



Insights from historical geography to ecology and conservation: lessons from the New England landscape

Keywords

New England, conservation, environmental history, land management, land planning, natural disturbance, cultural landscape, land-use history, geography, biodiversity.

In these days of supercomputer-based global climate models, large ecosystem experiments including Biosphere II, and aircraft-borne sensors of ozone holes, it is often overlooked that many fundamental insights into ecological processes and major environmental issues come not through reductionist or high tech studies of modern conditions but from thoughtful consideration of nature's history (Foster, 2000).

When I wrote those words for the millennium essay issue of this journal, I did not foresee the near-term opportunity to place these thoughts into action. However, in this issue we present a series of inter-related studies that employ varied historical and geographical approaches to address major ecological questions and conservation issues, with a focus on the New England landscape. Although the research addresses a region with its own unique attributes and history, the approaches, results and implications from these studies should resonate strongly with anyone faced with interpreting and conserving dynamic landscapes that are shaped by the interaction of environmental change, human activity and natural disturbance.

THE RATIONALE FOR GEOGRAPHICAL AND HISTORICAL STUDIES

The motivation for drawing on diverse scientific and historical disciplines to address ecological questions and to frame conservation management is quite simple: by broadening the temporal scope of studies to consider antecedent events and by conducting research on many ecological scales, new insights are provided into current and future patterns and processes. In particular, reconstructions of the past may: (1) reveal key (and even previously unrecognized) natural and human forces that have shaped modern environments and ecological patterns; (2) afford insights into ecological processes that unfold over lengthy periods of time; and (3) greatly expand the sample of community dynamics and assemblages beyond those recognized in the modern landscape. Geographical studies crossing a range of spatial scales enable: (1) the evaluation of broad-scale natural and cultural processes; (2) the opportunity to contrast results from different ecosystems and along environmental and compositional gradients; and (3) the assessment of system responses to the same factor across varying scales of biological organization (e.g. population, community, landscape, region). The result is not only a greater ability to interpret the current range of conditions and to anticipate their future trajectories but also the potential to use this information to manage landscapes more effectively for specific objectives.

THE RATIONALE FOR STUDIES IN NEW ENGLAND

As a result of its lengthy history of human settlement, broad-scale transformations and intensive research, the New England landscape provides an ideal laboratory for historical–geographical studies. Indeed, the region has provided many important case studies in this field (e.g. Dwight, 1822; Thoreau, 1842; Marsh, 1864; Bromley, 1935; Raup & Carlson, 1941; Day, 1953; Siccama, 1971; Henry & Swan, 1974; Lorimer, 1977; Oliver & Stephens, 1977; Cronon, 1983; Dunwiddie, 1989; Whitney, 1994; Motzkin *et al.*, 1996; Boose *et al.*, 2001; Goodale & Aber, 2001). As a result of its history of fire, pathogens, wind events and other meteorological disturbances and its remarkable cultural legacy of land cover transformations, the entire New England region is strongly shaped by historical processes. Although this history has its unique elements, many general patterns as well as specific ecological processes and dynamics are paralleled across the Eastern US and indeed have relevance for broad regions world-wide. The lengthy duration of human occupation and intensive

inquiry also means that the region's archives and data bases afford some of the longest and most detailed historical information available in the US.

From a very practical standpoint, pressing environmental and land management issues across the region make sound ecological information and conservation thinking a major imperative. Although remarkable in its extent of forest cover, New England supports a large and affluent population and is faced with potential widespread development and environmental degradation. As a result of its history and economic growth, the region also faces many conflicting proposals for conservation and stewardship. Thus, there is a great need for the type of broad ecological insights afforded by historical-geographical research and a crucial opportunity to apply this information across a large land area for which there is little regional thinking or planning.

STRUCTURE AND ORGANIZATION OF THE SPECIAL ISSUE

The issue is organized thematically into three sections: a series of case studies that apply historical-geographical approaches to a range of ecological questions and scales; a focused examination of the consequences of one historically important and unfortunately pressing ecological issue – the introduction of exotic pests and pathogens; and the application of historical-geographical insights to major issues in conservation and land management.

