CHAPTER 18

Insights for Ecology and Conservation

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As we have emphasized repeatedly and from different perspectives, the New England landscape and its forests have changed continuously, and oftentimes dramatically, over the past centuries and millennia. Through a variety of reconstructive techniques and perspectives, we have learned much about the behavior of plant and animal species and the assemblages they form and how these vary through time and across the land. Here we review some of the conclusions that emerge from these perspectives and explore the ways in which a dynamic view of forests and landscapes may be incorporated into the conservation and management of a landscape like New England. We begin by reviewing the relevance of our work for interpreting the landscape before and after European settlement and then discuss ways in which such an understanding may help to guide conservation efforts.

The Nature of Species Assemblages

Results from our paleoecological and other reconstructive studies not only provide the context with which to evaluate ecological dynamics and the development of the modern landscape but also have direct bearing on our interpretation of the nature of communities and the organization of species assemblages. Viewed across the past several thousand years, the New England landscape has continuously changed, largely as a result of the responses of many different plant and animal species to climate change, disturbance history, and different biotic factors. Although the composition of trees, shrubs, and herbs in our forests often appears relatively stable and strongly determined by local site conditions, in fact the distribution of each species has changed quite independently as the environment and various natural and human disturbance regimes have shifted over time.

For example, before the introduction of an Asian fungal blight and the widespread decline of chestnut in the early 1900s, this rapidly grow-

ing broad-leafed tree was common throughout much but not all of southern New England. Forests of chestnut and oak, oftentimes mixed with hickories, birches, and other species, were a natural and seemingly stable forest type across the region. Certainly they must have appeared that way to the nineteenth-century villagers in central Massachusetts or their Native American predecessors, both of whom relied heavily on the nuts and wood of these trees. And yet, chestnut did not become abundant in Massachusetts until approximately 1,500 years ago, when a subtle climate change initiated significant shifts in forest composition. In contrast, oak, which is frequently likened to and found with chestnut, has been dominant across the region for at least 9,000 years. Thus, although chestnut and red and white oak overlap to some extent in their habitat requirements and many ecological characteristics, their physiological tolerances, resource requirements, and migration rates are sufficiently different that through most of the postglacial period they differed substantially in their distribution and abundance. In fact, when examined over centuries, or generations of trees, as we have done at Chamberlain Swamp (see Chapter 6), there has been no long-term stability in the oak-chestnut association or other forest types that we encounter today or that were important historically.

Similar results from studies of fossil faunal remains suggest that animal assemblages have been equally dynamic and that individual species operate with striking independence. Our reconstruction of the history of changes in wildlife populations since European settlement highlights dramatic and largely individualistic changes in animal species distributions over just the past three centuries, driven by habitat and environmental change in addition to major human impacts including selective hunting. Thus, the individualistic quality and different rates of response of species to changing climate and disturbance suggest that community assemblages are typically rather transient and that "nonequilibrium" conditions may be widespread. These observations force us to anticipate the continuing reconfiguration of species assemblages and ongoing individualistic change in the future.

The relative independence of species is a major source of the resilience that our forests have shown in the face of many different forms of physical and biological disturbance over past millennia. When a selective process eliminates or transforms the ecological role of an important species, such as occurred in hemlock's response to a forest pest 5,000 years ago, slaughter of the passenger pigeon in the late 1800s, or chestnut blight in the early twentieth century, ecosystems do not collapse and catastrophic shifts in broad processes do not occur. Despite the apparent keystone or core role of some species, other species adjust in abundance, sometimes over lengthy periods, and a range of forest ecosystem processes exhibit great resilience. This is not to say that the loss of

species does not have important ramifications, including effects that may appear to be devastating at the time. To the squirrels, bears, domestic animals, or rural New Englanders that relied on the nuts or wood of chestnut trees, or to the many people, industries, and wildlife that cherish hemlock forests, the arrival of the chestnut blight or the hemlock woolly adelgid has had major repercussions. But historical studies suggest that all species have evolved in a dynamic environment and under conditions of change and that each has its own particular biology and response to these changes. This independence and individualistic character of species confers great resilience to the forest overall. Tight linkages are relatively few, and so, though species can be traced through remarkable stretches of geological time, their assemblages are transient and innumerable. The loss of any one, or even many, brings change, but continuity is facilitated through readjustment. Though the squirrel populations of New England apparently crashed initially with the loss of chestnuts in the early 1900s, it would be difficult to conclude that from the large numbers of gray, red, or flying squirrels in the woods today.

