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Archaeology, Ecological History, and Conservation

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Abstract
Ecologists have increasingly turned to history, including human history, to explain and manage modern ecosystems and landscapes. The imprint of past land use can persist even in seemingly pristine areas. Archaeology provides a long-term perspective on human actions and their environmental consequences that can contribute to conservation and restoration efforts. Case studies illustrate examples of the human history of seemingly pristine landscapes, forest loss and recovery, and the creation or maintenance of places that today are valued habitats. Finally, as archaeologists become more involved in research directed at contemporary environmental issues, they need to consider the potential uses and abuses of their findings in management and policy debates.
INTRODUCTION

Ecologists and conservation biologists have discovered the deep human past, long the province of archaeologists. Browse through their recent books and journals and you will find a growing number of studies that consider archaeological evidence to explain and manage current environments. This trend can be tied to (a) an increasing interest in how historical processes shape modern landscapes, (b) the recognition that humans are part of landscape history even in areas long thought of as pristine, and (c) the emergence of restoration ecology with its goal of aiding the recovery of degraded ecosystems using historical reference conditions. At the same time, archaeologists have begun to realize the potential application of their work to current environmental research, management, and policy (Cox et al. 1995, Erickson 2003, Erlandson 2005, Fisher & Feinman 2005, Lauwerier & Plug 2004, Louwe Kooijmans 1995, Lyman 1996, Macinnes & Wickham-Jones 1992, Peacock & Shauwecker 2003, Redman 1999, Spriggs 2001, van der Leeuw & Redman 2002). The development of historical ecology, which examines "the relationships of humans and the biosphere in specific temporal, regional, cultural, and biotic contexts" (Balée 1998b; see also Crumley 1994) has also triggered a rethinking of the long-term dynamics of nature and culture and their study through the archaeological and paleoenvironmental records.

The explicit incorporation of archaeology into studies of current ecosystems, or into conservation or restoration planning, is still incipient. A number of recent essays and studies have demonstrated the relevance of zooarchaeology to wildlife management (Kay & Simmons 2002, Lauwerier & Plug 2004, Lyman 1996, Lyman & Cannon 2004). Here, I join the discussion with a review of archaeology’s actual and potential contribution to understanding the history, long-term dynamics, and lasting effects of human impacts on vegetation and consider the implications of this work for ecology and conservation. Such a review is particularly timely as debates heat up over the disposition and management of landscapes and resources in the United States and abroad (e.g., the resilience of forests to exploitation, the extent to which human actions aid or mimic natural processes, the rights of indigenous groups to continued occupation or use of protected areas). These debates are fundamentally political and ethical in nature, but they are informed by the findings of researchers. Clearly, oversimplified assumptions about anthropogenic impacts and human nature based on an incomplete or skewed understanding of the past can only lead to misguided practices and policies. Archaeology can inform these debates by providing information on human actions and their environmental consequences over very long periods of time, a fact appreciated by ecologists who look to the archaeological record. The time has come for archaeologists to take a more active role in designing and participating in research that addresses contemporary environmental concerns and contributes to public policy.

Forest ecologist David Foster and colleagues have written extensively on the importance of history, including human history, to understand current ecosystems and landscapes (Foster 2000a, Foster 2000b, Foster &
Aber 2004, Foster et al. 2003). The historical record provides a window on long-term processes (e.g., succession, soil formation, responses to climate change), increases the sample size of observations [such as responses to natural and anthropogenic disturbances (fire, hurricanes, floods, clearing, farming)], and documents ecosystem responses to rare events (e.g., continental scale migrations, glacial cycles, major extinction episodes). Also, because of the time lag in ecosystem response to disturbance and environmental change, current ecosystem structure, function, and composition cannot be fully understood or explained without a historical perspective. The lasting effects of past human actions (termed “land-use legacies”) include changes in species composition, successional dynamics, soils, water, topography, and nutrient cycling. Many seemingly natural areas have a cultural past that is part of their ecological history; their conservation today requires knowledge of that past and assessment of the value of continuing or replicating past cultural practices.

The human imprint on seemingly natural areas was convincingly argued by Denevan (1992) in his critique of the “pristine myth” of the pre-Columbian Americas. Additional work by geographers, archaeologists, historians, and others continues to illustrate the ways that indigenous people of the Americas and elsewhere shaped the landscapes they inhabited (Balée 1998a; Denevan 2001; Doolittle 2000; Gómez-Pompa et al. 2003; Head 1989, 2000; Kay & Simmons 2002; Kirch & Hunt 1997; Lentz 2000; Minnis & Elisens 2000; Peacock 1998; Willis et al. 2004), a fact often missed by colonial observers who wrote at a time of dramatic population decline and severe social disruption. European colonial accounts have other potential problems, including misunderstanding or falsely representing indigenous practices. Thus these sources imperfectly or incompletely portray the pre-European reality and should be complemented with other historical evidence from archaeology, paleoecology, and indigenous histories. Comparison of complementary lines of evidence can also identify landscapes that were not significantly transformed in the past [i.e., areas that were unoccupied or had a light human imprint (Lepofsky et al. 2003a)].

