

From: HOLOCENE HUMAN ECOLOGY IN NORTHEASTERN
NORTH AMERICA
Edited by George P. Nicholas
(Plenum Publishing Corporation, 1988)

Chapter 5

Indian Fires in the Prehistory of New England

WILLIAM A. PATTERSON III AND
KENNETH E. SASSAMAN

1. INTRODUCTION

Humans have inhabited the northeastern United States for approximately 12,000 years (Figure 1). During that period the vegetation of the region changed first from tundra to boreal spruce and fir forests. For the past 8,000 years or so, mixtures of pines, spruces, fir, hemlock, and a variety of hardwoods including beech, several oaks, maples, hickories, and birches have occupied the landscape. Changing climate and the differential migration of plant species were responsible for the vegetation changes that occurred over time periods spanning several hundred to a few thousand years (Davis 1983). Today we see a vegetation pattern that can be related to regional variations in climate, topography, soils, and human settlement. Alpine tundra is found at high elevations in the White Mountains, spruce and fir forests cover much of northern Maine, Vermont, and New Hampshire, and pitch pine and oaks occupy the xeric, sandy soils of southern coastal areas. Mesic forest species occur over a broad area of central New England (Westveld *et al.* 1956).

Historically, ecologists have focused their study of vegetation dynamics on long-term changes that are largely a function of climate. Because climate changes

WILLIAM A. PATTERSON III • Department of Forestry and Wildlife Management, University of Massachusetts, Amherst, Massachusetts 01003. KENNETH E. SASSAMAN • Department of Anthropology, University of Massachusetts, Amherst, Massachusetts 01003.

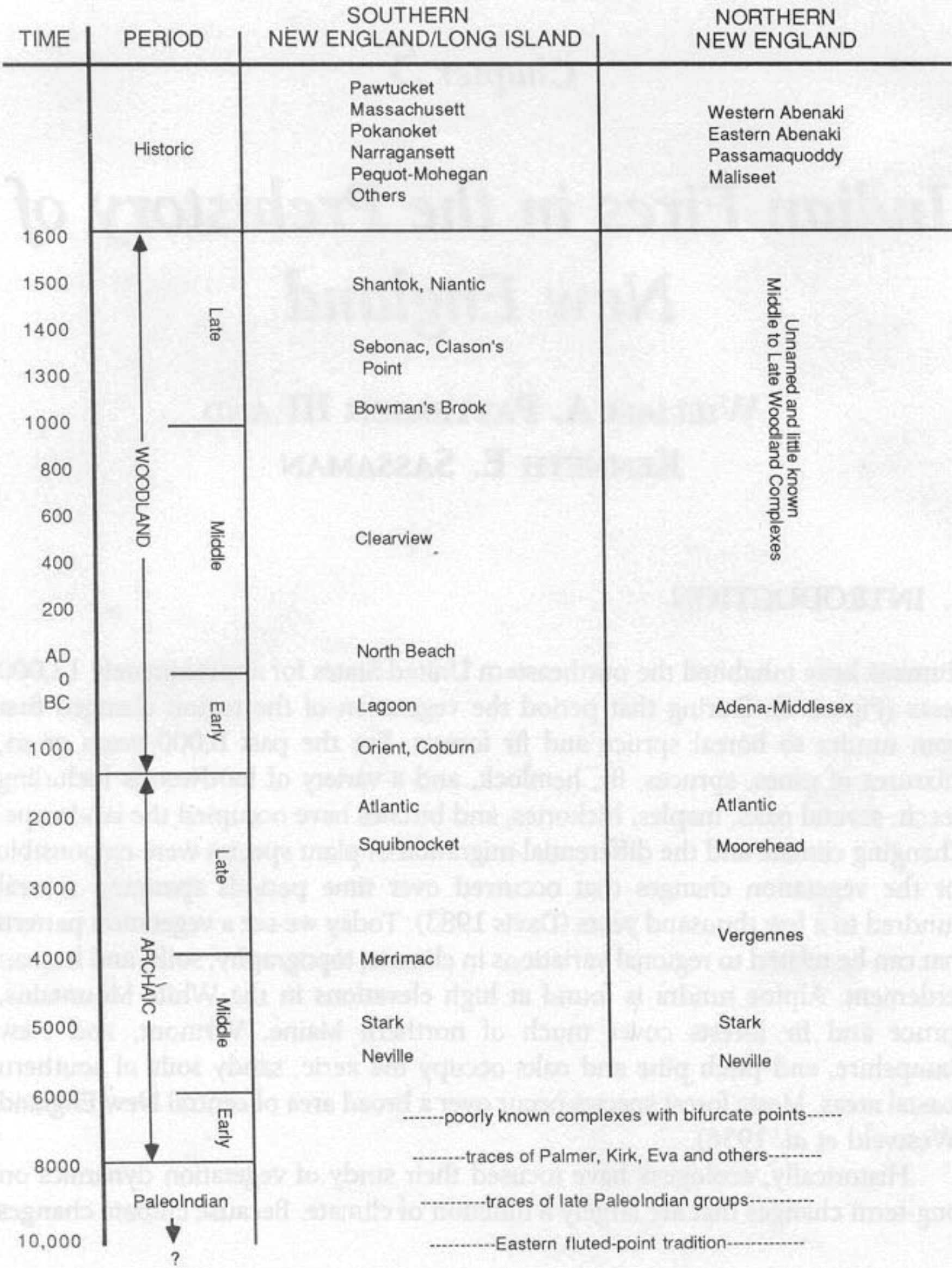


Figure 1. Cultural sequence and chronology for New England. Adapted from Funk 1983:306–307.

slowly, vegetation change related to it tends to be slow. This research emphasis on long-term changes in vegetation gave rise, during the early decades of this century, to the concept of climax vegetation, i.e., types that remain stable over broad areas for long periods of time. The gradual change in vegetation that occurs with time is known as succession, with a series of successional stages (or seres) leading ultimately to a climax vegetation type that maintains a stable species composition as long as climate is constant (Clements 1916).

Although the concept of climatically controlled climax vegetation types has been useful in comparing vegetation on a continental scale, recent research has shown that at both the regional and local levels vegetation is constantly changing in response to local perturbations (Brown 1960; Henry and Swan 1974; Spurr 1956; Stephens 1955). Disturbances such as wind storms, flooding, insect and disease outbreaks, grazing and browsing by animals, and fire can cause vegetation to change despite stable climate, topography, and soils. Of these disturbances, fire is of particular interest because it can affect very large areas (up to several thousand square kilometers) in a short period of time and because it can occur both naturally due to lightning and as a result of human activity. In the absence of human suppression activity, fires burn much of the earth's vegetation at varying intervals and intensity, depending upon ignition sources and local weather conditions and fuel accumulations (Kozlowski and Ahlgren 1974).

Lightning has caused wildland fires for millions of years, and humans have used fire for at least the last several hundred thousand years. Thus, fire has been an ecological factor long enough to affect both landscape composition and species evolution. Many plant and animal species show specific adaptations to living in environments that burn periodically. Humans are no exception, but, significantly, humans have the ability not only to exploit resources made available by wildland fires, but also to influence fire behavior and occurrence.

Ecologists and archaeologists have long recognized that fires had an important effect on the vegetation of North America prior to the Colonial period. Evidence from areas as widely separated as Alaska (Shackleton 1979), Minnesota (Craig 1972), and Maine (Anderson 1979) shows that fires burned since before the time when humans first emigrated to the continent at the end of the last ice age. It seems likely that the early inhabitants of North America were accustomed to living in environments that were periodically affected by fire.

2. EXTENT OF INDIAN BURNING

There is little agreement on the extent to which humans may have actually influenced fire occurrence in North America. Stoltman and Baerreis (1983) postulate that in the Northeast, Indians have used fire to clear land for agriculture for at least the last 1,000 years. Accounts by early explorers and missionaries imply

that Indians used fire to drive game, communicate among groups, clear away underbrush, and prepare land for planting (Day 1953). Interviews with elders from Indian villages in northern Alberta led anthropologist Henry Lewis to conclude that Indians had a sophisticated knowledge of fire effects and use and that they burned "to manipulate and eventually to create local environments of their own design" (Lewis 1982a:65). Of interest to ecologists is the fact that, according to Lewis, Indian fires "differed significantly from natural fires in terms of seasonality, frequency, intensity and selectivity" (Lewis 1982a:45).

Bromley (1935:64) reviewed accounts of early colonists in southern New England, concluding that, "all are in accord . . . that the original forest was, in most places, extremely open and park like, due to the universal factor of fire, fostered by the original inhabitants to facilitate travel and hunting." He estimates that "there was probably a sufficient population (of Indians) to bring about an annual burning of most of the country sufficiently dry for a conflagration," and cites Thomas Morton, who wrote in 1632 that "the Salvages are accustomed to set fire of the country in all places where they come; and to burn it, twice a yeare."

Russell (1983) notes that many early accounts were second hand in nature and were often based upon hearsay. She speculates that some writers may have had economic motives for portraying the land as open and parklike as a result of frequent burning (i.e., many of the early colonists hoped to encourage others to emigrate from the Old World, where few forests remained after centuries of exploitation for agriculture and fuelwood). Russell cites Brown and Davis (1973:16), who state that, "it is at least a fair assumption that no habitual or systematic burning was carried out by Indians." She concludes that "there is no strong evidence that Indians purposely burned large areas of the forested northeastern United States frequently," although she acknowledges that "the presence of Indians did, however, undoubtedly increase the frequency of fires above the low numbers caused by lightning." Forman and Russell (1983:5) expanded Russell's conclusions to North America as a whole: "This example touches on probably the most widespread problem of human disturbance history in North American ecology, regular and widespread Indian burning (Day 1953), an unlikely hypothesis that regrettably has been accepted in the popular literature and consciousness (Russell 1983)." This statement drew immediate and strong criticism from Myers and Peroni (1983), and controversy over the extent and purpose of Indian burning continues.

3. THE NEED FOR ADDITIONAL STUDY

The question of Indian burning deserves continued study because of the potential impact that frequent fires could have had on the vegetation of New

England. Analyses to date have suffered, on one hand, from rather subjective evaluations of sketchy historical accounts, as Russell (1983) observes, and on the other, from too strict adherence to the Clementsian concept of succession toward climatic climax vegetation associations.

