Fundamental shifts have occurred in scientific thinking about history and humans. Ecologists hope that historians can help provide better long-term data for ecological analysis. In this article, David Foster outlines the benefits of retrospective studies and how history can inform future decision-making by helping us ask better questions.

CONSERVATION LESSONS & CHALLENGES *from* ECOLOGICAL HISTORY

What is the landscape's history? Through diverse studies ranging in focus from wildfire in wilderness landscapes and ancient human impacts on tropical forests to the management of old-growth landscapes and the preservation of rare plant and animal species, the answer to this simple question is increasingly sought as a guide for ecological interpretation and the development of land management policies.[1] A new appreciation of history's value by scientists and conservationists has broadened the temporal framework of ecological research and environmental planning through the widespread use of retrospective or historical studies. This paper explores some of the arguments for and successes achieved through the integration of history, ecology, and conservation. It also identifies the kinds of historical arguments that have proven to be most persuasive with scientists and land managers. It begins by examining some changes at major ecological research programs and ends by focusing in on one region—New England—and arguing that the application of historical insights to conservation may yield a regional approach to planning that includes seemingly incongruous objectives.

Importantly, expansion of the timeframe for understanding

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nature has both informed and challenged ecologists and policy makers. Rapid changes in nature, the pervasiveness of human impacts on ecosystems, and the evident subjectivity of most environmental decisions confront us routinely. Therefore, the paper also discusses some of the problems that arise as we seek to adapt the lessons from history into recommendations for restoration and conservation. The focus ranges from the tropics to the temperate region but is largely on the New England countryside where the turn of history has yielded a dynamic newly reforested landscape that offers unusual opportunities for ecological interpretation and conservation.

ECOLOGICAL INSIGHTS FROM LONG-TERM AND RETROSPECTIVE STUDIES

Studies of nature based on short-term measurements of current patterns and conditions are inherently limited in their ability to interpret ecosystem and landscape characteristics or to anticipate future conditions.[2] By contrast, retrospective studies that seek to evaluate modern landscapes within the context of historical processes can broaden the interpretive base by providing at least five key sources of information.

Evaluate long-term processes. Many important ecological processes (e.g., succession, ecosystem response to climate change, soil development) occur gradually over decades to millennia. Modern studies, even so-called long-term ecological research, often have limited success in investigating such phenomena because they must: (i) extrapolate from observations covering only a fraction of the whole sequence; (ii) employ space-for-time substitution in which apparent stages in a process like succession are sought in the present landscape; or (iii) initiate studies that will not yield complete results until the distant future. Ecological modeling is another alternative, but ultimately it too depends on long sequences of data for validation. However, by reconstructing the sequence of past changes at one site or in the landscape, many of these key processes can be explored with few limitations.[3]

Increase sample sizes. One factor that commonly hampers our ability to generalize about ecological processes is our inability to compile adequate numbers of observations to identify patterns or to undertake statistical analysis. This is especially true of infrequent disturbance events like fire, hurricane impacts or volcanic activity. Through the expanded time frame of retrospective studies we can increase our sample size and range of observations, allowing us, for example, to define return intervals and disturbance regimes.[4]

Document rare or extreme events. Without historical approaches we cannot examine ecosystem behavior in response to extreme

PHOTO BY STEPHEN H. SPURR

The old-growth Pisgah forest in southern New Hampshire three years after the 1938 hurricane blew down most of the stand. Memories of the 1938 hurricane and ecological bias towards studying natural ecosystems led researchers at the Harvard Forest LTER site to focus on natural disturbances in their initial research proposals.

and uncommon conditions that exceed those recorded in our limited observational record. Using historical approaches we can evaluate earth-shaping events like extinctions, glacial cycles, continental-scale migrations of plants and animals, and major upheavals to aquatic and terrestrial systems.

Examine ecosystem response to contrasting cultural regimes. As recognition of the importance of human environmental impacts increases, our need to relate ecosystem dynamics to changes in management regimes or social environments has become critical. Retrospective studies can further this goal by providing a continuous record of ecological phenomena across historical cultural boundaries. For example, a fundamental objective for American ecologists has been to document and interpret the shifts in ecosystem structure and function that occurred as the landscape changed from Native American to European dominance.[5] Through a combination of social, biological, and geological approaches we can investigate the links between these critical social transitions and ecological responses.

Despite the many fundamental insights that emerge from historical studies as outlined above there is a single factor that ultimately motivates many scientists and managers to embrace history: it often provides critical information for interpreting current conditions.

Provide key insights into current ecosystem structure, function, and response. Time-lags develop in the response of all biological and physical systems to disturbance or environmental change. Therefore, in most situations instantaneous measurements of current conditions are inadequate because they are uniformed of ecosystem trajectories and dynamics and use only a subset of explanatory data.[6] As we will see below, history oftentime provides key insights into current conditions or ongoing changes in modern ecosystems.