History is also essential to ecological restoration, “an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability” (Soc. Ecol. Restor. Sci. Policy Work. Group 2002) by returning it to its historical trajectory based on reference conditions inferred from the historical, ethnographic, paleoecological, and archaeological record (Egan & Howell 2001). Restored ecosystems are not static, nor does restoration necessarily aim to recover a pristine (prehuman) environment (Winterhalder et al. 2004). Traditional cultural practices that reinforce ecosystem health and sustainability are incorporated into restoration projects and plans (Anderson & Barbour 2003, Egan 2003, Soc. Ecol. Restor. Sci. Policy Work. Group 2002). Archaeology can contribute to restoration ecology by providing material evidence of past environments and of how they were shaped by human actions, including but not limited to evidence on species ranges, extinctions, introductions, and the cultural practices that were used to manage local resources (Alcoze 2003, Alcoze & Hurteau 2001, Louwe Kooijmans 1995, O’Brien 2001).

This review is divided into four parts. It opens by introducing the kinds of evidence used to infer vegetation histories and human impacts. Second, I describe how archaeologists have documented different kinds of human impacts on vegetation, such as overexploitation and deforestation, but also consider management practices such as the renewable harvest of woody resources and the planting and tending of wild species, all of which have played a role in forming modern landscapes. Third, I present case studies of the complex interactions of people, plants, and landscapes through time and their long-term effects, focusing on tropical forests. In this and
preceding sections, the emphasis is on recent literature because of space limitations. Finally, the review would be incomplete without at least a brief treatment of the political issues surrounding studies of culture, nature, history, and conservation and how historical (including archaeological) studies might be applied or abused. Conservation biology and restoration ecology developed because of the dramatic degradation of ecosystems and the continuing threats to biological diversity. For some, human exclusion and the maintenance of or return to wilderness is seen as the best strategy. But many areas of concern for protection and restoration are home not only to endangered plants and wildlife, but also to people, including indigenous groups, whose practices over the generations may have contributed to creating valued “natural” habitats, or recent colonists hoping to make a living. If these areas are rich in resources (timber, mines, agricultural land), industries, large landowners, and politicians also stake their claims. Archaeologists may join the debate as consultants or advocates, or they may adopt a neutral stance; in any case, their work may be seized upon or reinterpreted in ways they never expected.

**CLASSES OF EVIDENCE**

Evidence of past human impacts and of their long-term effects comes from a wide range of sources, including environmental archaeology, paleoecology, history, geography, geology, and cultural anthropology. Categories of data include botanical, faunal, and geological observations from archaeological sites and natural or off-site contexts (e.g., wetland cores, packrat middens); the distribution of sites and landscape features (roads, paths, fields) that provide information on population distribution, densities, and land use; current vegetation patterning; experiments that replicate natural and cultural processes and their effects; and written and oral historical references to past environments and land-use practices.

For example, paleobotanical records from site and off-site areas are used to reconstruct the removal or burning of vegetation, the introduction and spread of new species, the cultivation and encouragement of wild and domesticated plants, and the harvesting of wood and other forest products for fuel, timber, food, and medicine. These practices and their long-term effects are inferred from changes in the types and frequencies of species represented (e.g., shade-tolerant versus light-demanding, mesic versus xeric, fire-sensitive versus fire-tolerant), changes in particle charcoal accumulations at off-site areas (reflecting possible changes in burning regimes), and evidence for harvest strategies (e.g., collection of dead wood or pruning that conserve woody resources versus cutting down trees, shifts through time to lower quality fuel types).

Although the great majority of vegetation histories are still derived from pollen, there has been an increase in studies relying on other microfossils, such as starch and phytoliths, as well as macrofossil wood and charcoal from archaeological sites (Hather 1994, Newsom 1993, Thiébault 2002). Geoarchaeological studies reveal the extent and timing of erosion events that may be linked to deforestation or intensified agriculture, whereas soil analyses are used to reconstruct the enrichment or depletion of soils through human actions and their long-term effects (Adderley et al. 2000, Beach et al. 2003, Glaser & Woods 2004, Kristiansen 2001, Lehmann et al. 2003b, Lopinot & Woods 1993, Sandor 1995, Simpson 1997, van Andel et al. 1990, Woods 2004).

Faunal remains may also reflect environmental or land-use changes. For example, the kinds and diversity of animals such as beetles, land snails, and small mammals can be used as indicators of forest integrity or disturbance (Coles 1988, Desender et al. 1999, Dincauze 2000, Hogue 2003, Hunt & Kirch 1997, Peacock & Melsheimer 2003, Stahl 2000). Human impacts on fauna (e.g., introduction of seed predators, extinction of seed dispersers, declining human predation with
depopulation) will also have significant, long-term effects on vegetation. Note, however, that in some cases the human role is still heavily debated, e.g., for Pleistocene megafaunal extinctions (Barnosky et al. 2004, Fiedel & Haynes 2004, Grayson & Meltzer 2003, Grayson & Meltzer 2004, Martin & Steadman 1999). Another critical source of information on human impacts are regional studies based on systematic survey and remote sensing, which provide information on the changes in land-use practices, human settlements, and population dynamics through time.

The combination of different lines of evidence leads to more robust interpretations of landscape histories, although there are relatively few areas for which all potential sources of information have been examined. Communication among researchers collecting different types of information—ecologists and archaeologists for example—is often limited because of traditional disciplinary boundaries in universities, funding sources, and academic literatures. Additionally, interdisciplinary research at the landscape scale is costly. Potential sources of funding include new programs on humans and the environment (e.g., the Human and Social Dynamics area of the U.S. National Science Foundation).

**HUMAN IMPACTS ON VEGETATION**

The section below introduces different kinds of human impacts on vegetation. It begins with the familiar examples of overexploitation that resulted in deforestation, extinctions, and degradation. I also include practices aimed at increasing the abundance or reliability of wild resources that had the effect of more sustainable exploitation, increased diversity, soil improvement, or the creation of anthropogenic environments that are valued habitats today. Case studies follow with illustrations of the complex interactions over time between people and plants in a long acknowledged cultural landscape (southern Sweden) and in environments long perceived as pristine (tropical forests).