For the Northeast in particular, too little emphasis has been placed upon evaluating both the factors that influence fire occurrence and the evidence for human cultural development available from archaeological and anthropological studies. We disagree with Russell (1983:78), who states that "the importance of man in the pre-Colonial forests can be approached directly only through the use of historical records." This statement would be true only if human and vegetation development were static for a long period of time prior to European settlement. It may never be possible to examine "the importance of man" in the pre-Colonial forest directly, but we feel that by examining indirect evidence covering long periods of time it should be possible to develop a logical construct that will help us to understand the development of forest conditions as they existed at the time of settlement. Although such a construct will be continually revised as new evidence accumulates, it is our purpose to review information and to provide a basis for further development of our understanding of the use of fire by Indians in New England.

4. FACTORS INFLUENCING FIRE OCCURRENCE

Pyne (1984:208) defines fire regime as "a particular complex of fuel, manifested as a biota, and a particular pattern of fire occurrence and behavior, described generally as its fire history." A fire regime describes, for a particular area, the way in which the combustion process (fire) interacts with fuels, topography, and weather conditions (i.e., the fire environment) to produce a specific frequency and pattern of burning leading to predictable effects on the plants and animals occupying the area. Pyne notes that "everywhere, and from the earliest times, humans have altered the natural fire regimes they have entered" (Pyne 1984:223).

Today humans are certainly an important component of fire regimes of New England, causing more than 95% of all fires in the eastern United States (Pyne 1984); similarly, Indians may have significantly altered natural fire regimes prior to European settlement. Before evaluating the potential impact of Indians, we must, however, understand (1) the elements that comprised prehistoric fire environments, and (2) how these elements could have interacted to produce a fire regime. Although there is no way to evaluate directly early fire environments, indirect evidence (e.g., fossil plant assemblages) provides information about paleoclimate and vegetation. We can also study the characteristics of modern vegetation, topography, and climate to identify potential analogs for past environments. Recently completed work allows us to do these things for at least some areas of

New York and New England (Backman 1984; Patterson *et al.* 1983, 1984a,b; Rudnicki 1984).

Wildland fires occur when favorable weather, fuels sufficiently dry to burn, and an ignition source combine to initiate and sustain the combustion process. Fires will not burn if any of these three elements is missing. Weather parameters, fuel moisture content, and ignition sources each vary seasonally within the year and from year to year. On a given day, each may vary within an area the size of New England.

Weather is a function of climate, and the present climate of New England is humid continental, with summers that are warm in the south and cool in the north (Espinshade 1976). Rainfall is ample for forest growth and evenly distributed throughout the year, although short periods of intense drought occur irregularly from year to year. Warmer temperatures in the south increase evapotranspiration, and coarse-textured soils on the coastal plain support a typically xeric vegetation comprised of pitch pine, scrub oak, and several ericaceous shrub species (e.g., blueberry, huckleberry). Fuels dry rapidly, and these forests are among the most flammable in New England. To the north, and inland at higher elevations, humidity increases and cooler temperatures result in reduced evapotranspiration. Soils retain water more effectively and physiological drought conditions are likely only on shallow soils on steep slopes.

Overall, air temperature, wind speed, relative humidity, and the duration of precipitation are the most important factors influencing the moisture content of forest fuels and the likelihood that ignitions will occur. Once a fire ignites, wind speed, fuel accumulations, and topographic factors influence the rate at which it will spread. In New England, weather conditions are generally most conducive to burning in exposed coastal areas and on hill tops.

Forest fuels may be living or dead, with the latter generally the most flammable, although the leaves of some ericaceous shrubs such as huckleberry and mountain laurel contain volatile organic compounds that allow them to burn even when green. Dead grass, herbs and ferns, and the needles and leaves that comprise the forest floor are referred to as fine fuels. They dry rapidly when temperatures rise in the spring prior to leaf out. The amount of fine fuels and their moisture content are important factors determining whether or not ignitions will occur. Once a fire is ignited, larger fuels (chiefly dead, woody material either standing or fallen) burn and generate the heat that further dries material in advance of a flaming front. Although initially driven by winds, free-burning fires produce convection columns as warm air rises. Air is drawn in from the perimeter of the fire, and in this way wildland fires can become self-propagating. As dead material accumulates within forests over time, the potential for large, self-propagating crown fires increases. Frequent fires prevent the accumulation of fuel and promote the growth of grasses and herbs that become fine fuels during the dormant season. These fine fuels further increase the likelihood of ignitions.

Frequent fires tend to burn near the ground. Fires at longer intervals allow heavier fuels to accumulate, and these promote larger "catastrophe" fires (Heinselman 1981).

Fire scientists classify ignition sources as being either natural or human. Lightning is the most important source of natural ignitions, but lightning ignitions are less important in the East than elsewhere in the United States (Pyne 1984). Lightning occasionally causes fires in interior sections of northern and central Maine (Fobes 1944), but along the coast and in southern New England, lightning fires are rare. Of 209 fires reported since 1937 at Acadia National Park on the Maine coast, only five were ignited by lightning and none of these fires burned more than 0.25 acre (Patterson *et al.* 1983). There were no lightning fires reported at Cape Cod National Seashore during 1974–1983 (Patterson *et al.* 1984b), but 112 were caused by humans during that period. Apparently the abundant moisture associated with coastal thunderstorms extinguishes the few lightning strikes that occur along the coast. Today humans are the primary cause of New England's wildland fires, and fires appear to be most common where population densities are greatest. It seems likely that this pattern also occurred prior to the Colonial period.

5. NEW ENGLAND CULTURAL ECOLOGY

5.1. Introduction

It is clear that for North America as a whole Indians were, when first encountered by Europeans, an important ignition source for wildland fire (Barrett and Arno 1982; Lewis 1973, 1977, 1982a,b; Lutz 1959; Stewart 1956). The same can be said for tribes of New England (Cronon 1983; Day 1953; Pyne 1982), although the extent to which these fires were ecologically significant is open to question (Forman and Russell 1983; Russell 1983). Comparable documentation of prehistoric fires does not exist. This precludes a straightforward evaluation of the evolutionary context of fire utilization in New England. Archaeological evidence of hearths indicates that fire was used domestically since the time humans first entered the region about 12,000 years ago, but nothing more specific is known about other uses of fire, or where and when these may have developed. Thus, the following discussion first focuses on Native American burning at the time of European contact. We then build upon this information to explore the potential for prehistoric fire use.

5.2. Protohistoric/Historic Fire Use

When European colonization began in the early seventeenth century the Atlantic seaboard from Nova Scotia to North Carolina was inhabited by peoples

collectively referred to as Eastern Algonquians. Territories occupied by Eastern Algonquian tribes generally corresponded to watersheds of major rivers and were bounded to the west by land of Iroquian-speaking peoples (Salwen 1978). The Eastern Algonquian shared many cultural traits, yet differences are evident between northern and southern New England groups with respect to subsistence economy, including the use of fire.

5.2.1. Southern New England

Early seventeenth century Indian populations in southern New England were divided into five major coastal groups and two series of smaller interior groups (Figure 2). The protohistoric subsistence economy of southern New En-

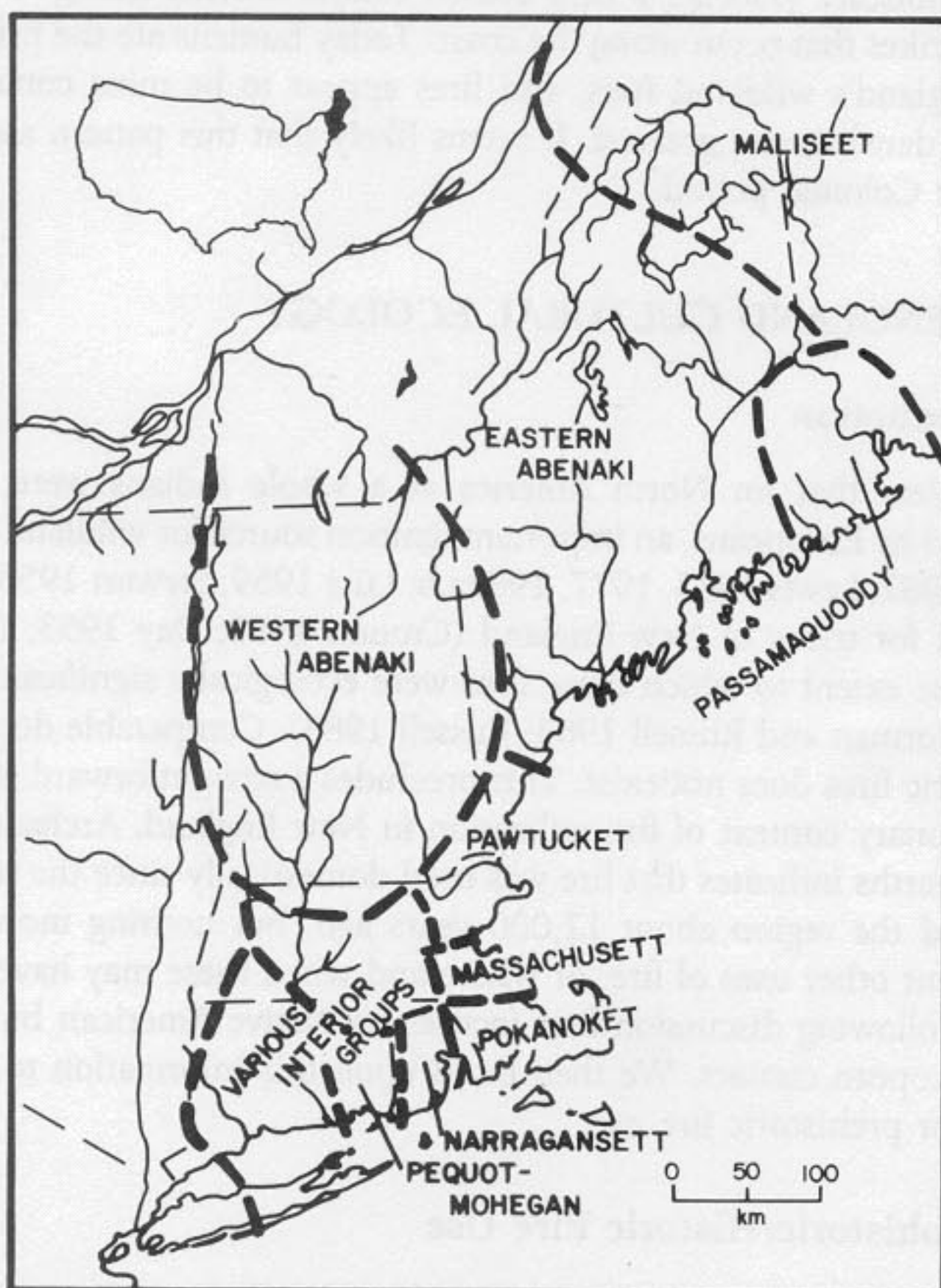


Figure 2. Approximate locations of New England Indian tribes at time of European contact.

