Our History: A Brief Overview

The forests of Massachusetts have a rich history. From the earliest Native American cultures to the modern conservation efforts, these forests have been shaped by human activity. The Massachusetts Forests: An Ecological History of the Commonwealth, by John P. Keefe and David R. Foster, provides a detailed account of the state's forest history and management practices.

John P. Keefe and David R. Foster

Massachusetts Forests

An Ecological History of the Commonwealth

Massachusetts, Massachusetts

Massachusetts, Massachusetts

Programs and Policies

care how the lessons of history can be applied useful to shape future

commissioner and environmental secretary Charles D. W. Foster and

cumbers Forest Today” by former Massachusetts animal resources

biologist and researcher. The concluding chapter, “The Mass-

McKillops account of the upright town forest movement in New
the landscape that greeted the settlers. One reasonable start for our forests' history is the end of the last glacial period, more than 13,000 years ago.

This chapter is composed of five sections. The first describes the dramatic changes following the melting of the glaciers as our present forests were developing. The second provides a view of the natural factors that help determine the distribution of different types of forest. The third examines the types of disturbance, both natural and human, that shaped the forests prior to European settlement. The fourth describes the amazing changes that our forests have undergone since European settlement as they were cleared for agriculture and have subsequently regrown on abandoned farmland. The final section reviews the current state of Massachusetts forests and the pressures and stresses they are under, and suggests some lessons from their past that might help direct their future management. Table 1 provides a chronology of some major events in our forests' history over the last 15,000 years.

The authors of this chapter are both ecologists on the staff of the Harvard Forest, a research and educational department of Harvard University located in Petersham, Massachusetts. David Foster is director of the Harvard Forest and John O'Keefe is coordinator of the Fisher Museum, a small museum devoted to understanding the land-use history, ecology, and management of New England's forests. Scientists at Harvard Forest have intensively studied the forests of central Massachusetts since the turn of the century and amassed an unparalleled database from these studies. The authors have drawn heavily on this database for information and illustrations, which is the reason for the numerous references to Petersham and north-central Massachusetts in their work and examples. However, they have noted when other areas may not fit these examples and present the story of all Massachusetts forests.

### Table 1. Approximate chronology for important events in the development of Massachusetts forests.

<table>
<thead>
<tr>
<th>Approximate Years Before Present (B.P)</th>
<th>Landscape Condition/Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 13,000</td>
<td>Glacial ice</td>
</tr>
<tr>
<td>13,000</td>
<td>Tundra</td>
</tr>
<tr>
<td>11,500</td>
<td>Spruce woodland and forest</td>
</tr>
<tr>
<td>10,000</td>
<td>Human arrival</td>
</tr>
<tr>
<td>9,500</td>
<td>Pine forest</td>
</tr>
<tr>
<td>8,000</td>
<td>Mixed deciduous forest</td>
</tr>
<tr>
<td>5,000</td>
<td>Hemlock decline</td>
</tr>
<tr>
<td>3,000</td>
<td>Arrival of chestnut trees</td>
</tr>
<tr>
<td>1,000</td>
<td>Native American agriculture</td>
</tr>
<tr>
<td>250-350</td>
<td>European settlement</td>
</tr>
<tr>
<td>150</td>
<td>Peak of agricultural clearing</td>
</tr>
<tr>
<td>85</td>
<td>Chestnut blight</td>
</tr>
<tr>
<td>60</td>
<td>1938 hurricane</td>
</tr>
</tbody>
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I. POSTGLACIAL FOREST DYNAMICS