**Overexploitation**

There are numerous studies of prehistoric clearing and the overexploitation of plants that resulted in lasting changes in soils, vegetation, and wildlife, including the extirpation or extinction of species as habitats were altered or eliminated. A well-known example, based primarily on pollen evidence, is the loss of areas of upland forests in the British Isles (Brown 1997, Dickson 2000, Simmons 2001). The process began in the later Mesolithic, as hunter gatherers maintained and created canopy openings within the forest and along forest edges to encourage the growth of favored species and to attract game. Increasing areas were cleared in later periods for farming, grazing, timber, and fuel, ultimately resulting in the creation of moors and heathlands characterized by poor soils and low biodiversity.

Within the United States, pollen and sediment studies by McLaughlan (2003) suggest local deforestation and increased soil erosion coincide with the rise in reliance on cultivated species during the Middle Woodland occupation (100 B.C. to A.D. 400) of the Fort Ancient site in southern Ohio. At Cahokia, a major Mississippian center (A.D. 1050 to A.D. 1350), residents deforested the area around them as they opened fields and collected wood for fuel and buildings, including the construction of a 3 km wooden palisade using about 15,000 trees. The resultant erosion and increased runoff triggered flooding that is linked to the decline and eventual abandonment of the site (Lopinot & Woods 1993; Woods 2003, 2004).

On islands, vegetation loss due to overexploitation and clearing can be exacerbated by geographic isolation and the lack of nearby seed sources for recolonization. Additional problems (possible in any newly colonized area, island, or continent) are the introduction by humans of seed predators (domesticated animals, rodents), or the loss of seed dispersers due to hunting, predation by
introduced animals, introduced disease, or habitat fragmentation and loss. The best known case is Easter Island, where overexploitation led to environmental degradation and demographic and societal collapse (Flennley & Bahn 2003, Kirch 1997). When visited by European explorers in the early eighteenth century, the island was described as covered in grasslands and virtually treeless. Pollen and sediment studies from wetland cores as well as the analysis of charcoal from archaeological sites reveal that the island was forested when Polynesian colonists first arrived in the late seventh century (the earliest reliable radiocarbon date). Trees were cleared for agriculture, burned for fuel, and used to make objects such as the large canoes necessary for open ocean transportation and fishing. Deforestation and erosion began around A.D. 800 and proceeded slowly but surely; by the mid-seventeenth century, the forests were nearly depleted and had been replaced by grasses and weeds. Forest loss may have caused intermittent streams to run dry, further changing the island landscape. The local extinction of 14 plant species was detected in the charcoal record. One of the lost trees was a species of palm; nuts recovered from the archaeological record all show evidence of rodent gnawing, and it is likely that these seeds were consumed by the Polynesian rat (*Rattus exulans*) that arrived with the island’s colonists. The Polynesian rat is also implicated in the dramatic decline of the lowland forests of the Hawaiian Islands (Athens et al. 2002).

Alternatives to Overexploitation

The preceding examples of overexploitation are well known, and many others could be given (Amorosi et al. 1997, Kohler 1992, Köhler-Rollefson & Rollefson 1990, Lagerås & Bartholin 2003, McGovern 1994, Miller 1990). For conservation purposes, they illustrate a “lost past” that may inform restoration efforts and also serve as essential cautionary tales on the environmental and human costs of overconsumption. But the history of human land use is not an inevitable story of depletion and degradation. There are also examples of sustainable use and practices that maintained diversity or that resulted in the creation of landscapes that are now valued habitats. These examples have received less attention, perhaps because they are less common or less dramatic (and thus perceived as less interesting or less relevant to current conservation concerns). They may also be harder to study; it is perhaps easier to infer depletion than conservation from the archaeological record. Assumptions about human nature or the nature of indigenous people (as inately wasteful or destructive) also play a role as Fairhead & Leach (1995) demonstrated in their work in the Kissigoudou peninsula of Guinea. Here, patches of forest surrounded by savannah had been characterized as the remnants of a vast forest that had been devastated by local inhabitants. A close study of the historical record and ethnographic observations clearly demonstrated that the supposed forest remnants were in fact forest islands that local residents had planted and tended in existing savannah. Similar examples of the management of wild plants can be found throughout the modern, historical, and archaeological records and help to balance our perceptions of human impacts.

Maintaining woody resources. Human needs for wood were not always met by cutting down trees. Archaeobotanical studies of charcoal can identify cases where dead wood, recognizable through the growth of fungus or the presence of insect holes, was collected for fuel. Recent examples are described from the coast of southeastern Brazil during the late Holocene (Scheel-Ybert 2001) and from the Neolithic site of Çatalhöyük in Anatolia (Asouti & Hather 2001). Driftwood was used for fuel and the manufacture of objects, even in heavily forested coastal areas. Driftwood accounted for at least 18% of the charcoal assemblage of the Cape Addington Rockshelter in southeast Alaska, occupied from A.D. 160 to 1420. Its importance as a fuel and raw
material is amply described in historical accounts (Lepofsky et al. 2003b).

In other cases, branches rather than whole trees were harvested and used for fuel and fodder. Small branches were burned at the Neolithic-Chalcolithic Pınarbaşı campsite in Anatolia, and Asouti (2003) notes that for these taxa (Pistacia, Amygdalus) pruning would have stimulated flowering and seed production, potentially increasing their local abundance. Terral (2000) also infers from the Bronze Age charcoal record from sites on the Mediterranean coast of France and Spain pruning was used to manage olive trees.