However, when we discuss "continuity of change" in our landscape, it is essential that we acknowledge the relative nature of this term. In particular, our paleoecological records embrace thousands of years and may provide somewhat deceptive interpretations of the nature of change. In general, the shifts noted before European settlement are many times slower and much less frequent than those occurring today or over the past few centuries. In fact, some sites exhibit evidence of exceedingly slow rates of change in vegetation or terrestrial and aquatic ecosystem processes over the few thousand years before European settlement. For example, although pollen diagrams from Lily Pond in central Massachusetts depict a rapid shift 1,500 years ago from oak to chestnut, both of these dominant tree species showed essentially no substantial change in abundance for the thousand years preceding or following this transition. In northern Vermont, our pollen diagram from Levi Pond exhibits a 2,000-year history of gradual and exceedingly slow increase in spruce and no evidence of fire or other disturbance to the watershed. Otherwise, this remote site exhibits few dynamics, even after European settlement. In similar fashion, hemlock has dominated the forest in the center of the Prospect Hill tract on the Harvard Forest for the past 8,000 years despite many changes in associated species and a 1,000-year fluctuation due to insect attack.

Although disturbances such as fire and insect outbreaks occurred over time, in many instances the broad environment changed only gradually, and the forest underwent repeated sequences of recovery requiring 250 to 1,000 years after these isolated impacts. Thus, although change is a constant factor in our forests, the rates and nature of these changes have varied considerably through time. By all measures the rate

and magnitude of change and introduction of novel impacts and stresses have accelerated tremendously over the past three centuries.

The Importance of Disturbance History

Many angles of investigation underscore the fact that the composition and stability of species assemblages over time are strongly influenced by disturbance, and in particular, its frequency, intensity, and geographic scale. Through paleoecological, historical, and modeling approaches, we have documented the long-term influence of fire, hurricanes, pathogens, and people on New England forests. In addition, we have seen that gradients in disturbance regimes influence vegetation patterns at site, landscape, and regional scales. Knowledge of the scales and manner in which disturbance processes operate assists greatly in the interpretation of stand and landscape patterns across New England. For example, there is a regional decline in hurricane frequency from the southeastern coast inland to the north and west across New England, and a local gradient of intense winds that is related to topography. Similarly, the influence of disturbances such as ice storms and pathogens varies geographically and topographically, although the effects of these types of disturbances on stand development and composition are often more difficult to document than broadscale events such as hurricanes. The frequency of disturbance required to maintain particular species or associations also varies considerably. For example, although moderately shade-tolerant species such as oak, pine, and chestnut are thought to require disturbance such as fire for their establishment, once established these species may persist for centuries with only relatively infrequent disturbance.

Because many plant species are relatively long-lived, significant lags may occur in vegetation response to shifting climate or disturbance regimes. This "ecological inertia" complicates interpretations of the factors that control community composition and structure and drive vegetation dynamics. A good example of this is the difficulty in teasing apart the causes of regional vegetation change in New England over the past 500 years. Most of these changes have been interpreted as driven by European land use for the simple reason that many studies compile vegetation descriptions at the time of settlement, compare these with modern data, and attribute the difference to human activity. In fact, broadscale changes such as the decline in hemlock and beech and the decrease in regional differences in forest composition across central New England appear to result from interactions among changing climate, land use, and possibly fire. Climate changes associated with the Little Ice Age extended from at least the 1400s to the mid-1800s and affected landscapes worldwide. In New England, this period overlapped with major cultural transitions, including shifts in Late Woodland Indian activity, disrup-

tion and near-eradication of Native American populations by European settlement, and major land-cover and land-use changes. Changes in forest composition that began in central Massachusetts just before European settlement included an increase in oak and bracken fern and a decrease in hemlock and beech; these shifts continued after Europeans arrived. Although many of the other historical changes that occurred in vegetation, such as an increase in early-successional and sprouting species (for example, birch and red maple), are reasonably attributed to cutting, clearing, and burning, others may represent long-term lags in vegetation response to previous climate change.