At the peak of the last glaciation, over 15,000 years ago, most of present-day Massachusetts was covered by ice up to a mile thick. Cape Cod and the offshore islands, Nantucket, Martha's Vineyard, and the Elizabeth Islands consist largely of what geologists call moraines, piles of debris accumulated at the front of the advancing ice sheet and left behind when the glaciers finally melted. The advancing glaciers not only smoothed and shaped the landscape by scraping and plucking the bedrock as they advanced, they also left behind a layer of ground-up rock, or till, which has developed into our present soil. As the glaciers melted, the tremendous volume of water produced seasonal streams that carried and sorted much of this material and deposited sands and gravels wherever they sloshed (Strahler 1966). The soils of Massachusetts are a product of this massive natural engineering, with the subsequent addition of organic material from the vegetation that covered the landscape. Along major rivers fine silt was deposited when the rivers overflowed their banks in springs in some depressions a surplus of moisture allowed thick layers of peat or muck to develop. The resulting pattern of soil types has strongly influenced the types of trees and forests growing in different locations.

Of course, as the glaciers melted, there were no forests in Massachusetts. The climate change that allowed the glaciers to develop limited the modern tree species of New England to favorable locations, or refugia, south of the glacial zone, presumably scattered across the southern Appalachians and the eastern coastal plain. The huge quantities of water trapped on land as glacial ice had once been seawater;
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In spite of all the changes and
increases in species diversity, there have been many
which dramatically decreased humdred populations for
several decades. The ground cover species, such as
Atriplex, are not as abundant as they were in the past.

The Harvard Forest Ecological Study
and the Harvard Forest Museum

Species richness has increased in the forest
over the past 40 years. The increase in species richness
may be due to the decrease in human
activity in the forest. The Harvard Forest
Ecological Study has been monitoring
species richness in the forest for the past 40 years.
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forest community dynamics were complex: while spruce, a northern species, increased — evidently in response to gradual cooling — chestnut, a southern species, was also migrating north across Massachusetts. In fact, chestnut is the most recent arrival in the pollen record, not appearing until about 3,000 years ago, much later than the other important deciduous species that occur in the region today.

II. NATURAL ENVIRONMENT

The development and distribution of forest types across Massachusetts during the presettlement period were controlled by the geographic pattern of the landscape, or physiography, the underlying geology, and the patterns of various types of disturbances such as windstorm and fire, which are all interrelated. Massachusetts, excluding Cape Cod, is roughly rectangular, 125 miles (200 km) east to west and 50 miles (80 km) north to south. Today we receive approximately 40 inches (100 cm) of precipitation annually, distributed fairly evenly throughout the year. With a mean annual temperature near 50°F, ranging from a mean of several degrees below freezing in January to a mean of about 70°F in July, our climate today is very well suited for trees and apparently has been for the last 10,000 years.

Within this relatively small compact area, Massachusetts contains six broad physiographic regions: the coastal lowlands, the central uplands, the Connecticut River valley, the Berkshire Mountains, the Berkshire valley, and the Taconic Mountains (Figure 2). The geologic substrate varies across the state. Except for parts of the Connecticut valley, the Taconic Mountains, and the Berkshire valley the soil is generally acidic and fairly nutrient-poor. The soils are generally shallow with patches of exposed bedrock. Elevation generally increases from east to west, reaching a maximum at Mount Greylock (3,487 feet [1,060 m]) in the Berkshires.

As mentioned, these physiographic and geological conditions interact with climate to produce vegetation zones sometimes referred to as ecoregions. Figure 3 shows the Massachusetts portion of a natural vegetation zone map of New England (Westveld 1956). Within Massachusetts these zones are largely determined by climate, which is principally controlled by elevation except in areas with close proximity to the moderating influence of the ocean. Southeastern Massachusetts, all of Cape Cod, and the offshore islands fall within the pitch pine-oak zone. This vegetation type, occurring on sandy and gravelly soils laid down as glacial moraines or outwash deposits, is characterized by drought-tolerant and fire-adapted species including pitch pine, scrub oak, and huckleberry. This type also occurs on scattered outwash deposits in inland Massachusetts. The remainder of the coastal lowlands, southern Worcester county, and the southern Connecticut River valley fall within the central hardwood-hemlock-white pine zone. This vegetation type represents the northern extension of the oak-hickory dominated forests of the central Appalachians and the Middle Atlantic states.