INCORPORATION OF HISTORY INTO ECOLOGICAL AND ENVIRONMENTAL STUDIES

One way to measure the growing use of historical approaches in ecology and conservation biology is to examine relevant changes in the major U.S. agency responsible for basic research, the National Science Foundation (NSF), and its ecological research arm, the Division of Environmental Biology (DEB). Within DEB, the Long Term Ecological Research Program (LTER), established in 1980 and now consisting of 25 sites extending from Puerto Rico to Alaska and from Antarctica to California and New England, is one of the world's largest and most visible ecological research networks.[7] A review of the LTER Network since its inception demonstrates some fundamental changes that include perhaps most notably, a growing awareness of the role of history and other retrospective sciences in ecological studies as well as the importance of studying humans as integral components of nature. Over the past two decades, archaeologists, geologists, historians, historical ecologists, and paleoecologists have joined LTER science teams or have emerged as principal investigators; two sites have been augmented explicitly to study social and ecological systems; two urban sites have been funded; and a network-wide working group on retrospective studies has been formed. These changes in a major research network are indicative of an emerging appreciation for the study of history and humans in ecology; a study that can be used as a basis for management decisions.

A close examination of developments at two very different sites within the LTER Network—the tropical Luquillo Experimental Forest (LEF) in Puerto Rico and the temperate Harvard Forest in New England—reveals the fundamental shifts that have occurred in scientific thinking about history and humans, as well as their underlying causes. Both sites wrote proposals for the NSF-LTER competition in 1987, were successfully funded as new LTER sites in 1988, and have just submitted continuation proposals for a third 6-year grant. Comparisons of the first and latest proposals and changes in the framework for studies at these sites over a 12-year period underscore how and why history has become important in ecological studies.

TALE OF TWO LTER SITES—HARVARD FOREST AND THE LUQUILLO EXPERIMENTAL FOREST

Even a cursory review of the history of New England and Puerto Rico suggests that these landscapes, having supported indigenous populations as well as some of the oldest European settlements in the New World, have been shaped over centuries by human activity interacting with natural process. However, despite the evident linkage between human and ecological history in these regions the scientists who gathered at the two sites in 1987 to write the initial LTER proposals decided to ignore this obvious theme for their studies. Instead both groups focussed their research plans solely on natural and current processes including recent environmental disturbances, global change, succession, and ecosystem processes. Neither group identified the need to focus on the history of people or human-driven landscape change. Thus, in Puerto Rico attention centered on such topics as forest gap dynamics, hurricane impacts, and landslides; in New England a similar program emerged on hurricanes, pathogens, future climate change, and the atmospheric deposition of nitrogen due to fossil fuel burning. The only retrospective work at the sites included the reconstruction of hurricane histories. Neither site addressed the glaringly obvious history of human impacts.

The focus on current and natural processes and the avoidance of history and human impacts were deliberate decisions that were based on a combination of scientific bias and pragmatic grantsmanship. Tropical biologists have generally focussed on primary (i.e., natural and old-growth) forests and have undertaken fewer retrospective studies than their temperate or boreal counterparts.[8] In the Puerto Rico LTER group there was a tendency among most scientists to assume either that the forests were natural or that decades as a forest preserve had healed any prior human impacts. In New England a related scientific bias crept in. With the detailed histories of land use that are available at the Harvard Forest and the ubiquitous evidence of stone walls coursing through the forests, landscape history and human activity are difficult to ignore.[9] However, both were deemed irrelevant to current and future ecosystem process by many participating scientists. As one biogeochemist responded when asked whether the land-use history of the conifer and hardwood forests that had been selected for comparative study of response to nitrogen fertilization was of interest: "No. Since conifer and hardwood stands have fundamentally different nitrogen

economies all we really need to know is whether the forests are green or brown in the winter." Clearly, instantaneous measurements of current conditions were the priority.

Independently, scientists at both sites discussed the perceived funding priorities at NSF and concluded that a focus on human impacts would score poorly with reviewers; a consensus emerged that people would not sell as an ecological focus at NSF. One poignant moment crystallized this interpretation at Luquillo as the scientists were working feverishly on their proposal in a

PHOTO BY DAVID R. FOSTER

Stonewalls running through the forests of New England provide a distinctive reminder of the earlier colonial history of forest clearance, agriculture, widespread farm abandonment, and natural forest regeneration. The mixture of natural process and human elements form a unique cultural landscape that can only be deciphered through careful reading of its history.

