United States
Department of
Agriculture

Forest Service

**Northeastern
Research Station**

Resource Bulletin NE-160

# The Forests of Connecticut

Eric H. Wharton
Richard H. Widmann
Carol L. Alerich
Charles J. Barnett
Andrew J. Lister
Tonya W. Lister
Don Smith
Fred Borman



## Authors

Eric H. Wharton, Richard H. Widmann, Carol L. Alerich, Charles J. Barnett, Andrew J. Lister, and Tonya W. Lister, Forest Inventory and Analysis Program, Northeastern Research Station, Newtown Square, Pennsylvania

Don Smith and Fred Borman, Connecticut Department of Environmental Protection, Division of Forestry, Hartford, Connecticut



**Photo credits:** cover, Paul Fusco, USDA Natural Resources Conservation Service; pages 3, 6, 10, 22, 27, 33, 35, Connecticut Department of Environmental Protection, Division of Forestry; pages 4, 11, Richard H. Widmann, USDA Forest Service; page 7, used by permission of the State of Connecticut; page 24, Maine Maritime Museum; page 26, Robert Burt, USDA Forest Service; page 29, upper right, Robert L. Anderson, USDA Forest Service, image 1748049 (www.forestryimages.org), lower left, Terry McGovern, USDA APHIS, image 2652087 (www.forestryimages.org); page 30, Robert A. Haack, USDA Forest Service, image 3225081, (www.forestryimages.org).

Published by:
USDA FOREST SERVICE
11 CAMPUS BLVD SUITE 200
NEWTOWN SQUARE PA 19073-3294

April 2004

For additional copies:
USDA Forest Service
Publications Distribution
359 Main Road
Delaware, OH 43015-8640
Fax: (740)368-0152

Visit our homepage at: **http://www.fs.fed.us/ne**

## Foreword

*There is something about Connecticut . . .*

- There is a reason why thousands of people – from all over the world – flock to Connecticut in the autumn to view nature's finest show.

- There is a reason why many of the world's producers of fine oak furniture, flooring, and paneling beat a path to Connecticut in search of raw materials.

- There is a reason why millions of people either come to Connecticut or stay in Connecticut to rest, relax, and recreate.

- There is a reason why so many species of wildlife, such as bear, fisher, bald eagle, turkey, coyote, and martin, have returned to Connecticut's landscape.

- There is a reason why so many people seek to nestle their homes in the natural beauty and serenity of Connecticut.

Yes, there is something about Connecticut . . . and I believe the something about Connecticut is our State's enduring treasure – our forests. These forests form the backdrop to life in Connecticut and contribute so much to the quality of life here.

This report is reassuring for the citizens of Connecticut: their beloved forests are healthy. But this report also raises a word or two of caution: the forests of Connecticut are in danger of being loved to death. Unchecked, our yearning to own and live in our own small piece of Connecticut's green treasure will eventually bring about a fundamental – and very sad – change. The very nature of our forests will change and the reasons that the forests of Connecticut are so special will diminish: less recreation, fewer wildlife, fewer forest products, and less natural beauty.

In a very real and paradoxical way, the future of Connecticut's forests is tied directly to the future of Connecticut's cities. If we strive to create cities that are a joy to live in, maybe the desire to build a home in the forest will decrease – and the forests of Connecticut will continue to endure. Think about it.

So, read this report and smile about Connecticut's forests today – but think about the future.

*Don Smith*
Connecticut State Forester

## Connecticut's Resilient Forests

### Historic Perspective

Forests provide wood and other forest products, watershed protection, wildlife habitat, a setting for recreation, and much more. They have played a major role in the history and culture of Connecticut. The State is one of the most densely populated in the nation, yet its forests remain as much a part of the landscape as its cities and towns.

Early settlers found nearly all of Connecticut covered by forests with open, park-like conditions. For more than 1,000 years before European settlement, the Native Americans of the region burned the forest in spring and fall to eliminate tangled underbrush. The forests that resulted provided a more suitable habitat for the game species on which they subsisted. Native American populations were small and had little impact on the forest ecosytems in which they lived. However, once Europeans arrived, the landscape changed dramatically.

Clearing land for agriculture began slowly as colonists built small subsistence farms. But by the early 1800s, the establishment of farms spread rapidly as Connecticut's farmers began to supply food and wool to a rapidly growing nation. Extensive forest lands were cleared, towns were built, and wood was harvested for homes and barns, furniture, and fuel. Thousands of small farms formed the basis for a strong, agricultural-based economy. The many stone walls and decaying chestnut fences found throughout the woods of Connecticut are evidence of this history.

By 1820, only 25 percent of Connecticut was forested. Substantial changes within forest-dependant communities followed, as black bear, elk, mountain lion, white-tailed deer, quail, grouse, and timber wolf disappeared from much of the State. The loss of habitat and extensive harvesting of certain wildlife species, such as beaver and wild turkey, contributed to alter the balance of Connecticut's natural communities.

Forests once thought to be unlimited began to disappear and the State faced declining wildlife populations and timber shortages. Soil erosion from farms increased and silt muddied the water in creeks that once ran clear. Because of the rapid runoff of storm water, springs that previously flowed all year began to dry during the summer.

In spite of these negative environmental impacts, farming continued to flourish until economic, rather than environmental, reasons converged to alter the landscape once again. In 1830, the Erie Canal opened and Connecticut's agricultural zenith passed. Within two decades, the small, stony farms of Connecticut were unable to compete with the larger, more mechanized farms of western New York and the Ohio River Valley.

Much of the farmland became exhausted and unsuitable for continuous agricultural crops and soon was abandoned. Farmers left marginal hillside farms to take city jobs created by the growth of manufacturing. Finally, the opening of the West after the Civil War and the

**Abandoned farm land reverting to forest has been repeated countless times. Since 1825, the acreage of forest land in Connecticut has more than doubled. However, the acreage in farmland has continued to decline to this day.**

added incentive of free land hastened the pace of farm abandonment across New England. Before long, forests began to return to much of Connecticut.

Without human interference, the vegetation of abandoned fields changed. Plants with seeds distributed by wind or birds were the first to germinate. These included many of the more common wildflowers – golden rod, New England aster, Queen Anne's lace, Joe-Pye weed, butterfly weed, and blackberries, for example. Trees more suited to open, grassy patches followed – white pine first, then oak and hickory. Other species such as birch and red maple also established themselves on recently abandoned cropland, the latter species particularly in bottomlands. Then, as the trees grew and formed a protective canopy, more shade-tolerant, deciduous species such as sugar maple, beech, yellow birch, and hemlock, became established in the understory.

At one time, Connecticut's forest were comprised predominantly of American chestnut. But in the early 1900s, the chestunt blight changed the composition of Connecticut's forests forever. This disease struck at a time when forests were being cleared extensively for charcoal production.

Harvesting wood for charcoal boomed between 1880 and 1925. Much of Connecticut's forests were cleared, sometimes more than once, to feed a hungry nation's need to heat homes and manufacturing facilities. When coal was introduced as a cheaper fuel, charcoal production declined. However, the state's forest composition had been significantly altered.

Oak, hickory, and other hardwoods grew in place of chestnut. Often originating as sprouts developing in full sunlight, these trees formed many of the even-aged stands of oak and hickory that covers much of Connecticut's woodlands today.

Over the years, other natural enemies, such as Dutch elm disease, gypsy moth, and storms such as the 1938 hurricane, have continued to alter the face of Connecticut's forests. Human influence, as well, continues to reshape the landscape. Today, the forests once again are being pushed back, not for agricultural use, but from the pervasive march of urban sprawl. What will the forests of Connecticut look like tomorrow?

### HOW WAS THE INVENTORY CONDUCTED?

The USDA Forest Service could not count every tree in Connecticut. Instead, it uses a scientifically designed sampling method. First, aerial photographs of the entire state are studied. A grid of nearly 12,000 points was overlaid on these photos. If forested, each of these points was classified according to the size of the trees. From this information, a sample of 451 plots was selected for measurement by field crews. Included in this sample were 401 plots established during previous inventories. By remeasuring plots, data was obtained on how individual trees grow. Some plots were first established in 1952 and were measured for the fourth time during 1997-1998. Field crews collected information on the number, size, and species of trees, as well as a host of other forest attributes. From the data, reliable estimates were made of the forest resource – its condition and health, and how it is changing over time.

## A New Forest Inventory

Widespread land abuse in the eastern United States during the 1800s led Congress to pass conservation legislation in the early part of the 20th century. Under this authority, the U.S. Forest Service began to conduct periodic forest inventories in all states to provide information about the forest resources of the nation. Now, continuing inventories are conducted throughout the country on many occasions, under the authority of the McSweeney-McNary Forest Research Act of 1928, and more recent legislation that includes the Renewable Resources Planning Act of 1974 and the Renewable Resources Research Act of 1978.

Previous inventories were conducted for Connecticut in 1952[1], 1972[2], and 1985.[3] In 1997-98, the fourth inventory of Connecticut's forests was conducted by the U.S. Forest Service, Forest Inventory and Analysis (FIA) Program, Northeastern Research Station. The Connecticut Department of Environmental Protection, Division of Forestry, cooperated in this effort.

The results of this most recent inventory detail the condition and extent of Connecticut's diverse forests. Highlighted in this report are some of the significant trends that have occurred in Connecticut's forests over the last half century. The reinventory of Connecticut's forest resources involved other associated studies and considerable analysis. Detailed statistical tables have been published separately.[4] In addition, information on Connecticut's private forest-land owners and its primary forest-products industry is available.

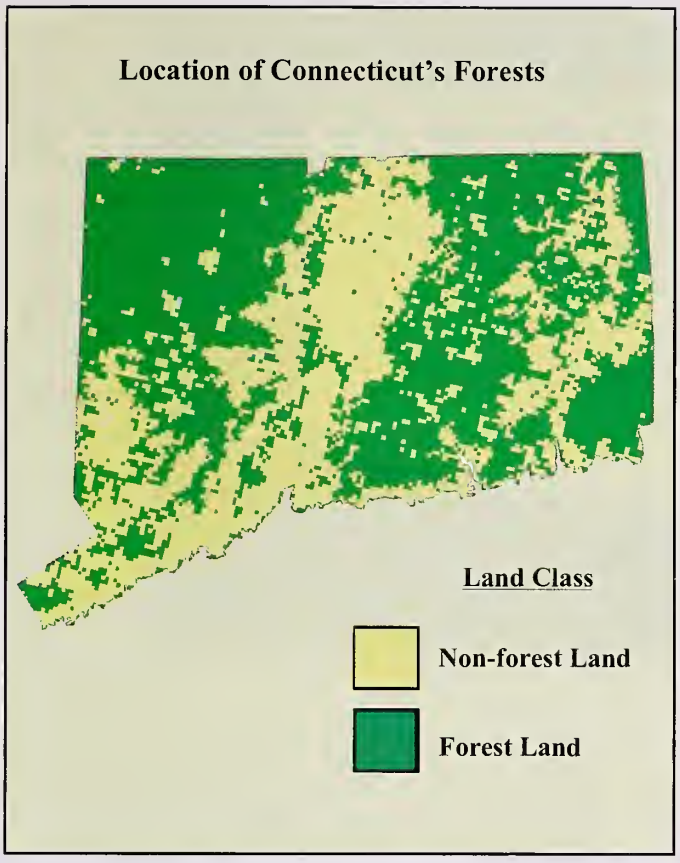
---

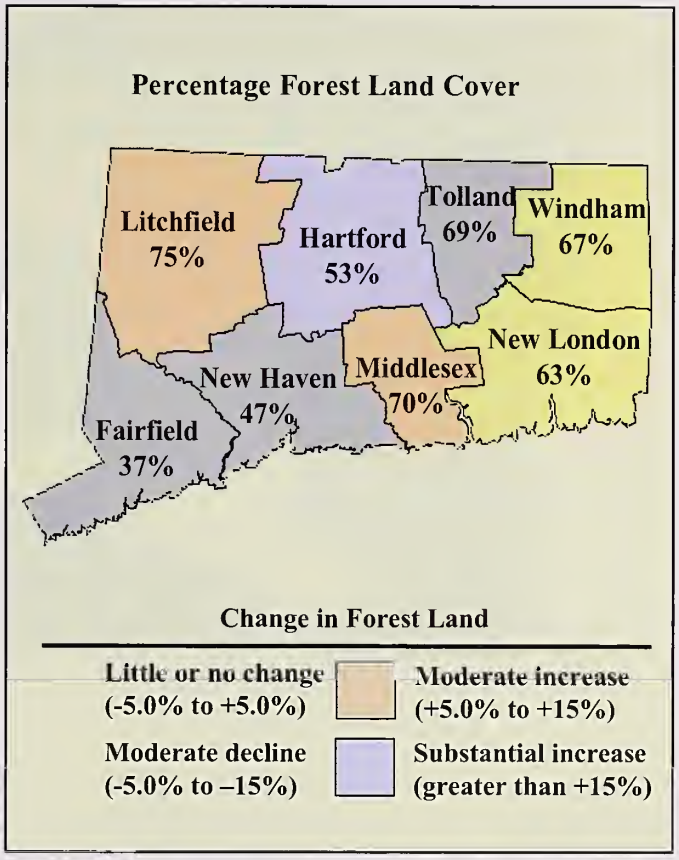
[1]Griswold, Norman B.; Ferguson, Roland H. 1957. **The timber resources of Connecticut.** Upper Darby, PA: U.S. Depart ment of Agriculture, Forest Service, Northeastern Forest Experiment Station. 36 p.

[2]Dickson, David R.; Bowers, Theresa M. 1976. **Forest statistics for Connecticut.** Resour. Bull. NE-44. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 40 p.

[3]Dickson, David R.; McAfee, Carol L. 1988. **Forest statistics for Connecticut – 1972 and 1985.** Resour. Bull. NE-105. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 102 p.

[4]Alerich, Carol L. 2000. **Forest statistics for Connecticut: 1985 and 1998.** Resour. Bull. NE-147. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 104 p.




## Land Base Characteristics and Trends

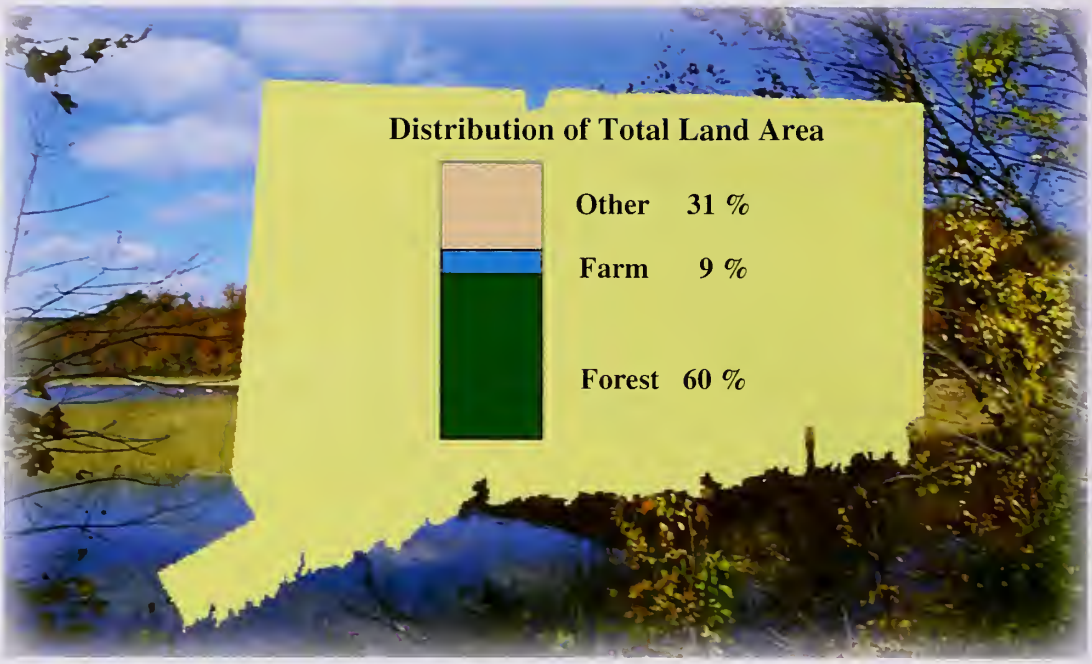
### Connecticut's Forests Today

Forest land dominates Connecticut's landscape. About 60 percent of Connecticut is forested – that's 6 out of every 10 acres. The remaining land is cropland, improved pasture, and other nonforest land such as housing, commercial and industrial facilities, rights-of-way, wetlands, and recreational areas.