Reconstructive studies enable us to place the composition of modern forests on the reforested agricultural lands in a long-term perspective. In fact, despite the lapse of a century or more since the decline of widespread agriculture, there is no indication that forest composition is reverting to that which occurred before European settlement. It seems that 200 to 350 years of active use, in conjunction with ongoing disturbance and environmental change, has significantly, and perhaps irrevocably, altered the forests of New England. This appears to hold true not only for sites that were cleared of native vegetation, such as pastures and tilled fields, but also for areas in which the only impact was a brief episode of intense logging. Whereas 100 years is clearly inadequate for complete recovery, there is considerable evidence to suggest that forest composition, both locally and across the region, has been permanently altered by the activities of the past few centuries.

The pervasive effect of human activity is often difficult to perceive and appreciate. Under close scrutiny, many areas that are valued today because they support remnant "old-growth" stands show direct or indirect evidence of human disturbance, including early historical cutting, grazing, or maple sugaring or introduction of nonnative pathogens. In fact, all of the New England landscape, and essentially all areas of the globe, has to some extent been affected by human disturbance, either directly or indirectly. As a result, it is likely that the distribution and abundance of every species on the landscape, both rare and common, have, to different degrees, been altered by historical land-use practices. Although it is quite remarkable that forests have become reestablished across much of New England relatively soon after agricultural abandonment, we realize that the forest is different in terms of composition, structure, and function from that which occurred before European arrival. Some species that we suspect were widespread on particular types of sites before European arrival were largely eradicated by agriculture and have not successfully recolonized old fields. Other species are apparently much more widespread today than they were in the early historical and prehistoric periods, having taken advantage of the increase in open and disturbed conditions that have come hand in hand with historical land use. We conclude, therefore, that modern species distribu-

tions and community patterns not only result from variation in current resource conditions, but also in many instances reflect a wide range of historical factors that have persistent influence on the landscape. When we view the forested landscape today, we must recognize that we are observing species at different points in their response to or recovery from past disturbances. As a result, even in the absence of further disturbance, forest composition and structure will continue to change in the future in response to past human disturbance.

Finally, we must emphasize that the history of land use over the past 300 years has been sufficiently complex that we will never know many of the details of historical disturbances. Although many of the effects of this complex history are likely to be significant, they are still largely undocumented and perhaps will always remain so.

The Importance of Retrospective Approaches for Conservation and Restoration

The historical approach that we have used to understand the composition and function of the modern landscape is also critical for evaluating conservation objectives and for developing management approaches for achieving those objectives. Retrospective studies are necessary to document the range of communities and processes that have been important within a region or on a site of interest over time. In turn, this information may help in our attempts to select desired and practical conservation goals as well as effective management approaches to achieve them. We must emphasize, however, that because most systems are characterized by continual change over the previous hundreds or thousands of years, generally no static baseline conditions emerge as clear conservation targets from any reconstructive study. Although many studies have attempted to determine conditions just before European settlement as a baseline for comparison with modern conditions, the fact that the pre-European period was highly dynamic suggests that it is arbitrary and oftentimes inappropriate to consider such a point in time (for example, just before European contact) as representing "natural conditions" or as the sole legitimate context for conservation and restoration efforts.