marathon writing session. The entire group was assembled around tables and computers in an open-air restaurant located in lush tropical vegetation at the lower edge of the LEF. With the mountain forest preserve at their backs and the panorama of hilly grazing lands and houses stretching off towards the glistening metropolis of San Juan on the Caribbean Sea in the far distance, the intense concentration of the group was broken late one afternoon by a sharp exclamation as one scientist sprang to his feet and pointed towards the deforested land and the city that was glimmering in the heat: "What the hell are we doing—focusing on a pristine reserve and natural processes when the real action and future of the tropics is out there?" A long and breathless pause, in which the truth in his statement collided with concern for our approaching deadline, was followed by a rejoinder: "You're right, Charlie! But, it will never get funded" With that and a sigh of relief the renewed tapping of computer keys filled the air as all of the ecologists went back single-mindedly to their plan to study natural processes. At the Harvard Forest a less memorable discussion yielded a similar conclusion. The upshot—both sides proposed to study modern nature while largely ignoring people and history—and both were funded.

In twelve years much has changed in these two research programs. In the most recent proposals both groups expressly embrace historical studies as well as research on the ecological legacies of past land-use. Both programs have also extended the geographical and thematic scope of their studies to include very humanized landscapes outside of their own property boundaries and to embrace people as a fundamental force in nature. These changes are the outgrowth of at least three factors: results from retrospective studies largely bootlegged from non-LTER sources, conclusions arrived at by skeptical colleagues, and fundamental shifts in the thinking and funding priorities at NSF and throughout much of the ecological world.

In the Puerto Rico LTER program at least three critical developments occurred. First, a series of historical studies confirmed a much greater impact of past land-use activity across the LEF than had been anticipated by most scientists.[10] In fact, it was revealed that in the 19th Century up to 90% of the Tabunoco zone, the low elevation, moist forest that is the focus of LTER studies, was either deforested or in secondary vegetation.[11] Secondly, it was shown that the modern forest composition varies with this history and that the distribution of "natural" disturbance processes (e.g., windthrows and landslides) is controlled in part by past and current human activity. Finally, and quite inadvertently, scientists studying forest regrowth after Hurricane Hugo discovered that these recovering stands continue to differ according to their prior land use. The legacies of history strongly persisted in the face of catastrophic natural disturbance. With extensive and enduring impacts so clear, human history was difficult to ignore.

At the Harvard Forest and across the New England landscape the legacies of history are even more profound: 19th Century land-use activity has a clear and defining role in shaping the modern composition, structure, function and response of all forests. Knowing history therefore emerged as a critical factor for LTER scientists as they sought to interpret and project the behavior of many ecological processes that have regional to global importance. In the mid 19th Century only 25–50% of New England was forested; most of the land was in various agricultural uses.

PHOTO BY DAVID R. FOSTER

Despite its natural appearance the moist tropical forest of the Luquillo Experimental Forest in Puerto Rico is strongly controlled in composition, structure and ecosystem process by its lengthy history of agriculture, logging, and charcoaling.

Today 65–95% is forested and, consequently each forest has a legacy of former use as either woodlot, pasture or plowed field. These contrasting histories exert a strong influence on modern forest composition. Likewise, even 100–150 years after formerly

plowed sites have naturally reforested and resemble natural forests, the soil retains a distinctive signature of the past in its structure, appearance and chemical composition.

The legacies of past land-use also influence regional and even global ecology. In particular, New England is dominated by a vast acreage of young and vigorous forests growing on sites that were repeatedly cut, or used intensively for agriculture. Due to the relatively young age of the forest, the depletion of soil organic matter by intense past land use, and relatively low logging intensity today, these forests are accumulating carbon at a surprisingly rapid rate and are projected to continue doing so for many decades. Indeed, mid-latitude temperate forests across New England and much of the eastern U.S. represent a globally important carbon sink.

PHOTO BY DAVID R. FOSTER

Despite 80 years of forest growth the sharpness of the plow horizon formed by 19th century agriculture indicates that past land-use activity generates important legacies in forest ecosystems.

A second broad-scale implication of these forests' history is the way in which they respond to novel environmental stresses that modern society imposes on them. One emerging environmental threat to ecosystems across the eastern U.S., and a major focus at the HF LTER program since its onset, is the fertilizing impact of the vast quantities of nitrogen that enter the atmosphere due to fossil fuel combustion.[12] The initial HF LTER experiment studying forest response to nitrogen deposition contrasted hardwood versus conifer sites without regard to history. However, this study yielded surprising results. The persistent effects of land use (e.g., whether 150 years ago the site was intensively grazed, burned, or cut and consequently depleted of nitrogen, or conversely was plowed and fertilized and thereby enriched with nitrogen) actually have a stronger impact on forest response to nitrogen deposition than does forest composition. As a consequence of these unexpected findings land-use history has become a critical variable in ongoing attempts to assess and predict forest productivity across the entire northeastern U.S. At the Harvard Forest, Luquillo Experimental Forest, and elsewhere in the LTER network, history and human impacts have become mainstream ecological currency.