Some trees sprout vigorously from the stump (called coppicing) or roots (suckering) when cut down. If a high stump is left (to keep the tender sprouts out of the reach of grazing animals), the practice is termed pollarding (Rackham 1998a). Coppicing and pollarding stimulate growth and extend the life of trees (up to 1000 years for species studied in Europe), ensuring a rapidly renewable and potentially sustainable supply of wood for fuel, poles for construction, and branches for fodder. Using written sources and fieldwork on old coppiced trees, Rackham has painstakingly documented the history of these practices and their ecology in Britain and the Mediterranean (Rackham 1996, 1998a,b).

Archaeological evidence for coppicing in England extends back to the Neolithic [circa (ca.) 5000 before present (B.P.)], when poles were used to construct tracks for crossing the wetlands at the Somerset Levels site (Coles & Coles 1986). In pre-Columbian sites in Florida and the Caribbean, the reliance on mangrove for fuel over many generations by growing populations without depletion is also likely due to its prolific coppice growth (Newson 1993, Newsom & Wing 2004, Scarry & Newsom 1992). In some heavily modified landscapes, the persistence of forest patches into modern times may be due to coppicing management practices. This is clearly the case in the highly managed coppice woodlands of Britain and the Mediterranean, where ancient coppice stools (the stumps) are still evident, but may also be true for other areas, where coppicing has not persisted in recent times or left such obvious evidence.

The renewable harvest of wood or bark is also recorded in the Pacific Northwest and northern Scandinavia, where the cambium layer of certain conifers was consumed. It was often removed in strips, which did not kill the tree but left a characteristic scar. Similarly, Native Americans of the Great Basin removed long, narrow pieces of wood to manufacture bow staves from live junipers without killing the tree. Examples of these “culturally modified trees” record past harvesting practices and are also evidence of a historical human presence in areas where other kinds of archaeological remains may be sparse or difficult to detect (Mobley & Eldridge 1992, Östlund et al. 2004).

**Planting and tending.** Wild plant species were also transplanted, cultivated, tended or encouraged, resulting in their potentially sustainable use. For example, in the late pre-Hispanic Andes, the Inka planted Buddleia and possibly other trees for harvest as fuelwood (Chepstow-Lusty & Winfield 2000, Hastorf & Johannessen 1996). There are also many examples, both past and present from throughout the world, of useful species planted in settlements, gardens, and fields or spared during clearing (e.g., the ethnographically observed “managed succession” of trees in fallows). These practices could extend the range of certain species, or increase their abundance, in areas of human activity.

Both historical and archaeological evidence point to the management of nut trees by Native Americans in the eastern United States (Scarry 2003). Two recent studies provide evidence for this practice by comparing the distribution of Native American settlements and “witness trees,” interval markers noted on the maps and notes of early U.S. government surveyors. In southeastern Pennsylvania, Black & Abrams (2001) compared the spatial distribution of witness
trees recorded in the eighteenth century and Susquehannock villages occupied in the late sixteenth through mid-seventeenth centuries. The higher than expected occurrence of hickory (*Carya*) and, to a lesser degree, walnut (*Juglans*) in village catchments is not explained by topographic or edaphic differences. This suggests their purposeful encouragement or cultivation, a practice recorded in historical accounts. Similar observations were made by Foster et al. (2004) in an analysis of witness trees around historic Creek Indian villages in Alabama. Because witness tree records are often used in the United States to establish the “natural” baseline in long-term ecological studies and for the purposes of restoration, these examples highlight the importance of understanding the many ways that landscapes were shaped by indigenous inhabitants.

Human manipulation of vegetation to increase the production or reliability of wild plant foods has a very deep history. Evidence from throughout north temperate Europe, indicates that late Mesolithic hunter gatherers burned forests to create or maintain clearings to attract game and to encourage grasses and other open habitat species (such as hazel, valued for its nuts) (Mason 2000, Mithen et al. 2001, Zvelebil 1995). It is also likely that they cultivated or transplanted wild plants beyond their natural ranges. Archaeologists are increasingly paying attention to the ways that hunter-gatherers manipulate plant resources to increase their abundance or reliability, what Smith (2001) refers to as “low level food production.” These activities suggest that the presumed natural (prefarming) pollen baseline used in vegetation history studies may in fact reflect a landscape that had already been significantly altered by people.

Other archaeological and paleoecological examples of the tending or cultivation of wild and semidomesticated trees are reported for the Pacific Islands (Latinis 2000), Japan (Kitagawa et al. 2004), the Caribbean (Newsom & Pearsall 2003, Newsom & Wing 2004), the Maya region (discussed below), and Spain and Portugal (Harrison 1996).

**Burning.** The use of prescribed burning is a much debated issue in ecology and forest management, particularly in areas prone to major wildfires that threaten people, property, and forests. In the United States, the likelihood of catastrophic fires increased with the practice of fire suppression that interrupted the natural and cultural fire regimes of the past and resulted in large fuel accumulations. Fire history and the presence or absence of anthropogenic burning in the past informs decisions about forest and grassland management today as well as decisions concerning how or whether prescribed burning should be carried out.