Even in cases where it is possible to develop a detailed picture of the pre-European landscape, it is typically impossible to re-create former conditions precisely. Several centuries of human disturbance as well as altered climatic and disturbance regimes have transformed the landscape sufficiently such that it is usually not possible to "restore" some prior state, although it may be possible to manage for particular attributes (for example, disturbance regimes, specific vegetation structure, minimum population levels of rare species, etc.). For example, it has long been recognized that fires have strongly influenced vegetation dy-

namics on sand plains throughout the Northeast, and paleoecological investigations have confirmed that fires were important prehistorically on many of these sites. As a result of the widespread perception that modern sand plain communities differ from their prehistoric "analogs" largely as a result of twentieth-century fire suppression, many conservation and resource management agencies throughout the Northeast have implemented prescribed fire management programs in these communities. For several reasons, however, it is unlikely that simply reintroducing fire to these systems will result in the restoration of prior community states. In fact, most sand plain communities have experienced a wide range of disturbances in addition to twentieth-century fire suppression that have influenced their current composition and structure. On sites where species were largely eradicated by historical agriculture, new species have become established, and soil conditions have been changed (see, for example, Chapters 8 and 9), and it is highly unlikely that simply restoring fire will result in the reestablishment of historical assemblages. In addition, the landscape setting of modern sand plain communities differs substantially from that which occurred in the early historical period. Whereas thousands of hectares of sand plain vegetation formerly occupied many areas, today most stands are small and isolated, creating significant differences in processes that are sensitive to landscape patterns, including species dispersal and establishment after disturbance. Finally, management fires do not closely mimic pre-European burning regimes, which were undoubtedly quite varied and at least occasionally burned intensely and during the most flammable conditions over large areas. Because it is not practical to set such types of intense or large fires, other management approaches (for instance, mechanical treatment and soil scarification) may be necessary to regenerate species that require such disturbances. Thus, even with the reintroduction of some fire into these systems, it is unlikely that conservation managers can create conditions that closely approximate the pre-European landscape.

One of the paradoxes of New England's history of intensive land use is that it has created landscapes that are often attractive to us and harbor plants and animals that we value but that depend on continued human disturbance for their perpetuation. Thus, in New England, many aesthetically desirable and indeed characteristic scenes—including open fields, spreading fencerow maples, graceful old-field pine stands, heathlands, and sand plain grasslands—are products of a cultural history that is transient, changing rapidly, and frequently difficult or impossible to reproduce. To retain fields, heathlands, and grasslands, we would need to replicate or reintroduce the traditional methods of plowing, grazing, mowing, and burning that produced these landscapes in the first place. Similarly, though we could generate new old-field pine stands, it is not possible to retain or regenerate the existing forests on the same sites.

Such successional communities and landscapes are inherently transient.

Likewise, the plants and animals that thrive in these cultural settings are highly dependent on human disturbance for their maintenance and therefore represent some of the most vulnerable species in our region, and indeed in many parts of the United States and even globally. Shifts in agricultural activity, including reforestation in New England and intensification of agricultural use in many other regions, have resulted in a loss of the cultural practices that maintained traditional landscapes and their wildlife and plant assemblages. Regardless of the condition of the land at the time of European arrival, recognition that many current landscape characteristics are the result of cultural activity is a critical step in interpreting and conserving important landscape features. It is precisely this appreciation of history that has recently led some conservation organizations to promote the use of sheep and cattle grazing, mowing, and other practices in the management of many early-successional habitats. Similarly, such an understanding has led to the pragmatic decision to attempt to protect particular species such as grassland birds, which were once found abundantly in New England's agricultural landscape, in alternative cultural habitats today, such as airports, right-of-ways, military training grounds, and landfills. These peculiar artifacts of modern human activity replace some of the function that historical fields played in centuries past.

In this example and in many others, historical perspectives are useful in identifying the range of conditions and processes that have been important over time, in clarifying species response to disturbance, and in setting some constraints on what conservation goals and approaches may be desirable or practical on particular sites. However, although decisions about what we should manage for may be informed by ecological study, they are ultimately based on our cultural values. The extent to which cultural values influence conservation objectives is well-illustrated by a comparison of European and American approaches to conservation. In many parts of Europe, where a history of intense human activity has altered the landscape over millennia, the conservation value of cultural landscapes such as agricultural meadows, hedgerows, heathlands, and wood pastures is widely accepted and serves as a major motivation for management and financial expenditure. In fact, these cultural landscapes and the species they support are regarded as among the highest priorities for conservation precisely because they embody cultural history and identity while maintaining biological diversity. In contrast, and in large part as a result of the relatively brief history of intensive human disturbance in North America and the wilderness ethic that pervades American culture, conservation efforts in the United States typically emphasize protection of "natural systems," "natural dynamics," "wilderness," "wildlands," "native species," and similar concepts. This

emphasis on naturalness causes human-modified and cultural landscapes to receive less appreciation and conservation focus. When coupled with incomplete historical information, such perspectives may also lead conservationists into misinterpreting features of the modern landscape as "natural" and thus managing with the wrong tools.