Likewise, a wide range of reconstructive approaches are now well-integrated into other research and management programs. National conservation organizations and public agencies like The Nature Conservancy, Wilderness Society, National Park Service, U. S. Forest Service, and many state natural heritage, wildlife and forestry programs routinely support and apply such integrated research to provide background in their efforts to understand and manage landscapes, habitats, and species. Arguably such research has been instrumental in defining objectives such as the use of prescribed fire, identifying restoration goals for forest structure and composition, modifying landscape-level cutting patterns,

HARVARD FOREST ARCHIVES

PHOTO BY JOHN OKEEFE

*Although New England's extensive forest appears natural, much of it is relatively recent and is controlled in structure and composition by its history of past land use. Photographs of the same site in Petersham Massachusetts from the late 1880s (**top**) and 1980s (**above**) indicate that former pastures in the foreground are currently filled with white pine forest and former woodlots on the horizon remain composed of hardwoods.*

and establishing stand-level management prescriptions for coarse woody debris, snags, etc. In New England, historical studies, based on dendrochronological, archival, photographic, and paleoecological approaches have played a key role in lake restoration, identification and protection of old-growth forest areas, formulation of regional strategies and partnerships for land conservation, and the restoration of forest, heathland and grassland landscapes.[13] Historical perspectives are increasingly integrated into conservation assessment and strategy.

CHALLENGES EMERGING FROM HISTORICAL STUDIES FOR CONSERVATION PLANNING

Despite the embrace of historical studies in ecology and their emerging role in land planning this new perspective doesn't come without cost—the insights emerging from retrospective research create new challenges for policy makers and land managers. In fact, these studies oftentimes yield complex results that challenge traditional and rigid approaches to ecological thinking and conservation planning. The consequences of these results have not yet been fully acknowledged or addressed by the conservation community, let alone clearly articulated in a vision for action. Below, a number of such results are reviewed and ways are suggested in which a historical assessment of a landscape like that of New England can yield an integrated approach combining multiple strategies for conservation.

1. The story is complex, thwarting simple remedies. Regardless of the geographical setting, historical studies almost invariably yield a pattern of long-term, ongoing dynamics in which multiple factors drive population, ecosystem, and landscape changes in complex ways. These factors are often interrelated or confounded in space or time making it difficult to separate them. Historical results also require us to acknowledge the absence of established baseline conditions (e.g., unchanging "primeval" or "natural" conditions) and the involvement of many human and natural factors in environmental change.

An example from the Massachusetts landscape captures these issues well. Routinely, when ecologists are interested in understanding the impact of European settlement on the "original" vegetation they obtain survey data (e.g., township property surveys akin to the better-known General Land Office surveys) from the time of settlement, compare these to modern data, and interpret the difference as a consequence of the 300+ years of European land-use. When we place such results from New England in the 1000-year framework yielded by paleoecology we discover major complications to this simple story. Well before European arrival, our forests were changing in composition: two major species began declining about 500 years ago—hemlock and beech. These same species continued to decline after settlement. We now attribute the early change to the Little Ice Age, a relatively cold period extending from approximately 1450 to 1850 A.D. that was marked by highly variable weather and growing-season length. Based on these data and perspectives, the post-settlement changes were clearly a consequence of multiple factors: ongoing climate change, the loss of Native Americans who had undoubtedly altered landscape patterns, and new European activity. The larger message is that there was no fixed "original" landscape and that some portion of the post-settlement vegetation change was probably driven by natural factors. Throughout time disturbance, Native American and European cultures, and the environment have changed continuously though at varying rates. For restorationists and conservationists this means that there are many alternative models to use, a strong need to expect future change, and no true ability to re-create or preserve the past.[14]

The larger message is that there was no fixed "original" landscape

2. We live in and need to learn to manage cultural landscapes. Much to the consternation of many Americans who place high value on wilderness and naturalness, retrospective studies increasingly show that few landscapes lack human legacies. Oftentimes, these legacies continue to control modern conditions. Many of our most cherished landscapes, from the Brazilian Amazon, to many National Parks and Wilderness Areas, to apparent natural and old-growth forests, depend to varying degrees on human activity for their current structure and composition. Recognition that familiar and valued landscapes may have strong cultural roots confronts us with the philosophical and management dilemma that certain cherished species, plant and animal assemblages, or landscape patterns actually require ongoing human activity for their persistence.[15]

In New England, where the duration and intensity of European activity are among the greatest in the U.S., this dilemma is confronted regularly. For example, when we study most of our best examples of mature forests, comprised of 150 to 200-year

PHOTO BY JIM GIPE

Although very natural in appearance, with snags, coarse woody debris, and large late-successional species, most old hemlock forests like this one had a colonial history of intensive cutting that greatly altered their original composition. Initially dominated by beech, white pine and hemlock, this forest area developed into a sprout chestnut forest following early logging and then into hemlock as chestnut died and logging ceased.