The first section commences with two papers covering the entire New England region. A study by Cogbill *et al.* (2002) utilizes, for the first time, witness tree data from towns across the region to generate the first reconstruction of vegetation at the time of European settlement. Based on this new data base, the study analyses the patterns of species and forest-type distributions and their relationships to underlying environmental gradients. The following paper by Parshall & Foster (2002) provides a complementary perspective by using palaeoecological studies of lake sediments across the region to define the regional variation in fire history over the past 2000 years. In particular, this study analyses variation in fire history across the major cultural horizon (i.e. Native American to European transition) and discusses the relative importance of human, biotic and environmental factors in controlling geographical and temporal patterns in this important disturbance process.

The next two papers focus on the state of Massachusetts and address long-term ecological dynamics that are of great relevance to modern research and conservation planning. The first is a broad-scale assessment of 400 years of land-use and land-cover change since European arrival, with a specific focus on changes in forest structure and composition (Hall *et al.*, 2002). The subsequent paper takes off from this theme and assesses the way in which wildlife populations have responded to this dynamic history of habitat and cultural change (Foster *et al.*, 2002a). Both studies underscore the remarkable changes that have occurred in the relatively brief period since European settlement and the recent recovery of many natural attributes of the New England landscape.

Following is a series of six papers that focus on different landscapes across the state and provide complementary views on New England history and ecology. Two papers examine the changing importance of Native Americans, fire, climate and European land use in shaping contrasting landscapes: low diversity upland forests of oak and chestnut (Foster *et al.*, 2002b) and the unique coastal vegetation of forest, scrubland and grassland on the island of Martha's Vineyard (Foster *et al.*, 2002c). Three papers assess the relative importance of land-use history vs. edaphic factors in controlling the composition of vegetation in very different environmental settings: high diversity mesic hardwood forests (Bellemare *et al.*, 2002), low diversity mixed forests (Gerhardt & Foster, 2002), and pine and hardwood forests, heathlands and shrublands in the droughty coastal landscape of Cape Cod (Motzkin *et al.*, 2002a). A final paper investigates a rare dwarf pitch pine community on a mountain summit in western Massachusetts and contrasts the unusual dynamics of this community to the more common sand-plain communities of pitch pine and to other notable montane sites (Motzkin *et al.*, 2002b).

The second section begins with an introduction by Orwig (2002) and explores an unfortunately all too important process in the New England landscape: the decline in dominant tree species as a consequence of introduced pests and pathogens. The studies seek to explore the direct and indirect ecological effects of such introductions using current and historical examples and they describe general findings with relevance to related incidents elsewhere. A set of three papers focus on the hemlock woolly adelgid (*Adelges tsugae*), an introduced, aphid-like insect that is spreading relentlessly across the range of eastern hemlock (*Tsuga canadensis*) and causing widespread decline and mortality in this long-lived and shade tolerant species. The regional and landscape patterns of decline in hemlock are

examined by Orwig *et al.* (2002), whereas Kizlinski *et al.* (2002) contrast the ecosystem consequences of this decline to the impacts generated by pre-emptive or salvage harvesting of hemlock, which is an increasingly common response by forest landowners. Tingley *et al.* (2002) assess the changes in avian assemblages resulting from the dramatic habitat alterations that occur as the dominant conifer is replaced by an assortment of native broad-leaved hardwood species. In the final paper in this section, Paillet (2002) places current concerns over introduced organisms into a historical perspective by examining the long-term history of chestnut in New England. In this treatment he evaluates chestnut's regional dynamics and assesses the various roles that the species has played through time, most notably its transformation to an understory tree over the past eight decades with the arrival of the introduced chestnut blight.