Generally north and west of the central hardwood zone we find the transition hardwood zone. This zone also extends up the major river valleys in the western part of the state. The transition hardwood zone is characterized by increasing amounts of more northern species such as yellow birch, black birch, sugar maple, and beech; less oak (especially white oak); and the general occurrence of paper birch on heavily disturbed sites. The higher elevations in the Berkshire and Taconic
III. NATURAL AND PRESENTENT DISTRIBUTANCE

Because of several factors (hills, bogs, and rapids), it is difficult to develop a single distribution map. However, approximately 90% of the habitat exists below the mountains, while the remaining 10% is in the mountains. The distribution is further influenced by factors such as climate, soil, and topography.

Figure 3: The major forest vegetation zones in southern New England, including:
- Pine
- Deciduous decidous
- Hemlock
- Black Cherry
- Birch
- Spruce
- Firs
- Pines
- Redwood
- Hardwood

They are distributed in a checkerboard pattern across the region, with the northernmost zone being the most extensive. The distribution is also influenced by historical and current land use practices, with areas of higher forest cover often being located in more remote and less accessible areas.
frequent and significantly smaller in the Berkshires than in southeastern Massachusetts and on Cape Cod (Patterson and Sassaman 1988). The droughty, sandy soils of the southeastern area supported a much more fire-adapted vegetation largely dominated by pitch pine, scrub oak, and other oaks and huckleberry. Pitch pine, like all conifers, contains resins in its needles that make it much more flammable than our broadleaf, deciduous trees. Huckleberry, although a broadleaf, deciduous species, also contains resins in its leaves and therefore provides a very flammable understory. All the oaks, especially scrub oak, are prolific sprouters following injury. Pitch pine is unique among Massachusetts’ native conifers in possessing dormant buds beneath the bark and near the base of its trunk that enable the tree to sprout and survive if the main stem is severely damaged by fire. Moreover, the cones of pitch pine tend to be serotinous, which means they may remain closed with seed inside until the heat from a fire triggers an opening mechanism to release the seeds onto the recently burned landscape. Although pitch pines in Massachusetts rarely exhibit this behavior today, it is commonly observed in pitch pines in the frequently burned New Jersey pinelands.

The northern hardwood species — sugar maple, beech, and yellow birch — while capable of sprouting, tend to have thinner bark that provides less protection from understory fires. Hemlock, a major associate in the northern hardwood forest, is also thin-barked as well as slow-growing, long-lived, and incapable of sprouting. Therefore, where these species were dominant, we can conclude that fires could not have been frequent or severe. Moreover, during the growing season, broadleaf foliage normally contains enough water to be nonflammable. This moisture tends to limit the fire season in our broadleaf forests to spring and fall, when the fallen dry leaves will burn in surface or brush fires. In fact, the combination of these factors led some to nickname the northern hardwood forest “asbestos forests.”

Aboriginal Impacts

There is considerable debate regarding the extent of aboriginal impact across the broad-scale forest landscape. American Indian populations migrated into Massachusetts shortly after the trees, some 10,000 years ago, but their populations remained quite low until 4,000 or 5,000 years ago. Some researchers speculate that the hemlock decline about this time, and subsequent increase in mast species (mast means hard food
When this began the face of our forests since the arrival of Europeans
(1620-1850).
- when forests were healthy, dynamic communities
  - Below the forest, forest communities are dynamic.