old hemlocks that early ecologists like Stephen Spurr and Hugh Raup interpreted as good examples of climax or natural vegetation, we receive a surprise. If examined carefully, these sites generally show striking evidence of intensive cutting in the 18th or early 19th Century that transformed their composition. The modern stands display no overt evidence of human activity, and the massive size of trees, the deep shade, and the abundance of dead and downed trees resemble old-growth conditions. However, these forests are unlike any that ever existed on the site and have a distinctive though nearly invisible cultural history.[16]

At the other extreme are many coastal areas like outer Cape Cod, Nantucket, Martha's Vineyard, and Long Island which support sandplain vegetation of pitch pine and oak forests, heathlands, shrublands and grasslands that harbor some of our most diverse and unusual collections of plants and animals. Regionally it is species of these habitats, and the old agricultural lands, rather than those of mature-forests (e.g., neotropical migrant birds) that are declining most rapidly and are most highly threatened with extirpation. A historical inquiry into the coastal landscapes shows that they were largely forested when Europeans arrived; therefore the current landscape is the product of intense and lengthy human activity, notably logging, sheep and cow grazing, plowing, mowing and burning. Variation in the type, intensity and duration of these activities gives rise to much of the striking and varied patterns that we see today. However, as agriculture and human subsistence from the land have waned, the open lands and their rich flora and fauna are being overgrown by less diverse woody vegetation.

There are at least three major conservation voices that are easily heard in New England today: wildland preservation, cultural restoration, and intensive natural resource use.

This conclusion raises many difficult questions: Should we attempt to maintain these culturally-dependent landscapes and their species? If so, how? Can conservation organizations undertake, and will the public support and tolerate, the required activity? The intensity of human effort that generated these landscapes was immense and is difficult or costly to replicate today. Many specific practices like overgrazing, clearcutting, plowing, and wetland drainage that initiated the current landscape patterns would be deemed environmentally destructive by modern society. Although the inclination of many conservation organizations is to attempt to maintain or restore these habitats, a failure to recognize their true cultural origins, or distaste for attempting to replicate former practices, may lead to historically inaccurate or ineffective management prescriptions. One example is the use of fire to maintain these old deforested, agricultural lands. Although fire was a common element in dry and sandy coastal landscapes, in general the direct impacts by humans and their grazing animals were much more important in shaping the historic lands and modern communities.[17] Thus, to retain these clear elements of the cultural landscape we may need to replicate the effect, if not the actual details, of the practices that generated them.

3. Change is rapid and ongoing. Most landscapes are changing rapidly as a consequence of past human activity, natural disturbance, and environmental change. In New England, even if we could eliminate future climate change or land-use, the landscape would continue to change at a remarkable rate. Remaining fields would fill with growing trees, forests would mature over decades to centuries and would store vast quantities of carbon, and forest composition and wildlife would change progressively for generations. In fact, past and projected changes due to New England's history of land-use greatly exceed the changes expected in the next century from even the most extreme projections of climate change. Indeed, over the past century and a half, the landscape has gone from agrarian to forested and from a condition in which Henry Thoreau could state that "the muskrat is the largest wild animal in town" to the current situation where the region is experiencing an invasion of moose, bear, coyote, beaver and other animals. Managing this extent of change, and recognizing that many of our landscapes, assemblages and growth forms are transient and ephemeral, are difficult challenges indeed.

USING HISTORY TO IDENTIFY OPPORTUNITIES FOR CONSERVATION—A NEW ENGLAND EXAMPLE

So, how can we use an historical perspective to understand the context and directions for conservation and to devise a regional plan that fits this landscape history? New England affords an example of a landscape with multiple histories and current directions. In large part as an outgrowth of its dynamic but geographically varied cultural history, there are at least three major conservation voices that are easily heard in New England today: wildland preservation, cultural restoration, and intensive natural resource use. Although these different voices and the directions that they lead may seem incompatible they are easily understood within the historical context of the land. In fact, using an understanding of landscape history and its geographical variation it should be possible and advantageous to accommodate all three directions for conservation and forge a broad vision and coordinated strategy for New England's future.

The wildland orientation arises from long-held American appreciation for wilderness and a simple historical fact: despite a lengthy history of intense human activity, immense tracts of northern Maine and the mountains of Vermont and New Hampshire have remained uninhabited, and even larger areas of these states and southern New England are forested and becoming wilder with time.[18] As forest areas in southern New England have coalesced and begun to mature and as the human population has concentrated in suburban areas, vast semi-natural forests have emerged that offer an unprecedented opportunity for preservation and the enhancement of natural characteristics.