gland was a diverse mix of hunting, fishing, shellfish collecting, plant gathering, and agriculture. The relative contributions of these pursuits to particular economies depended on natural distributions of resources, as well as on regional distributions of people, technology, and labor. Corn agriculture, for instance, became relatively more important in southern coastal areas, where the growing season was long, fertile land was plentiful, and populations tended to be concentrated (Snow 1978a). In these areas, fire became essential to the success of agriculture (e.g., Brasser 1971). Early accounts of coastal settlements describe vast open fields resulting from the Indian's slash-and-burn (i.e., swidden) technique of farming. At Narragansett Bay, Rhode Island, Verrazano noted "open plains twenty or thirty leagues in extent, entirely free from trees" (cited in Pyne 1982:48). Similar observations were made by Champlain at Cape Ann in 1606 (Champlain 1907). Letters by Higgeson and Graves in 1629 also describe numerous barren fields near Salem, Massachusetts (Byers 1946). Reports such as these were often biased toward economic or religious self-interests (Russell 1983), so we must exercise caution in interpreting their accuracy.

A more conservative interpretation based on vegetational history is that Indian burning resulted in a mosaic of forests and fields in varying stages of succession. This mosaic effect can be attributed to the shifting patterns of settlement that characterized slash-and-burn agriculturalists (Harris 1972). Equally important was the intensity to which fixed locations were used for planting, plant gathering, firewood collecting, and hunting (Cronon 1983). Once sites were cleared for cultivation they were usually reoccupied each growing season for a decade or more (Cronon 1983; Snow 1978a). Often these sites were reburned to replenish soil nutrients and to expand fields, or to maintain them as hunting and gathering locations by encouraging new browse.

Hunting territory surrounding coastal farming sites may also have been modified by fire (Brasser 1971). In his 1634 account of coastal Massachusetts, Wood observes,

. . . for it being the custome of the Indians to burne the wood in November, when the grasse is withered, and leaves are dried, it consumes all the underwood, and rubbish, which otherwise would over grow the Country, making it unpassable, and spoil their much affected hunting: so that by this means in those places where the Indians inhabit, there is scarce a brush or bramble, or any cumbersome underwood to bee seene in the more champion ground. (Wood 1634, quoted in Byers 1946:19)

Besides leaving the forest passable for hunting and gathering, broadcast burning would have had other advantages. One objective of Indian fires "was to produce fresh and sweet pasture, for the purpose of alluring the deer to the spots on which they had been kindled" (Dwight 1823:50). White-tailed deer seem to have been the most economically important terrestrial species hunted in southern New England (Salwen 1978; Snow 1978a). By improving the quality and quan-

tity of browse for deer with fire, hunters effectively increased the carrying capacity of the environment for this species. These improvements would also have increased the growth rates and reproductive success of game (Mellars 1976). Moreover, the efficiency of hunting was enhanced through fire. Improved visibility within burned hunting grounds allowed hunters to be more selective in their kills. By concentrating deer in burned areas, Indians reduced the uncertainty of hunting and created better opportunities for cooperative hunting ventures (Mellars 1976).

Indian-set fires were apparently also common to some portions of interior southern New England. In Massachusetts, histories of North Brookfield (Temple 1887), Palmer (Temple 1889), and Hadley (Judd 1863) (all cited by Byers 1946:22) contain references to parklike forests and open meadows, although the latter could have been marshy areas in some instances. Though common, fires in the interior were probably not as widespread as those on the coast. Almost all accounts of the interior describe cleared or open land in or near the valleys of major rivers. Native populations favored these locations for settlement and subsistence activities. Annual fish runs attracted many groups to the banks of the Connecticut and Housatonic Rivers and their larger tributaries. At the time of contact, maize agriculture was also being practiced in the bottomland of interior drainages (Thomas 1976). Agricultural sites in these locations appear to have been moved with greater frequency than coastal ones, but abandoned plots were often kept clear with fire for hunting and gathering activities. Upland forests along major interior drainages were also thinned, though not cleared, by Indian fires (Byers 1946). Interriverine uplands, on the other hand, were only temporarily used and fired less often, if at all.

5.2.2. Northern New England

Historical accounts of aboriginal burning in northern New England are more difficult to find. The lack of information and evidence for burning in the north is partly a function of relatively few first-hand accounts and less intensive burning practices. At the time of European colonization, northern New England was inhabited by four major groups: Western Abenaki, Eastern Abenaki, Passamaquoddy, and Maliseet (Figure 2).

A major contrast between northern and southern New England subsistence economies was the near absence of agriculture in the north. Referring to tribes north of the Kennebec River, Verrazano reported "no sign of cultivation" in 1524 (Wroth 1970, quoted in Cronon 1983:38). Champlain also noted a distinction between communities of the Saco River and those to the northeast (Snow 1978a). Maize cultivation was, in fact, a late arrival for the Eastern Abenaki in southern Maine, and it never gained the economic importance it did farther south. Instead, northern populations drew most of their sustenance from the seashore and major

rivers. According to ethnohistorical documents, the spring months were spent exploiting fish runs in the rivers, whereas summer brought groups to the coast to collect a diversity of plant and animal resources. In midfall, populations dispersed inland along river tributaries to hunt and trap through the winter.

Prior to contact, the settlement patterns of northern populations were quite different. Faunal remains from prehistoric sites on the coast of Maine document late winter–early spring occupations (Bourque 1973). Bourque (1973) hypothesized that a shift in settlement practices took place in the early historic period to accommodate trade with European explorers. Additional analyses of faunal collections at sites in the Gulf of Maine suggest that seasonal relocation was not practiced among all groups, and that a diverse range of adaptive strategies, including some year-round occupation, can be identified for the late prehistoric period (Sanger 1982).

At the time of contact, burning vegetation for purposes of hunting did not convey the same advantages for northern coastal groups as it did for groups in the south. During those seasons when the benefits of broadcast burning could be realized, fish, shellfish, and other aquatic resources were abundant and accessible. Canoes provided the chief mode of transportation in the north, so the travel advantages of open forests were inconsequential. Most importantly, as Cronon (1983:41–42) points out, because the northern New England Indians did not practice agriculture, they were less dependent on fixed locations (i.e., less sedentary) and thus less apt to alter their environment out of economic stress.

Nevertheless, the late historic record of northern New England does include a few descriptions of anthropogenic fires. For instance, Pyne cites one account describing the diminished pine forests near Lake Champlain: an explanation given for the shrinking forests was “the numerous fires that happen every year in the woods, through the carelessness of the Indians, who frequently make great fires when they are hunting, which spread over the fir woods when everything is dry” (Kalm 1770–1771, quoted in Pyne 1982:44). This account may indicate that burning was conducted by groups lacking access to coastal resources, who were consequently more dependent on the procurement of terrestrial species. Alternatively, post-Contact burning activity in the interior, as well as on the coast, was almost certainly intensified in conjunction with Indian participation in the fur trade.

6. ECOLOGICAL AND CULTURAL FACTORS AFFECTING FIRE USE

Our discussion of Indian burning at the time of contact indicates that (1) fire practices were not universal among New England tribes, and (2) beyond dif-

ferences in fire regimes, variation in anthropogenic fires depended on the nature of human subsistence activities and the way those activities were distributed on the landscape. The evidence reviewed thus far shows that frequent burning would have been most advantageous to agricultural tribes of southern New England. Following the argument of Cronon (1983), we can further state that the nature of agriculturalists' fires was a function of relatively stationary land use. Once established, agriculture promoted higher population density and growth, placing a greater demand on limited resource space. Fire became important for two reasons. First, it afforded greater returns on investments in hunting and gathering by increasing the quality and quantity of resources, by reducing the risk of uncertainty, and by promoting cooperation in resource procurement. Second, fire became important to agricultural activity itself as a means of creating arable land and maintaining its fertility.

We can hypothesize that among agriculturalists, the economic importance of burning varied directly with population density. The ethnohistorical record indicates that agricultural tribes were concentrated in coastal and riverine areas of southern New England, so we may expect that our most abundant sedimentary records of fire would show strongest evidence for burning in this subregion (discussed below). Although Indians may have become especially dependent on fire in this subregion, this does not mean that fire had little relevance to adaptations elsewhere. If the question to debate is whether or not Indian fires were sufficiently widespread to have an impact on the ecology of New England (cf. Russell 1983), then the deciding issue is the way settlement and subsistence governed the ecological impacts of burning. The fire practices of agriculturalists were *intensive* and left a lasting mark on the landscape of New England largely because they were geographically redundant.

The burning activities of mobile hunters and gatherers may have been more *extensive*, but were not as redundant as those of agriculturalists. Over much of interior and northern New England, fires set by hunter-gatherers would have only complemented infrequent lightning-set fires, and these areas may have experienced only a few fires per millennium. The ability of hunter-gatherers to relocate camps and exploit diverse resources acted to prevent overexploitation of the land. Burning vegetation as a means of improving resource productivity was probably not a significant strategy for groups able to maintain relatively unrestricted settlement mobility. On the other hand, burning to facilitate travel, control pests, flush game, and clear settlements and burning by accident were probably common, albeit irregular, events in certain sections of New England for thousands of years.

An exception to the relatively low ecological impact of hunter-gatherer burning is resource specialization. For instance, hunters and gatherers on the Great Plains of North America specialized in the exploitation of bison for thousands of years. Plains hunters often took advantage of the bison's gregariousness

by mounting cooperative drives and surround kills. Fire was an important tool for driving the game, and its benefits in manipulating herd size and distribution were long recognized. Enthusiastic use of broadcast burning for these purposes was a contributing factor in the expansion and maintenance of prairie vegetation (Pyne 1982; Stewart 1953). White-tailed deer, which are largely solitary animals, were the chief game in New England, and fire would have been most useful for improving habitat. Modern wildlife managers recognize that deer range need be burned only occasionally to sustain adequate levels of cover and browse.