From this, we see:
- The forest floor, dune systems, and coastal areas were
  habitats important near the coast and inland, up to the
  forest zone. During periods of drought, the forest floor
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IV. POST-EUROPEAN DYNAMICS

The Colonial Period

European settlement in Massachusetts spread inland from the coast at uneven rates. Essex, Suffolk, Norfolk, Plymouth, and Bristol counties were largely settled by 1675, as was the Connecticut River valley, with settlers moving northward from settlements in the Springfield area that dated from the 1630s. Concentrated in the coastal lowlands and major river valleys, this early settlement pattern closely overlapped the areas where aboriginal practices had most affected the forests. Settlement then spread to much of Middlesex and Worcester counties in the late seventeenth and early eighteenth centuries and expanded into the foothills of the Connecticut River valley during the same period. In 1725 Massachusetts began using land grants to pay off debts, especially for military service (Clark 1983), which encouraged the settlement of the central upland areas. The last areas to be settled, from the second half of the eighteenth century into the beginning of the nineteenth century (Figure 6), were the northern portions of Worcester County and the uplands of the Berkshires.

Initially, clearing occurred quite slowly for several reasons, including lack of markets for excess production and a town organization based on the European model of a centralized settlement and common field system (Whitney 1994, Foster 1995). More than 100 years after its settlement in 1635, Concord was still more than 50 percent forested. This rate of about 0.4 percent deforestation per year was typical of towns in the seventeenth century (Whitney 1994). A shift to a town pattern of dispersed settlement and individual ownership of private land, with all land in the township distributed, led to much more rapid deforestation toward the middle of the eighteenth century. Rates of 0.8 percent to 1.0 percent per year were common in both older towns like Concord and new ones like Petersham in the second half of the eighteenth century (Figure 7). This clearing coincided with a shift toward a market economy, partly driven by a developing beef trade with the West Indies. Animals were a suitable crop on remote hilltown farms during this period because they could be walked to market on the rudimentary roads that precluded the long-distance transport of most products. The difficulty of transport also partly explains the methods most commonly used to clear the forest, girdling and leaving the dead trees in place to fall apart slowly, or cutting the trees and burning them (Whitney 1994). Except where water transport was available, trees were valuable only locally as lumber or firewood. Potash, a relatively more compact and transportable product, was probably the major marketable product from the trees of these early farms.

Pasture suited the landscape of most of Massachusetts quite well. The rockiness of most soils made clearing land for tillage a long and backbreaking chore. It has been said that it took two generations to clear upland farms for plowing, the first to remove the trees and the second to remove the stones. The massive stone walls surrounding abandoned fields across the state attest to the effort required by the second endeavor. And yet the great number of rocks scattered throughout the remaining pastures and second growth woods suggest that the majority of the landscape was never tilled, but rather grazed or at most mowed. The principal exceptions of course were the major river valleys where postglacial alluvial deposits provided excellent tillage after the
The new roads and railroads allowed many crops to be harvested, processed, and shipped to market, thus increasing the demand for agricultural products. This growth in agriculture led to the development of new markets for farm products. The increasing demand for wood products and related industries, such as paper and furniture, provided additional economic opportunities. These developments contributed to the growth of local economies and the creation of new jobs. The expansion of communication networks, such as the telegraph and telephone, facilitated the national and international exchange of goods and ideas. This period was marked by significant social and economic changes, with the growth of cities and the rise of industrialization. However, the rapid pace of this development also had its downsides, including environmental degradation and social inequality.
Figure 8. The township of Petersham, Massachusetts. (a) Soil suitability, (b) stonewalls and (c) forest cover from the periods 1830 and 1985 are depicted.

Stone walls and agricultural land are concentrated in areas of more productive soil. Maps are compiled from the atlas of Worcester County (1830, unpublished) and analysis of aerial photographs for 1985.
In the early 19th century, the population of Massachusetts was concentrated along the coast and in the western interior. The industrial revolution and the expansion of railroads and canals led to an increase in population, especially in the eastern part of the state. By the mid-20th century, the population distribution had shifted to the urban areas, particularly in the Boston metropolitan area. Today, the population is still concentrated in the eastern part of the state, with significant populations in the Boston, Providence, and Springfield areas.