Fire histories are generally based on the analysis of off-site evidence, such as charcoal and pollen from wetland cores, or fire scar sequences from trees, together with historical evidence on fire frequency, lightning frequency, and human burning practices. This information is compared against climatic reconstructions to identify periods of drying that may have increased the probability of natural (lightning) ignitions. Evidence for human versus natural ignition is inferred, for example, by an increase in charcoal accumulations accompanied by the presence of pollen from cultigens, suggesting burning to clear and prepare land for crops. The use of archaeological evidence to reconstruct fire histories has been largely indirect, such as the coincidence in timing for an increase in fire frequency with human colonization or the expansion of agricultural settlements. On-site archaeological evidence alone may not be sufficient to reconstruct burning history, but it contributes to the interpretation of off-site evidence.

In Southern Appalachia, archaeological and paleoecological evidence has been combined to argue for the effects of human actions, including burning, on forest composition in the Late Archaic and Early Woodland periods beginning 3000 B.P. (Delcourt & Delcourt 1997, 1998a,b; Delcourt et al. 1998). On the basis of off-site pollen and charcoal records, the location of settlements, and the reconstruction of
farming and hunting practices from archaeological remains, researchers inferred that fire was used to clear small garden plots and to create open grassy areas to attract game on upper slopes and ridgetops. This action encouraged the growth of fire tolerant oaks, chestnut, and pine. Mixed mesophytic forest persisted on the lower slopes and in ravines, resulting in a diverse vegetation mosaic. Recently, fire-adapted species have been declining owing to the low incidence of lightning along with fire suppression in the twentieth century. The persistence of valuable fire-adapted species as major forest components and the preservation of the landscape mosaic may therefore depend on prescribed burning.

CASE STUDIES
The complex role of people in landscape history is perhaps best illustrated through more extended presentation of case studies. I begin with an area where the human role in shaping the landscape has long been recognized—southern Sweden—and discuss how a historical perspective has been used to address current conservation concerns. I then discuss how archaeology informs our understanding and perceptions of tropical forests, where the human role in shaping landscapes over time is still debated and closely linked to alarm over the rapid rate of modern deforestation and resultant conflicts over how forests should be managed and protected.

Anthropogenic Landscapes: Southern Sweden
A key conservation concern in southern Sweden has been the decline of rich deciduous forests and their replacement by species poor forests dominated by spruce (Picea) or beech (Fagus). Although partly explained by natural causes (climate-driven continental scale migrations) and recent forestry practices, this transformation has also been linked to past land uses, including grazing, burning, and clearance for agriculture (Björkman & Bradshaw 1996; Börse & Bradshaw 1998; Lagerås 1996; Lindbladh & Bradshaw 1995, 1998; Lindbladh et al. 2000; Mikusinski et al. 2003). The remaining patches of mixed deciduous forest can also be partly attributed to cultural causes.

In a remote sensing study, Mikusinski et al. (2003) noted that today stands of deciduous forest, often with old trees, are concentrated around villages where trees would have been retained for “practical, aesthetic, and cultural reasons.” This distribution is also explained by the differential management of lands dating back to the Medieval period, if not earlier, when infields included intensively farmed cereal fields and hay meadows for winter fodder production, and outfields were used for forest grazing and slash and burn agriculture. Historical sources suggest that conifers that sprouted in infields were weeded out because of the high acid and low nutrient content of their litter, reducing their spread into maintained deciduous patches.

Lindbladh & Bradshaw (1995, 1998) compared pollen evidence from one infield and two outfield areas at neighboring estates in Småland. They found that prior to A.D. 1100 all areas were covered by mixed deciduous forests. After that date the pollen evidence from the infeld suggests the creation and prolonged (800 years) management of a mosaic of meadows, fields, pastures, and pollarded trees that supported a high diversity of species. With abandonment 100 years ago, floristic diversity declined. A previous decrease in diversity began at ca. A.D. 1400 when the population of local residents (and maintenance of the meadow system) declined with the spread of the black death. In contrast to the infields, the outfields maintained continuous forest cover, and there was no evidence for intensive grazing as has been observed in the outfields of other regions. Conifers first gained a foothold in these forests around A.D. 1400. Slash and burn agriculture was practiced in outfields during the eighteenth and nineteenth century, and once outfields were abandoned,
conifers spread and dominated regenerating forests.

Although deciduous forests and the threatened species they support have a high conservation value, there is also a need to protect and restore species in rich seminatural grasslands. Eriksson et al. (2002) observe that natural grasslands predate human occupation of southern Scandinavia, but they argue that grassland habitats and connectivity increased with human management (mowing and grazing) dating as far back as the Neolithic (Cousins et al. 2002). In this way, human activities may have increased local plant species diversity over time in these grasslands (Eriksson et al. 2002). The high diversity found in these areas is now sharply declining; in Sweden, the loss of seminatural grasslands over the past 80 years is estimated at approximately 90% (Eriksson et al. 2002), owing to forest encroachment once grazing or other maintenance ceases and to direct conversion to agricultural fields or plantations. This decline in grassland habitats and connectivity has resulted in an increase in local extinction rates and a decrease in species richness. Historical studies, including archaeology and paleoecology, reveal how these landscapes evolved and how they might be preserved.

**Anthropogenic Landscapes: Tropical Forests**

Tropical forests today are valued for the abundance, uniqueness, or diversity of the plant and animal life they support and for their large-scale effects on atmospheric processes and conditions. As such, they have often been defined as pristine, natural, or wild, and the effects of human impacts have often been overlooked or misconstrued. Many are located in areas that were subjected to European colonial expansion that resulted in (a) the abandonment of land (and its subsequent “return to nature”) because of forced resettlement, migration, and depopulation caused by introduced diseases, warfare, and genocide and (b) the characterization of indigenous land-use practices (such as swidden farming and hunting) as inherently wasteful and destructive, further justifying the control or exclusion of indigenous inhabitants.