These forests of Connecticut sweep northward from Long Island Sound, through the oak- and hickory-dominated woodlands of the Connecticut River Valley and into the northwestern corner of the State. Here, the foothills of the Berkshires and New England Highlands begin, along with an increasing predominance of northern hardwoods.

Litchfield County rests in this northwest corner of Connecticut and is the most heavily forested. More than 75 percent of its land area is covered by forests. Throughout the remainder of the state, the percentage of forest-land cover falls below half only in the more heavily urbanized counties of Fairfield and New Haven. These two counties are the least forested – 37 and 47 percent, respectively. The Upper Connecticut River Valley county of Hartford is 53 percent forested.

Very little change has occurred since the last inventory in the heavily urban and suburban counties of southwestern Connecticut. The small increases or declines have not been significant in these counties. Forest land is being lost, however, in eastern Connecticut. New London and Windham Counties, both with more than




60 percent forest cover, have shown moderate declines in forest land – by 5 and 7 percent, respectively. Most of the increases in forest land have occurred through the center and into the northwestern part of the state. Forest cover in Hartford County, in particular, increased by nearly 23 percent.

Nearly 1.9 million acres of forest land carpet the Connecticut countryside. But this was not always so. As mentioned previously, nearly two-thirds of original forests had been converted to farm land by the middle of the 19th century. Since then, the forests of the State have exhibited their resilience, reclaiming farmland until by 1952, forests blanketed more of Connecticut than at any time in the last hundred years.

Farm land (cropland and pastures) covers 9 percent of Connecticut. The amount of pasture land has stabilized from previous inventories, but cropland continues to decline. The remaining nonforest land includes not only land devoted to housing, but also land associated with urban development: rights-of-way, industrial and commercial facilities, churches, and schools, etc. These account for 31 percent of the land area, which has been increasing steadily in Connecticut.

The trend of reverting farm land, however, began to slow over the last half century. Between the first two inventories in 1952 and 1972, forest land declined from 1.99 million acres to 1.83 million acres. After the post-war baby boom in the 1950s and 1960s, people migrated from the cities. First farm land and then forest land was converted to home sites and other associated uses to accommodate a burgeoning suburban population.

In the 26 years that followed (during which two additional inventories were conducted) forest land increased once again – to 1.85 million acres in 1985, and to 1.86 million acres in 1998. Statistically, these most recent changes are negligible, and forest land can be considered to have remained essentially unchanged.

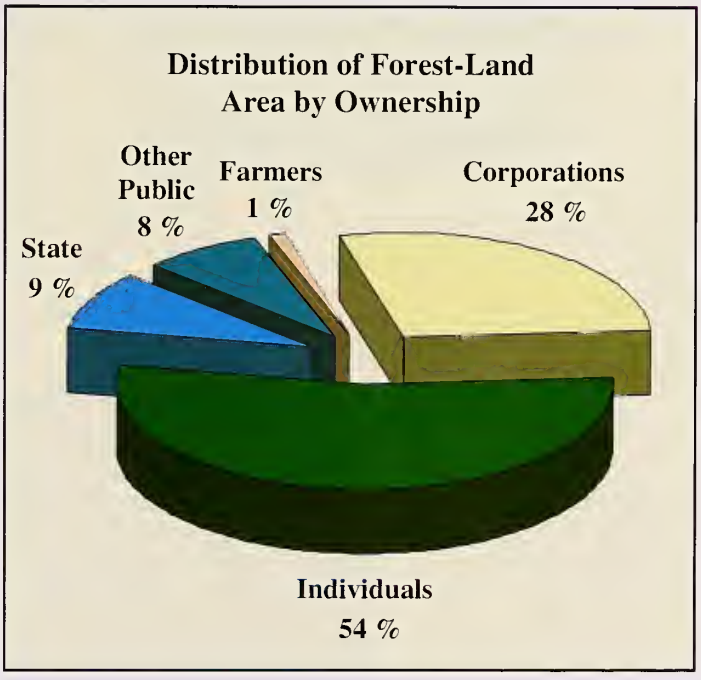
As the forests were returning to Connecticut over the past decades, a land-hungry population was expanding. Since 1972, the amount of new forest land coming from abandoned farms has roughly equaled its loss from development, resulting in a stable balance. But this trend is unlikely to continue. There are no longer large amounts of marginal farm land available to revert to forest. Today, urban development shows little signs of slowing, and pressures are increasing on both farm and forest.

As urban development continues to spread, the trend of a stable forest land base may begin to reverse itself. Connecticut's future forests will be shaped not only by biological factors, but also by social factors: the need for more living space and the increasing demands on the forest brought about by diverse attitudes of the populace, attitudes that may extend well beyond the borders of Connecticut.

## People and the Forest

Population size and how people live on the land are significant forces in shaping the forest. Between 1953 and 1998, the population of Connecticut grew 51 percent, to 3.3 million people. Today, Connecticut is the fourth most densely populated state in the nation. Yet it also ranks 13th in percentage of forest cover. Few places have as many people living among so much woodland.

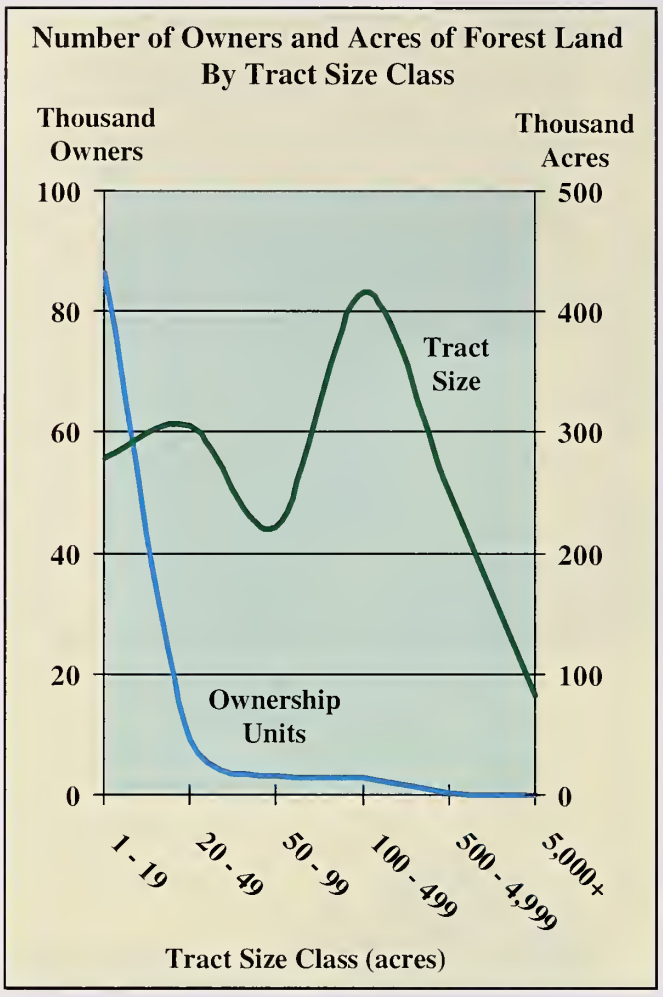
Altered perceptions about how the State's forest should be managed have caused more forest land to be reserved for public use. Public land is the primary location for forest-related recreation across much of the state. In 1985, 14 percent of the forest land base was publicly owned, but by 1998 that proportion had risen to 17 percent. County and municipal lands, in particular, increased by nearly 25 percent – from 86,000 acres to more than 107,000 acres. The amount that the State owns and manages has remained relatively stable, increasing by only 6,000 acres. Resource management decisions about the public use of Connecticut's forests are beginning to be made at the local level.




Private forest-land owners comprise the bulk of owners, controlling 83 percent of the State's forests. These landowners are farmers (1%), individuals (54%), corporations (28%)(other than forest-industry owned lands), and other miscellaneous groups, such as hunting clubs and land trusts. The amount of forest land they own remained essentially unchanged, decreasing by only 2 percent from the previous inventory. However, the responsibility for managing Connecticut's forest land within this private landowner group has shifted in recent decades.

Some changes have come from forest industry divestment of land they own. Forest industries are companies or individuals that operate a primary or secondary wood-manufacturing facility. The size of this group has decreased steadily until by 1998, they controlled only a negligible amount of forest land. However, an increase in corporate ownership other than forest industries has accounted for the largest shift. In 1985, companies owned only 350,000 acres of forest land. That had increased nearly 50 percent by 1998, to 522,000 acres. Conversely, the area owned by farmers declined from 153,000 to only 19,000 acres.

The proportion of forest land owned by nonindustrial private forest-land owners has decreased since the previous inventory, yet this category of owners still predominates. There are 102,000 of these owners in the State. The size of their holdings vary considerably, which strongly influences motives and management activities. Owners of large tracts of forest are more likely to manage for timber products. Private and public water utilities also own some of the largest forested tracts in Connecticut, but they manage their lands very differently. Owners with tracts of forest land greater than 100 acres account for only 3 percent of all owners, but collectively they control 48 percent of the forest.




Small tracts are usually home sites, and their owners exhibit a variety of objectives that cover the full spectrum of management objectives, from the purely economic to aesthetic enjoyment and safeguarding their woodland for posterity. Owners of small tracts comprise the largest number of landowners in Connecticut.

Although many in number, owners with small holdings account for a small portion of the forest land base. Almost 85 percent of the private forest landowners hold tracts less than 20 acres. Three-fourths of the private forest landowners own fewer than 10 acres and they collectively own only 9 percent of all forest land in the State.

The number of these landowners, however, is on the rise. All private forest landowners with fewer than 50 acres of forest land have increased by 68 percent since 1975.

The large number of landowners with small tracts of forest land highlights a growing concern throughout the northeastern United States – forest fragmentation.

Population growth often is accompanied by increases in the expansion of residential and urban land uses and the effects of this urban expansion on forest land are just beginning to be understood.

Forest fragmentation, or the division of contiguous forest land into smaller or more complex patches, has the potential to change local hydrology, reduce forest interior habitat, increase site disturbances, and promote the invasion of exotic plant species. Wildlife biologists have found that breaking up large tracts of forest into many smaller forests by roads, homes, and other related land development can be detrimental to many species of wildlife.

To help answer some important questions about changes to the Connecticut landscape, a special study involving aerial photo interpretation was initiated. By looking at forest inventory data in relation to patch size and nearest land use, scientists have gained a better understanding of the extent of fragmentation and effect on the forest resource.

In Connecticut, the most commonly occurring forest patch size is between 250 and 1,250 acres. Litchfield County contains the greatest proportion (16.8 percent) in patches greater than 2,500 acres. Such large, contiguous forest patches provide unique habitat and ecological stability for certain animal and plant species and the data suggest that forests of northwest Connecticut are less fragmented than elsewhere.

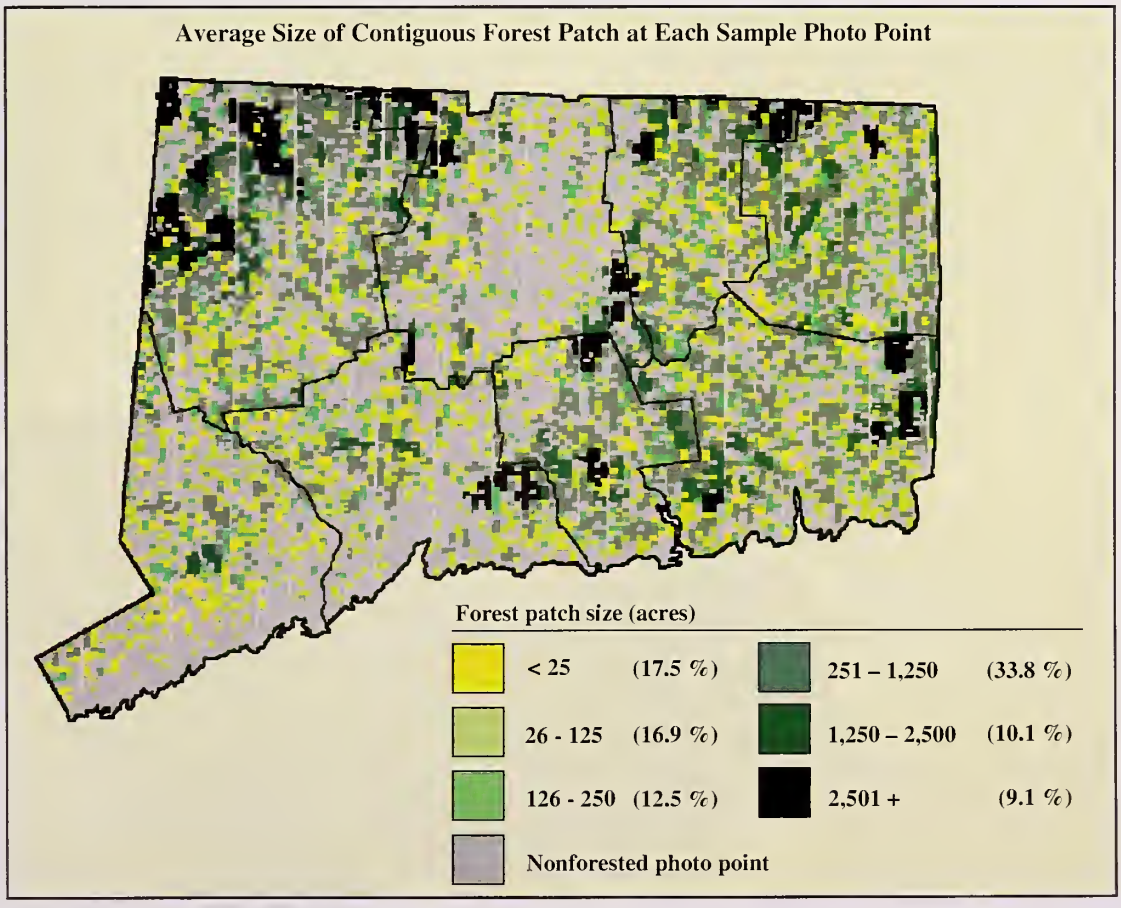
The percentage of urban land is slightly more than 12 percent in Litchfield County compared to the state average of 26 percent. U.S. Bureau of Census data for 2000 shows that population density in Litchfield County is also low, about 198 people per square mile. However, that density has increased by nearly 5 percent over the last 10 years, and growth such as this will influence the structure and distribution of forest land in the future.

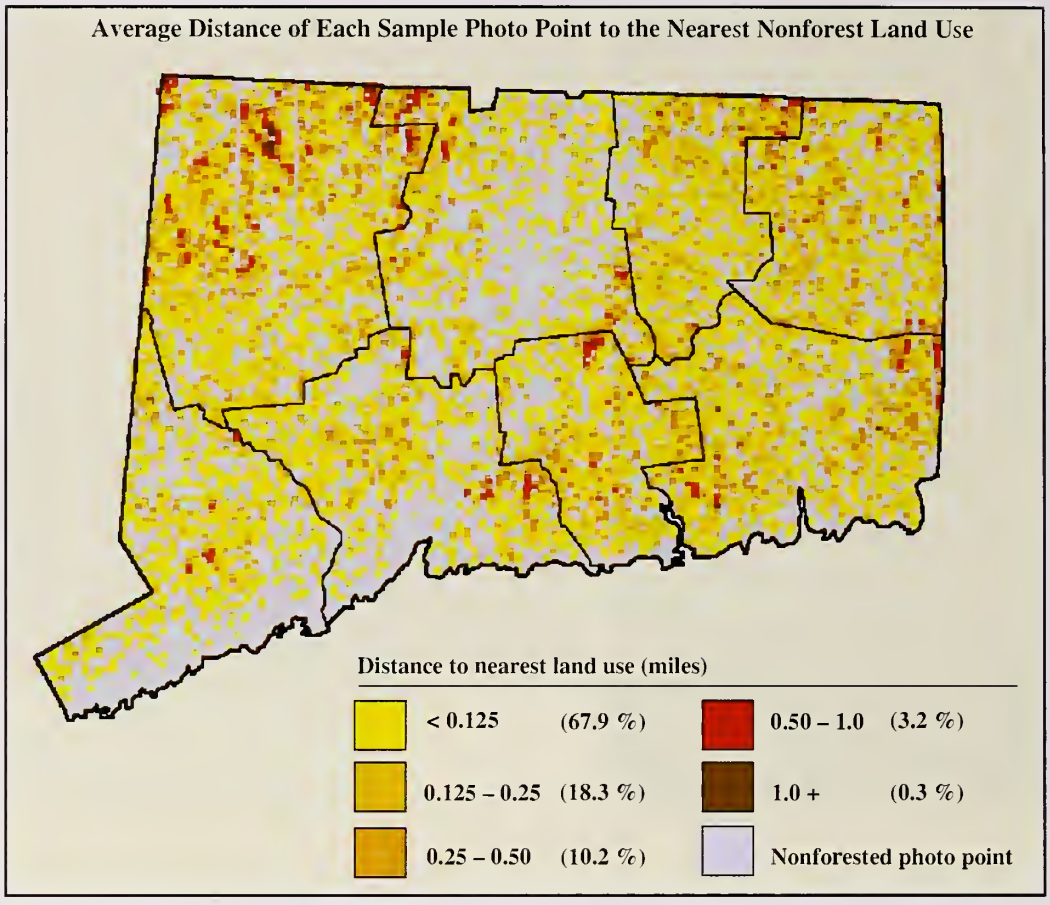
Small forest patches provide less interior forest habitat and may increase the forest's susceptibility to diseases and to the invasion by exotic plant species. Nonforest land and these smaller forest patches predominate in the southern and central areas of the State.