The final section in the issue is introduced by Foster (2002a) and seeks to use the information and perspectives developed in the previous papers to address conservation issues of regional and broader significance. Berlik *et al.* (2002) examine some of the global consequences of local conservation efforts and management decisions in areas like New England and use the example of wood products to make a global environmental argument for regional planning for forest protection, intensive logging and the establishment of large nature reserves. Motzkin & Foster (2002) focus on an important conservation priority – openland vegetation of grasslands, heathlands and shrublands – and argue that a long-term perspective is essential in evaluating the dynamics of these areas and for developing effective management guidelines. Not surprisingly, they identify historical human activity as a critical driver of current conditions in coastal openlands and consequently suggest that cultural practices such as grazing and mowing may be effective management treatments. In the final paper Foster (2002b) identifies three major directions of conservation in the dynamic landscape of New England – maintenance of cultural landscapes like the coastal communities, intensive management of natural resources, and establishment of wildland reserves – and illustrates how each of these are derived from the history of the land and people. By proposing broad recommendations for the implementation of these contrasting conservation directions, the paper seeks to integrate historical and geographical insights from ecology into active conservation planning.

INSIGHTS FROM HISTORICAL GEOGRAPHY TO SCIENCE AND MANAGEMENT

Although each of the individual papers in this issue provides specific answers to ecological questions from a broad temporal or spatial perspective, collectively they lead to general conclusions that are likely relevant to many other regions of study. These conclusions have a bearing on ecological themes as well as the way in which historical and geographical studies are undertaken.

1. Historical studies continue to provide new data and perspectives on perennial questions and often lead to re-interpretations of the modern landscape.

Many of the specific questions addressed in this issue have intrigued ecologists and challenged land managers for decades. What was the natural vegetation of the region? How important were Native Americans in controlling vegetation patterns? What is the relative contribution of natural disturbance, human activity and environmental factors in shaping current patterns of vegetation? What management practices are most likely to maintain desired landscape conditions and biotic assemblages?

For some of these questions prior interpretations have not tapped into the range of historical tools and data that are available and consequently new perspectives have emerged in the studies reported here. For example, Cogbill *et al.* (2002) present the first reconstruction of regional forests at the time of European settlement based on town-level data. These data lead them to highlight the heretofore-ignored importance of beech and to conclude that prior assessments of pine, hemlock and chestnut abundance in pre-European forests were exaggerated. They also identify a striking tension zone between central and northern vegetation that has been largely overlooked in the past. Studies that examine the history and role of chestnut in detail (e.g. Foster *et al.*, 2002b; Hall *et al.*, 2002; Paillet, 2002) concur that it was less abundant than suggested by many previous estimates, but add much new information regarding the history and role of this important species. For example, palaeoecological results indicate that the relatively recent regional increase in chestnut was largely a local population response to climate change as opposed to a broad-scale migration event.

More broadly, numerous studies confirm the important role that history has played in determining the current abundance and distribution of species in our landscape, regardless of whether the focus is wildlife (Foster *et al.*, 2002a), uncommon species and vegetation (Bellemare *et al.*, 2002; Motzkin *et al.*, 2002a,b) or common species and forest types (Gerhardt & Foster, 2002). Collectively, the papers confirm that the modern landscape is strongly conditioned by its human past and that this mandates that ecology and conservation need to recognize, understand and embrace cultural processes. The historical controls over modern pattern and process place all landscapes on long-term trajectories in which species are undergoing contrasting dynamics, and lags in species or system responses may lead to surprising changes well into the future.

2. Historical data quality and resolution are surprisingly good, whereas their modern counterparts are frequently disappointing in comparison.