Efforts to emphasize the natural character of tropical forests are also spurred by the real threats posed by logging, urbanization, intensive agriculture, and the conversion of forest to pasturelands. Many fear that acknowledging the human past of wild areas will be used to justify their intensive use today. These fears are valid because arguments of this type have been made in other contexts [e.g., the equation of anthropogenic and natural burning with clear cutting in North American forests (Bonnicksen 1994; see discussion in Fritz 2000)]. But the response should be more research, not less, on historical human impacts (which in some areas may in fact be minimal) to understand current landscapes and to identify alternatives to destructive contemporary land-use practices. Increasingly, conservationists are realizing that strict preservation (whether desirable or not) is not feasible for most of the world’s tropical forest areas.

Toward these ends, there has been a growth in research by both natural and social scientists on forest history and the role of disturbances both natural and cultural, such as fire, hurricanes, logging, clearing for agriculture and grazing, and their interactions. How do forests respond to disturbances of different kinds, scales, intensities, and durations? How does past land use affect modern structure, composition, and function? What are examples of both degradation and enhancement in the past, and how might this knowledge inform contemporary land use (e.g., by illustrating possible lower impact alternatives to deforestation)?

**Disturbance.** Whitmore & Burslem (1998) reviewed evidence on the significance of large-scale disturbances on the structure and composition of tropical rainforests. Disturbances are events that create gaps in the
forest canopy; an example of a small-scale natural disturbance would be an individual tree fall. Small-scale disturbances occur with high frequency and are easily observed and studied. Larger scale disturbances include natural events such as landslides, wind storms, floods, and fire, as well as human activities such as clearing plots for agriculture and logging. These rarer disturbances, with return intervals of decades or centuries, appear to be important components of forest history in most if not all tropical areas. Clearings or gaps in the canopy encourage the establishment of more light-demanding trees and understory species or recruitment of established seedlings and saplings of shade tolerant species. Small gaps tend to favor shade-tolerant species, whereas larger disturbances that destroy understory vegetation result in the establishment and numerical dominance of light-demanding trees. If these trees are allowed to grow (e.g., in a swidden system with a long fallow period or under natural disturbance regimes), the result is a mosaic of forest patches in different stages of succession. Similar disturbance dynamics have been examined for other kinds of forests.

**Solomon Islands.** These ideas are explored in the Marovo Lagoon region of the Solomon Islands by Bayliss-Smith et al. (2003). The study area is a large tract of unbroken forest often depicted as pristine and under consideration as a United Nations Educational, Scientific, and Cultural Organization World Heritage Area. Historical sources suggest that in ca. 1800, before intensive European contact, local inland residents relied on irrigated pondfields (taro), mixed bush fallow swidden farming (mainly dryland taro and yams), and the products from secondary forests of fallowed fields (*Canarium* nut trees, leafy greens, ferns, wild yams, and medicinal plants). Depopulation and social disruption caused by increased European contact led to the eventual abandonment of the inland area by the late nineteenth century, and the remaining population moved toward the coast. Cleared areas of the forest regenerated, resulting in the apparent wilderness seen today. Archaeological survey confirms the inland presence of numerous settlements, forts, ceremonial grounds, taro terraces, and nut groves. The locations of settlements correlate with patches of forest dominated by *Campnosperma brevipetolata*, a light-demanding species that recruits well in areas of large-scale disturbance. In this case, the forest gaps colonized by *Campnosperma* were probably abandoned swidden fields. The authors argue that the anthropogenic disturbance history of these forests indicates greater resilience than is commonly acknowledged and they suggest that some relatively light forest disturbance activities, such as reduced-impact logging, may be viable and sustainable land-use options today.

In the Solomon Islands, population decline and reforestation occurred within the past 200 years. The Maya forest and the wealth of archaeological, paleocological, and ecological studies that have been conducted present the opportunity to explore an example of long-term forest history and the dynamics of people, plants, landscape, and climate (Gómez-Pompa et al. 2003, Turner et al. 2004)

**Maya: deforestation and recovery.** In the Maya Lowlands, where a series of lake core studies (primarily from the Petén) complements decades of archaeological survey and excavations, four general periods in the Holocene history of the forests can be discerned (Brenner et al. 1990, Curtis et al. 1998, Dunning et al. 1998, Islebe et al. 1996, Leyden 1987):

1. A prehuman landscape, when the pollen of mature forest species is most prevalent;

2. A prolonged episode of clearing seen as a decrease in the abundance of high forest species and as an increase in disturbance taxa (grasses, weeds) and in secondary forest taxa, attributable to human entry in the region, as well as the
establishment and spread of agriculture near settlements;

3. A period of increased deforestation detected as a dramatic drop in tree pollen abundance (both mature and secondary forest taxa), a rise in grass, weeds, and maize pollen, as well as widespread soil erosion, seen as a thick layer of “Maya clay” in many of the lake cores; and finally

4. Reforestation, when both high and secondary forest taxa rebounded. Maize pollen persisted.

Reforestation has been dated to either the period following the Classic Maya collapse of ca. A.D. 800–1000, or much later, on the heels of the Spanish invasion in the seventeenth century. This discrepancy can be attributed to the lack of absolute dates for the early cores together with the fact that some areas continued to be occupied and farmed throughout the Postclassic (i.e., recovery took place at different rates in different places). A recent, well-dated core from the large Lake Petén Itza indicates that reforestation of at least some areas began ca. 1100 to 1000 B.P., following the Classic Maya collapse (Curtis et al. 1998).