The forests of Fairfield County are more highly fragmented. Nestled in the southwest corner of Connecticut, it has the least amount of forest land in relation to total land area, with the remainder of its land mostly residential. Nearly 39 percent of the total area in the county is residential land, which accommodates a population density of more than 1,400 people per

Color infrared aerial photography highlights the fragmentation of forest land due to farmland, urban development, and roads in Columbia, CT. Currently, studies are being conducted to characterize this distribution and fragmentation of forest land. Forest fragmentation indicators were interpreted from aerial photographs on a grid of points across several northeastern states, with a sampling intensity of one plot for every 285 acres. In Connecticut, this involved overlaying a grid of 11,417 points on 1:40,000 aerial photography. Each forested point was analyzed for three fragmentation indicators: 1) the size of the contiguous forested patch containing the point; 2) the distance from the point to the nearest developed land use; and 3) the type of nonforest land use encountered closest to the forested point. For a more complete description of methods, refer to Reimann and Tillman (1999).[5]

[5]Riemann, Rachel; Tillman, Kathy. 1999. **FIA photointerpretation in Southern New England: a tool to determine forest fragmentation and proximity to human development.** Res. Pap. NE-709. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 12 p.





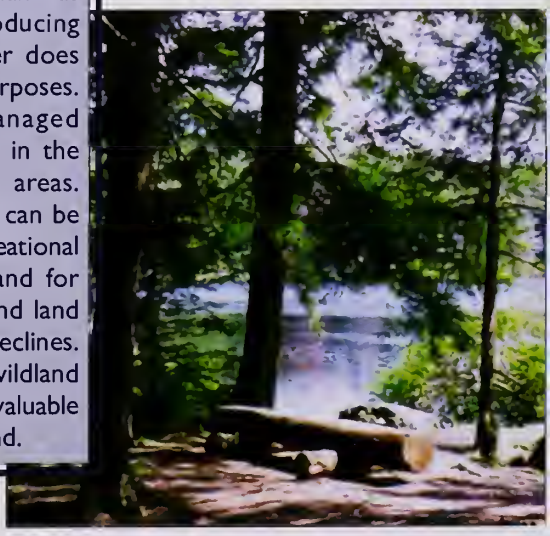

square mile. Forest land here occurs in relatively small patches – more than 20 percent of the sample points were in forest patches smaller than 2.5 acres in size.

In the entire state, more than 86 percent of the sample points were within 1/4 mile of a forest edge, and nearly 68 percent were within 1/8 mile. In Fairfield County, more than 80 percent were within 1/8 mile of the forest edge. In contrast, Litchfield County appears to have the greatest amount of interior forest, based on distance to the nearest nonforest land use.

The potential effects of adjacent nonforest land on forest composition and structure depends, in part, on the type of land use encountered at the forest/nonforest interface. In Connecticut, residential land was the most common land use found closest to the sample points, and agricultural land was the second most common – 60 percent and 24 percent, respectively. The proximity to developed land can subject forest patches to human influence. It also can increase the amount of edge habitat, influencing both floral and faunal species composition.

Urban and agricultural lands have the potential to influence bordering forest patches in different ways. The shape and abruptness of the transition from forest to nonforest land is related to the type of adjacent land use. Seed dispersal by animals and wind, as well as local climate and moisture dynamics, may be affected by the nonforest land uses surrounding a forest patch.

The classification of timberland as forest land capable of producing commercial crops of timber does not limit its use for other purposes. Today, timberland is managed differently than it has been in the past, especially in suburban areas. Privately owned timberland can be an important source for recreational opportunities, as the demand for outdoor experiences rise and land available for these activities declines. It also can be preserved as wildland for posterity. All of these are valuable commodities from timberland.



These and other biotic and abiotic factors affect the composition and structure of forest patches. Some studies have shown that forests in urban areas generally have fewer understory species, lower stem densities, and greater proportions of non-native plant species than similar forests in rural and agricultural areas. Research is currently under way to better define the relationship between land-use context, forest fragmentation, and forest structure and health. Once these links are better understood, decisionmakers will be able to use forest fragmentation information to make informed development choices.

Forest types are based on relative stocking and are assigned according to the most dominant and codominant trees on the site. Forest-type groups are composed of a diverse collection of specific forest types. For example, the northern hardwood forest-type group can range from pure stands of black cherry to mixed stands containing maple, beech, birch, and other deciduous species, with no single species dominating the composition.

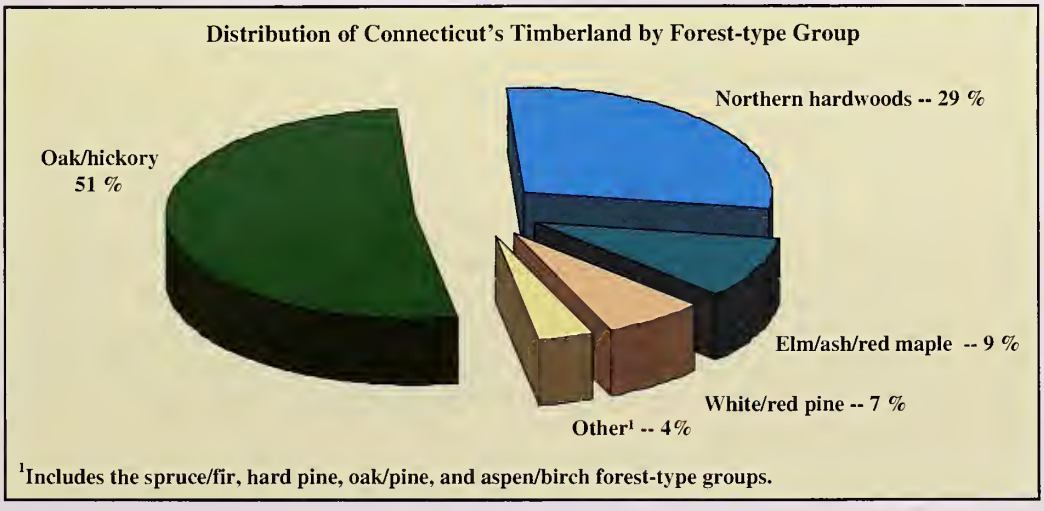
## Timberland

An important component of forest land is timberland, which is forest land that is capable of producing commercial crops of timber. In Connecticut, timberland accounts for 91 percent of all forest land. In 1972, there were 1.81 million acres of timberland. That declined to 1.78 million acres by 1985, though the decline was not statistically significantly. By 1998, timberland had declined to 1.70 million acres – again, not significantly different. In nearly 25 years, the amount of forest land potentially available for harvesting has shifted by only 110,000 acres.

Noncommercial forest land, the other component of forest land, includes reserved forest land, unproductive forests, and urban forests. Harvesting for timber products on these lands is restricted administratively or is not economically practical. Examples of noncommerical forest land include parks, wildlife preserves, and mountaintops and wetlands with poor growing conditions – all of which account for only 9 percent of forest land in Connecticut.

The structure of Connecticut's timberlands vary with the abundance and character of its forests. One common characteristic that helps describe the landscape is the distribution of forest-type groups. Connecticut forests contain a mixture of forest types that are distributed throughout the State, each helping to define the character of forests that occur across the hills and river valleys. Their distribution depends on terrain position, soil depth, climate, and other factors.

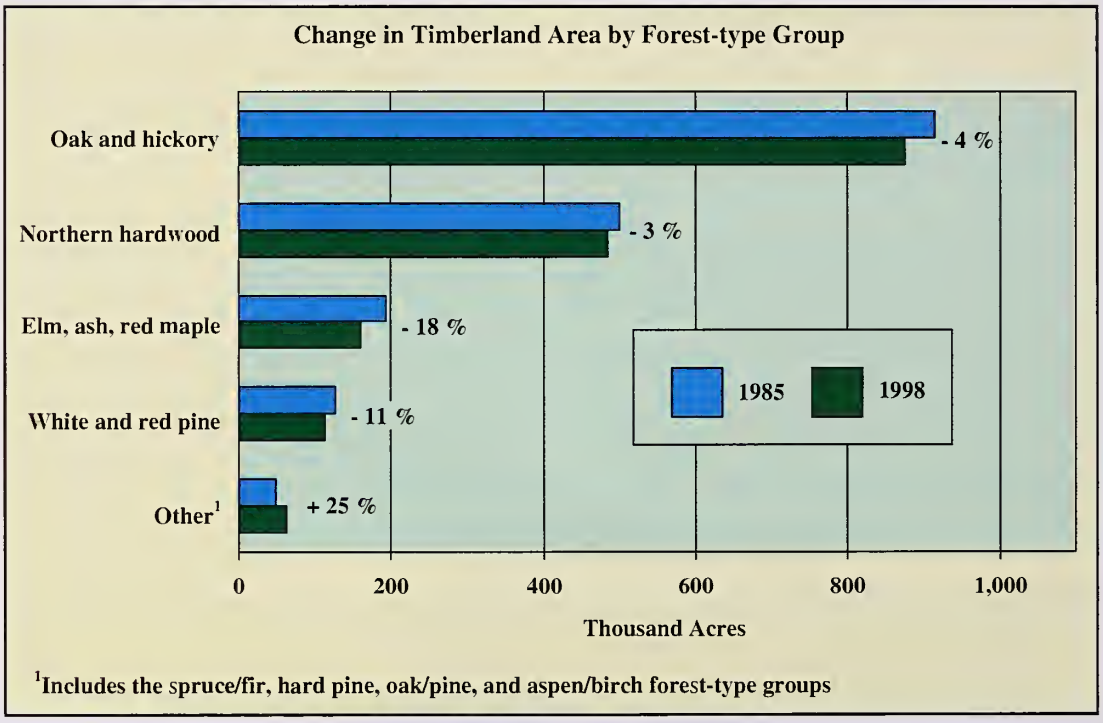
Of the nearly 1.7 million acres of timberland in Connecticut, about 51 percent is in the oak/hickory forest-type group. The next most abundant forest-type group is northern hardwoods, which accounts for 29 percent of timberland. Northern hardwoods are commercially the most valuable forest-type group, and one of the more aesthetically pleasing. Other forest type groups individually account for no more than 9 percent of the timberland base. But, knowing which are the most abundant forest types completes only part of the picture.



**Area of Timberland by Forest-type Group and County**
**(in thousands of acres)**

| County | White and red pine | Oak and hickory | Elm, ash, red maple | Northern hardwood | Other types[1] | All types |
|---|---|---|---|---|---|---|
| Fairfield | 6.9 | 49.0 | 11.1 | 25.2 | 0.0 | 92.2 |
| Hartford | 11.7 | 105.6 | 26.7 | 66.4 | 20.0 | 230.4 |
| Litchfield | 53.9 | 177.6 | 25.3 | 162.5 | 7.2 | 426.5 |
| Middlesex | 1.7 | 99.4 | 19.6 | 42.0 | 0.0 | 162.7 |
| New Haven | 9.8 | 67.1 | 14.5 | 52.4 | 0.0 | 143.8 |
| New London | 3.5 | 172.5 | 35.0 | 42.1 | 9.3 | 262.4 |
| Tolland | 14.1 | 84.5 | 11.8 | 62.8 | 5.6 | 178.9 |
| Windham | 12.0 | 120.2 | 15.5 | 31.3 | 20.1 | 199.0 |
| Total, all counties | 113.7 | 875.8 | 159.6 | 484.7 | 62.3 | 1,696.1 |

[1]Includes spruce/fir (7.0 thousand acres in Litchfield County), hard pine (5.9 thousand acres in New London County), oak/pine (24.2 thousand acres in Hartford, Litchfield, New London, and Windham Counties), and aspen and birch (25.2 thousand acres in Hartford, Tolland, and Windham Counties).




Spatial and temporal information about different forest types also helps illuminate prevailing forest conditions. For example, most of the white/red pine forest-type group can be found along the northern edge of the state, concentrated mainly in Litchfield County. Any spruce and fir that can be found will most likely occur here as well. The hard pine group, which includes the eastern redcedar forest type, is found primarily in New London County. Aspen/birch forest-type group is found in Hartford County; the elm/ash/red maple forest-type group is distributed evenly throughout Connecticut.

While the oak/hickory group predominates in every part of Connecticut, it begins to lose its dominance in the northwestern corner of the state. In Litchfield County, oak and hickory forests account for 43 percent of the timberland area, while northern hardwoods account for 38 percent – almost an equal distribution. Conditions in this corner of the state are sufficiently different from the rest of Connecticut that a different kind of forest can be found, one which includes the possibility of finding rarer species, such as spruce and fir.

While the oak/hickory forest-type group continues to prevail throughout the state, its area has been decreasing for many years. Oak forests once flourished because of prevailing timber harvesting practices and other disturbances associated with wildfires. Oaks are more resistant to fire damage due to their bark, and resprout more easily than other species after a fire. Oaks also benefit from openings that result from timber harvests. At the time of the first inventory in 1952, there were 2.7 million acres of oak and hickory. That area declined 57 percent to 1.155 million acres in 1972, 21 percent to 913.8 thousand acres in 1985, and 4 percent to 875.8 thousand acres in 1998.

The white/red pine, and elm/ash/red maple forest-type groups have declined as well. During the previous inventory, both showed an increase. At that time, white pine had exhibited a reversal from the devastation of the 1938 hurricane. Elm, ash, and red maple had increased largely due to the continued abandonment of farmland. The species in this forest type are some of the first found in old fields, particularly in the more moist, bottomland sites. Since that time, however, farmland abandonment has declined, as have these pioneer species.

The continued maturing of Connecticut's forests, recurring apprehension about over-harvesting and high-grading, and the control of wildfires have resulted in a lack of disturbance that once promoted oak regeneration. That, as well as urban expansion, tree mortality from gypsy moth, and deer browse of established seedlings, have contributed to the decline of the oak-dominated forests of Connecticut.

