatial, economic, and social interactions with the subsistence–settlement system." Thus, to an archaeologist, the environment is a "potential resource catchment" from which people draw

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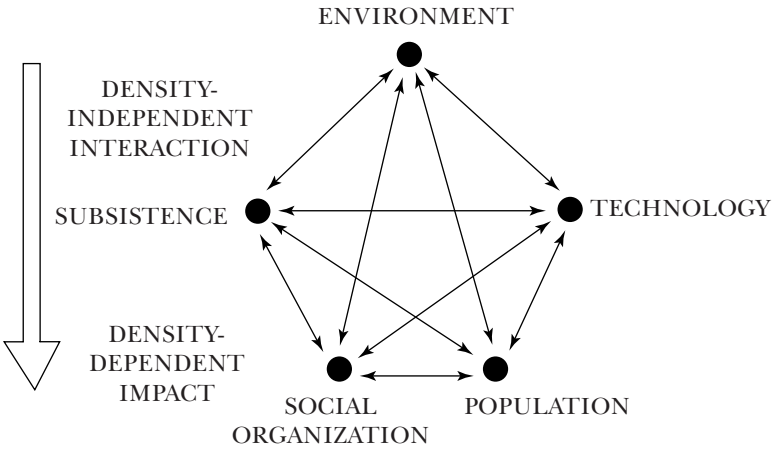

Figure 1.1 Model of the human ecosystem displaying the spectrum of human–environment interactions that reflect increasing impacts associated with larger populations (modified from Stoltman and Baerreis, 1983).

their sustenance. This viewpoint differs substantially from that of the paleoecologist, who views the activities of humans as one of many potential influences on ecosystem patterns and processes (Delcourt and Delcourt, 1991). To achieve integration of the reciprocal relationships between humans and environment, researchers from each discipline must be open to new viewpoints concerning the implications of their data. Only by integrating ecological, archaeological, and Quaternary paleoecological information can alternative hypotheses concerning the interrelationships of prehistoric Native Americans with their environment be tested.

Perceived obstacles to interpretation

A major reason for continued debate on the ecological effects of prehistoric Native Americans is the increasing rigor required for hypothesis testing. Perceived obstacles to achieving an effective synthesis of paleoecological and archaeological data include several traditional stumbling blocks in scientific investigation (Birks, 1988).

The first of these obstacles is that time series of fossil pollen or of cultural artifacts document unique sequences of events at particular places and may not be replicable as "natural experiments" (Deevey, 1969).

Second, paleoecological studies are primarily descriptive accounts of changes in landscapes through time, and thus interpretations may be

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difficult to present as falsifiable hypotheses; instead, multiple working hypotheses are necessary because several interpretations may be consistent with available evidence (Birks, 1988). In addition, a reductionist view of nature, in which a single factor is isolated as a cause of change, is untenable because many environmental and biological variables change simultaneously at a given location (Gunderson *et al.*, 1995; Abel 1998). Hence, as the demand for quantitative and reproducible data has grown, so has the realization that statistical correlations and determination of cause and effect are made more difficult by real-world circumstances where the paleoecological investigator cannot always separate environmental causes of ecological change from the effects of human cultural evolution.

Interdisciplinary integration also requires becoming open to new sources of data. Intermeshing of data sets reaches its highest fruition as a result of collaboration on data analysis (Griffin, 1984). Because of the tendency for specialization along disciplinary lines (Butzer, 1975), developing a holistic integration of data requires interpretation of many lines of evidence simultaneously, following discussion from several different sources of informed opinion.

Scaling issues

Correct interpretation of the interrelationships between humans and their environments requires an appropriate choice of spatial–temporal window through which prehistory is viewed (Delcourt *et al.*, 1983; Delcourt and Delcourt, 1988). To be effective, an interdisciplinary research strategy must take into account how humans view their environment, and at what scales in space and time their activities have influenced ecosystem development. We can begin to test hypotheses about human–environment interactions only if we can match the spatial and temporal scale of archaeological evidence for past human activities with that of paleoecological evidence for ecological changes. Determining the appropriate spatial and temporal scales (Levin, 1992) and choosing the appropriate analytical tools with which to compare archaeological and paleoecological evidence (Delcourt *et al.*, 1983) is the key to integrating these traditionally disparate forms of data.

Three discrete scaling issues are important in detecting human influences on ecosystem pattern and process: (1) determining the "grain" of landscape patterning in ecological and human cultural systems; (2) establishing the appropriate extent of the geographic area to be sampled by the different techniques; and (3) finding the appropriate temporal and spatial scales at which to detect interrelationships between humans and their environments.

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By choosing appropriate techniques and sampling sites, optimal scales can be chosen for integrated paleoecological and archaeological studies. For example, alpha diversity (species richness, Whittaker, 1972) and local human impacts can be studied by combining pollen, plant macrofossil, and charcoal particle studies from soils and barrow pits with artifacts, ethnobotanical remains, and faunal remains from individual features and structures (microscale analysis). Beta diversity, or community composition across environmental gradients on watersheds (Gauch, 1982) can be studied through paleoecological analysis of sediments from ponds or small lakes located within tens of meters to a kilometer from an archaeological site representing a village or ceremonial complex (mesoscale analysis). Gamma diversity, or the patchwork of the ecological mosaic across a broad, regional landscape (Whittaker, 1972), can be determined from paleoecological studies of medium-sized to large lakes combined with analysis of integrated site systems across a large region (macroscale analysis).

CONCLUSIONS: FORGING A NEW SYNTHESIS

Several trends in research directions in the late twentieth century and early twenty-first century are setting the stage for developing a new synthesis forged from the extensive literature in ecology, archaeology, and Quaternary paleoecology. Landscape, historical, and restoration ecologists are increasingly focused upon the issue of future biological sustainability (Lubchenco *et al.*, 1991). Increasingly, ecologists are gaining an appreciation of the role of traditional agriculture in the cultural history and sustainability of human ecosystems both in Europe (Birks *et al.*, 1988) and in North America (Turner *et al.*, 2000). In addition, information gleaned from oral histories and ethnographic accounts is leading to a better understanding of human–environment interactions based upon traditional ecological knowledge (Berkes *et al.*, 2000). The legacy of prehistoric Native American ecosystems for future land management can be understood through synthesis of the development of such ecological interactions over time scales of hundreds to thousands of years.

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