Resource specialization among protohistoric Northeastern Indians was encouraged through participation in the swelling trade of Europe (Wolf 1982). Indian fire practices were undoubtedly affected by these economic changes. The Eastern Abenaki, for example, were eager participants in the French and English fur trade, and during the first half of the seventeenth century, they reorganized settlement and subsistence practices to accommodate full-time trapping (Snow 1978b). Similarly, coastal Algonquians on Long Island became specialized in the production of wampum for trade. On the basis of this change, some Long Island villages became completely sedentary and maize agriculture was intensified to offset the growing inaccessibility of seasonal wild food resources (Ceci 1979).

The foregoing discussion provides a substantive and theoretical basis for prehistoric fire utilization in New England. Several important factors have been identified. These include (1) population density, (2) the geographic structure of subsistence (i.e., land use), and (3) resource specialization. Processes affecting these variables are intrinsically linked, and prolonged debates have been conducted over the causal relationships between land use, subsistence, and population. In this paper we will use these three variables, which were important to the fire ecology of historic Indians, as a basis for reviewing current knowledge of prehistoric adaptation in New England to build inferences for burning during the pre-Contact era.

7. ARCHAEOLOGICAL BASIS FOR INFERRED PREHISTORIC FIRE IN NEW ENGLAND

7.1. Southern New England

Demographic patterns and the nature of land use observed in seventeenth century southern New England began to take shape around 3,000 years ago. Snow (1980) refers to this episode as the "Early Horticulture" (or Woodland) period, based upon expectations for parallel developments in the cultivation of native plants documented in the Midwest. Changes in settlement and subsistence in southern New England during the third millennium are consistent with patterns existing among contact period agriculturalists, although direct proof of

early horticulture is lacking. The beginnings of horticulture in southern New England were apparently embedded in a shift to increased utilization of lowland habitats. Site locational data document a rise in coastal occupation accompanied by a regional drop in the number of sites during the third millennium (Mulholland 1984). Mulholland suggests that a decrease in the amount of oak forests beginning around 4000 B.P. made inland and upland habitats less attractive to human foragers. At the same time, stabilization of tidal waters enhanced the productivity and attractiveness of coastal zones.

Trends toward increased utilization of coastal habitats continued over the subsequent two millennia. For instance, on the basis of site counts, we can infer that Cape Cod supported relatively dense populations throughout this time (Mulholland 1984). Similar densities could be expected for Long Island, although comparable site data are not readily available. The development of agriculture in these areas during the last millennium was probably predicated on an established horticultural economy. The maintenance of garden plots (as opposed to fields during the later agricultural period) may have involved regular burning (Stoltman and Baerreis 1983). Given the general similarities in population and land use between the late prehistoric and contact periods, it is likely that coastal groups of the third and second millennia relied on burning for hunting and gathering.

During the mid-Holocene, southern New England provided a benevolent and productive temperate forest habitat for the expansion of hunter-gatherer populations [the Foraging Ecosystem Type of Stoltman and Baerreis (1983)]. Warming temperatures during this time encouraged the growth of mast-producing species. Site distributions tend to correspond with areas where pollen assemblages are characterized by high oak percentages, perhaps because mast resources were important to the hunter-gatherer economy (Dincauze and Mulholland 1977; Mulholland 1984).

By the fifth millennium, site frequencies reached their highest levels in southern New England. Unlike subsequent patterns, the fifth millennium distribution demonstrates a wider use of available habitats. Large clusters of sites are located in estuarine, coastal, riverine, and inland lowland locations (Mulholland 1984). Intraregional variation in patterns of subsistence and technology reflect broad trends toward regional specialization and demographic circumscription. Concentrations of people in these habitats placed greater demands on local environments and thus promoted the need to manipulate resources with fire. The mid-Holocene fire environment of New England may also have been characterized by more lightning fires (due to generally warmer and drier conditions that would be more likely to produce convective thunderstorms). Populations may have developed strategies for reaping the benefits of these natural fires.

The early prehistory of New England was probably characterized by less intensive land use and low population density. The original colonizers of New England entered the region when late glacial tundra had given way to spruce

parkland between 11,000 and 12,000 years ago. One model suggests that early groups adapted to the low density and diversity of early postglacial forests by utilizing a wide variety of resources and by being highly mobile (Dincauze and Curran 1983). Lowland areas and river valleys seem to have been slightly favored for settlement, particularly during the later part of the period, when deciduous species began to migrate into the region. Despite preferences for certain landforms, land use was generally nonredundant. Accordingly, the need for burning to enhance productivity may have been low. If they did burn, early postglacial populations may have done so for reasons that were quite different from those of populations encountered by the first European explorers. By way of analogy, Indians of northern Alberta regularly set fire to grasslands within the boreal forest habitats that are important to elk, bison, deer, and moose. By burning in early spring, the Indians encourage grasses to sprout 2–3 weeks earlier than they might otherwise (Lewis 1982b). Such a strategy applied to the early postglacial period would be advantageous to populations trying to glean resources from environments characterized by short growing seasons.

Models of late-glacial and early postglacial subsistence/settlement that are based on assumptions of low population density and low intensity land use are being reevaluated. Nicholas (1982, 1983, 1987) argues that the initial drainage of glacial lakes in New England created landscape mosaics with resource potentials greater than either the early riverine or full lake stages (cf. Curran and Dincauze 1977). Human exploitation of these basins during the early Holocene is predicted to be more intensive and regular than in nonbasin areas. As the productivity of basin habitats diminished through time, strategies to maintain existing exploitation patterns, including the use of intentional burning, may have become important (Nicholas 1987).

7.2. Northern New England

North of Massachusetts the changes in vegetation and climate described above were delayed by several centuries. The potential constraints this may have put on the early occupation of northern New England are important to an understanding of the variability throughout the region. Dincauze and Mulholland suggest that intensive exploitation of northern New England was limited until 8000 B.P. By this time the oak-forest ecotone [represented by 20% oak isopoll of Bernabo and Webb (1977)] had penetrated southeastern New Hampshire and extended up the Maine coast as far as Penobscot Bay (Dincauze and Mulholland 1977). Areas north and west of the oak-forest ecotone were probably less attractive to southern New England foragers. Certain habitats, especially the Champlain Lowlands, probably did not suffer these environmental limitations, as they seem to have supported occupation continuously throughout the Holocene (Thomas 1980). Thus, despite local variations, regional population density in

northern New England remained low until about the fifth millennium, when populations expanded and diversified in much the same way as those of southern New England.

During the third millennium, distinctive coastal and inland cultural patterns emerged in northern New England. This development basically established the pattern of cultural variability that was evident at the time of contact. Over the course of the last two millennia, site concentrations formed at Casco Bay, Boothbay, Penobscot Bay, Frenchman Bay, Machias Bay, and the Quoddy Group (Passamaquoddy and Cobscook Bays). Among these, relatively higher site densities are found at Penobscot and Frenchman Bays (Sanger 1979). Sites of the interior cluster along large streams and lake shores; few sites are located away from permanent water (Sanger 1979). Given this distribution, the potential for pre-Contact fire in northern New England was greatest on the coast around bays and estuaries, and least along inland waterways. It seems unlikely that fire reached the level of economic importance that it did farther south, however.

8. PALEOECOLOGICAL EVIDENCE

8.1. Introduction

We can observe directly and record the effects of modern (and to a lesser extent historic) fires, but not so those of prehistoric times. Climate is constantly changing, but it is difficult to envision changes in weather patterns during the past two to three millennia that could have significantly altered the frequency or intensity of fires in New England. Changes comparable to the midpostglacial climatic optimum would be required to alter burning patterns at the regional level.

The structure and composition of New England's vegetation have changed since pre-Colonial time, and we might reasonably expect that the pattern and distribution of fuels have changed also. Similarly, modern human population numbers far exceed those of prehistoric times, and it is likely that with more humans inhabiting the landscape, more ignitions have occurred and fires have been more pervasive. Fahey and Reiners (1981) found that during the twentieth century, fire incidence (i.e., number of fires per land area) has varied directly with population density in Maine and New Hampshire. Even with modern fire prevention and suppression techniques, as many as 10,000 wild fires occur in Massachusetts each year.

Given the differences in fuels and human population levels outlined above, the frequency and effects of modern fires probably differ from those of the pre-Colonial period. According to Neiring and Goodwin (1962), fire adaptations in oak, chestnut, hickory, and pitch pine suggest that these species, which were

common in southern New England when Europeans arrived, formed plant communities that were subjected to at least occasional burning. We cannot, however, study modern fire regimes and extrapolate directly to the past. We must turn to paleoecological studies for evidence of fire occurrence prior to European colonization.

8.2. Methods of Constructing Fire Histories

A number of methods are available for investigating past fires. Analyses of fire records maintained by federal and state agencies provide information on the number, size, and cause of fires. These records are only available for the twentieth century, a period when fire occurrence has been influenced by rapidly expanding populations, increased industrial activity, and increasingly efficient fire prevention, detection, and suppression programs. Study of these records can tell us little about the number and extent of fires prior to the Colonial period, but modern records do provide clues about fire causes. The incidence of lightning fires prior to settlement, for example, was probably similar to the low levels observed today.

Tree ring studies and fire scar analyses have been helpful in reconstructing prehistoric fire occurrence in some areas (e.g., Frissell 1973 and Heinselman 1973 in Minnesota, Arno 1980 in the northern Rocky Mountains). These methods can not be used in New England, however, because few stands dating to pre-Colonial times remain. We have used fire scars to reconstruct fire occurrence during historic times (Patterson *et al.* 1983), but not for the prehistoric period.

Written records and accounts yield information about fire occurrence at the time of contact. Russell's (1983) reservations notwithstanding, we believe that the early accounts from New England clearly indicate that the Indians understood the importance of fire to the environment in which they lived, and that, at least in southern coastal and riverine areas, Indians intentionally used fire to enhance resource availability. The argument for intentional burning by New England tribes is strengthened by later, more authoritative accounts of Indian burning elsewhere on the continent. We feel that Forman and Russell's (1983) opinion about regular and widespread Indian burning being "The most widespread problem of human disturbance history" and "an unlikely hypothesis" is overstated, especially when applied to North America as a whole. We agree with Myers and Peroni (1983:218), who state that the "use of historical accounts alone would only have provided information for a few locations over a relatively brief period of less than four centuries."