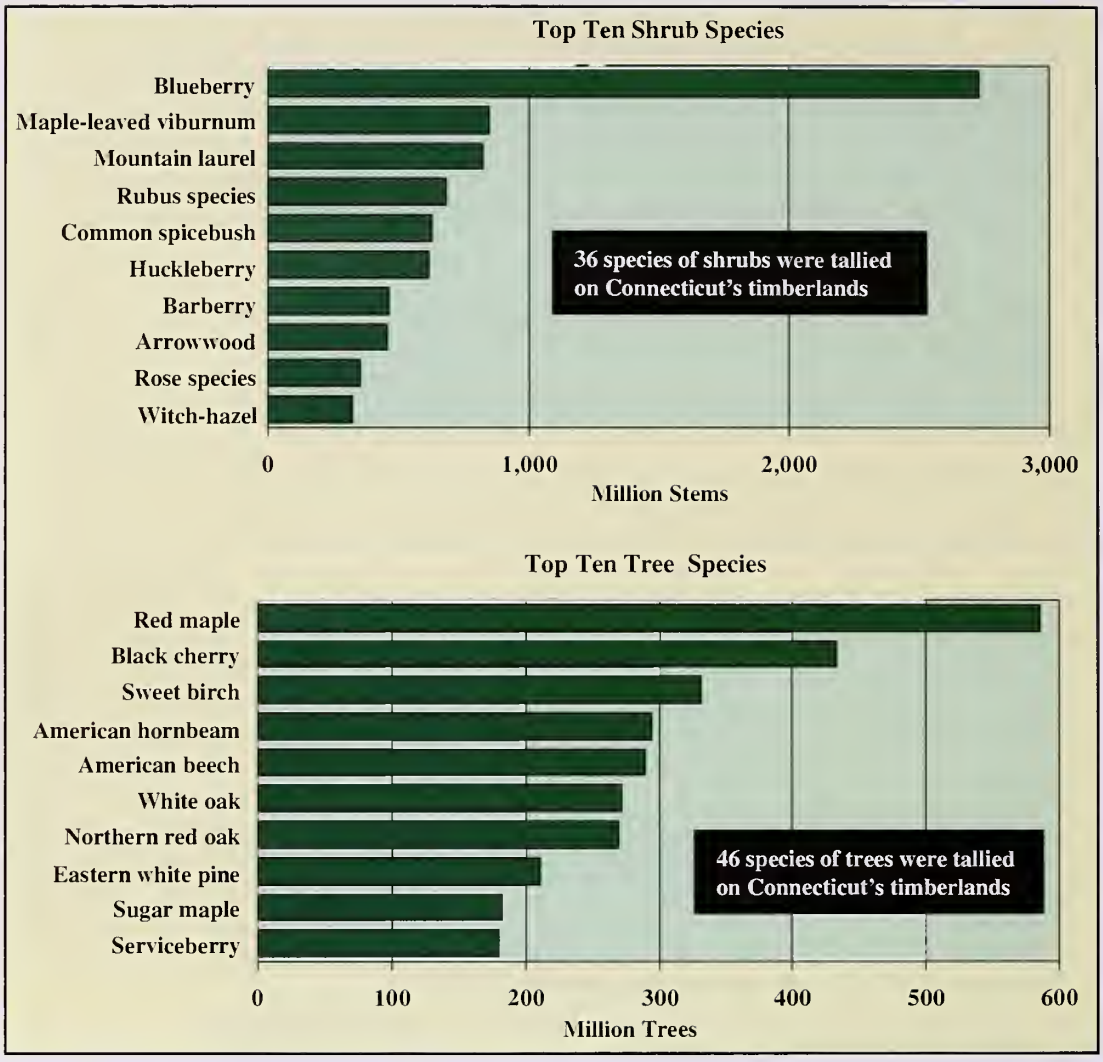
## Composition and Structure of the Forest

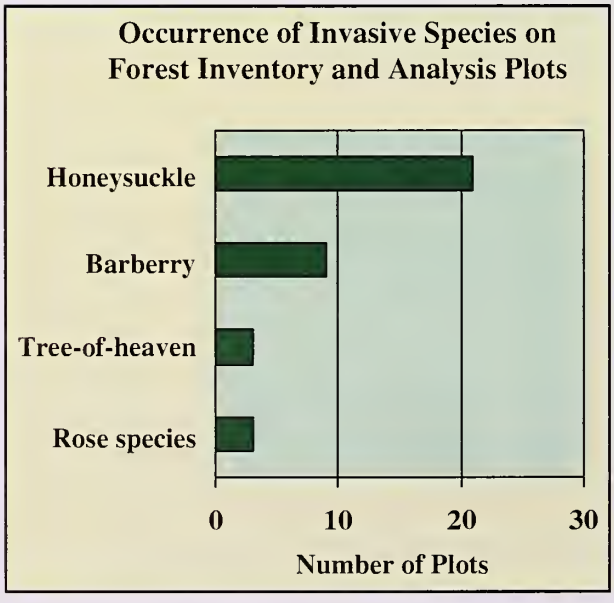
### Species Diversity

Connecticut's forests are interwoven with a rich tapestry of biological diversity. All kinds of forest vegetation – living trees and shrubs, dead and downed woody stems, microflora, lichens, mosses, and herbaceous plants – contribute to a diverse habitat for wildlife. This diversity supplies forage, shelter for forest-dwelling wildlife and wildlife that inhabit forest-dependent aquatic systems, and the invaluable edge characteristics that exist between forest and other land uses.

Species diversity is evident in the number of different species encountered. The forest inventory identified 82 different tree and shrub species. Among shrub species, blueberry clearly predominates – the 2nd through 10th most abundant shrub species are found in nearly equal abundance. Eastern white pine is the most common softwood tree species encountered in terms of numbers of stems. But Connecticut's forests are flush with a variety of hardwood tree species that bring richness to the forest landscape, the most common of which are red maple, black cherry, and sweet birch.

However, not all species are welcome. Connecticut contains a variety of invasive or potentially invasive plants. These are species that, either by accident or intentionally, tend to replace other species and become dominant, reducing species diversity. Some of the more widespread in Connecticut include tree-of-heaven, Japanese barberry, Asiatic bittersweet, autumn olive, winged euonymus, honeysuckle, and multiflora rose.




During the 1998 inventory, several invasive species were encountered on 268 of the forested field plots. Honeysuckle and barberry were found to be the most pervasive. Four of the species combined – honeysuckle, barberry, tree-of-heaven, and rose species – were the predominant invasive species encountered on the forested plots.

While a few notable species – bittersweet, autumn olive, euonymus, and Norway maple – were not encountered, they can still exist in profusion. Frequency of encounter is a function of sampling intensity and natural growing conditions. Invasive species frequently found in open fields, riparian areas, or shorelines, are less likely to be encountered in forest inventories.

## Timber Volume Changes

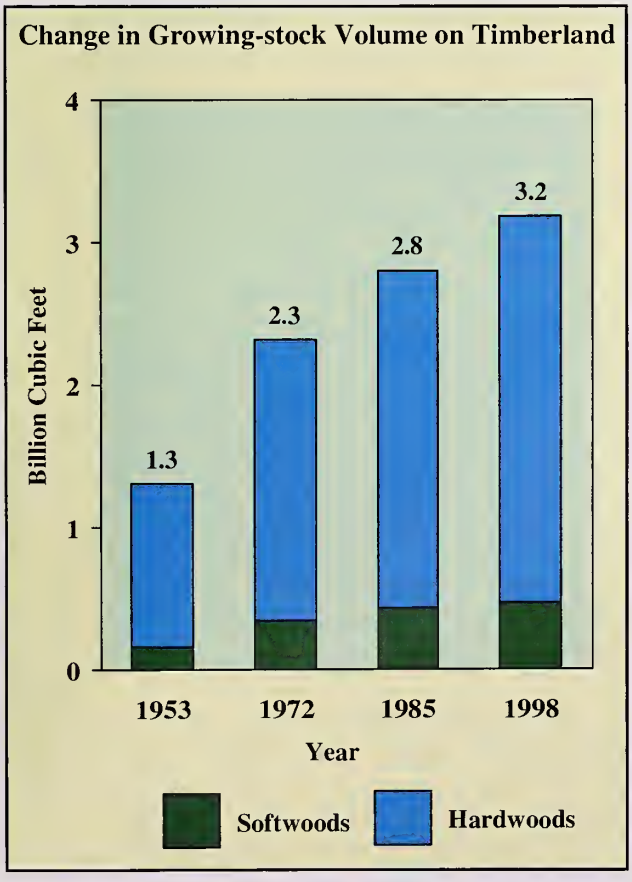
The volume of trees in Connecticut has been increasing steadily for more than half a century. At the time of the first inventory, there were 1.3 billion $ft^3$ of growing stock. By 1972 and 1985, that amount increased to 2.3 billion $ft^3$ and 2.8 billion $ft^3$, respectively. But during the most recent inventory, Connecticut's growing stock increased to 3.2 billion $ft^3$. That's nearly a 14 percent increase since the last inventory, and more than double what was there in 1952.

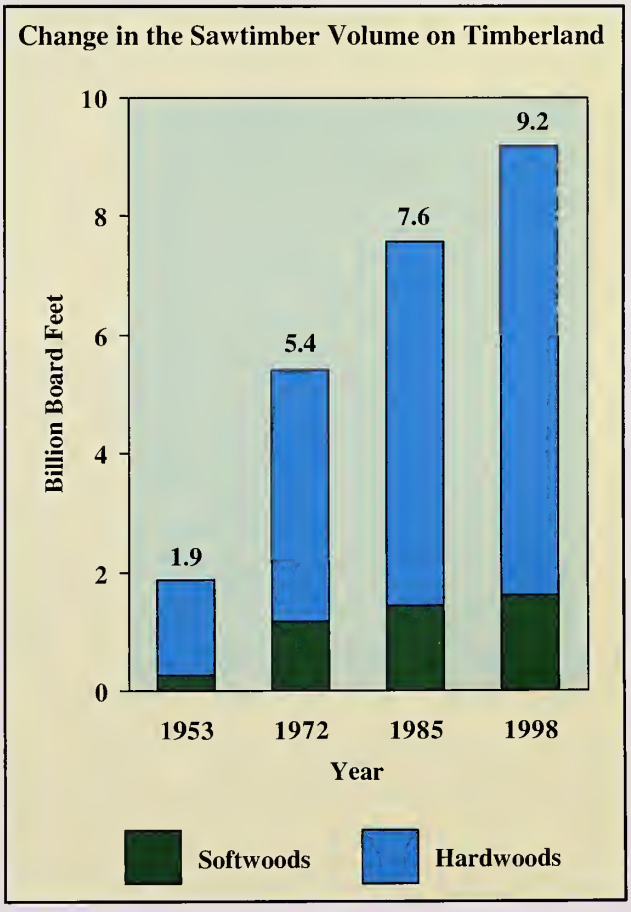
About two-thirds of the total volume contained in Connecticut's forests is comprised of broadleaf and deciduous, or "hardwood" species. The remainder is comprised of coniferous, or "softwood" species. At first, a small increase of softwood species occurred, but softwood volumes have remained stable over the past few decades. Almost all of the recent increases in growing-stock volume have been due to increases in hardwood species.

The same trend can be found in sawtimber. Between 1952 and 1972, there were significant increases in softwood sawtimber volume. Since then, sawtimber volume has been steadily increasing almost entirely due to hardwood sawtimber. Between 1952 and 1972, sawtimber volume increased from 1.9 billion board feet to 5.4 billion board feet – nearly tripling. More recent increases have not been so extreme: 41 percent between 1972 and 1985, and 20 percent between 1985 and 1998.

Growing-stock volume is the cubic-foot volume in trees 5 inches (d.b.h.) and larger, between a 1-foot stump and a 4-inch top diameter outside the bark, or until the stem breaks into branches before that point.

Sawtimber volume is board-foot volume: for softwoods – it is in trees 9 inches d.b.h. and larger, to a 7-inch top diameter outside the bark, or until the stem breaks into branches before that point. For hardwoods, it is in trees 11 inches d.b.h. and larger, to a 9-inch top diameter outside the bark, or until the stem breaks into branches.

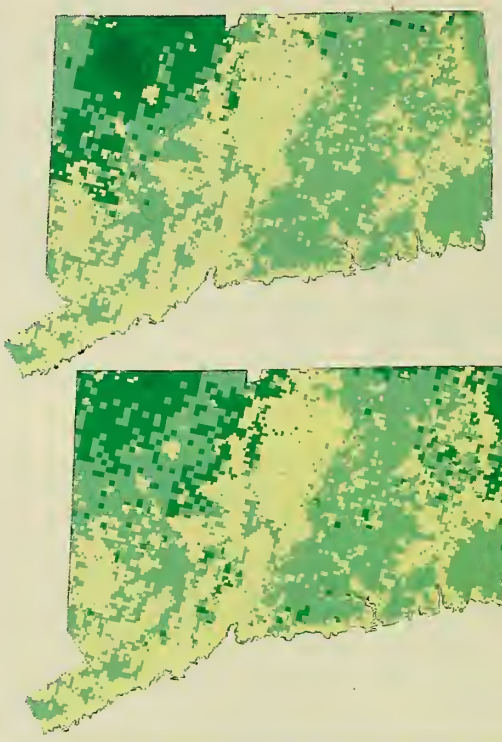


### HOW WERE THESE MAPS CREATED?

These maps were created using an estimation procedure called sequential Gaussian conditional simulation. Forested plots were used as "known" data and we predicted values at unknown locations using information found at these known locations. For example, an unknown area near a group of plots with large amounts of hemlock probably has high amounts of hemlock as well. Using this principle, we made predictions at every location on the map. The values are actually "relative importance," or the relative proportion of that species' basal area.

**Species Distribution of Selected Softwood Species**




## Distribution of Tree Species

The forests of Connecticut contain a remarkable mixture of tree species. The distribution is determined by each species' suitability to site conditions and past disturbance.

Site conditions include attributes such as soil type, drainage, terrain, and competition from other species. Conditions also vary by the numbers and types of mammals present. Deer, mice, and squirrels influence the composition of the forest by browsing seedlings or consuming available seeds of preferred species. Disturbance is caused by natural events and human activity: fire, windthrow, insect outbreaks, harvesting, and land clearing followed by abandonment. These and other factors acting together over time have shaped Connecticut's forests.

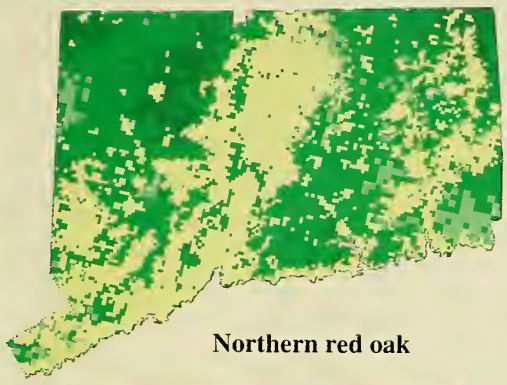
Hemlock is the most abundant softwood species in terms of growing-stock volume and is concentrated in the northwestern corner of Connecticut. Extracts from its bark produced a tanning agent called tannin and once played a key role in the manufacture of natural leathers. Over the years, tannin was replaced by synthetic agents and the demand for hemlock bark subsided. Likewise, hemlock was not a preferred species for charcoal production. Because of these factors, and also because of fewer markets for hemlock framing lumber, the harvesting of hemlock declined.

However, since the previous inventory, hemlock growing-stock volume has remained essentially unchanged, unable to keep pace with the general increase in growing-stock volume for all species. In 1985, its growing-stock volume was 216 million $ft^3$. By 1998, it had increased to 225 million $ft^3$ – only a 4 percent increase. During that time, hemlock sawtimber volumes declined. The hemlock wooly adelgid probably has contributed to keep hemlock volume increases down.

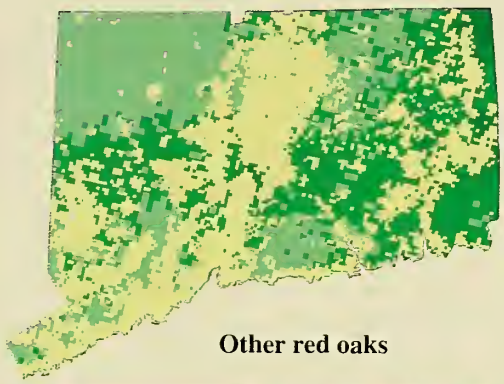
The other major softwood species in Connecticut – eastern white pine – can be found growing abundantly along the rolling hills adjacent to the Massachusetts border in about the same region as hemlock. It grows best on the deep, well-drained fertile soils of glacially deposited sands or gravels, and in cooler climates. These conditions are common here and to a certain extent limit competition from hardwoods. But some of the highest quality stands also can occur on pockets of land that were once cleared for agriculture – land that might be found in the far eastern portion of the state along the Rhode Island border.