Figure 9: Population distribution in Massachusetts, 1810-1990.
and never were developed for agriculture to the extent that the remainder of the state was. Figure 7 shows the trends of deforestation and reforestation. The statewide peak deforestation was reached about 1860, by which time nearly 70 percent of the land was cleared. Many areas east of the Berkshires show the pattern exemplified by Petersham and the Prospect Hill tract of Harvard Forest, with maximum clearance in the 1840s, when less than 20 percent of the forest remained. The pattern of remaining forest was strongly influenced by regional as well as local geography (Figure 10). For example, in the north-central portion of Massachusetts from the Connecticut River valley to eastern Worcester County, the hills east of the valley, with many rocky ridges, remained more forested, as did the north-south-trending, poorly drained valleys farther east. Most of the rest of the region was cleared.

Of course, even the uncleared areas were harvested intensively for wood by the nineteenth century. The increasing rural populations, peaking in the mid-1800s, required large amounts of cordwood for fuel. Petersham, for example, had a population of nearly 1,800 people in 1840. Assuming an average household size of six, this population would have represented 300 households to heat. If each household used 15 cords per year (a conservative figure when fireplaces are used), together they would have required 4,500 cords of fuelwood per year. The 20 percent of Petersham that remained forested in 1840 represented about 6,000 acres. Because Massachusetts forests can be expected to grow between one half and one cord of hardwood per acre per year, virtually all the woodland growth in Petersham could have been used for fuelwood. These hardwoods were probably managed by means of a "coppice" system, in which trees would be harvested very young (every 20 to 40 years), left to resprout, and then harvested again as soon as the new growth was big enough to burn. Across upland Massachusetts most farms could maintain woodlots to satisfy their fuel needs, but along the coast, where settlement had been in place longer, and near cities, the fuelwood was soon exhausted and had to be brought great distances by ship at considerable expense.

Although fuelwood represented by far the greatest use of the remaining forests in the early 1800s, the forests also faced other demands. Trees (especially hemlock and chestnut) were cut to provide tanbark for tanneries. Lumber was needed for constructing houses, barns, out-

Figure 10. Maps of three townships characteristic of different physiographic regions in central Massachusetts depicting distinctive amounts and patterns of forest, open land, and meadow in 1830 and 1980. Ashburnham, on rocky hills near the New Hampshire border, was least extensively cleared and today is the most forested. Barre, on rolling terrain in the central uplands, was extensively cleared for agriculture but has largely reverted to forest. Deerfield, in the Connecticut valley, was extensively cleared except for a few north-south bedrock ridges and the fertile valley bottom remains in agriculture today.
An Ecological History of Massachusetts Forests

In many ways, what the forests of Massachusetts have been to the state is as unique as the forests of any other state. The forests of Massachusetts have been an integral part of the state's history and culture, and have been shaped by a variety of factors, including human activity, climate change, and natural disturbances. The forests of Massachusetts have been a source of wood, a habitat for wildlife, and a place for recreation, and have played a significant role in the state's economy and society.

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Figure 13. 1850 — Agricultural abandonment and establishment of old-field white pine.

Figure 14. 1910 — First crop of old-field white pine harvested.
planted, because red pine is not affected by either pathogen. Although red pine is at the very southeastern edge of its range in western Massachusetts, these plantations have generally done well. Many are now maturing and being harvested.

The extensive old-field white pine stands also played a major role in the most dramatic natural disturbance to affect our forests in the twentieth century, the hurricane of September 21, 1938 (Figure 4). Historically, hurricanes have been a major force in shaping most Massachusetts forests. The 1938 storm followed a track similar to that of other historically significant storms (1788, 1815), but several factors conspired to make it the most destructive storm in our recorded history. The week prior to the hurricane’s arrival had been very wet, saturating the soils and predisposing trees to windthrow. The added rain from the storm produced massive property damage from flooding along rivers, compounding wind damage. Large areas of central Massachusetts still supported stands of old-field pine on land abandoned in the late nineteenth century. Even pine stands as young as 30 years of age suffered severe damage if their sites were not protected topographically from the southeast winds. Hardwood stands on similar sites were not as susceptible to damage until they were twice that age (Foster 1988). The expanses of old-field pines set the stage for the unprecedented impact of the storm on our forests, nearly three billion board feet of timber blown down. We had unintentionally created about as vulnerable a landscape as possible. There is evidence that the 1815 storm may have been similar in intensity and path (Figure 4), but it encountered a landscape largely cleared of forest and its impact was quite different.