The hypothesis that the forests of the Northeast had, at the time of European settlement, been modified by centuries of prehistoric burning is testable by pollen analysis, charcoal counts, and archaeological investigations (Davis 1983). We have reviewed the archaeological evidence for cultural adaptations that would encourage the use of fire. This evidence suggests that fire *might* have been em-

ployed for resource augmentation. It *does not* prove that fire was actually present in the pre-Colonial landscape. To do this, we must turn to sedimentary records of fossil pollen and charcoal.

Wildland fires are characterized by incomplete combustion; uneven aeration and varying moisture contents of fuels ensure that large quantities of charcoal result from most fires. Some charcoal is carried into the air and away from the site of a fire by the strong winds that typically accompany large fires. Most charcoal remains on or near the burned area, however. Some of this charcoal is carried by surface runoff to streams and then to lakes or ponds, where it settles through the water column. Charcoal from successive fires is buried as sediments accumulate over time, and in this way a history of fire in a basin's watershed is preserved. Fires alter the species composition and age structure of vegetation, and changes associated with fires are reflected in variations in the types and amount of pollen reaching a basin. Thus, sediments also preserve a history of postfire vegetation development. Pollen and charcoal analyses have been used to detect the effects of prehistoric fires on vegetation of several areas (e.g., Cwynar 1978; Davis 1967; Fredskild 1967; Iversen 1941; Swain 1973; Tolonen 1978; Tsukada 1966; Tsukada and Deevey 1967; Waddington 1968). In New England, Anderson (1979), Backman (1984), Winkler (1982), W. A. Patterson (unpublished), and A. M. Swain (unpublished) provide stratigraphic evidence for pre-Colonial fires. Data are available for 11 sites (Table 1). Most involve records of no more than the past 1,000 years, but two (Upper South Branch Pond in Maine and Duck Pond on Cape Cod) span the Holocene. Sites are available for both inland and coastal as well as northern and southern areas (Figure 3).

Charcoal abundance is often measured as the ratio of the sum of the areas (measured in square micrometers) of fragments tallied on microscope slides prepared for pollen analysis to fossil pollen found on the slides (Swain 1973). Typical charcoal area to pollen (C:P) values for New England lake sediments range from <100 to 3000 or higher. One New England site (The Bowl) lies within the boundaries of the Great Bar Harbor Fire that burned nearly one-fourth of Mount Desert Island, Maine, during October 1947. The charcoal profile for this pond shows C:P values of 600–800 in sediments that date to the late 1940s (Figure 4). The C:P values for sediments of similar age in Sargent Mountain Pond, which is near The Bowl but outside the boundaries of the 1947 fire, are <200 (Backman 1984). The results from these two sites demonstrate that sedimentary charcoal can be used to detect the local occurrence of fire (Patterson *et al.* 1984a).

Average C:P values for sediments of pre- and post-Colonial age (Table 2) show wide variation within the region. With the exception of Duck Pond on Cape Cod, charcoal is more abundant in recent sediments than in those deposited prior to European settlement. Differences are greatest at the inland sites where pre-Colonial values are very low. At these locations, fires were apparently rare before Europeans arrived. Along the coast, and especially in southern New England,

Table 1. Site Information for Eleven New England Basins with Sedimentary Charcoal Analysis

Site	Location	Physiographic region	Modern vegetation type ^a	Time span (B.P.)	Analyst ^b	Reference
Larkum Pond	Otis, MA	Central-inland	Northern hardwoods—hemlock—white pine	0–800	A. Backman (P), A. Hine (C)	Backman 1984
Basin Pond	Kenebec Co., ME	North-inland	Transition hardwoods—white pine—hemlock	0–1600	K. Gajewski (P), M. Winkler (C)	Gajewski 1983, Backman 1984
Conroy Lake	Aroostook Co., ME	North-inland	Spruce—fir—northern hardwoods	0–2000	K. Gajewski (P), M. Winkler (C)	Gajewski 1983, Backman 1984
Upper South Branch Pond	Piscataquis Co., ME	North-inland	Spruce—fir—northern hardwoods	0–11,000	R. Anderson (P&C)	Anderson 1979
The Bowl	Bar Harbor, ME	North-coastal	Spruce—fir—northern hardwoods	0–500	W. Patterson (P), A. Hine (C)	Backman 1984
Sargent Mt. Pond	Bar Harbor, ME	North-coastal	Spruce—fir—northern hardwoods	0–280	A. Backman (C&P)	Backman 1984
Long Pond	Isle au Haut, ME	North-coastal	Spruce—fir—northern hardwoods	0–430	A. Backman (C&P)	Backman 1984
Duck Pond	South Wellfleet, MA	Central-coastal	Pitch pine—oak	0–5000	A. Backman (P), A. Hine (C)	Backman 1984
Charge Pond	Wareham, MA	Central-coastal	Pitch pine—oak	0–12,000 0–800	M. Winkler (C&P) A. Backman (C&P)	Winkler 1982 Backman and Patterson 1984
Widgeon Pond	Wareham, MA	Central-coastal	Pitch pine—oak	0–1000	A. Backman (C&P)	Backman and Patterson 1984
Deep Pond	Wading River, NY	South-coastal	Pitch pine—oak	0–2100	A. Backman (C&P)	Backman 1984

^aFrom Westveld *et al.*, 1956.

^bP = pollen; C = charcoal.

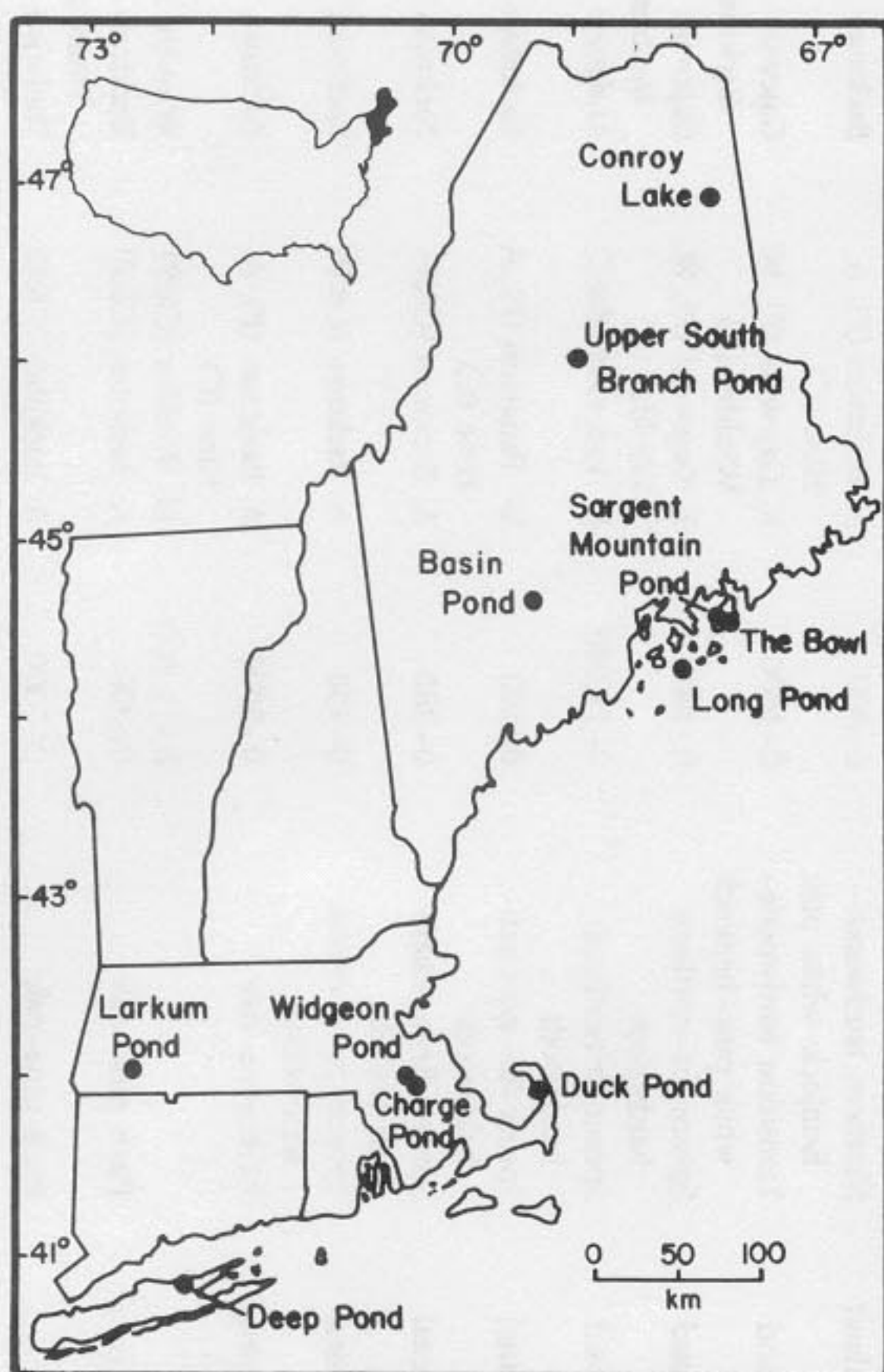


Figure 3. Locations of sedimentary fire-history studies in the Northeast.

differences are not so great, with average pre-Colonial values for the southern sites comparable to those observed at The Bowl for sediments dating to the 1947 fire. Pre-Colonial fires must have been common within the drainage basins of the four southern sites. Occasional pre-Colonial fires apparently burned near three coastal Maine sites. By contrast, there is no evidence for fire in the 500 years prior to local settlement at Larkum Pond in the Berkshire Mountains of western Massachusetts (Backman 1984).