Conservation Directions in New England: The Possibilities from History

The history of rapid change across New England has left many opportunities and challenges for land managers and conservationists. First and foremost, species abundances and habitats are changing dramatically, with many woodland species increasing in the vast maturing forest and openland birds, insects, and plants declining as forests and human development encroach on grasslands, thickets, and shrublands. The great variation in landscape setting and history in New England leads to contrasting approaches to conservation within the region. For example, in portions of northern New England (for instance, the so-called "northern forest lands") where historical agriculture was not widespread and where considerable expanses of primary (that is, previously cut, but not cleared) forest remain, there has been an emphasis on conservation of vast tracts of forestland and associated woodland species, including the reintroduction of native predators. In contrast, in southern and coastal New England, with an intensive agricultural history, large human population, and increasing development pressure, more attention has been focused on the maintenance of uncommon species that are largely dependent on agricultural or other cultural landscapes. Across New England, there is also a need to address increased utilization of resources ranging from wood products to wildlife itself. In fact, each of these conservation approaches is consistent with aspects of the region's history and may be appropriate in order to achieve differing objectives. However, our analyses suggest that each strategy is being frustrated by a lack of regional perspective and coordination and incomplete information, including a consideration of history.

For example, in our collaborations with local land trusts, environmental organizations, and government agencies in central Massachusetts, we have been surprised by the incomplete use of broadscale information—on land-use history, ownership patterns, modern disturbance, and activities of the diverse land-management organizations. We recognized that although a tremendous amount of conservation land existed in the region, there was little information pertaining to a simple series of important questions:

- Who owned the land and what was its conservation status?
- How effective was communication and coordination among the range of

organizations and agencies involved in land management and conservation?

- What was the current pattern of land use, especially logging, across the region on private and public lands?
- Were there possibilities for planning a more spatially coherent and ecologically effective strategy of ownership and management across the region?

The results of our inquiries have been surprising, and, perhaps equally surprising, they have had a modest effect on conservation planning. First, we determined that approximately 40 percent of the region's land was protected from development (but not harvesting) through legal restriction, agency mandate, or other encumbrance. Although striking, the GIS-based analysis also showed that the resulting pattern of protected lands was haphazard and collectively less effective than might have been achieved through design and coordination (Figure 18.1). The lack of coordination and haphazard design were the result of more than twenty-eight public agencies and private organizations and untold numbers of private citizens operating independently with individual mandates including drinking water protection, wildlife habitat protection, timber production, rare species protection, open space protection, research, and wildland protection.

Equally impressive was the intensity and pattern of forest harvesting (Figure 18.1, bottom). Approximately 1.5 percent of the forest landscape was selectively harvested annually in a spatially random pattern that was unrelated to physiography, land-use history, broad cover type, or distance from roads. The only correlate of harvesting pattern was ownership class, a result that yielded some surprises of its own. Indeed, among major land ownerships, the Quabbin Reservation, which is the water-supply land for Boston and the largest conservation property in southern New England, is harvested most intensively, followed by private land, and then the state forests.

Thus, although conservation had successfully protected a large percentage of the natural landscape from development, the resulting protected lands were disjointed, vulnerable to fragmentation, and managed in a fashion that provides most effectively for neither intensive natural resource removal nor extensive blocks of maturing interior forest. Instead, current management distributes early-to-mid-successional habitat and forest openings from logging throughout the region. An alternative approach is possible that considers history in an attempt to fashion a regional plan to address many conservation and societal objectives simultaneously.