Forest recovery is typically attributed to the decrease in population following the collapse, but changes in forest composition also suggest a possible alteration of farming practices, which were based primarily on swidden in the upland areas and supplemented by wetland agriculture in the low-lying, seasonally flooded bajos, terracing of upland slopes, and agroforestry (in swidden fields and house gardens) (Whitmore & Turner 2001). The very low abundance of both mature and secondary tree taxa during the period of maximum disturbance suggests both increased clearing and a shortening of fallow periods. The recovery of both mature and secondary forest taxa during the last phase together with the continued presence of maize suggest (a) that less total area was cultivated with more areas converting to mature forest and (b) a return to longer periods of fallow, enabled by population de-

clines but perhaps also reflecting a cultural response to the crisis of soil and forest loss.

Ecologists have pondered the reforestation of the Maya region. How did it take place? One possibility is that the uplands were recolonized by trees from the less heavily farmed bajos, as suggested by Pérez-Salicrup (2004) for the southern Yucatan. However, many upland forest species are absent from or extremely rare in bajos in the Maya region today (Schulze & Whitacre 1999), which argues for an upland seed source during postcollapse reforestation. Other possible seed sources were managed plots dominated by economic species, such as house gardens, tended groves, and “forests gardens” resulting from selective cutting and planting of trees in swidden fields (Gómez-Pompa et al. 1990, Lentz et al. 2000, McIlhoop 1994, Peters 2000, Turner & Misicek 1984). Also important were the forested, unoccupied areas between competing polities that served as both buffer zones and battle grounds (Taube 2003). Forests were conceptualized by the ancient Maya as sinister places, associated with darkness, evil, wild animals, and disorder, as opposed to the well-delineated, socially constructed spaces of fields, houses, and settlements. Thus expanses of forests were preserved out of respect for and fear of wild and human threats. Finally it’s important to note that the collapse was not a single, brief event. Instead, the abandonment of major centers and shifts in population took place at different times and at different rates (Webster 2002). Thus Allen et al. (2003) observe that forest resources may have been depleted in some areas while recovering in others, resulting in a shifting mosaic that helped to preserve biodiversity.

Other land-use legacies that potentially affected the recovery of the Maya forest and its current structure and composition were changes in soils and topography from upland erosion and aggradation in lakes and bajos (Beach 1998, Beach et al. 2003, Dunning & Beach 2000), the construction in some areas of soil conservation features (terraces, check dams) that captured eroded sediments (Beach
et al. 2002, Dunning & Beach 1994), the addition of soil amendments both intentional (fertilizers on fields) and unintentional (human waste at settlements), and the creation of microenvironments on the ruins themselves. Certain tree species (notably *ramón* or *Brosimum alicastrum*) prefer the edaphic conditions of the high limestone structures (Lambert & Arnason 1982, Schulze & Whitacre 1999), and their seeds are dispersed by bats, who feed on the fruit and reside in the ruins (Peters 2000).

In summary, the lesson of the Maya forest is not simply that “tropical forests are resilient” but rather that (a) human land use has lasting effects, (b) a recovered forest may be different from the forest prior to intensive use (even with significant population decline), and (c) the conservation and recovery of biodiversity may be dependent on the purposeful cultivation and tending of plants, changes in land-use practices, reduced or shifting populations over long periods of time to allow for local and regional recovery, and the preservation of uninhabited areas (the buffer zones).

**Amazonia: anthropogenic forests and soils.** Perhaps the one area where the pristine character of the forest has been most heatedly debated is Amazonia. The debate is closely tied to the long held idea that rainforests, with their impoverished soils and concentration of energy in the canopy, create severely limiting conditions for foraging and farming. Yet ethnographic and archaeological research has repeatedly demonstrated how people transformed or enhanced the Amazonian landscape, both creating and managing resources (Balée 1993, Denevan 2001, Erickson 2000, Erickson 2003, Glaser & Woods 2004, Lehmann et al. 2003b, Oliver 2001, Petersen et al. 2001, Politis 2001, Posey 2002, Roosevelt 2000, Stahl 1996, Zent & Zent 2004). Of particular interest for ecology and conservation is how unintentional and intentional human actions have resulted in compositionally distinct patches or stands of plants. These anthropogenic forests may cover 12% or more of the Amazon forest (Balée 1989). Some species, including the babaçu palm (*Orbignya phalerata*), readily colonize burned clearings such as fallows, and populations may expand in response to anthropogenic disturbance. Favored tree species may be spared during clearing or planted in fields, clearings along trails, and house gardens. The discarded seeds of collected fruit sprout and thrive in the enriched soils of camps and settlements. Game animals are also attracted to the high abundance of fruits at these sites, and some disperse seeds in the immediate area, further enriching the stand. Old habitation sites (whether temporary or permanent) and fallows thus form resource-rich patches, which may be revisited or reoccupied over generations.

Clearly, not all patches of useful species have a human origin and edaphic conditions, the habits of animal dispersers, and natural disturbances must be taken into account. In the Columbian Amazon, Politis (2001) noted that plantain favors the unstable soil of ridgetops, whereas moriche palm (*Mauritia flexuosa*) is abundant in poorly drained areas. Animals create aggregations by depositing the seeds of palms and other trees in the areas of consumption [e.g., agoutis (Silvius & Fragoso 2003)] or at distant latrine sites [e.g., tapirs (Fragoso et al. 2003)]. Babaçu readily sprouts in fallows, but it does not require human forest disturbance for regeneration. These observations are important to keep in mind when using vegetation to identify areas of past human activity or when quantifying areas of anthropogenic forest, just as studies of “natural” aggregations and diversity need to consider possible cultural origins.