The results of these sedimentary studies suggest that prior to European settlement, fires were most common in areas where, on the basis of archaeological site distributions, Indian populations were greatest. We lack charcoal data for the inland riverine environments of central New England, but the data for coastal areas seem convincing. We know of no archaeological sites within the watersheds

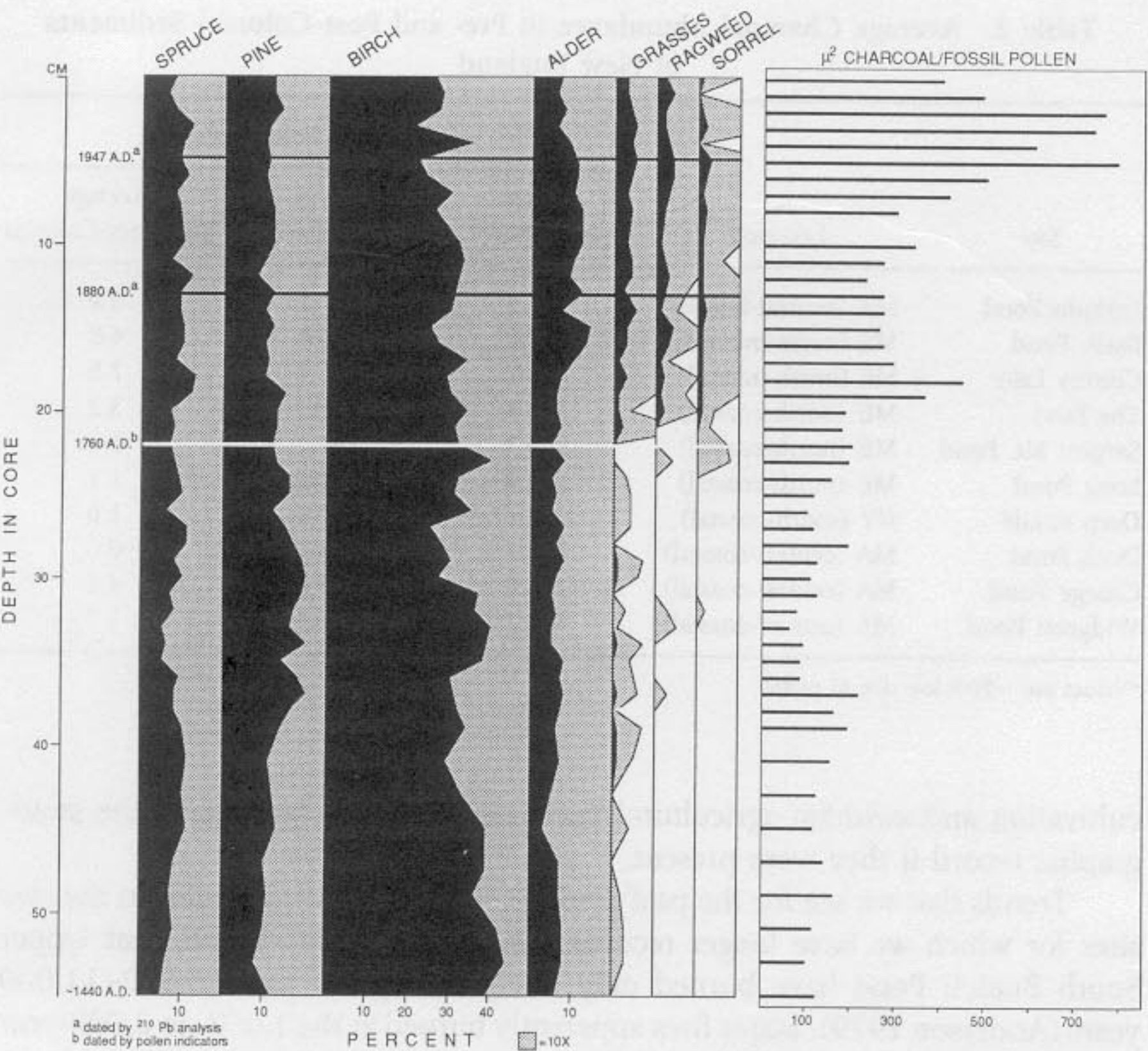


Figure 4. Pollen and charcoal profiles for The Bowl, Mount Desert Island, Maine. Evidence for the 1947 Bar Harbor Fire is seen in the peak in charcoal between 3 and 6 cm. Dating is by ^{210}Pb analysis (a) or pollen indicators (b) (see Clark and Patterson 1984).

of our study sites¹ and the pollen profiles show no evidence for local cultivation [e.g., the presence of corn (*Zea mays*) pollen or the pollen of other cultigens]. Thus, sedimentary charcoal in these basins probably reflects more generalized burning as opposed to the burning of small, highly localized garden plots. McAndrews' (1976) studies of Crawford Lake in Ontario suggest that local

¹A review of Mulholland's (1984) data files and the site files of the Massachusetts Historical Commission, Boston, indicated no recorded sites within the watersheds of sample locations in Massachusetts. Likewise, no sites are known from sample locations on the coast of Maine (David Sanger, personal communication, 1985). Site records from sample areas of interior Maine and Long Island were not consulted. We should note that a lack of *recorded* sites does not preclude the possibility of aboriginal settlement in these areas. The distribution of recorded sites is as much, if not more, an artifact of archaeological sampling as it is of prehistoric land use (Wobst 1983).

Table 2. Average Charcoal Abundance in Pre- and Post-Colonial Sediments of New England

Site	Location	Charcoal: Pollen value		
		Average pre-Colonial	Average post-Colonial	Average post-pre-Colonial
Larkum Pond	MA (central-inland)	27.5	190.5	6.9
Basin Pond	ME (north-inland)	80.9	385.5	4.8
Conroy Lake	ME (north-inland)	38.7	291.1	7.5
The Bowl	ME (north-coastal)	123.4	390.9	3.2
Sargent Mt. Pond	ME (north-coastal)	131.3	161.2	1.2
Long Pond	ME (north-coastal)	151.9	320.9	2.1
Deep Pond ^a	NY (south-coastal)	650.1	1040.2	1.6
Duck Pond	MA (central-coastal)	250.7	160.7	0.6
Charge Pond	MA (central-coastal)	713.9	2895.0	4.1
Widgeon Pond	MA (central-coastal)	580.7	968.2	1.7

^aValues are ~50% low due to pyrite.

cultivation and swidden agricultural practices would be detected in the stratigraphic record if they were present.

Trends that we see for the past several centuries are evident also in the two sites for which we have longer records. The central Maine forests near Upper South Branch Pond have burned only rarely during the past 10,000–11,000 years (Anderson 1979). Major fires apparently burned at the 1,000- to 2,000-year intervals predicted by Lorimer's (1977) analysis of natural fire rotations. At Duck Pond on Cape Cod, however, abundant charcoal throughout the stratigraphic column suggests that fire has played an important role in maintaining pine–oak forests throughout the Holocene (Winkler 1982).

9. DISCUSSION

Fire occurrence in the eastern United States is a function of broad regional variations in climate and vegetation. To the south and west of New England, drier climate and/or seasonal periods of prolonged drought promote the development of complexes of vegetation and fuel that burn more readily than many of those of the Northeast. Within this broad regional framework, ignition sources, be they natural or human, influence the seasonality and frequency of fires. As an example, the average annual precipitation of 45–65 in. in south Florida equals or exceeds the amount of precipitation received throughout much of New England. The seasonal distribution of rainfall is quite uniform in the Northeast, however,

whereas Florida is characterized by dry winters and wet summers (Wade *et al.* 1980). Florida is among the most fire-prone regions of North America (Pyne 1984), with human ignitions important during the winter and lightning ignitions important during spring and early summer (Taylor 1981). By contrast, fires are less common in New England, and some areas of interior, mountainous terrain have the lowest occurrences of fire in the East (Bormann and Likens 1979). Human ignitions are usually restricted to a short period between late March and early May and following short periods of late-summer drought that are the exception rather than the rule.

Lightning accounts for a small fraction of the total ignitions in the Northeast (Pyne 1984), and it is generally true that human factors become more important in wildland fire ignitions toward the east and north in North America. This pattern, which is so evident today, probably duplicates patterns that prevailed during prehistoric times. It is clear that Indians were an important source of ignitions in other portions of North America prior to European settlement (Lewis 1982a), and it seems likely that they were important in New England as well. Restricted opportunities for burning may have limited the areal extent and frequency of fires, however, and thus it is all the more important that we understand the demography of prehistoric Indian populations if we are to understand the role of Indians in pre-Colonial fire regimes of the Northeast.

Our comparison of sedimentary charcoal counts to archaeological site distributions indicates that fires were most common where Indian populations were greatest and their land-use practices most intensive. Lewis (1982b) discusses a number of reasons why Indians used fire to enhance resource availability. It is tempting to conclude that demographic pressure to intensify resource production caused Indians to use fire to modify prehistoric environments (Cohen 1977). We hesitate to correlate sedimentary charcoal concentrations with intensity of land-use, however, because charcoal influx to sediments is influenced by many factors besides the simple occurrence of fire within the watershed of a lake or pond (Patterson *et al.* 1987). Other things being equal, however, intense fires or repeated low-intensity fires should result in greater accumulations of sedimentary charcoal than infrequent, low-intensity fires. Swain (1980) has shown this to be true for northeastern North America as a whole, and it is likely that it is also true within a region the size of New England and for individual basins subjected to varying fire occurrence through time. In New England, the abundant charcoal in sediments from ponds in areas burned by south-coastal Indians probably reflects intensive land-use practices. Although burning documented by abundant charcoal in sediments from Cape Cod and Long Island may represent fires set for nonagricultural purposes, these fires appear to be geographically and temporally congruent with dense occupations of late-prehistoric agriculturalists.

Ethnohistorical accounts of fire use in New England suggest that generalized burning among hunter-gatherers may have been as intensive as that of agri-

culturalists. Extrapolation to prehistoric times is difficult, however, because ethnohistorical documentation describes patterns of land use among hunter-gatherers, as well as agriculturalists, that were being affected by European trade opportunities, introduced disease, and ensuing intergroup conflict. Intentional burning may have been common to prehistoric hunter-gatherers throughout New England, but charcoal records are probably inadequate to distinguish between the various types of fires that burned.