Although forests in this region were historically fragmented by deforestation and agriculture, natural reforestation over the past century or more has generated a modern landscape in which more than 80 percent of the uplands are forested, including a few large continuous blocks (Figure 18.1, top). One major opportunity for land conservation would

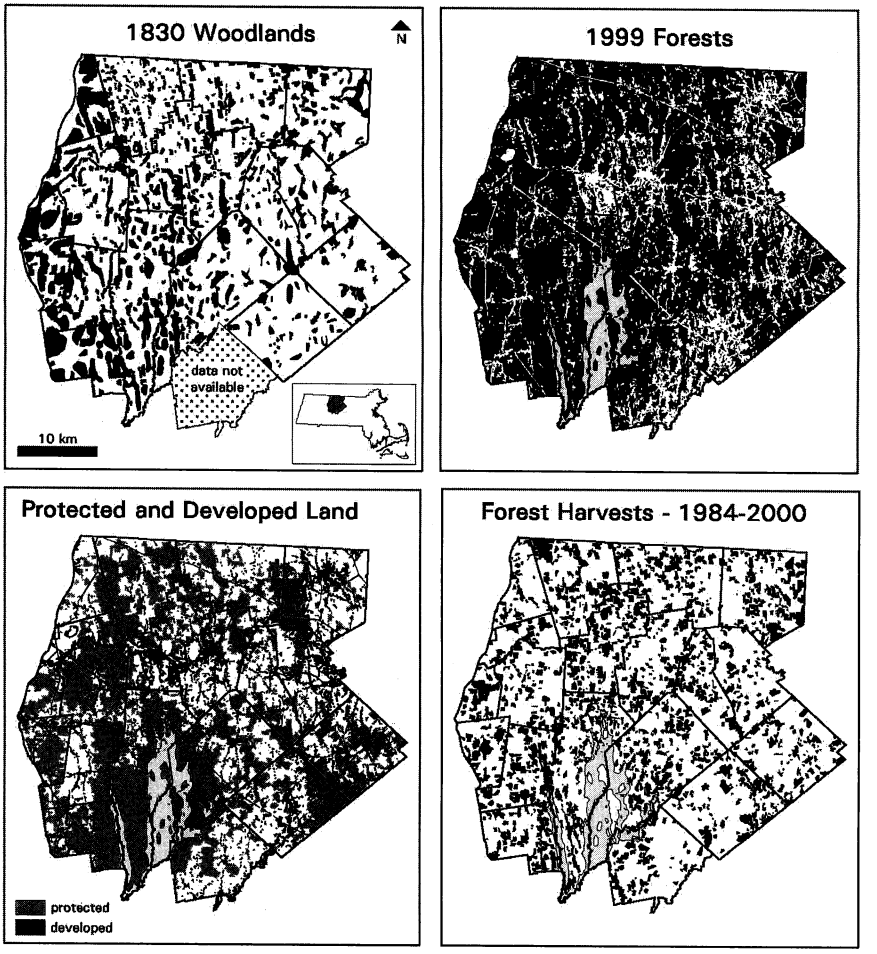

Figure 18.1. Landscape change and conservation activity in the North Quabbin region of central Massachusetts. Like most upland areas of the state, the region has been transformed from largely agricultural to heavily forested in the past 170 years (top figures). In 1995 our compilation of land-ownership records indicated that nearly 40 percent of the land area was protected from development (gray; bottom left). However, the spatial pattern of protection was haphazard because of the history of uncoordinated activities by diverse agencies and independent organizations. Across the region, forest harvesting is widespread and frequent and forms a spatially random pattern that is unrelated to protection status, distance from roads, or physical factors such as topography. Forest cover data for 1999 from MassGIS 2002.