Since the previous inventory, white pine growing-stock volume has increased from 167 million $ft^3$ to 214 million $ft^3$ of growing stock – a 27 percent increase. Its sawtimber volume increases have been even greater – 33 percent. Left to flourish after the extensive damage caused by the 1938 hurricane, much of the white pine

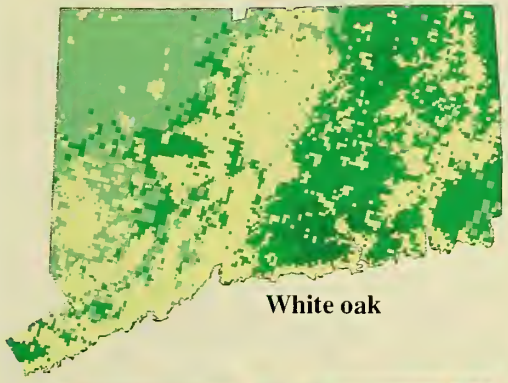
## Species Distribution of Selected Hardwood Species



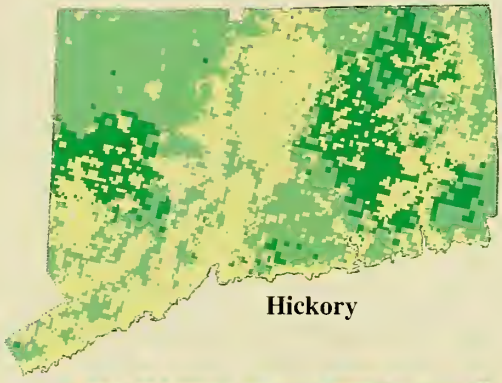
Northern red oak



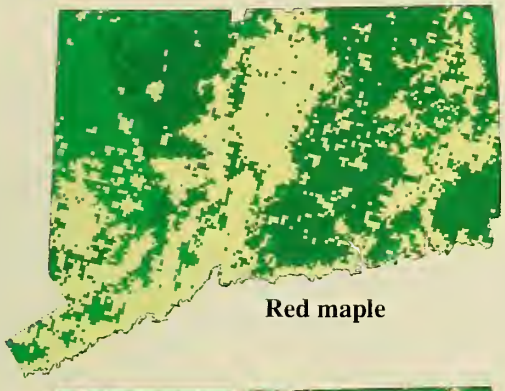
Other red oaks



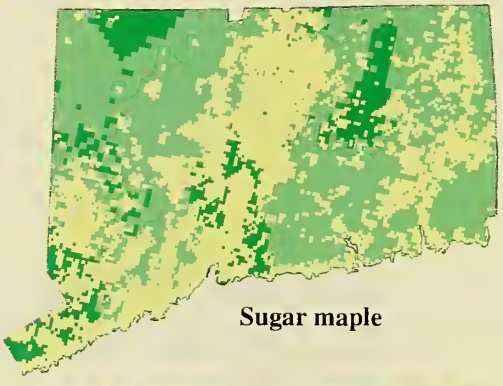
White oak



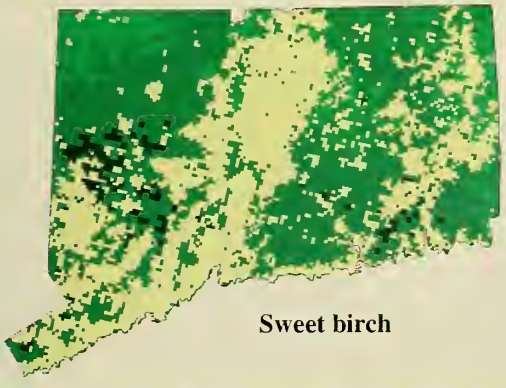
Hickory



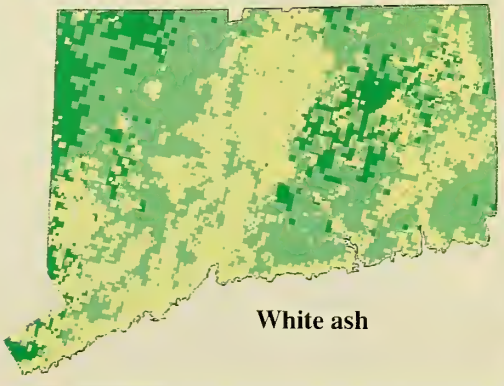
Red maple



Sugar maple



Sweet birch



White ash

that remained has now grown into sawtimber-size trees. Generally, increases of growing stock volume have been facilitated by the vestiges of farm abandonment.

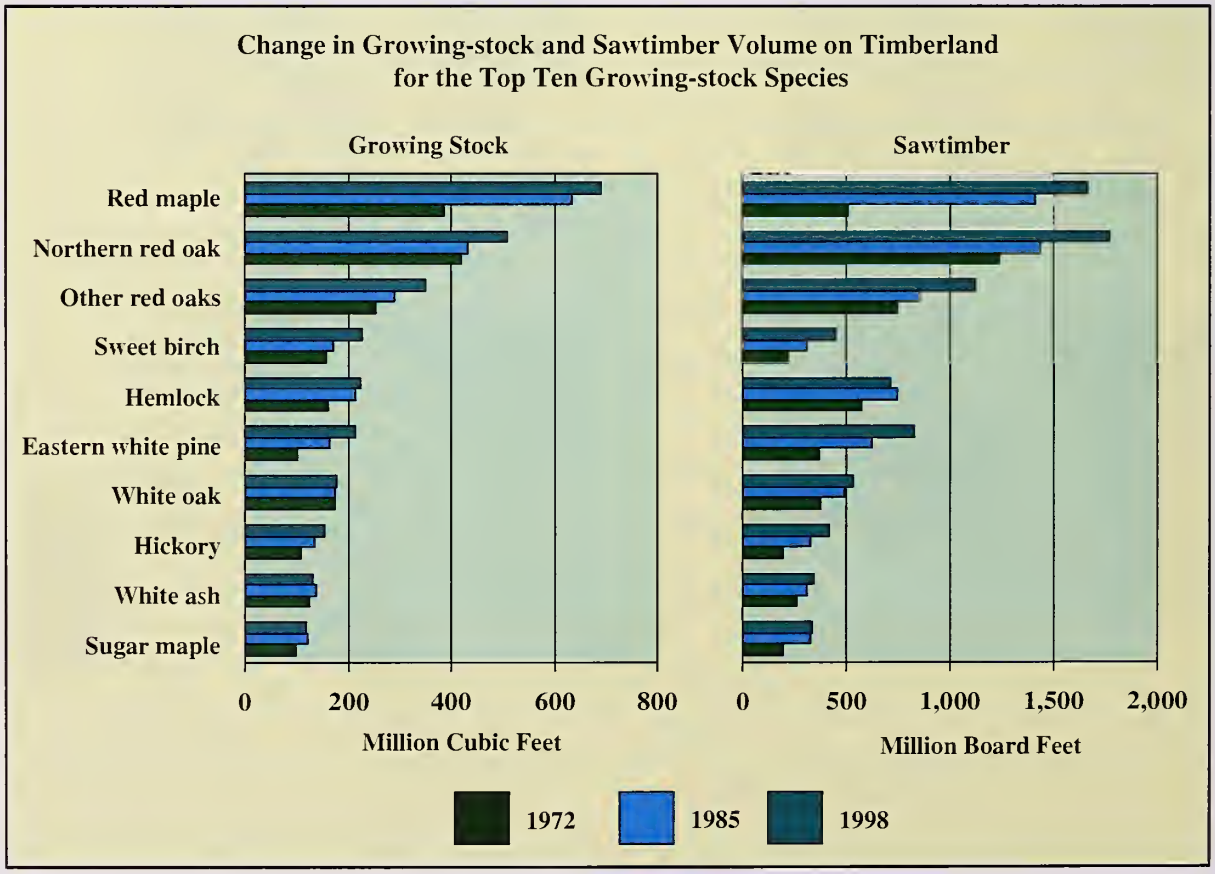
Northern red oak and white pine commonly are found growing in association with one another and their distributions are somewhat similar. Northern red oak is a major component of the oak/hickory forest-type group and also an associate of the northern hardwoods forest-type group, both of which are found in almost equal distribution in northwestern Connecticut. At one time northern red oak was the leading species in both growing-stock and sawtimber volume. It now ranks second to red maple in growing-stock volume but remains the leading sawtimber species, with a volume that has increased by 16 and 24 percent over the past two inventories.

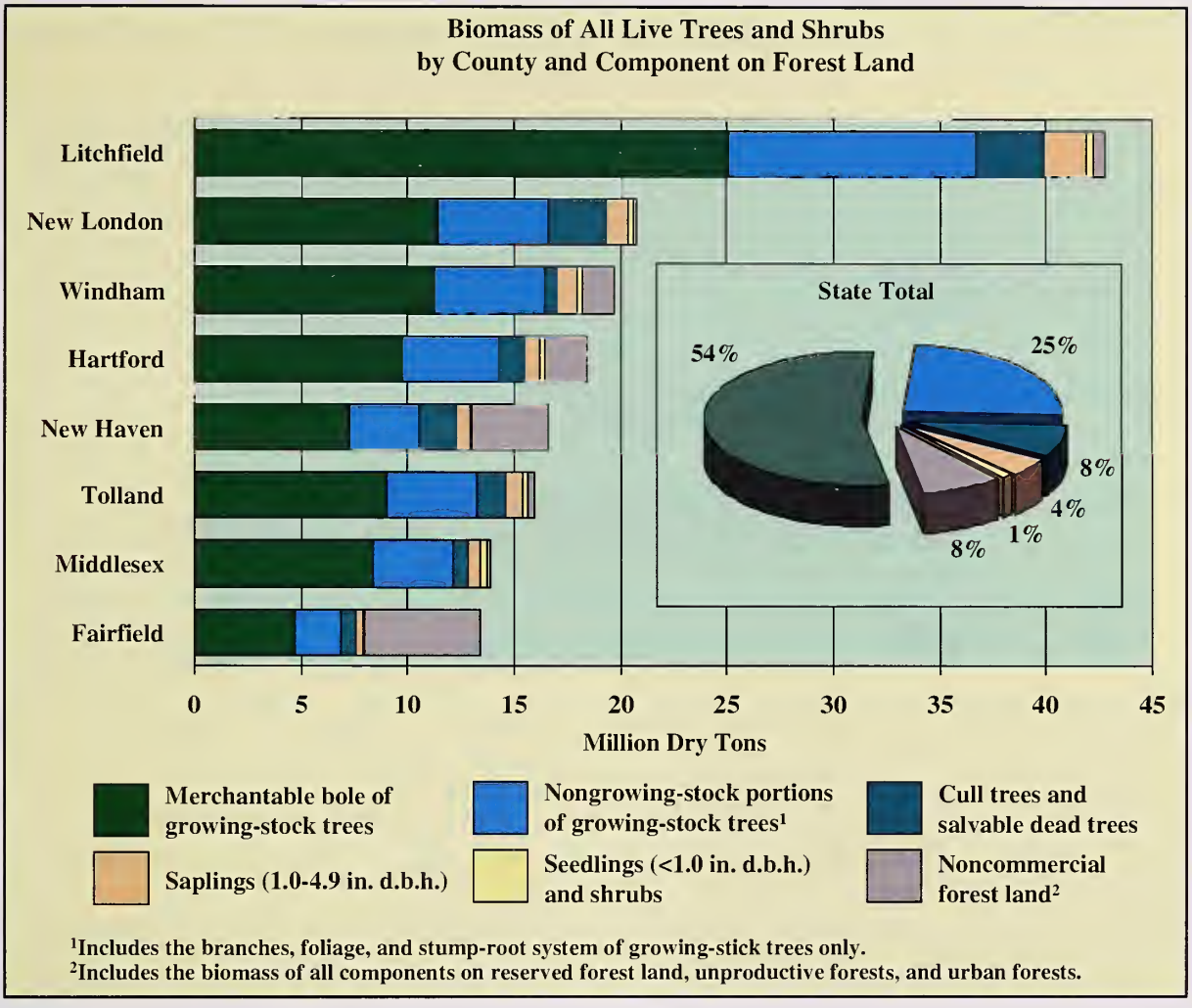
In addition to northern red oak, white oak and three other species of the red oak subfamily were also tallied. These other red oaks include scarlet oak, pin oak, and black oak. Some chestnut oaks were encountered, but in such small amounts that they were included under other hardwoods. Red oaks (other than northern red oak) usually are found distributed along the southern tier of Connecticut counties in the well-drained upland soils.

There is a small pocket in the very northeastern corner that extends into the state from Rhode Island. This pocket is most likely scarlet oak, which is found on dry ridges and south facing slopes. Other red oaks consistently have increased in both growing-stock and sawtimber volumes.

White oak exists throughout much of eastern Connecticut but is heavily concentrated in Middlesex County, along the banks of the lower Connecticut River as it flows out of the New England Highlands and into Long Island Sound. This pocket of white oak is surrounded by less of an urban population than surrounding areas. While growing stock volume has shown essentially no increase, 175 million $ft^3$ to 178 million $ft^3$, sawtimber volume has increased by 8 percent. Much of the volume in this stately citizen of the woods is primarily found growing in the small forested patches that are primarily sites for larger homes and estates, bringing peace and tranquility to its surroundings. Elsewhere, it forms a minor component of Connecticut's woodlands.

Sugar maple is one of the most valuable species in Connecticut, prized for its wood, maple-syrup production, and beauty. Who can deny the impact that





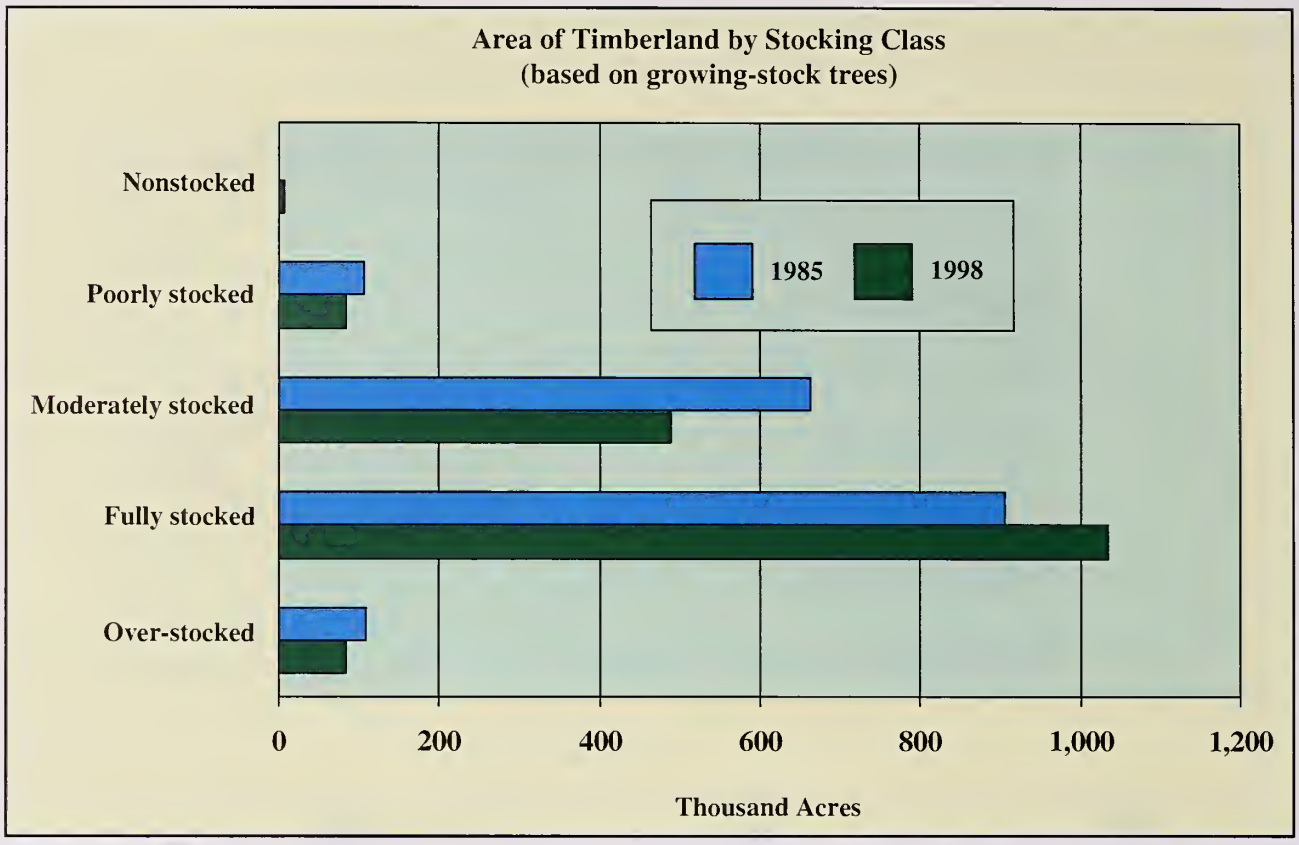

its splash of bright golden foliage has on the visual appeal of autumn in Connecticut? Yet, it's likely that the value it holds as a high-quality hardwood is what keeps volume increases low. Since 1985, sugar maple has remained essentially unchanged in terms of growing-stock and sawtimber volume.

Red maple and sweet birch are adapted to a broad range of growing conditions and can be found in heavy concentrations across the state. Red maple in particular – the leading species in terms of growing-stock volume – increased by nearly 65 percent between 1972 and 1985. That tapered off to only 9 percent between 1985 and 1998. Red maple is a volunteer species on abandoned farmland, especially on moister sites. Cutting practices that remove more valuable species and leave the less-valued red maple probably promoted its volume increases more than any other factor. But since red maple is not long-lived, species such as northern red oak may be starting to reassert their dominance, especially in terms of sawtimber volume.

## Total Resource

Standard means of measuring the forest – in terms of cubic feet and board feet, for example – often miss a significant portion of the total forest resource and in many cases account for only half of the woody material contained in trees and shrubs. One way to capture this missing material is to measure it in terms of weight, or biomass. This is most often reported in dry tons. In 1998, the forests of Connecticut contained more than 161 million dry tons of trees and shrubs.

Most of the forest biomass was in growing stock – almost 54 percent. The remainder was in nongrowing-stock components: portions of growing-stock trees outside of the merchantable bole (25 percent), cull trees and salvable dead trees (8 percent), saplings between 1 and 5 inches diameter at breast height (d.b.h.) (4 percent), small material such as seedlings and shrubs (1 percent), and biomass on the reminder of the forest land base besides timberland (8 percent). The bulk of the biomass resource is concentrated in Litchfield County, but Fairfield County contains a substantial proportion of biomass on noncommerical forest land.