These studies uncovered many new or underutilized sources of information that enabled completely novel perspectives regarding important ecological and conservation questions. Development of new historical resources in a region that has been investigated for centuries is exciting and should encourage future studies in New England and beyond. For example, despite their occasional use in local studies, the witness tree survey data, available largely in the file drawers of individual town halls, has been completely overlooked by investigators interested in describing the regional pre-European forests (but, cf. Whitney, 1994; Siccama, 1971). Although the effort undertaken by Cogbill *et al.* (2002) and Hall *et al.* (2002) to collect these data was lengthy and arduous, it has resulted in an unparalleled view of the region's history. In a similar vein, the compilation of the 1830 town maps for Massachusetts by Hall *et al.* (2002) provides a unique record of land-use impacts that serendipitously depicts the landscape at its height of deforestation. The resulting map is not only useful for addressing focused ecological studies, but also provides key information for conservation planning (BioMap, 2001). Field historical studies also provide new angles on ecological pattern and process. These include such techniques as local-scale palaeoecological studies of small hollows, wetlands or organic soils (Foster *et al.*, 2002b), and the detailed examination of soil profiles for evidence of stand history and land use impacts (Bellemare *et al.*, 2002; Gerhardt & Foster, 2002; Motzkin & Foster, 2002; Motzkin *et al.*, 2002a).

In contrast, all the studies reported here underscore the surprisingly incomplete and low quality of modern environmental and vegetation data. Repeatedly, in undertaking these studies researchers commented that historical maps, census records, surveys and vegetation data were more comprehensive and higher in quality and resolution than their modern counterparts. This is certainly true of modern vegetation data with which it is impossible to forge a truly effective comparison with the witness tree data collected three or four centuries ago (Cogbill *et al.*, 2002; Hall *et al.*, 2002). Although few individuals outside scientific and regulatory circles are aware of the situation, the information base on modern environmental conditions and ecological characteristics is completely inadequate. Whether the concern is wildlife populations, forest land-use activity, or the dynamics of invasive plants and pests, modern science and policy are largely reliant on the whim of individual scientific or agency investigators to collect and provide much of the truly pertinent and useful information on pressing issues (cf. Kizlinski *et al.*, 2002; Orwig *et al.*, 2002).

3. The spatial and temporal variability within individual landscapes and regions is remarkably high.

To most individuals living outside New England, the region is probably casually summarized as wooded suburbia, with variation represented by coastal and upland habitats. However, within the region, and indeed even at a landscape scale, the patterns of variation are extraordinary. Within small coastal islands such as Martha's Vineyard the landscape varies from mesic forests to coastal grasslands to scrub plains, and the fire regimes vary from producing the highest levels of sedimentary charcoal in the north-east to low background levels (Foster *et al.*, 2002a; Motzkin & Foster, 2002; Parshall & Foster, 2002). Likewise, the history of the land across the island ranges from intensive to environmentally abusive to relatively low impact. Similar variation occurs throughout the region leading to the diverse directions for conservation activity, spanning the natural to cultural gradient.

4. Historical-geographical science and its findings are frequently generalizable.

Many US ecologists approach studies of natural landscapes and their processes (e.g. fire regimes in wilderness areas) and research on culturally modified lands and processes (e.g. agricultural land-use) as entirely different subjects requiring completely different expertise. However, these different studies share many common objectives and frequently overlap strongly in disciplinary base, methodology and technique. Effectively, whether the land has been dominated by wilderness processes or intensive agriculture, historical-geographical approaches strive to utilize every bit of field,

archival, remote sensing, or reconstructive data available to describe the processes, environments and biotic patterns that have shaped the land through time. All such studies capitalize on serendipity, by utilizing whatever evidence or data happen to turn up as a consequence of the peculiarities of fossilization, legislative history, photographic forays, or prior scientific whim. Indeed, many of the tools of the trade, as well as the individual investigator's ability to read the land and 'nature's history' are the same, regardless of the specific landscape.

Similarly, although we are geographically and culturally separated and frequently do not draw adequately on each other's literature, scientists in every country can benefit greatly by sharing and learning from each other's studies in historical-geography. In fact, there are remarkable parallels from seemingly different landscapes. For New England, there is much in common with the questions, findings, and concerns from many areas world-wide that have lengthy histories of human activity. Most immediately relevant is the science and thinking in conservation biology emerging from Europe. For example, the approaches and perspectives that George Peterken, Keith Kirby, Martin Hermy and many others take into their field sites in Britain, Belgium and beyond, immediately work for studies in the Vermont hill country or the coastal islands of Massachusetts. Similarly, conservationists across Europe grapple with many of the same issues arising in our landscape – how to value and protect cultural landscapes and their dependent species, how to anticipate the impacts of newly arriving native and exotic species, whether to encourage the development of natural process and wildlands in a humanized world, and how to turn the understanding of landscape history into effective management applications. As we all work to address such issues, there is much to be gained from insights from lands with different histories than our own.