The vast tracts of blown-down pine presented another problem beyond economic loss and landscape damage, the threat of fire. Fires often follow other disturbances, especially in conifer stands where the resinous foliage and lack of new green sprouts contribute to flammability. With this in mind, and in an attempt to recover some of the value of the blown-down timber, a massive salvage operation was undertaken that recovered much of the windthrown timber. Logging crews were brought in from all over the Northeast, temporary camps were set up, and logs were salvaged and brought to the mills. Because the volume of logs far exceeded the capacity of all the available mills, logs were stored in every available pond in the area. As long as the logs remained underwater, away from oxygen in the air, they were preserved. Many
In Exposed Habitats, Fossils provide abundant clues of the past. Intercontinental climate, providing favorable habitats for life, were exposed to the ocean in the past. The ocean, in turn, allowed the formation of sedimentary layers that contain these fossils. The fossils, in turn, provide valuable information about the Earth's history. For example, the fossils of marine organisms can tell us about the conditions of the environment in which they lived. The fossils can also help us understand the changes that have occurred in the Earth's climate over time.

Figure 1: Fossils from the bottom of the ocean can be found in eastern North America. This figure shows the distribution of various types of fossils found in eastern North America. The fossils are found in various depths, ranging from shallow to deep water. The fossils are also found in various latitudes, ranging from the Arctic to the tropics. The map also shows the distribution of different types of fossils, such as marine invertebrates, reptiles, and mammals. The map provides valuable information about the Earth's history and the evolution of life on Earth.
been taken by a mixture of species, especially oaks, but its wood and
uts cannot be replaced.

Several other native tree species have also been significantly affected
by human-introduced agents, although none so completely as the
chestnut. Dutch elm disease, a wilt fungus transported by a bark beetle,
dramatically changed the look of almost every town in the state in the
1950s and 1960s as it killed the stately shade trees that lined most of our
main streets. The disease is passed from tree to tree by insects above-
ground and through root grafts below ground, where the trees are
growing adjacent to each other, as in street plantings. This disease was
somewhat less traumatic in our forests because elm occurred in mixed
stands, primarily near wetlands, and exhibited a greater range of natu-
ral resistance than did chestnut. The devastation of the elms in our
urban tree stands again demonstrates the susceptibility of human-
induced monocultures to various pathogens. More recently, many of
our beech trees have been disfigured and killed by beech-bark disease.
This disease, caused by the coincident impact of a fungus and a scale
insect working together, is spreading steadily south after being intro-
duced into the Canadian Maritimes. Most recently, hemlock woolly
adegid is beginning to cause mortality in the southern Connecticut
River valley area and has been reported from many other areas of the
state as it slowly advances north. This aphidlike insect, introduced on
nursery stock from Japan to the West Coast and then to Maryland,
poses an extreme threat to hemlock forests because hemlocks have
shown little resistance and are incapable of sprouting. Moreover,
because of the steep habitats many hemlock stands occupy and the unique
microenvironments they create, loss of hemlock would cause extreme
changes in many of our forests.