Problems associated with interpreting sedimentary charcoal records underscore the importance of developing more rigorous theory and method for examining prehistoric fire practices in New England. Additional research would benefit from closer attention to studies of prehistoric burning in Europe, where the environmental impacts of prehistoric populations has long been a subject of interdisciplinary research. Recent studies in Great Britain have begun to explore relationships between Mesolithic site locations, vegetation, soils, and fire. Simmons *et al.* (1981) suggest that hunter-gatherer fires were concentrated in areas of natural forest edge, particularly along the upland tree line and in coastal zones. Forest edge in these areas was economically attractive to Mesolithic groups and was especially prone to burning, and thus easy to manage with fire. Similar conclusions are drawn by Mellars and Reinhardt (1978) from comparisons of site locations and soil types. They document a preponderance of Mesolithic sites in southern England on well-drained, coarse sandy soils. They argue that these locations may have been selected for settlement because of their susceptibility to fire. Evidence for repeated Mesolithic burning at these sites includes vegetational change (Dimbleby 1962; Mellars and Reinhardt 1978), soil deterioration (Keef *et al.* 1965; Rankine and Dimbleby 1960, 1961), and increased erosion (Mellars and Reinhardt 1978:264).

Ecological and archaeological research in New England should focus on the identification of landscapes especially prone to fire. These locations can be compared to existing archaeological site records, and thus provide the basis for directed archaeological surveys. The success of regional approaches will depend, however, on our ability to recover specific evidence for burning at multiple sites. British researchers have employed a wide range of techniques and data sets to detect local fire use. In North America, wood charcoal from stratified sites was used to reconstruct changes in forest composition and structure, and together with pollen cores, is providing direct evidence for human prehistoric burning practices in Tennessee (Chapman *et al.* 1982).

10. CONCLUSION

Our work has implications beyond the role of Indians in prehistoric fire regimes of the Northeast. The methods brought to bear on prehistoric fire use

will be limited only by the types of questions posed. Models that emphasize environment-dependent relationships for hunter-gatherers obscure evidence for environmental modification. The construction of models that emphasize the impacts of hunter-gatherer land-use activities allows us to look at old data in new ways and to develop methods for analyzing additional evidence. More importantly, a change in perspective toward interactive human-land relationships should provide new insight into the causes and consequences of population growth, settlement change, and food production.

ACKNOWLEDGMENTS

We thank Dena Dincauze, George Nicholas, Fred Dunford, Michael Nassaney, Arthur Keene, and David Foster for comments on earlier drafts of the manuscript. Mitch Mulholland, Eric Johnson, Catherine Carlson, Omer Stewart, and David Sanger provided unpublished reports and data that were helpful in our analysis. The study was supported in part by the McIntire-Stennis Cooperative Forestry Research Program (Grant MS-33 to W.A.P.) and was completed while the senior author was a Charles Bullard Fellow at Harvard University.

11. REFERENCES

- Anderson, R. S., 1979, *A Holocene Record of Vegetation and Fire at Upper South Branch Pond in Northern Maine*, M.Sc. Thesis, University of Maine, Orono, Maine.
- Arno, S. F., 1980, Forest Fire History in the Northern Rockies, *Journal of Forestry* 78:460-465.
- Backman, A. E., 1984, *1000-Year Record of Fire-Vegetation Interactions in the Northeastern United States: A Comparison between Coastal and Inland Regions*, M.Sc. Thesis, University of Massachusetts, Amherst, Massachusetts.
- Backman, A. E., and Patterson, W. A., III, 1984, Vegetation and Fire History of Myles Standish State Forest Interpreted from Sedimentary Pollen and Charcoal Analyses, University of Massachusetts Cooperative Forestry Research Unit, Report no. 2, 21 p.
- Barrett, S. W., and Arno, S. F., 1982, Indian Fires As an Ecological Influence in the Northern Rockies, *Journal of Forestry* 80:647-651.
- Bernabo, J. C., and Webb, T., III, 1977, Changing Patterns in the Holocene Pollen Record of Northeastern North America, *Quaternary Research* 8:64-96.
- Bormann, F. H., and Likens, G. E., 1979, Catastrophic Disturbances and the Steady State in Northern Hardwood Forests, *American Scientist* 67:660-669.
- Bourque, B., 1973, Aboriginal Settlement and Subsistence on the Maine Coast, *Man in the Northeast* 6:3-20.
- Brasser, T. J. C., 1971, The Coastal Algonkians: People of the First Frontier, in: *North American Indians in Historical Perspective* (E. B. Leacock and N. O. Lurie, eds.), Random House, New York, pp. 64-91.
- Bromley, S. W., 1935, The Original Forest Type of Southern New England, *Ecological Monographs* 5:61-89.
- Brown, A. A., and Davis, K. P., 1973, *Forest Fire Control and Use*, 2nd ed., McGraw-Hill, New York.

- Brown, J. H., Jr., 1960, The Role of Fire in Altering the Species Composition of Forests in Rhode Island, *Ecology* 41:310–316.
- Byers, D., 1946, The Environment of the Northeast, in: *Man in Northeastern North America* (F. Johnson, ed.), Robert S. Peabody Foundation for Archaeology, Andover, Massachusetts, pp. 3–32.
- Ceci, L., 1979, Maize Cultivation in Coastal New York: The Archaeological, Agrinomical and Documentary Evidence, *North American Archaeologist* 1:45–74.
- Champlain, S. de, 1907, *Voyages of Samuel de Champlain 1604–1618. Original Narratives of Early American History*, Vol. 3 (W. L. Grant, ed.), Barnes and Noble, New York.
- Chapman, J., Delcourt, P. A., Cridlebaugh, P. A., Shea, A. B., and Delcourt, H. R., 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.
- Clark, J. S., and Patterson, W. A., III, 1984, Pollen, Pb-210, and Opaque Sperules: An Integrated Approach to Dating and Sedimentation in the Intertidal Environment, *Journal of Sedimentary Petrology* 54:1253–1265.
- Clements, F. E., 1916, *Plant Succession: An Analysis of the Development of Vegetation*, Publication No. 242, Carnegie Institute, Washington, D.C.
- Cohen, M. N., 1977, *The Food Crisis in Prehistory: Overpopulation and the Origins of Agriculture*, Yale University Press, New Haven, Connecticut.
- Craig, A. J., 1972, Pollen Influx to Laminated Sediments: A Pollen Diagram from Northeastern Minnesota, *Ecology* 53:46–57.
- Cronon, W., 1983, *Changes in the Land: Indians, Colonists and the Ecology of New England*, Hill and Wang, New York.
- Curran, M. L., and Dincauze, D. F., 1977, Paleoindians and Paleolakes: New Data from the Connecticut Drainage, *Annals of the New York Academy of Science* 288:333–348.
- Cwynar, L. C., 1978, Recent History of Fire and Vegetation from Laminated Sediments of Green Lake, Algonquin Park, Ontario, *Canadian Journal of Botany* 56:10–21.
- Davis, M. B., 1983, Holocene Vegetational History of the Eastern United States, in: *Late Quaternary Environments of the United States* (H. E. Wright, ed.), University of Minnesota Press, Minneapolis, pp. 166–181.
- Davis, R. B., 1967, Pollen Studies of Near-Surface Sediments in Maine Lakes, in: *Quaternary Paleoecology* (E. J. Cushing and H. E. Wright, Jr., eds.), Yale University Press, New Haven, Connecticut, pp. 144–173.
- Day, G., 1953, The Indian as an Ecological Factor in the Northeastern Forests, *Ecology* 34:329–346.
- Dimbleby, G. W., 1962, *The Development of British Heathlands and Their Soils*, Oxford Forestry Memoirs.
- Dincauze, D. F., and Curran, M. L., 1983, Paleoindians as Generalists: An Ecological Model, Paper presented at the 48th Annual Meeting of the Society for American Archaeology, Pittsburgh, Pennsylvania.
- Dincauze, D. F., and Mulholland, M. T., 1977, Early and Middle Archaic Site Distributions and Habitats in Southern New England, *Annals of the New York Academy of Science* 288:439–456.
- Dwight, T., 1823, *Travels in New England and New York*, W. Baynes, London.
- Espinshade, F. B. (ed.), 1976, *Goode's World Atlas*, 14th ed., rev., Rand McNally, Chicago, Illinois.
- Fahey, T. J., and Reiners, W. A., 1981, Fire in the Forests of Maine and New Hampshire, *Bulletin of the Torrey Botanical Club* 108:362–373.
- Fobes, C. B., 1944, Lightning Fires in the Forests of Northern Maine, *Journal of Forestry* 42:291–293.
- Forman, R. T. T., and Russell, E. W. B., 1983, Evaluation of Historical Data in Ecology, *Bulletin of the Ecological Society of America* 64:5–7.
- Fredskild, B., 1967, Paleobotanical Investigations at Sermermiut, Jakobshavn, West Greenland, *Meddeleser om Grønland* 178.