CONCLUDING THOUGHT

Although greatly aided by our New England collaborators, much of the best work represented in these studies was inspired by individuals studying what might seem to be highly contrasting landscapes, for example: the rugged and 'natural' landscapes of the Pacific north-west; the millennially tamed countryside of Britain, Scandinavia, and northern Europe; or tropical forests in Puerto Rico and the Yucatan Peninsula of Mexico. Perhaps this is not surprising because the broad temporal and spatial framework for historical-geographical and conservation studies always benefits from the introduction of new and diverse ideas and tools (cf. Sutherland, 2002).

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REFERENCES

Bellemare, J., Motzkin, G. & Foster, D.R. (2002) Legacies of the agricultural past in the forested present: an assessment of historical land-use effects on rich mesic forests. *Journal of Biogeography*, **29**, 1401–1420.

- Berlik, M.M., Kittredge, D.B. & Foster, D.R. (2002) The illusion of preservation: a global environmental argument for the local production of natural resources. *Journal of Biogeography*, **29**, 1557–1568.
- BioMap (2001) *BioMap. Guiding land conservation for biodiversity in Massachusetts*. Massachusetts Natural Heritage and Endangered Species Program, Boston, MA.
- Boose, E.R., Chamberlain, K.E. & Foster, D.R. (2001) Landscape and regional impacts of hurricanes in New England. *Ecological Monographs*, **71**, 27–48.
- Bromley, S.W. (1935) The original forest types of southern New England. *Ecological Monographs*, **5**, 61–89.
- Cogbill, C., Burk, J. & Motzkin, G. (2002) Pre-settlement vegetation of New England: composition and environmental determinants. *Journal of Biogeography*, **29**, 1279–1304.
- Cronon, W. (1983) *Changes in the land, Indians, colonists and the ecology of New England*. Hill and Wang, New York.
- Day, G.M. (1953) The Indian as an ecological factor in the northeastern forest. *Ecology*, **34**, 329–346.
- Dunwiddie, P.W. (1989) Forest and heath: the shaping of the vegetation on Nantucket Island. *Journal of Forest History*, July, 126–133.
- Dwight, T. (1822) *1969 Travels in New England and New York*, 4 volumes. Harvard University Press, Cambridge.
- Foster, D.R. (2000) From bobolinks to bears: interjecting geographic history into ecological studies, environmental interpretation, and conservation planning. *Journal of Biogeography*, **27**, 27–30.
- Foster, D.R. (2002a) Conservation issues and approaches for dynamic cultural landscapes. *Journal of Biogeography*, **29**, 1533–1535.
- Foster, D.R. (2002b) Thoreau's country: a historical–ecological perspective on conservation in the New England landscape. *Journal of Biogeography*, **29**, 1537–1555.
- Foster, D.R., Motzkin, G., Bernardos, D. & Cardoza, J. (2002a) Wildlife dynamics in the changing New England landscape. *Journal of Biogeography*, **29**, 1337–1357.
- Foster, D.R., Clayden, S., Orwig, D.A., Hall, B. & Barry, S. (2002b) Oak, chestnut and fire: climatic and cultural controls of long-term forest dynamics in New England, USA. *Journal of Biogeography*, **29**, 1359–1379.
- Foster, D.R., Hall, B., Barry, S., Clayden, S. & Parshall, T. (2002c) Cultural, environmental and historical controls of vegetation patterns and the modern conservation setting on the island of Martha's Vineyard, USA. *Journal of Biogeography*, **29**, 1381–1400.
- Gerhardt, F. & Foster, D.R. (2002) Physiographic and historical effects on forest vegetation in central New England, USA. *Journal of Biogeography*, **29**, 1421–1437.