Many of these areas are rather unexciting from the perspective of biodiversity: they tend to harbor few species and even fewer rare or threatened species. However, as native wildlife have

reappeared as the land recovered from 300 years of persecution and deforestation, the value of these extensive forestlands has become clear. These areas offer the potential to support natural ecosystem processes and wide-ranging mammals, large birds, and anadromous fish that require wide expanses, clear water, and minimal fragmentation by human land use. Our historical studies admonish us not to conceive of these landscapes as reverting to primeval conditions or representing true wilderness. Nonetheless, these lands, ecosystems, plants, and wildlife are assuming an increasingly natural appearance and function through time. Consequently, they have the potential to support most of the major deep woods species and processes that New England has experienced in the past. It is this potential that drives such movements as the effort to establish a 4 million-acre National Park in Maine.

The historical resurgence of forest also yields another opportunity, one that some would call a moral imperative, to derive more natural resources from the New England landscape.[19] The argument for conservation (and active use) of wood resources from the northeastern U.S. has found recent environmental support in the global analysis of natural resource utilization. History confirms that New England forests recover rapidly from intense human impact. Currently this region supports immense tracts of maturing forest lands precisely because most of its resources come from other parts of the earth. In general the livelihood of most New Englanders is completely separated from the land. Consequently, the large and prosperous population of this region, and indeed the Eastern U.S., is heavily subsidized by global resources. With regards to wood products, the result is that a variety of external sources—southeastern U.S., the Pacific Northwest, Canada, Malaysia, Brazil and other tropical sources—are supplying materials to New England, where the forests continue to mature. The environmental argument posits that second-growth forests of the Northeast are a resilient source of wood, that increasing local supply might relieve some pressure on more sensitive, oftentimes old-growth sources, and that this would place the responsibility for natural resource extraction under the local eye of an environmentally conscious public.

Although much of the attention on wood production in New England is focussed on the large industrial forest lands of Maine, the opportunities for sustainable forestry extend across the entire

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*The diversity of the landscape patterns and history provide at least three directions for conservation in New England. Extensive intact forests such as seen south of Moosehead Lake in Maine (**top**) provide the opportunity for preserving natural landscape processes and wide-ranging wildlife species. Open cultural landscapes (**above**) harbor grassland, shrubland, and early successional plants and animals but require continuation or restoration of the agricultural practices that generated them. The abundance of rapidly growing forest (**left**) provides the opportunity for local production of a substantial portion of the vast quantity of wood resources that this affluent region consumes.*

region to include a diverse range of products and forest types.[20] Not only do extensive woodlands cover the rural areas of central and southern New England but the suburbs are heavily forested as well. In these populated areas, the logistics of coordinating many private landowners, agencies, and municipalities are immense, however they also present interesting opportunities to use approaches like community-based forestry to manage woodlands and to reconnect a large suburban population with the land and the responsibilities of resource utilization. Concentrating logging on the more fragmented areas also enables retention of contiguous blocks of unmanaged wildlands.

A final direction in conservation that emerges from New England's history is the effort to conserve the species and to maintain biological and aesthetic elements of the region's cultural history. Much of this activity focuses on grasslands, shrublands, scrublands, and early successional forests—habitats that are disappearing rapidly, that oftentimes form a fine-grained landscape mosaic, and that support a high diversity of organisms and many unusual and highly valued species. Although many of these species are probably native to the eastern U.S., they maintained low populations in the landscape of the Woodland Indians as their habitats—grassy freshwater meadows, coastal scrub, abandoned Indian fields and burnings—were uncommon.[21] All of this changed with European arrival and disturbance by fire, cutting, and grazing animals. The proliferation of lowland and upland pastures, hayfields, meadows, and scrublands supported a major increase in the plants and animals of open and successional landscapes. Today, many open-land species are in jeopardy due to the predominance of the even-aged maturing forest, the conversion of sandplains, wetlands and coastal areas to industrial and residential uses, and the loss of native habitat such as prairies elsewhere in North America. These include important though under-appreciated insects including many butterflies, moths and dragonflies, birds such as bobolinks, meadowlarks, upland sandpipers and grasshopper sparrows, and some better known animals such as bog turtles, New England cottontails, and woodcock.

Efforts to protect and restore populations of these species have been diverse although they oftentimes emphasize "natural" processes like fire under the guise of restoring "native" habitat. Recognition of the cultural origins of these habitats based on sound historical studies may encourage the use of other approaches including some traditional land management activities, such as grazing, intense timber cutting, and mowing.

Given the size and diversity of the New England landscape it should be possible, and perhaps desirable, to attempt to accommodate all three directions for conservation. Success in achieving this will obviously require a regional vision and planning, for example with large wildlands surrounded by extensive managed forests and separated from the open, cultural landscapes and areas of intensive human activity. But, it will also require recognizing that the history of the land enables such diverse approaches to be accommodated. That New England retains upland sandpipers and bobolinks while the populations of moose and bear are increasing is a consequence of history. If it is to continue to support all groups, lessons from ecological history will need to be applied.