- Frissell, S. S., Jr., 1973, The Importance of Fire as a Natural Ecological Factor in Itasca State Park, Minnesota, *Quaternary Research* 3:397–407.
- Funk, R. E., 1983, The Northeastern United States, in: *Ancient Northern Americans* (J. D. Jennings, ed.), Freeman, New York, pp. 303–371.
- Gajewski, K., 1983, *On the Interpretation of Climatic Change from the Fossil Record: Climatic Change in Central and Eastern United States over the Past 2000 Years Estimated from Pollen Data*, Ph.D. Dissertation, University of Wisconsin, Madison, Wisconsin.
- Harris, D. R., 1972, Swidden Systems and Settlement, in: *Man, Settlement and Urbanism* (P. J. Ucko, R. Tringham, and G. W. Dimbleby, eds.), Duckworth, London, pp. 245–262.
- Heinselman, M. L., 1973, Fire in the Virgin Forests of the Boundary Waters Canoe Area, Minnesota, *Quaternary Research* 3:329–382.
- Heinselman, M. L., 1981, Fire Intensity and Frequency as Factors in the Distribution and Structure of Northern Ecosystems, in: *Fire Regimes and Ecosystem Properties* (H. A. Mooney, ed.), U.S.D.A. Forest Service General Technical Report WO-26, pp. 7–57.
- Henry, J. D., and Swan, J. M. A., 1974, Reconstructing Forest History from Live and Dead Plant Material—An Approach to the Study of Forest Succession in Southwestern New Hampshire, *Ecology* 55:772–783.
- Iversen, J., 1941, Land Occupation in Denmark's Stone Age, *Danmarks Geologiske Undersøgelse. Series II*, No. 66.
- Keef, P. A. M., Wymer, J. J., and Dimbleby, G. W., 1965, A Mesolithic Site on Iping Common, Sussex, England, *Proceedings of the Prehistoric Society* 31:85–92.
- Kozlowski, T. T., and Ahlgren, C. E. (eds.), 1974, *Fire and Ecosystems*, Academic Press, New York.
- Lewis, H. T., 1973, Patterns of Indian Burning in California: Ecology and Ethnohistory, *Anthropological Papers*, No. 1, Ballena Press, Ramona, California.
- Lewis, H. T., 1977, Maskuta: The Ecology of Indian Fires in Northern Alberta, *Western Canadian Journal of Anthropology* 7:15–52.
- Lewis, H. T., 1982a, Fire Technology and Resource Management in Aboriginal North America and Australia, in: *Resource Managers: North American and Australian Hunter-Gatherers* (N. M. Williams and E. S. Hunn, eds.), AAAS Selected Symposia 67, Westview Press, Boulder, Colorado, pp. 45–67.
- Lewis, H. T., 1982b, A Time for Burning, University of Alberta Boreal Institute of North America, Occasional Paper 17.
- Lorimer, C. G., 1977, The Presettlement Forest and Natural Disturbance Cycle of Northeastern Maine, *Ecology* 58:139–148.
- Lutz, H. J., 1959, Aboriginal Man and White Man As Historical Causes of Fires in the Boreal Forest, with Particular Reference to Alaska, *Yale University School of Forestry Bulletin*, No. 65.
- McAndrews, J. H., 1976, Fossil History of Man's Impact on the Canadian Flora: An Example from Southern Ontario, *Canadian Botanical Association Bulletin* 9:1–6.
- Mellars, P. A., 1976, Fire Ecology, Animal Populations and Man: A Study of Some Ecological Relationships in Prehistory, *Proceedings of the Prehistoric Society* 42:15–46.
- Mellars, P. A., and Reinhardt, S. C., 1978, Patterns of Mesolithic Land-Use in Southern England: A Geological Perspective, in: *The Early Post-Glacial Settlement of Northern Europe* (P. A. Mellars, ed.), University of Pittsburgh Press, Pittsburgh, Pennsylvania, pp. 243–294.
- Mulholland, M. T., 1984, *Patterns of Change in Prehistoric Southern New England: A Regional Approach*, Ph.D. Dissertation, University of Massachusetts, Amherst.
- Myers, R. L., and Peroni, P. A., 1983, Approaches to Determining Aboriginal Fire Use and Its Impact on Vegetation, *Bulletin of the Ecological Society of America* 64:217–218.
- Neiring, W. A., and Goodwin, R. H., 1962, Ecological Studies in the Connecticut Arboretum Natural Area: Introduction and a Survey of Vegetation Types, *Ecology* 43:41–54.
- Nicholas, G. P., 1982, Former Glacial Lake Basins and Early Postglacial Settlement, *AMQUA Abstracts* (American Quaternary Association) 7:148.

- Nicholas, G. P., 1983, A Model for the Early Postglacial Settlement of the Central Merrimack River Basin, New Hampshire, *Man in the Northeast* 25:43–63.
- Nicholas, G. P., 1987, Rethinking the Early Archaic, *Archaeology of Eastern North America*, 15:99–124.
- Patterson, W. A., III, Saunders, K. E., and Horton, L. J., 1983, Fire Regimes of the Coastal Maine Forests of Acadia National Park, U.S.D.I. National Park Service Office of Scientific Programs, Report OSS 83-3, Boston, Massachusetts.
- Patterson, W. A., III, Backman, A. E., and Davis, R. B., 1984a, Sedimentary Charcoal as an Indicator of Forest Fires in Acadia National Park, Maine, *Sixth International Palynological Congress Abstracts*, p. 126.
- Patterson, W. A., III, Saunders, K. E., and Horton, L. J., 1984b, Fire Regimes of Cape Cod National Seashore, U.S.D.I. National Park Service Office of Scientific Programs, Report OSS 83-1, Boston, Massachusetts.
- Patterson, W. A., III, Edwards, K. J., and Maguire, D., 1987, Microscopic Charcoal as a Fossil Indicator of Fire, *Quaternary Science Reviews* 6:3–23.
- Pyne, S. J., 1982, *Fire in America: A Cultural History of Wildland and Rural Fire*, Princeton University Press, Princeton, New Jersey.
- Pyne, S. J., 1984, *Introduction to Wildland Fire*, Wiley, New York.
- Rankine, W. F., and Dimbleby, G. W., 1960, Further Investigations at a Mesolithic Site at Oakhanger, Selbourne, Hants, *Proceedings of the Prehistoric Society* 26:246–262.
- Rankine, W. F., and Dimbleby, G. W., 1961, Further Excavations at Oakhanger, Selbourne, Hants, *Wealdon Mesolithic Research Bulletin*.
- Rudnick, J. L., 1984, Vegetation and Fuel Types on Fire Island National Seashore and the William Floyd Estate, M.Sc. project, University of Massachusetts, Amherst, unpublished.
- Russell, E. W. B., 1983, Indian-Set Fires in the Forests of the Northeastern United States, *Ecology* 64:78–88.
- Salwen, B., 1978, Indians of Southern New England and Long Island: Early Period, in: *Handbook of North American Indians: Northeast*, Vol. 15 (B. G. Trigger, ed.), Smithsonian Institution, Washington, D.C., pp. 160–175.
- Sanger, D., 1979, The Ceramic Period in Maine, in: *Discovering Maine's Archaeological Heritage* (D. Sanger, ed.), Maine Historic Preservation Commission, Augusta, Maine, pp. 99–115.
- Sanger, D., 1982, Changing Views of Aboriginal Seasonality and Settlement in the Gulf of Maine, *Canadian Journal of Anthropology* 2:195–202.
- Shackleton, J., 1979, *Paleoenvironmental Histories from Whitefish and Imuruk Lakes, Seward Peninsula, Alaska*, M.Sc. Thesis, Ohio State University, Columbus, Ohio.
- Simmons, I. G., Dimbleby, G. W., and Grigson, C., 1981, The Mesolithic, in: *The Environment in British Prehistory* (I. G. Simmons and M. J. Tooley, eds.), Cornell University Press, Ithaca, New York, pp. 82–124.
- Snow, D. R., 1978a, Late Prehistory of the East Coast, in: *Handbook of North American Indians: Northeast*, Vol. 15 (B. G. Trigger, ed.), Smithsonian Institution, Washington, D.C., pp. 137–147.
- Snow, D. R., 1978b, Eastern Abenaki, in: *Handbook of North American Indians: Northeast*, Vol. 15 (B. G. Trigger, ed.), Smithsonian Institution, Washington, D.C., pp. 137–147.
- Snow, D. R., 1980, *The Archaeology of New England*, Academic Press, New York.
- Spurr, S. H., 1956, Natural Restocking of Forests Following the 1938 Hurricane in Central New England, *Ecology* 37:443–451.
- Stephens, E. P., 1955, *The Historical-Developmental Method of Determining Forest Trends*, Ph.D Dissertation, Harvard University, Cambridge, Massachusetts.
- Stewart, O. C., 1953, Why the Great Plains are Treeless, *Colorado Quarterly* 2:40–49.
- Stewart, O. C., 1956, Fire as the First Great Force Employed by Man, in: *Man's Role in Changing the Face of the Earth* (W. L. Thomas, ed.), University of Chicago Press, Chicago, Illinois, pp. 115–133.

- Stoltman, J. B., and Baerreis, D. A., 1983, *The Evolution of Human Ecosystems in the Eastern United States* (H. E. Wright, Jr., ed.), University of Minnesota Press, Minneapolis, pp. 252–268.
- Swain, A. M., 1973, A History of Fire and Vegetation in Northeastern Minnesota as Recorded in Lake Sediments, *Quaternary Research* 3:383–396.
- Swain, A. M., 1980, Environmental Changes between 600–100 B.P. in Mid-Latitudes of North America: Pollen and Charcoal Evidence from Annually Laminated Lake Sediments, *5th International Palynological Conference Abstracts*.
- Taylor, D. L., 1981, Fire History and Fire Records for Everglades National Park, U.S.D.I., National Park Service Everglades National Park Report T-619.
- Thomas, P. A., 1976, Contrastive Subsistence Strategies and Land-Use: 20 Factors for Understanding Indian–White Relations in New England, *Ethnohistory* 23:1–18.
- Thomas, P. A., 1980, Comments on Recent Trends in Vermont Archaeology, *Man in the Northeast* 19:3–14.
- Tolonen, K., 1978, Effects of Prehistoric Man on Finnish Lakes, *Polskie Archiwum Hydrobiologii* 25:419–421.
- Tsukada, M., 1966, Late Postglacial Absolute Pollen Diagrams in Lake Nojiri, *The Botanical Magazine* (Tokyo) 79:179–184.
- Tsukada, M., and Deevey, E. S., Jr., 1967, Pollen Analysis from Four Lakes in the Southern Maya Area of Guatemala and El Salvador, in: *Quaternary Paleoecology* (E. J. Cushing and H. E. Wright, Jr., eds.), Yale University Press, New Haven, Connecticut, pp. 303–331.
- Waddington, J. C. B., 1968, *The Postglacial Vegetation History of the Big Woods Area of Minnesota*, M.Sc. Thesis, University of Minnesota, Minneapolis, Minnesota.
- Wade, D., Ewel, J., and Hofstetter, R., 1980, Fire in South Florida Ecosystems, U.S.D.A. Forest Service General Technical Report SE-17.
- Westveld, M., et al., 1956, Natural Forest Vegetation Zones of New England, *Journal of Forestry* 56:332–338.
- Winkler, M., 1982, *Late-Glacial and Post-Glacial Vegetation History of Cape Cod and the Paleolimnology of Duck Pond, South Wellfleet, Massachusetts*, M.Sc. Thesis, University of Wisconsin, Madison, Wisconsin.
- Wobst, H. M., 1983, We Can't See the Forest for the Trees: Sampling and the Shapes of Archaeological Distributions, in: *Archaeological Hammers and Theories* (J. A. Moore and A. S. Keene, eds.), Academic Press, New York, pp. 37–85.
- Wolf, E., 1982, *Europe and the People without History*, University of California Press, Berkeley, California.