The antiquity of management practices is inferred from (a) the presence in archaeological sites of the remains of plants that are managed today (Morcote-Rios & Bernal 2001, Oliver 2001, Politis 2001, Scheel-Ybert 2001) and (b) the association of stands of useful plants with archaeological sites, particularly with Amazonian dark earth (ADE) deposits (Balée 1989, Clement et al. 2003), most

ADE: Amazonian dark earth
of which are between 500 and 2500 years old (Neves et al. 2003).

ADEs are fertile anthrosols capable of much higher production than the natural upland (terra firme) soils. They are characterized by a high charcoal content and other organic inputs. The charcoal addition stimulates the development of beneficial microorganisms, improves nutrient uptake, and reduces nutrient loss from leaching (Glaser et al. 2003, Lehmann et al. 2003a). The darker (terra preta) ADE is laden with artifacts and the organic trash (bone, shell and plant remains, nightsoil, ashes, construction material) typically generated at settlements (Erickson 2003). The lighter, more extensive, and artifact free terra mulata was probably formed through agricultural practices (and enabled short cropping/short fallow) with the addition of charred plant remains, ash, compost, and mulch (Denevan 2004). Both types of ADEs were likely farmed in the past, and remarkably, they continue to maintain their fertility into the present (Glaser et al. 2003). The productive potential of ADE has been linked to the development of complex societies in the ancient Amazon (Neves et al. 2003).

Today, ADE is of conservation interest because of the high diversity of plants it supports (Clement et al. 2003). Also, efforts to revive this indigenous technology today hold the promise of slowing the rate of deforestation by providing an alternative to more extensive, unsustainable land-use practices (Madari et al. 2004, Soembroek et al. 2003, Steiner et al. 2004). Uncertainty remains about the processes by which ADE is formed, as well as the time required for transformation of weathered, nutrient-poor Amazonian soils to nutrient-rich, stable ADEs, doubts that could in part be resolved through continued examination of the archaeological evidence.

SUMMARY AND DISCUSSION

In the preceding sections, I presented examples of the ways that archaeology can contribute to understanding the long-term dynamics of people, plants, and landscapes. It is a source of information on land-use practices (burning, grazing, cultivation) that shifted vegetation composition and succession and that sometimes resulted in overexploitation, degradation, and extinctions. Archaeology also shows us how people in the past maintained, increased, or protected plant resources resulting in long-term, sustainable harvest and the creation of patches of certain species, fire-adapted forests, or grasslands and other open habitats. In some cases, the anthropogenic origins of seemingly natural landscapes are only now being recognized and investigated. We are beginning to see how human maintenance over generations has created ecosystems that will disappear or deteriorate without continued care. The grasslands of southern Scandinavia provide one such example, as do the fire-adapted forests of Southern Appalachia. The managed woodlands of Europe also suffer from neglect, partly intentional and derived from a desire to “return” these woods to nature, resulting in the loss of species (Rackham 1998a).

In considering anthropogenic landscapes, it is important to emphasize that not all human disturbance is the same, and different practices can have very different effects. For example, the discovery of artifacts or ancient settlements deep in a forest by itself tells us nothing about the extent and kinds of human impacts nor about forest resilience and recovery. Thus for archaeology and other historical disciplines to inform modern decision making, we need to be as specific and accurate as possible about the events and processes of the past and their environmental, ecosystemic, and cultural contexts. Some restorations may not be feasible at present because climates have changed. Current proposed economic uses (e.g., logging) may have radically different effects than uses (e.g., farming) in the past. Species reintroductions may fail because key components of past ecosystems are missing or cannot be replicated. It may be difficult to revive past cultural practices, even if they are seen as desirable from a conservation
point of view, because of radical differences in human values, social organization, and new economic and political realities.

We also need to understand how the past informs contemporary decision making because of the different spins put on the discovery that a landscape is not pristine or that people manipulated nature. It can be used in several ways:

- To depict indigenous people as despoilers of the land, influencing public opinion and creating possible grounds for denying land or resource use rights (see examples in Head 1989, Head 1990, Spriggs 2001). Head (1990) notes that this same logic is not used to question the rights of European colonizers.

- To excuse modern destructive land-use practices or episodes of pollution on the principle that the land was already spoiled (Wooley 2002). A variant argues that intensive logging is justified because forests have recovered in the past (without regard for the conditions or extent of past deforestation or the conditions and time needed for recovery).

- As justification for modern development (logging, mining) on the grounds that these practices mimic natural processes and indigenous practices [e.g., the equation of clear cutting with natural and anthropogenic burning (Bonnicksen 1994)]. A variant argues that modern genetic modification of crops mimics ancient practices (early domestication) and is therefore time tested and safe (Fedoroff 2003).

History matters in understanding ecosystems, in formulating management plans and policy, in shaping public opinion, in reinforcing or negating indigenous rights, and in neglecting certain landscapes because they are not natural enough or in degrading others because they are not pristine. As archaeologists take a larger role in research relevant to current environmental and land-use issues, the intersection of research and public policy debate is inevitable. Others will use archaeological findings in ways we had not anticipated, in many cases misinterpreting or deliberately misusing them. Only by taking active roles can we shape how our research results are interpreted in public discourse and applied to policy outcomes.

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