Forest biomass can play an important role in the world's carbon cycle. Trees and shrubs act as carbon sinks, removing carbon from the atmosphere in the form of carbon dioxide (a greenhouse gas) and storing it in the form of cellulose. It's possible that forest vegetation my help mitigate the effects of increased carbon dioxide levels in the atmosphere from the burning of fossil fuels. If so, increases in biomass show that in the future, Connecticut's forests could play an increasing important role in carbon sequestering and associated global climactic change.

## Timber Supply

### Levels of Stocking

The numbers of trees per acre and tree size determine how well a stand is stocked. Stocking measures indicate how well a site is being utilized to grow trees of economic value. In fully stocked stands, trees are fully using the potential of the site. If allowed to continue to grow, these stands will eventually become overstocked.

In overstocked stands, trees are crowded and growth slows. Trees in these stands are less vigorous and more susceptible to insect and disease damage. If not thinned or harvested, commercially valuable trees may die and their value for timber products lost. Good forest management involves reducing overstocked and fully stocked stands to a moderately stocked level through thinning or harvesting, which includes thinning and other silvicultural treatments.

Poorly stocked stands have widely spaced trees, are occupied with trees of little or no commercial value, and with little or no regeneration. These stands often are the result of harvesting only the best and biggest trees, leaving trees of poor form and undesirable species. The result is large gaps in the forest canopy in which no desirable regeneration exists. Poorly stocked stands are difficult to manage because they will not mature into a fully stocked condition in a reasonable amount of time.

Historically, Connecticut's forests have shown an increase in stocking levels. The number of acres of poorly and moderately stocked stands has decreased, while the area of fully-stocked stands have increased. At the same time, a more productive forest has been maintained through declining levels of over-stocked stands. The increased number of fully-stocked stands present opportunities for management without decreasing forest growth. Management of these stands can prevent them from becoming overstocked. At present, there are very few over-stocked stands and few non-stocked stands.

## Timber Quality

Today, Connecticut forests contain an abundant supply of nearly every size tree. There have been substantial increases in almost every diameter class except for small trees, and a shift toward the larger diameter classes.

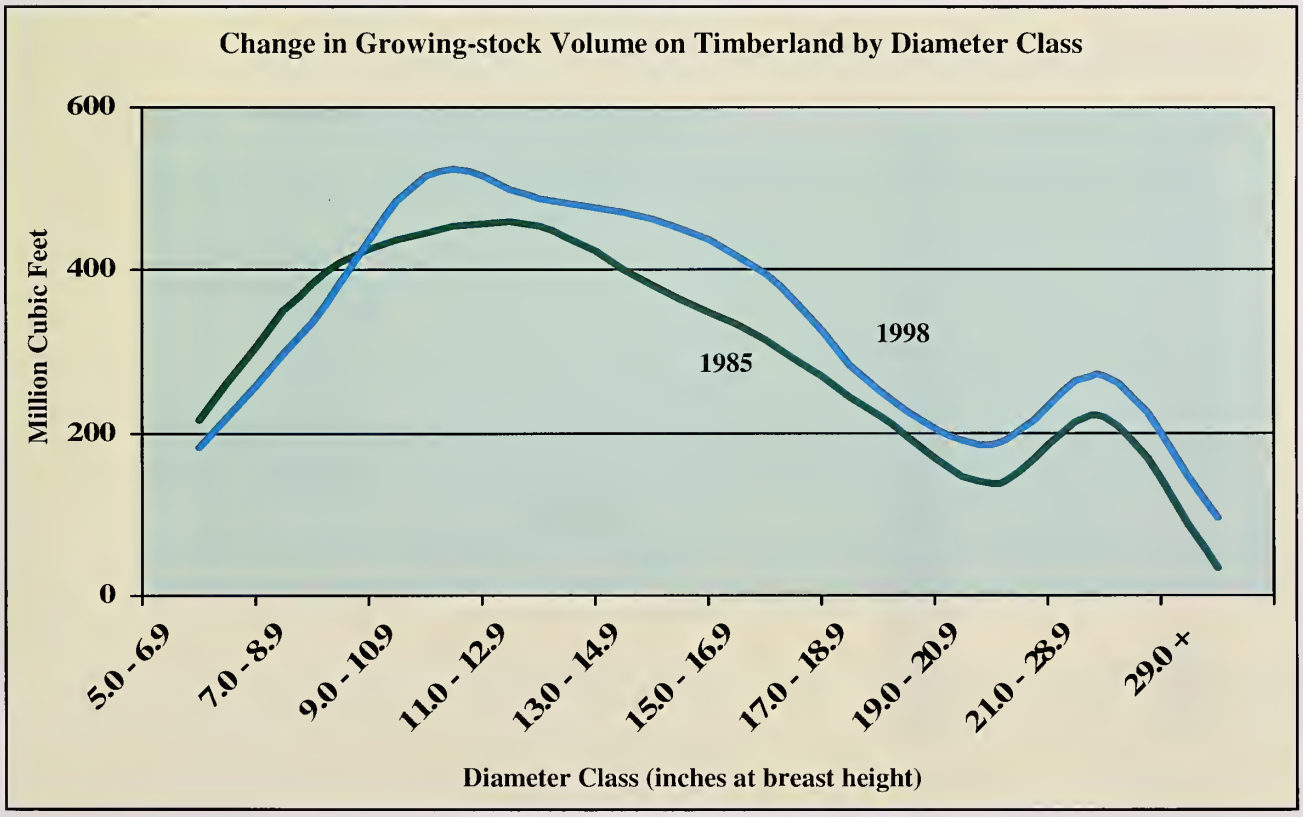
The value of a tree for timber products rises as the tree becomes large enough to produce higher value products. Value increases first as trees grows large enough to produce small sawlogs (greater than 9 inches d.b.h. for softwoods and 11 inches d.b.h. for hardwoods), and again as the trees grow large enough to produce high-grade sawlogs or veneer logs (greater than 15 inches d.b.h.). Large trees with boles free from branches produce the clear lumber that is sought by furniture makers.

While timberland in Connecticut remained essentially unchanged, the inventory of growing-stock volume increased 16 percent since the previous inventory. This is largely due to a declining demand for timber, a slackening of past timber harvesting practices, and continued recovery from storm damages. Younger stands with trees between 5 and 9 inches d.b.h. represent the future of Connecticut's forests and have declined by 14 percent. This decrease is a concern to forest resource managers.

A 27 percent decrease in the volume of oak species in the smaller diameter classes was largely responsible for the shift. Most oak species are slow growing and it might be necessary to consider aggressive silvicultural treatments in the future to encourage oak regeneration.

The portion of trees that are large enough to produce sawlogs (sawtimber) increased by 20 percent, to 9.2 billion board feet. These are the trees that yield high quality stems from timberlands.

Foresters measure tree diameters at 4½ feet above the ground and refer to this as d.b.h. (diameter at breast height). Growing stock is the volume of commercially acceptable trees 5 inches d.b.h. and larger, from a 1-foot stump height to a 4-inch top diameter (outside bark), or until the stem breaks into branches. In a maturing resource, curves of growing-stock diameter class distribution (based on d.b.h.), show not only an increase in each class, but also a move toward the larger diameter classes. This was the case in Connecticut, as the average d.b.h. increased to 9.8 inches.

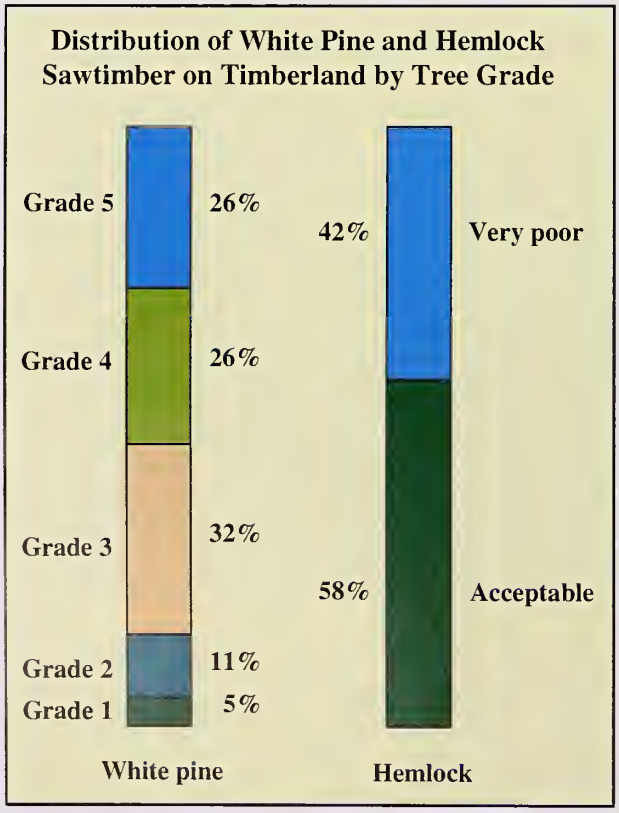


Sawlogs of tree grade 1 and 2 are the most sought after because they yield more volume in the better lumber grades when manufactured into high value-added products, such as furniture. Connecticut is endowed with a unique mixture of tree species preferred by manufacturers of quality wood products. These preferred species—red oak, ash, maple, and birch—are in an abundant and increasing supply.

The quality of Connecticut's hardwood sawtimber is relatively high. Within softwoods – almost all of which is white pine and hemlock – quality is sometimes poor. Hemlock is graded differently than other species. It is either acceptable or very poor. Fifty-eight percent of hemlock sawtimber volume is acceptable. The remainder is graded as very poor. This may be due to the consequences of more than 10 years of hemlock woolly adelgid infestation and other factors affecting hemlock quality.

Tree grade is a rating of sawtimber quality based on a classification system of guidelines for hardwoods, white pine, and southern pine. Generaly, the lower th number, the higher the quality and the higher the value. The ability of a tree to produce high quality sawlogs can be enhanced by thinning and pruning it. This is especially helpful in white pine since it exhibits an excurrant branching habit, or branching throughout the entire length of the tree bole. This picture shows white pine that have been pruned.

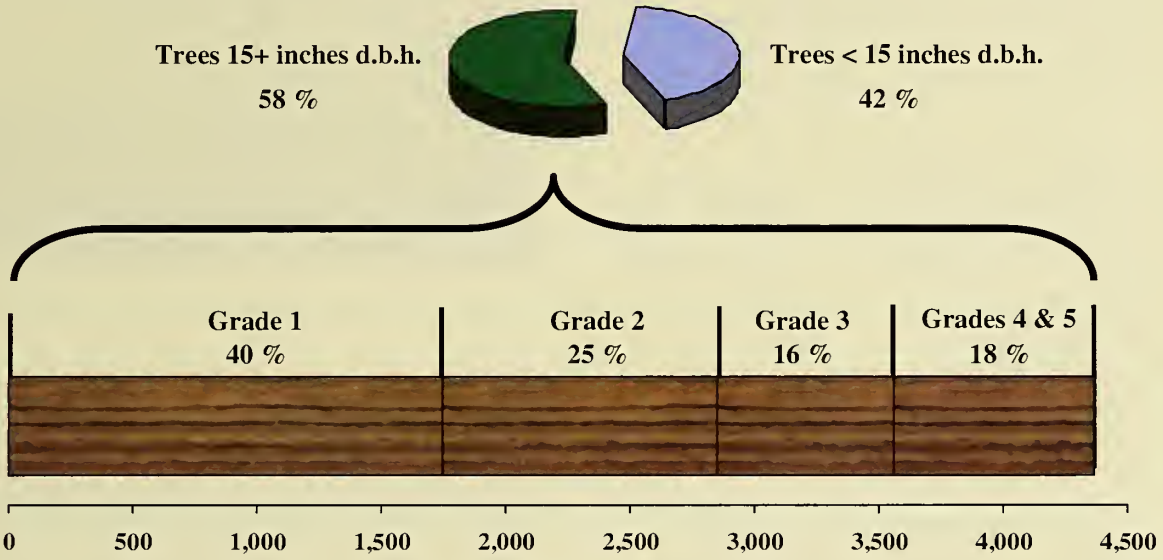
Eastern white pine is a valuable softwood species. However, most of its sawtimber volume in Connecticut is of poorer quality. About 84 percent, or 700 million board feet, is in tree grade 3, 4, and 5. Only 128 million board feet are in the more preferred tree grades. Many white pine trees have poor form because they were either open grown or attacked by the white pine weevil.



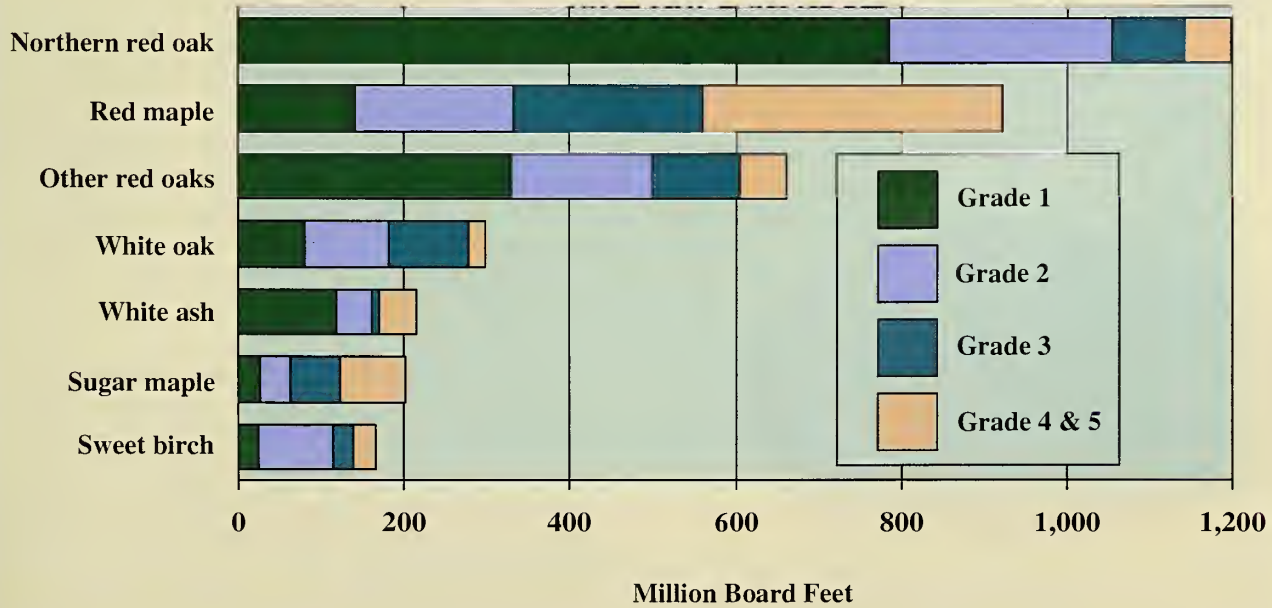

Hardwoods generally are in much better shape. Fifty-eight percent of the hardwood sawtimber volume is in trees of sufficient size to produce grade 1 logs. Of these, about 65 percent are in tree grades 1 or 2. The more valuable species have greater volumes in these better tree grades, but that's not true for all hardwood species.

Northern red oak has the largest portion of trees over 15 inches d.b.h. in tree grade 1. Sixty-six percent of the volume of large northern red oaks is in tree grade 1. It is followed by other red oaks (scarlet, pin, and black oak), red maple, and white ash. Other hardwood species have considerably fewer grade 1 trees.

## Distribution of Hardwood Sawtimber Volume on Timberland by Size and Tree Grade




## Volume of Hardwood Sawtimber Trees 15.0 Inches and Greater by Species and Tree Grade



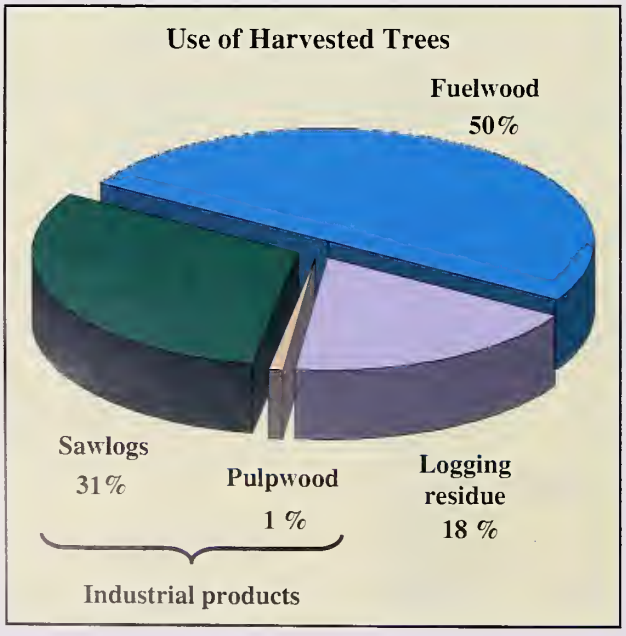
The growth characteristics of red maple cause it to have more defects than other species, so it tends to contain less commercially valuable material. It is only the high volume of red maple encountered in the state that allows it to remain among the top species in terms of grade. While it had more than 332 million board feet in grades 1 and 2, only 36 percent of its sawtimber volume was in trees at least 15 inches d.b.h. Almost 328 million board feet were in tree grade 5.