- Goodale, C.L. & Aber, J.D. (2001) The long-term effects of land-use history on nitrogen cycling in northern hardwood forests. *Ecological Applications*, **11**, 253–267.
- Hall, B., Motzkin, G., Foster, D., Syfert, M. & Burk, J. (2002) Three hundred years of forest and land-use change in Massachusetts, USA. *Journal of Biogeography*, **29**, 1319–1335.
- Henry, J.D. & Swan, J.M.A. (1974) Reconstructing forest history from live and dead plant material – an approach to the study of forest succession in southwest New Hampshire. *Ecology*, **55**, 772–783.
- Kizilinski, M., Orwig, D.A., Cobb, R. & Foster, D.R. (2002) Direct and indirect ecosystem consequences of an invasive pest on forests dominated by eastern hemlock. *Journal of Biogeography*, **29**, 1489–1503.
- Lorimer, C.G. (1977) The presettlement forest and natural disturbance cycle of northeastern Maine. *Ecology*, **58**, 139–148.
- Marsh, G.P. (1864) *1965 Man and nature: or physical geography as modified by human action*. Harvard University Press, Cambridge.
- Motzkin, G., Eberhardt, R., Hall, B., Foster, D., Harrod, J. & MacDonald, D. (2002a) Vegetation variation across Cape Cod, Massachusetts: environmental and historical determinants. *Journal of Biogeography*, **29**, 1439–1454.
- Motzkin, G. & Foster, D.R. (2002) Grasslands, heathlands and shrublands in Coastal New England: historical interpretations and approaches to conservation. *Journal of Biogeography*, **29**, 1569–1589.
- Motzkin, G., Foster, D., Allen, A. & Harrod, J. (1996) Controlling site to evaluate history: vegetation patterns of a New England sand plain. *Ecological Monographs*, **66**, 345–365.
- Motzkin, G., Orwig, D.A. & Foster, D.R. (2002b) Vegetation and disturbance history of a rare dwarf pitch pine community in western New England, USA. *Journal of Biogeography*, **29**, 1455–1467.
- Oliver, C.D. & Stephens, E.P. (1977) Reconstruction of a mixed-species forest in central New England. *Ecology*, **58**, 562–572.
- Orwig, D.A. (2002) Ecosystem to regional impacts of introduced pests and pathogens: historical context, questions and issues. *Journal of Biogeography*, **29**, 1471–1474.
- Orwig, D.A., Foster, D.R. & Mausel, D.L. (2002) Landscape patterns of hemlock decline in New England due to the introduced hemlock woolly adelgid. *Journal of Biogeography*, **29**, 1475–1487.

- Paillet, F. (2002) Chestnut: the history and ecology of a transformed species. *Journal of Biogeography*, **29**, 1517–1530.
- Parshall, T. & Foster, D.R. (2002) Fire on the New England landscape: regional and temporal variation, cultural and environmental controls. *Journal of Biogeography*, **29**, 1305–1317.
- Raup, H.M. & Carlson, R.E. (1941) The history of land use in the Harvard Forest. *Harvard Forest Bulletin*, **20**, 1–64.
- Siccama, T.G. (1971) Presettlement and present forest vegetation in northern Vermont with special reference to Chittenden County. *American Midland Naturalist*, **85**, 153–172.
- Sutherland, W.L. (2002) Openness in management. *Science*, **418**, 834–835.
- Thoreau, H.D. (1842) *Journal*, Vol. 2 (ed. R. Sattelmeyer). Princeton University Press, Princeton, NJ.
- Tingley, M., Orwig, D., Field, R. & Motzkin, G. (2002) Avian response to removal of a forest dominant: consequences of hemlock woolly adelgid infestations. *Journal of Biogeography*, **29**, 1505–1516.
- Whitney, G.G. (1994) *From coastal wilderness to fruited plain*. Cambridge University Press, New York.

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