APPLICATION OF ECOLOGICAL HISTORY

There can emerge from a simple consideration of landscape history a range of insights as well as challenges for ecologists and conservationists. At the most fundamental level, retrospective studies enable us to study ecological processes that are missed or under-appreciated by standard field and experimental approaches. These insights also provide information of direct and practical benefit as they enhance our ability to understand the many factors that have shaped and continue to condition ecosystem structure, function and composition. As appreciation of the utility and breadth of these insights has grown, a range of historical techniques and disciplines have been embraced by ecologists, land managers and conservationists and supported by funding agencies.

This integration of history and modern ecology is not without its challenges. The dynamic and complex pattern of change in landscapes and populations make management decisions difficult and sometimes arbitrary. Among the most difficult challenges is to recognize and accept the role of people in natural systems and within the context of a conservation system that values wilderness and naturalness. By expanding our timeframe of research and planning, however, we can develop a deeper appreciation for the importance of cultural and natural history in our current and future landscapes. □

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NOTES

1. See for example David Foster and Glenn Motzkin, "Historical influences on the landscape of Martha's Vineyard. Perspectives on the management of the Manuel F. Correllus State Forest." *Harvard Forest Paper* 23 (1999); Foster, "Disturbance history, community organization and vegetation dynamics of the old-growth Pisgah forest, south-western New Hampshire, U.S.A." *Journal of Ecology* 76 (1988) 105–134; Foster and George King, "Vegetation pattern and diversity in S.E. Labrador, Canada: Betula papyrifera (birch) forest development in relation to fire history and physiography." *Journal of Ecology* 74 (1986) 465–483; and Foster, *Thoreau's Country: Journey Through a Transformed Landscape*. Harvard University Press, Cambridge (1999).
2. Much of the range of retrospective approaches and their application to diverse ecological and conservation issues are outlined in David Foster, David Orwig and Jason McLachlan, "Ecological and conservation insights from retrospective studies of old-growth forests." *Trends in Ecology and Evolution* 11 (1996) 419–424; David Foster, Peter Schoonmaker and Steward Pickett, "Insights from paleoecology to community ecology." *Trends in Ecology and Evolution* 5 (1990) 119–122; and Schoonmaker and Foster, "Some implications of paleoecology for contemporary ecology." *Botanical Review* 57 (1991) 204–245.
3. One method that has been recently applied to the study of disturbance

and succession involves combining reconstructive approaches such as dendrochronology and paleoecology with historical data to interpret the long-term history of a forest. In particular this approach has provided new insights into the surprising history of mature hemlock forests; see McLachlan, Foster, and Fabian Menalled, "Anthropogenic origins of late-successional structure and composition in four New England hemlock stands." *Ecology* 81 (2000) 717–733.