Logging and land conversion to suburban use are the two direct
human changes that have most affected our forests over the past several
decades. Regrowth after the old-field pine stands and other forests were
cut early in this century, and after the 1938 hurricane, has provided an
abundant middle-aged and maturing forest, much of which has been
and is being harvested with varying intensities. Environmental disputes
resulting in limitations on harvesting on federal lands in other regions
of the country and a strong export market have put added harvesting
pressure on Massachusetts forests. However, despite these pressures the
average size of trees in our forests has been steadily increasing (Figure

17). In some instances we have even managed to reduce the impact of
suburban development on the forest. Significant numbers of people are
now building homes on large forested lots, clearing only immediately
around the buildings, and some developments cluster buildings to-
gether, reserving the majority of land as forest or open space. While
both of these patterns of development alter the forest, they are much
less destructive of it than traditional tract development.

Wildlife species have very much been influenced by human-
induced changes in the landscape as well as by hunting (Figure 18).
Although much of this information is indirect and difficult to gather,
most of the large, broad-ranging species were probably largely elimi-
nated during the initial period of forest clearance. This group would
include elk, wolf, mountain lion, and moose. Deer were nearly elimi-
nated by the mid-1800s. However, being an edge species, utilizing both
open areas for browsing and forests for cover and tolerating human
activities, deer have responded so favorably to the return of the forest
that they have reached densities detrimental to the vegetation in areas
where they are not controlled by hunting (Kyker-Snowman 1989).

Figure 17. Historical trends in land-use activity and forest structure for the town of
Petersham, Massachusetts, during the period of farm abandonment and re-
forestation. Note that the 1885 data for height structure depicts 40-foot height
classes, whereas the later years depict 20-foot height classes. As the township
became increasingly covered with forest, there occurred a progressive aging and
height increase in the extant forest. Sources include Cook (1917), Rane (1908), and
MacConnell and Niedzwiedz (1974).
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Present Conditions and Future Prospects

V. Present Conditions and Future Prospects

and meadowlarks have decreased at the forest edge towns and measured. Other species, mostly native open-land birds such as bobwhites, have significantly increased on forested land and numbers within the excitement of forested areas are higher due to increased inERJAC. These increases can be attributed to improved habitat conditions. The increased forest cover has provided better nesting and feeding opportunities for bobwhites. Other species, such as meadowlarks, have continued to thrive in the forested areas.

Bears were eradicated by the forest cover in the value of their prey. They

Figure 19: Forest cover (black) over Forest Inventory and Analysis data from 1992 and 1998.
some wetlands within them, and are under the greatest pressure at the edges of these zones (Figure 20).

The major changes in the geographic pattern and stand structure of our forests have strongly favored a new landscape of even-aged forests and sharp boundaries between forest types. Agricultural clearing and abandonment, heavy fuelwood cutting, intensive harvesting of old-field pine and other species early in this century, and the 1938 hurricane with its subsequent salvage harvesting have all pushed our forests toward an even-aged condition. Land-use regulations and land ownership boundaries create visible differences that tend strongly to be perpetuated through time and subsequent ownership changes. General trends in field size, farm size, and regional timber harvesting practices have worked to impose a repetitive patchwork of forest classes on top of the natural vegetation patterns described early in this chapter. The even-aged structure and imposed pattern present across much of our forest today increase the potential for future disturbances to be more damaging than they might be in a more diverse forest. Moreover, the relative lack of very young forests presents problems for species dependent on such habitat.

Ever since the heavy fuelwood cutting in the early 1800s, there have been repeated public concerns about the condition of our forests. As Figure 17 shows, over the past 100-plus years the forests in Petersham have continually increased in area and size, and this trend has been general throughout the state. How has the composition of our forests been affected? Agricultural clearing and subsequent abandonment led to the dramatic increase in white pine discussed previously. Prior to European settlement white pine was probably found principally on sandy outwash soils, on sites heavily burned by Indians or following a natural disturbance, and as scattered, emergent individuals in old stands. Following agricultural abandonment, especially of pastures, white pine proliferated throughout most of the state on sites it would never have occupied in the absence of clearing and grazing. Despite intensive harvesting and the 1938 hurricane, white pine remains much more widely distributed and dominant today than it was before. The repeated fuelwood cutting and agricultural burning practiced in the nineteenth century would have favored an increase in invasive, pioneer species intolerant of shade such as gray and paper birch, aspen, pin cherry, and black cherry, as well as species that sprout prolifically such as chestnut, oak, red maple, birch, and hickory. Chestnut is probably the species that responded most favorably to nineteenth-century disturbances because it sprouts prolifically from dormant basal buds and is capable of phenomenal rates of height and diameter growth when reproducing vegetatively (Zon 1904; Paillet and Rutter 1989).