### Products from Connecticut's Trees

From the very beginning of European colonization, tree harvesting was an integral part of life in Connecticut. Early settlers relied on forests as a source of raw materials for daily life and looked for means to harvest and process its bounty more quickly and easily. The earliest sawmill in New England was operating near York, Maine in 1623, and by 1645 there was a mill operating in Farmington, Connecticut.

But these early sawmills bear little resemblance to their modern descendents. Usually they contained a single saw, with an up-and-down motion powered by water and hand-fed logs. Their shrill scream and slow progress soon gave way to parallel gang saws, usually using four blades and a water-powered feed system.

The numerous local mills in operation and the extensive harvesting of massive spar trees destined for foreign shipbuilders soon began to take a toll on Connecticut's timber supply. White pine also was used by clapboard and shingle mills, which might well have been the single greatest danger to the white pine reserves. Timber shortages began to appear.

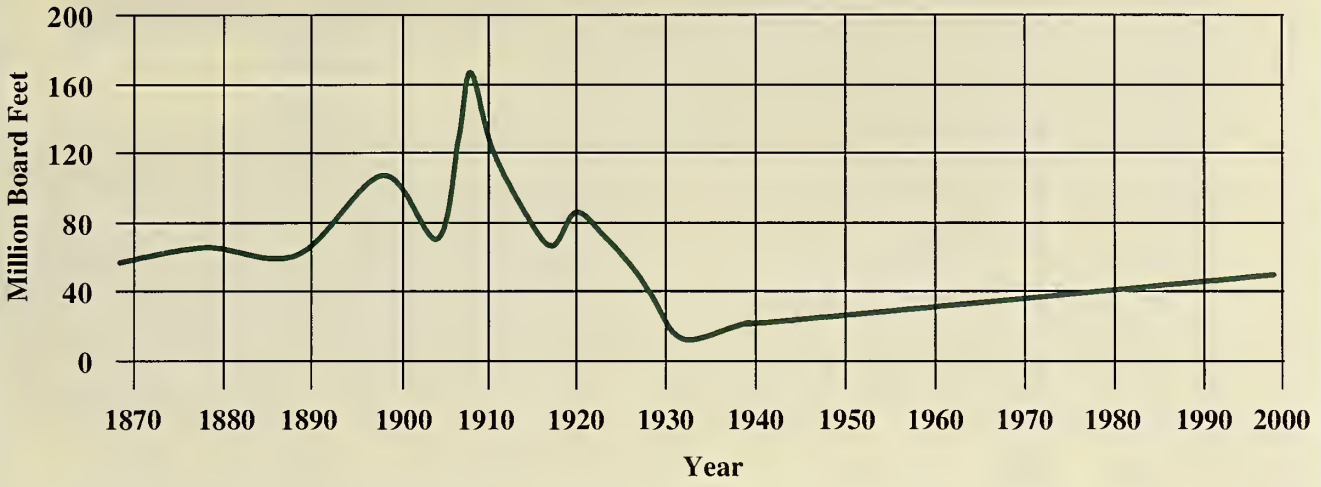



Overseas markets were strong for other species as well. Oaks were particularly valuable for barrels and casks in addition to building materials.

Lumber production continued to rise steadily through Connecticut's early history. Furniture, blanks for tool handles, rails for fences, and studs for bridges were all important products that were manufactured along with what the sawmills produced to construct the homes and buildings to expand their communities. By 1869, these mills were producing 56 million board feet of lumber annually.

Lumber production began to slump toward the end of the 19th century. At that time, much of the state's forests were cut heavily for charcoal production and little hardwood timber may have been allowed to grow large enough to produce acceptable boards. Production rebounded, however, when processors found lucrative pine-box markets for softwoods. Lumber production peaked in 1909 at 168 million board feet, which was primarily due to these new markets.

Never again would Connecticut record the high volumes of lumber production that it had at the turn of the previous century, as production steadily dropped for the next quarter century. During this period, suitable pines from Connecticut's "Second Forest" became harder to find. By the 1920s, the softwood industry had shifted to the South and Lake States. The state became a softwood importer rather than a softwood producer and thereafter produced predominantly hardwood lumber, which recovered after the nation found coal to be a cheaper form of energy near the turn of the century.




[a]Sources: Steer, Henry B. 1948. **Lumber production in the United States, 1799-1946**. U.S. Forest Service, Division of Forest Economics. 233 p. U.S. Bureau of Census, Current Industrial Reports.

Between 1929 and 1933, lumber production hit bottom, coinciding with the national economic collapse. In 1932, sawmills in Connecticut produced a record low of only 8 million board feet of lumber. In just 25 years, lumber production had declined 95 percent. But the nation's economy would eventually recover, as would Connecticut's timber industry.

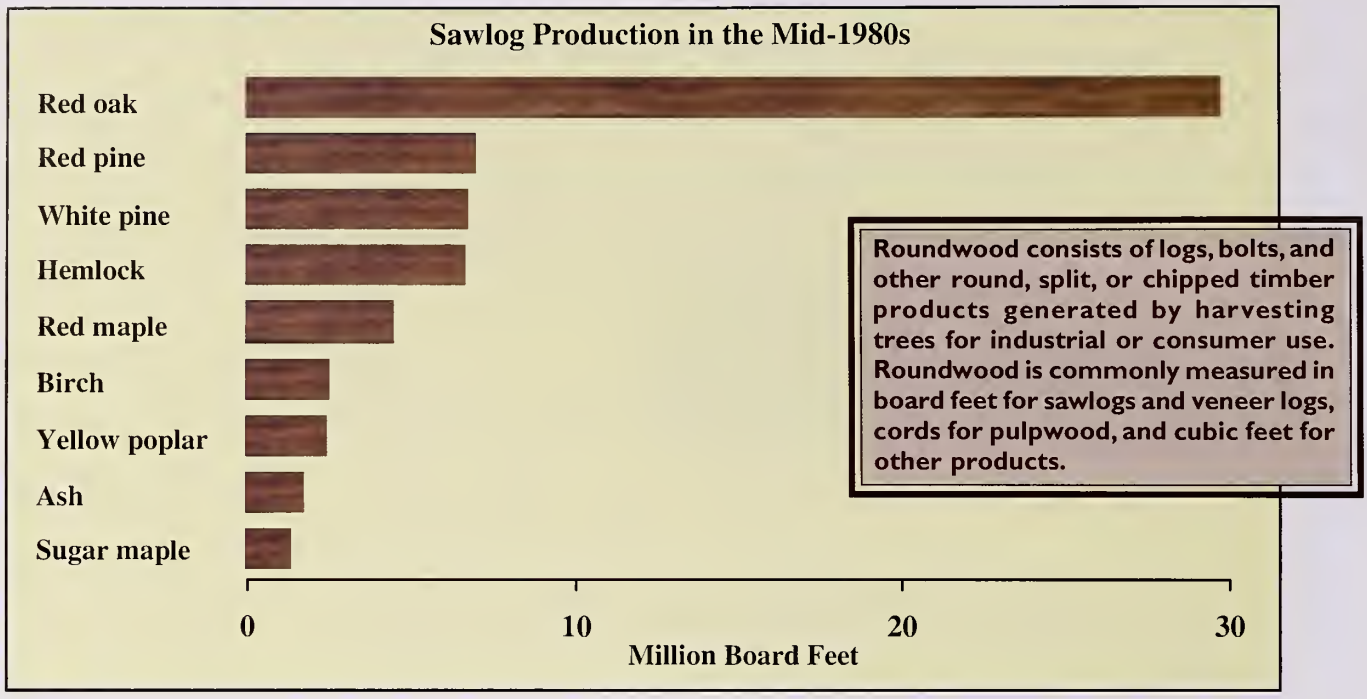
Improvement was at first sparked by wartime demand for raw materials. It was followed quickly by post-war housing demand that stimulated an influx of mostly low-capacity sawmills. But by the early 1960s, the circumstances that had been responsible for rapid increases in lumber production essentially disappeared and so too did the smaller facilities. As production returned to pre-depression levels, the cost of maintaining low-capacity mills skyrocketed and the industry increasingly shifted to fewer mills of greater production capacity. What followed was long-term growth under normal economic conditions, helped at times by the development of products such as wooden pallets that more fully utilized low-quality hardwoods.

When trees are harvested today, the high-quality lower trunk of the tree is used for lumber, while the upper stem, large branches, small trees, and undesirable species are used for lower value-added products, pulpwood, and fuelwood. Parts of the tree that can't be used and have no markets are left in the woods as logging residue. In Connecticut, 32 percent of the volume of trees that is harvested is used for industrial products (sawlogs and pulpwood), 50 percent is used as fuelwood, and 18 percent is logging residue.

Sawlogs remain the primary industrial use of wood harvested in Connecticut. Lumber produced from Connecticut's red oaks is highly valued and is the basis for nearly half of Connecticut's timber harvesting activities. By the mid-1980s, almost 67 million board feet of sawlogs were harvested annually. About 45 percent, or 30 million board feet, of the sawlogs were red oak. Softwood sawlog production, however, is almost as high. The volume harvested from the primary softwoods –pine and hemlock – was nearly 21 million board feet.

Some pulpwood is produced, but only in small amounts. None is used within the state but pulp mills in neighboring states provide an important market for low-value wood from Connecticut. In 1996, about 3,000 cords of pulpwood were shipped out of the state, almost all of which was hemlock. By that time, there was only a handful of pulp mills located within 200 miles of Connecticut's western border – in New York and northeastern Pennsylvania. Yet the region remains a center for the production of fine papers.

In 1997 there were 36 paper mills remaining in Massachusetts, New Hampshire, and Vermont – 22 in Massachusetts alone. These mills produce specialty-grade papers such as ledger stock, fine writing paper, glassine, carbons, and blank-note papers. They utilize




pulp purchased from manufacturers of other products and provide a valuable market for wood harvested from Connecticut.

Forest products other than sawlogs and pulpwood are no longer manufactured to any great extent in Connecticut. At one time, there was a thriving softwood wooden box industry and softwood cooperage products, such as fish pails and butter firkins, were an important part of the state's economy. Markets for similar specialty products had risen substantially by the early 1970s, but by the mid 1980s only 4 percent of total industrial roundwood production in Connecticut was for other products – primarily veneer logs, cabin logs, posts, and poles. Almost all of the other products had been displaced by substitute products.

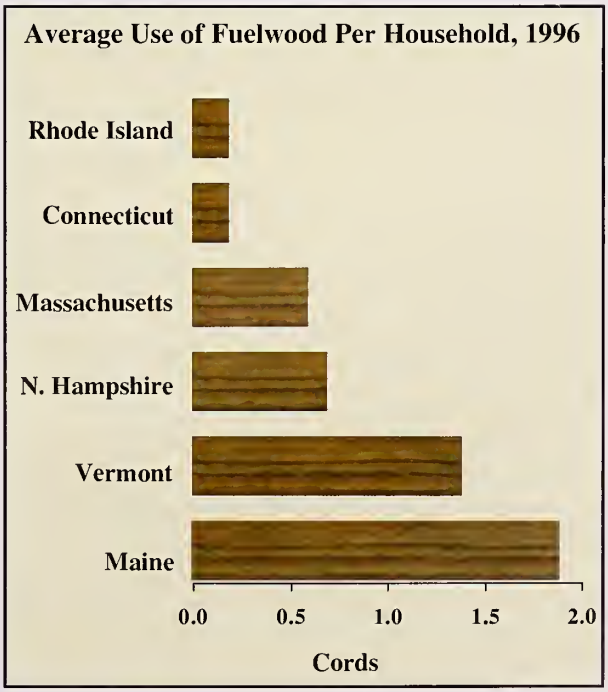
Fuelwood remains the leading product harvested from trees in Connecticut. In the early 1970s, an oil embargo and the desire for self-sufficiency by many Connecticut residents brought about a upsurge in residential fuelwood use. While it has not reached the maximum use it once had, fuelwood use remains significant.

Some households in Connecticut are still dependant to some extent on wood for fuel. But fuelwood includes not only what is used by many homeowners who burn wood for heat, it includes wood burned in commercial facilities as well. In 1996, there were more than 210,000 cords of wood used for fuelwood, nearly all of which came from hardwood species. About three-fourths of this wood came from nongrowing-stock sources – dead and cull trees from the forest and trees from fences rows and yards. Fuel is an ideal use for this kind of material since it has little commercial value otherwise.

Maple sugaring has been in some families for many generations, though the process has been modernized. The sight of buckets hanging from sugar maple trees in late winter is no longer as common as it once was, since today most sap can be gathered by plastic tubing. Today, sugaring is one of the few remaining viable cottage industries. Local farmers or woodlot owners with a saphouse can market their product directly or sell it wholesale to specialty shops and stores.

For many in Connecticut today, products from the woods are part of a traditional way of life and can contribute additional income. There are a host of these other forest products. The most common is maple sugar, but lesser recognized products also abound and remain an integral part of many rural communities. These include boughs and floral greenery; weaving and dyeing materials; botanical flavorings and medicinal herbs, such as ginseng, cultivated and wild mushroom production; and cones, berries, and numerous other specialty and novelty items gathered from trees. Also, Connecticut has the distinction of supporting American Distilling, which is one of the last remaining manufacturers of witch-hazel extract and is located in East Hampton.

Unlike coal and oil reserves, the forest resource renews itself, as evidenced by the return of Connecticut's forests following past abuses. Trees can be thought of as a crop – they can be cut today and by future generations if nothing is done to degrade their productive capacity. The state's forests have been repeatedly harvested for various wood products but remain productive and continue to provide a host of benefits. Except for parks and forest preserves, nearly all forests have been harvested three or more times. The sustainability of today's forests is aided by regulations and adoption of the best management practices available.



**Average Annual Net Growth and Removals***

| Top 12 species | Net growth (Thousand cubic feet) | Removals (Thousand cubic feet) | Ratio of Growth to Removals |
|---|---|---|---|
| Red maple | 10,291 | (4,921) | 2.1 : 1 |
| Northern red oak | 9,437 | (4,379) | 2.2 : 1 |
| Other red oaks | 6,355 | (5,009) | 1.3 : 1 |
| Sweet birch | 4,972 | (979) | 5.1 : 1 |
| White pine | 4,968 | (1,379) | 3.6 : 1 |
| Eastern hemlock | 3,581 | (285) | 12.6 : 1 |
| Hickory | 2,448 | (1,889) | 1.3 : 1 |
| White ash | 2,281 | (1,480) | 1.5 : 1 |
| Beech | 2,079 | (318) | 6.5 : 1 |
| White oak | 1,985 | (1,651) | 1.2 : 1 |
| Sugar maple | 1,862 | (279) | 6.7 : 1 |
| Yellow birch | 900 | (301) | 3.0 : 1 |
| State total | 55,676 | (25,526) | 2.2 : 1 |

* Estimates of growth and removals are made only from remeasured plots.
* These estimates can differ from volume change estimates that are made using all plots.

## Sustainability of the Timber Supply

The ability of forests to sustain themselves is measured by their ratio of growth to removals. Net growth is the total growth of trees, plus gains from land coming into forest, minus losses to mortality from insect and disease outbreaks and disturbances such as and wind and ice storms. Removals include harvesting plus losses due to changes in land use.

In Connecticut, the net growth of trees has exceeded removals since the first inventory in 1952. Between 1985 and 1998, annual net growth averaged 55.7 million $ft^3$ and annual removals averaged 25.5 million $ft^3$. Of the volume removed from timberlands, 62 percent is attributed to harvesting and 38 percent to the conversion of forests to nonforest uses or the reclassification of forest land to a reserved or other noncommercial forest land category. The surplus growth over removals yields an annual net increase of 34.8 million $ft^3$ – a 1 percent annual increase.

The ratio of net growth (which includes losses from natural mortality) to removals has averaged about 2.2 : 1 over the past decade. That is, 2.2 times as much wood was grown as was being cut or removed. The growth of trees has exceeded harvesting since the first inventory in 1952, and today's well-stocked stands are the result of these steady gains that have been accumulating in Connecticut's standing forest.