4. A prime use of long historical sequences is in the reconstruction of natural disturbance regimes a technique that was fully developed by Miron Heinselman in his classic study of fire in northern Minnesota, "Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota" *Quaternary Research* 3 (1973) 329–382. In New England, where infrequent hurricanes are one of the major natural disturbances, a combination of historical studies and meteorological modeling have allowed the long-term disturbance regime to be reconstructed as seen in Emery Boose, Kris Chamberlain, and David Foster, "Landscape and regional impacts of hurricanes in New England." *Ecology* 81 (2000). In press.
5. See Foster, G. Motzkin and B. Slater, "Land-use history as long-term broad-scale disturbance: regional forest dynamics in central New England." *Ecosystems* 1 (1998) 96–119 and Janice Fuller, David Foster, Jason McLachlan and Natalie Drake, "Impact of human activity on regional forest composition and dynamics in central New England." *Ecosystems* 1 (1998) 76–95.
6. See Glenn Motzkin, William Patterson, and David Foster, "A regional-historical perspective on uncommon plant communities: pitch pine-scrub oak in the Connecticut Valley of Massachusetts." *Ecosystems* 2 (1999) 255–273; and Glenn Motzkin, Paul Wilson, David Foster and Art Allen, "Vegetation patterns in heterogeneous landscapes: the importance of history and environment." *Journal of Vegetation Science* 10 (1999) 903–920.
7. Information regarding the Long Term Ecological Research network of sites is available at: http://lternet.edu/. Evaluation of the evolution of LTER and NSF thinking concerning ecological history as well as details on the science at the Luquillo and Harvard Forest LTER sites comes from the author's experience as a Principal Investigator at both sites and his role as a member of the LTER Coordinating and Executive Committees.
8. See David Clark, "Abolishing virginity." *Journal of Tropical Ecology* 12 (1996) 735–739 and David Foster, Marche Fluet and Emery Boose, "Landscape vegetation dynamics in response to land-use history in eastern Puerto Rico." *Ecological Applications* 9 (1999) 555–572.
9. The broad details of the land-use history of New England and some of their ecological impacts are related in Hugh Raup, "The view from John Sanderson's farm." *Forest History* 10 (1966) 2–11; David Foster, *Thoreau's Country. Journey Through a Transformed Landscape*. Harvard University Press, Cambridge (1999); and David Foster and John O'Keefe, *New England Forests Though Time: Insights from the Harvard Forest Dioramas*. Harvard Forest and Harvard University Press (2000).
10. Studies connecting the land-use history and current ecology of the Luquilllo forest, which influenced the historical thinking in the LTER program, include Diana Garcia-Montiel and Fred Scatena, "The effect of human activity on the structure and composition of a tropical forest in Puerto Rico." *Forest Ecology and Management* 63 (1996) 57–78 and J. Zimmerman, T. Aide, M. Rosario, M. Serrano, and L. Herrera, "Effects of land management and a recent hurricane on forest structure and composition in the Luquillo Experimental Forest, Puerto Rico." *Forest Ecology and Management* 77 (1995) 65–76.
11. David Foster, Marche Fluet and Emery Boose "Landscape vegetation dynamics in response to land-use history in eastern Puerto Rico." *Ecological Applications* 9 (1999) 555–572.
12. Background on nitrogen deposition and the results emerging from the Harvard Forest LTER program are well covered in John Aber, "Nitrogen cycling and nitrogen saturation in temperate forest ecosystems." *Trends in Ecology and Evolution* 7 (1992) 220–223; John Aber and Charlie Driscoll, "Effects of land use, climate variation and N deposition on N cycling and C storage in northern hardwood forests." *Global Biogeochemical Cycles* 11 (1997) 639–648; John Aber, Scott Ollinger, C. Federer and Driscoll, "Modeling nitrogen saturation in forest ecosystems in response to land use and atmospheric deposition. *Ecological Modelling* 101 (1997) 61–78.
13. See for example Foster and Motzkin, "Historical influences on the Landscape of Martha's Vineyard. Perspectives on the management of the Manuel F. Correllus State Forest." *Harvard Forest Paper* 23 (1997). Foster and Motzkin, "Ecology and conservation in the cultural landscape of New England: lessons from nature's history." *Northeastern Naturalist* 5 (1998) 111–126. Alisa Golodetz and David Foster, "Land protection in central New England: historical development and ecological consequences." *Conservation Biology* 11 (1996) 227–235. Foster, David Orwig and Jason McLachlan, "Ecological and conservation insights from retrospective studies of old-growth forests." *Trends in Ecology and Evolution* 11 (1996) 419–424.
14. The interaction between long-term climate change and land-use history in driving modern forest patterns in New England has become a major focus of the Harvard Forest LTER program, e.g., Foster, Motzkin and Benjamin Slater, "Land-use history as long-term broad-scale disturbance: regional forest dynamics in central New England." *Ecosystems* 1 (1998) 96–119 and Janice Fuller, David Foster, Jason McLachlan and Natalie Drake, "Impact of human activity on regional forest composition and dynamics in central New England." *Ecosystems* 1 (1998) 76–95.
15. Foster, *Thoreau's Country. Journey Through a Transformed Landscape*. Harvard University Press, Cambridge (1999).
16. See Jason McLachlan, David Foster, and Fabian Menalled, "Anthropogenic origins of late-successional structure and composition in four New England hemlock stands." *Ecology* 81 (2000) 717–733.
17. Peter Dunwiddie, *Changing Landscapes: A Pictorial Field Guide to a Century of Change on Nantucket*. Nantucket Conservation Foundation, New Bedford, Mass (1992).
18. Any issue of the *Northern Forest Forum* will provide numerous articles regarding the potential for preservation of wildlands and reintroduction of large mammals such as cougar and wolf into New England.
19. See, for example M. Berlik, *The illusion of conservation: an environmental argument for forest cutting in Massachusetts*. Harvard College Honors Thesis (1999).
20. Brian Donahue, *Reclaiming the Commons : Community Farms and Forests in a New England Town*. Yale University Press, New Haven (2000).
21. Robert Askins *Restoring North America's Birds : Lessons from Landscape Ecology*. Yale University Press (2000). P. Vickery and P. Dunwiddie (Eds.), *Grasslands of Northeastern North America : Ecology and Conservation of Native and Agricultural Landscapes*. Massachusetts Audubon Society, Lincoln, Mass (1997). Foster and Motzkin, Ecology and conservation in the cultural landscape of New England: lessons from nature's history. *Northeastern Naturalist*. 5 (1998) 111–126.