Figure 16 traces the changes in tree species abundance from the agricultural period to the present, as recorded in the pollen collected in the humus soil in a hemlock woodlot in Petersham. The most striking feature is the tremendous increase in chestnut followed by its virtual elimination following the blight. The other major changes are the decreases in several long-lived, shade-tolerant species, including hemlock, sugar maple, and beech, during the agricultural period. Both hemlock and beech are very sensitive to fire and could be largely eliminated from upland areas by repeated fires, a rather common agricultural practice. The site represented in Figure 16 is a moist lowland, and hemlock has become dominant there following the loss of chestnut to the blight. Oak, pine, and red maple have also increased, replacing beech and sugar maple.

Figure 20. The progression of urbanization in the state of Massachusetts during the last half of the twentieth century. A growing population and an improved road transportation system have resulted in a conversion of former agricultural and industrial towns to residential communities around the major cities of Boston, Worcester, and Springfield. Modified from Wilkie and Tager (1991).
The growing environmental interest has led to the discovery of

ローカルspread of populations (pathway model) points to the importance of such

As our forests have grown back and matured following the trauma

An Ecological History of Massachusetts Forests

Shopping bag to look forward
the major limiting nutrient for plant growth in our soils. Initially nitrogen works as a fertilizer, but at higher concentrations it may saturate the soils and become damaging, even leading to nutrient loss through leaching (Aber et al. 1989). Low-level ozone is another pollutant with potential serious forest impacts. Pollutant impacts are extremely complex, and the effects of long-term chronic exposure to and accumulation of these compounds is still largely unknown.

Elevated carbon ($\text{CO}_2$) levels affect plant growth, competitive interactions, leaf chemistry and thus organic-matter quality, as well as potentially changing the global climate. We do not yet understand how forest communities and ecosystem processes might ultimately be changed by elevated $\text{CO}_2$ levels, nor do we know the local effects of global warming. Massachusetts forests do have some impact on the global $\text{CO}_2$ level. Because they are still relatively young and growing, and our landscape is still recovering from agricultural clearing, our forests take up and store significant amounts of $\text{CO}_2$, slightly offsetting the increases from fossil fuel burning and deforestation. $\text{CO}_2$ levels and pollution are both international issues that will require unprecedented levels of cooperation if they are to be managed.

CONCLUSIONS

We have traced changes in Massachusetts forests from a time when there were no forests through natural forest development and change, aboriginal impacts, European settlement and forest clearance, reforestation and regrowth, and down to the present, when the state is nearly two-thirds forested again. What comparisons can be made between change under natural processes and the more recent changes from human disturbances? Although our forests have been very dynamic throughout geologic and historical time, human-induced changes over the past 300 years have been much more frequent, varied and extensive than most changes in previous forest evolution (Table 2). These changes were superimposed upon natural disturbance processes, and where they interacted, as in the 1938 hurricane, the impacts were substantial. On the whole, human disturbances have been more frequent and more systematic in both time and space than their natural counterparts. Human activities have tended to mask natural forest patterns by overlaying imposed patterns on them and homogenizing them.

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**Literature Cited**

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**Figure 1:**

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**Legend:**
- Introduction
- Methods
- Results
- Discussion
- Conclusion
Stepping Back to Look Forward


Mulholland, M. Personal communication.


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