therefore be to promote natural ecological processes and interior forest species by setting aside extensive areas, protected from future harvesting or other human activities. Though these forests will retain many of the legacies of past land use, including stone walls, cellar holes, soil plow horizons, and unique species assemblages, the forests will grow

and age and will gradually produce many of the structures, processes, and characteristics of old-growth forest, including snags and dead wood, tip-up mounds, windthrows and active beaver meadows, and immense forest trees. This approach would be most successful in areas with extensive protected land under individual ownership and little fragmentation that might be effectively buffered by land subjected to logging or rural land use. An obvious choice for consideration for such an approach in central New England would be the watershed of the Quabbin Reservoir, a continuous 30,000-hectare area of land and water. As the largest conservation property in southern New England, the Quabbin is often heralded as "an accidental wilderness," and yet timber harvesting is more intensive here than elsewhere in the region. A wildland created from Quabbin lands would not be wilderness and certainly would retain cultural legacies, particularly given the history of agriculture, milling, and dams. It would, however, also provide a unique habitat and preserve common forest types, wildlife, and ecological processes that are typical of the New England uplands. Over time it could emerge as an unmatched reserve for wildlife and forest processes while fulfilling its role as a municipal watershed.

The current distribution of the other conservation lands in the region suggests that a more effective pattern might emerge from protection of a relatively small area of additional connecting lands. This not only would forge linkages among existing parcels, thereby facilitating corridors and movement for wildlife and humans, but also would generate much more extensive continuous blocks of conservation land, thereby improving their effective management. With large blocks of wildlands established, much of the remaining forestland could be devoted to timber management, through various coordinated approaches depending on forest type and diverse objectives. Large areas managed for timber could buffer intact unharvested blocks and would provide habitat for species dependent on openings, gaps, young forests, and landscape mosaics.

The region around the Harvard Forest is typical of the broad New England uplands, where extensive agricultural lands and "hot-spots" of high biodiversity are uncommon. Conservation for those attributes is best achieved where such species and features predominate, including such areas as the Connecticut River Valley and the diverse coastal landscape. Although the uplands are not high in diversity, they have a history that has produced a remarkable expanse of forest that may be best suited for the promotion of large populations of common woodland species and habitats.

In ecological and environmental science we are conditioned to work outside policy circles, and we typically exert little effect when we seek to enter into these. However, the information and considerations described above have had some modest effect. In central Massachusetts, the North Quabbin Regional Land Partnership, a loosely coordinated

group composed of the diverse conservation organizations and agencies in the region, was formed in response to analyses that highlighted the obvious need for communication and cooperation. This group has launched some focused projects that address mutual needs, and, in turn, it has attracted attention from the state government and considerable attention and funding for land protection and education. Although many groups and constituent members may not endorse the regional scenario proposed above, there is broad agreement on the need for regional information, coordination, and action that are rooted in the history and modern characteristics of the land. The success of this partnership suggests that effective conservation of diverse values and landscapes throughout the New England region would benefit greatly from similar coordinated planning efforts.

Conclusion

The conflict between conservation values that emphasize limited human disturbance and a history of intensive land use that has altered community composition and function has given rise to significant conservation dilemmas. As woodland species have increased in abundance with reforestation, species that are characteristic of agricultural and disturbed landscapes have generally declined, including numerous species that are currently rare or very uncommon. Should we expend considerable effort and resources to maintain these uncommon species and their habitats, or should we allow them to decline and perhaps disappear from the region? Were these openland species native to the region, and if so, at what population levels and in what types of habitats? Whether or not openland species and assemblages occurred before European settlement, is there value in maintaining the cultural landscapes and associated species that have developed over time and are now part of our landscape heritage?

Conservation and natural resource managers must not only acknowledge the dynamic nature of the landscape and the influence of history on modern communities, but also find ways to incorporate landscape change into long-term planning. It is often inappropriate and futile to attempt to manage natural areas as static and unchanging. Instead, protecting a wide range of sites across physiographic boundaries may enable species to adjust to changing climate and disturbance regimes. Protection of multiple examples of communities of interest may also be desirable, as it is unlikely that all sites will experience catastrophic disturbance simultaneously. In addition, in developing conservation objectives, it may be worthwhile to emphasize protection of functioning systems, including varied and often complex disturbance regimes, rather than concentrating on attempts to maintain the distribution of individual species or current species assemblages.