The ratio of growth-to-removals (G/R) varies among species. Comparing ratios for individual species to the average for all species indicates relative changes for each species, and helps explain change in the structure and composition of a forest. Species with the most favorable G/R ratios are hemlock, sugar maple, beech, and birch; these species are increasing in the portion of the total resource they represent.

Until recently, cutting pressure has been greater on softwood species (other than hemlock) than on hardwoods. Ratios of less than 1.0 occur where removals exceed growth. During the period covered by the most recent inventory (1985-1998), no important species had a G/R ratio less than 1.0, although a few – red maple, white oak, other red oaks, hickory, and ash – fell below the state average.

## Forest Health

### Damaging Agents

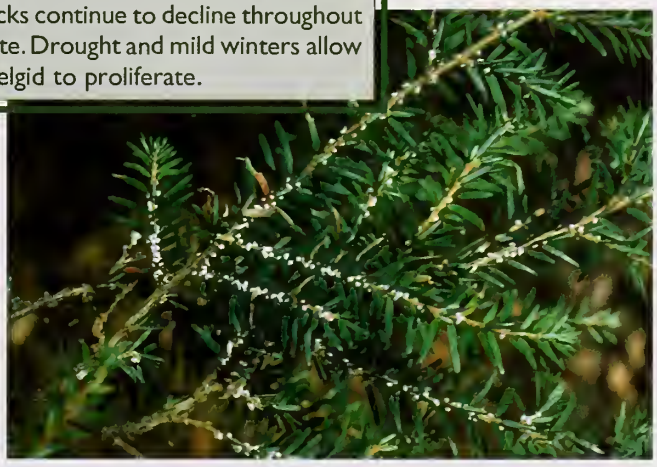
Natural stresses have always challenged the health of forests. Damage from biotic agents, such as insects and diseases, consistently plague the vitality of trees. Diverse abiotic agents have confounded those practicing sound forest management since mankind first decided he could control the forest. Thousands of acres of Connecticut's forests were killed or declined due to the effects of frost, drought or flooding (the latter attributed to beaver dams).

Two pests in particular have extracted a heavy toll on the forests of Connecticut over the years: chestnut blight and the gypsy moth caterpillar. At one time the forested landscape of Connecticut was dominated by American chestnut trees. This majestic giant of the woods had been a staple in home construction and furniture manufacturing for many years. Imposing chestnut beams and joists still found in older homes attest to its importance. In 1904, an Asian fungus was discovered in the Bronx Zoo. By 1920, the fungus had either killed or infected almost every mature chestnut tree in Connecticut. It is also commonly found on oaks – white oaks in particular. There is so little that can be done to control this disease under forest conditions that American chestnut today is relegated to an understory species. These once-proud trees now simply sprout from tree stumps, become infected, die back, and resprout.

The spread of gypsy moth also has been well documented. Gypsy moth was introduced into the United States in 1869 by a French scientist in Massachusetts. The first outbreak occurred in 1889 and by 1905, it had reached Connecticut. For nearly 100 years, it has established itself throughout the state, though at times population levels have plummeted. In the late 1970s, Connecticut was almost free of this persistent pest, but that was soon followed by an extensive outbreak. In the mid 1980s, the gypsy moth caterpillar had defoliated about 15,000 acres in a single year. Since that time, populations have declined and over the past decade have been uncharacteristically low. This may be due to a number of agents, including insects and birds that feed on eggs and early instars, and a fungus that infects the caterpillar. Persistent efforts of control have helped to contain its damaging effects.

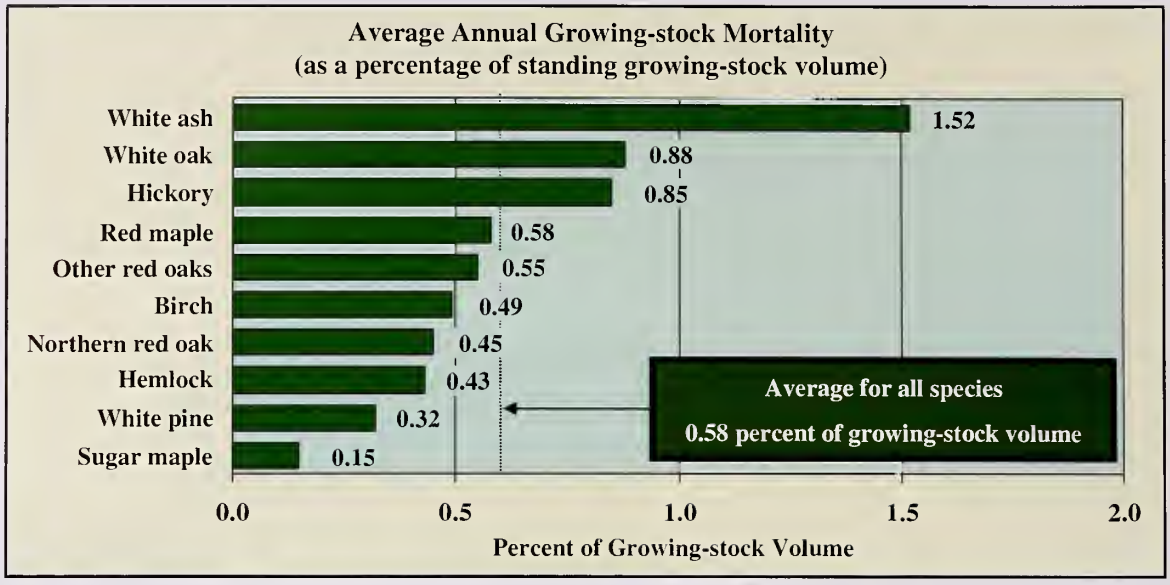
Adult gypsy moth

A number of insects and diseases have left their imprint on Connecticut's forests over the years. The most recent is the hemlock woolly adelgid. Currently, no known control of this aphid exists and hemlocks continue to decline throughout the state. Drought and mild winters allow the adelgid to proliferate.



A more recently discovered insect is causing widespread mortality in hemlocks. Initially identified in 1924 as originating from Asia, the hemlock woolly adelgid was discovered along the coast of Connecticut in 1985 and heavy infestations have occurred throughout the state since then. This aphid sucks the sap of young twigs, causing almost complete defoliation within a few years. A quarantine on nursery stock from heavily infested states like Connecticut was imposed, yet recent infestations have been found in surrounding states which has raised widespread concern about its continued spread. Effective control of the insect is still unknown, though promising research is currently under way at the Connecticut Agricultural Experiment Station on a biological control agent.

Elm is a minor species in Connecticut's forests but its charm and ability to grow well in compacted soils and under polluted conditions have made it a favorite in urban settings for years. But in the 1930s, diseased logs from Europe brought a deadly disease carried by an insect – Dutch elm disease. Since then, it has killed almost all the elms and constantly threatens those that remain. Control under forest conditions is impractical since sanitation is the only viable alternative.




When butternut trees develop cankers on twigs, branches, and stems, and then quickly deteriorate, look for the butternut canker to be present. This a fungus was first discovered in 1967 in the north central United States, but has quickly spread in the past 30 years. As yet, there is no known control for the disease, but a few native butternut trees have shown resistance to the disease. Both Connecticut and New Hampshire are cooperating with the USDA Forest Service to locate healthy trees and graft material to test for disease resistance.

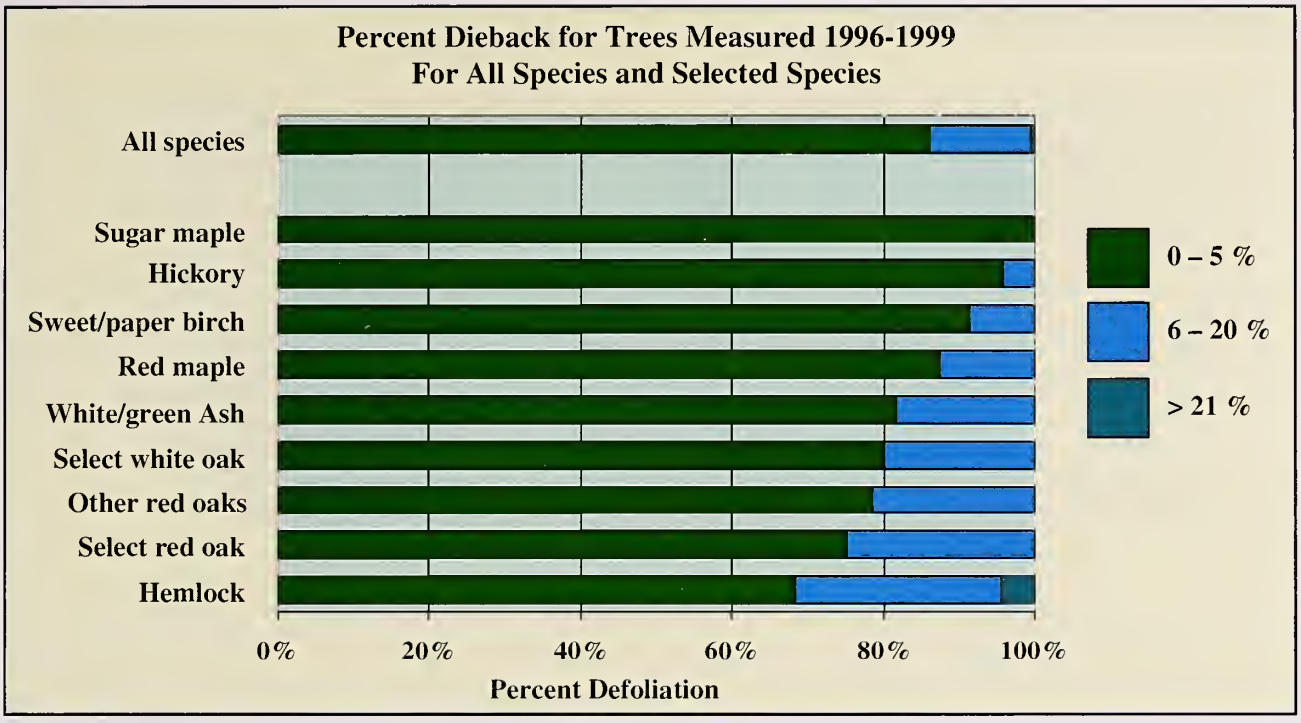
Of growing concern is the Asian longhorned beetle. Largely limited to maple species in Connecticut near the New York border, this introduced pest girdles trees by the tunneling activity of the beetle larvae. It was first discovered in New York City in 1996, but an extensive program of eradication is currently being conducted and heavily infested areas have been quarantined. Surveys to monitor spread and provide early detection of this damaging insect continue to be conducted throughout much of southern Connecticut.

Signs of damage from Asian longhorned beetles

A cousin, the recently introduced Japanese cedar longhorned beetle, was discovered in Milford in the fall of 1998. This small pest poses a serious threat in Connecticut nurseries, many of which have been inspected. Infestations also have been found in in Greenwich, North Haven, and Stamford. Since it has so recently been introduced, research to study the insect's development and possible control is still in its infancy.

Other pests that infect Connecticut's trees occur periodically, usually when the trees are stressed from environmental conditions, such as drought. Known pests include: dogwood anthracnose fungus, which causes tan, circular leaf-spots surrounded by purple borders that can progress into necrotic veins and leaf margins, and eventual dieback; pear thrips, which are a serious pest of sugar maple and whose population increases may be tied to years of heavy sugar maple flowering; white pine blister rust, which continues to cause dieback in mature trees and mortality of seedlings and saplings; and beech bark disease, carried by the beech scale, continues to cause scattered mortality.

Insects, disease, fire, wind, ice, and other destructive agents have contributed to tree mortality in Connecticut. But in general, the primary species of Connecticut's forests are healthy. Between 1985 and 1998, annual mortality averaged more than 16 million $ft^3$ of growing stock, or 0.58 percent of the standing growing-stock volume of 1998. Important tree species suffering the most mortality (higher than the average for all species) were white ash, white oak, and hickory. However, not even the most affected species of white ash approaches the level of mortality experienced by a tree species in serious danger. For example, the mortality rate for elm, after nearly a century of Dutch elm disease, is almost 4 percent of its growing-stock volume.




## Crown Dieback

For years, Connecticut residents have heard warnings about potential for withering vegetation, wide-spread defoliation, and denuded hillsides brought about by new damaging agents such as acid deposition and various other environmental instruments. Indeed, new challenges seem to appear each year. In response to this, The USDA's Forest Health Monitoring Program was established to monitor trends in the health of forest ecosystems. It is a national program implemented with the cooperation of individual states. In Connecticut, measurements were taken from 1996 to 1999 and included a wide set of indicators which reflect forest conditions. One of these measures is crown dieback.

Crown dieback occurs in the upper and outer portions of a tree and represents recent branch mortality, which begins at the tip of a branch and proceeds toward the trunk. It can be a sign that the tree is suffering from health problems. Low dieback ratings are considered to be an indicator of good health because the tree has been able to support foliage and growth in the outer portions of its crown. Crown dieback measures the percent of branch tips that are found dead. If dead twigs and branches occupy no more than 5 percent of the crown area, crown dieback is considered low; more than 20 percent dieback is considered high.

Very few trees surveyed in Connecticut had significant amounts of crown dieback. Ratings were low on 86 percent of the trees, and dieback was high on less than 1 percent of the trees. Average dieback was about 4 percent, influenced by largely high dieback on eastern hemlock.

Dieback was low on only 68 percent of eastern hemlock trees and high on 4 percent of these trees, which may be the result of repeated heavy infestations of hemlock wooly adelgid. Damage indices bear this out. On eastern hemlock, 77 percent of tree damage was related to dead or broken tops, which usually results from adelgid attack. This was high compared to the average of all species, in which 19 percent was related to dead or broken tops. Select red oaks also varied from the average, except 86 percent of the damage was related to decay.

The continued observations of dieback, damage, and similar attributes will allow identification of trends and improve evaluations of forest conditions. But in the end, it has been the remarkable resilience of Connecticut's forests, along with aggressive pest management, that have allowed the forests to withstand damaging agents and remain healthy. While humans have been responsible for introducing some pests, they also have been responsible for their eradication or control, allowing forests to grow and flourish.

## Connecticut's Changing Forest

### Stand Size

The Native Americans were the first to practice forest management to create stands of trees that produced optimal benefits for their society. They knew that if allowed to mature without human interference, the woodlands would climax into densely shaded forests of hemlock and beech. Birch, red maple, ash, pine, understory, brush, and herbaceous vegetation would soon disappear.

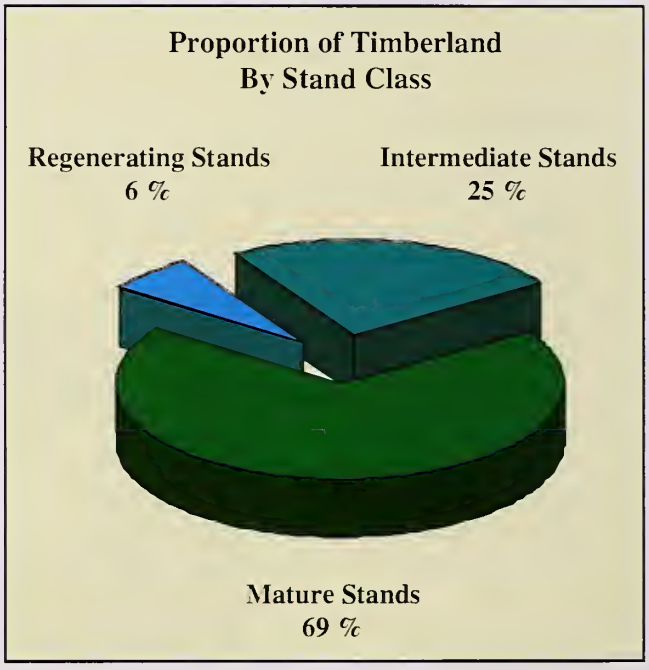
By burning the forests on a regular basis, the earliest inhabitants of Connecticut found that a variety of cover types and a balanced mixture of tree sizes could be maintained and would be beneficial. It would provide the proper blend of mast, nesting and mating sites, and shelter for the variety of wildlife species upon which they depended.

Forest management through the widespread use of wildfire is neither practical nor tolerated today. Yet, proactive management of Connecticut's forests can yield a rich forest diversity, beneficial for watershed protection, general aesthetics, floral and faunal species diversity, and the full range of both industrial and nonindustrial forest products.

In regenerating stands (seedling-sapling class) after major disturbances – such as fire, timber harvesting, and land abandonment – wildlife species that utilize the low growing herbaceous and shrub vegetation become common. Species that prefer this habitat include song sparrow, bluebird, American goldfinch, cedar waxwing, golden-winged warbler, bobolink, and eastern cottontail.

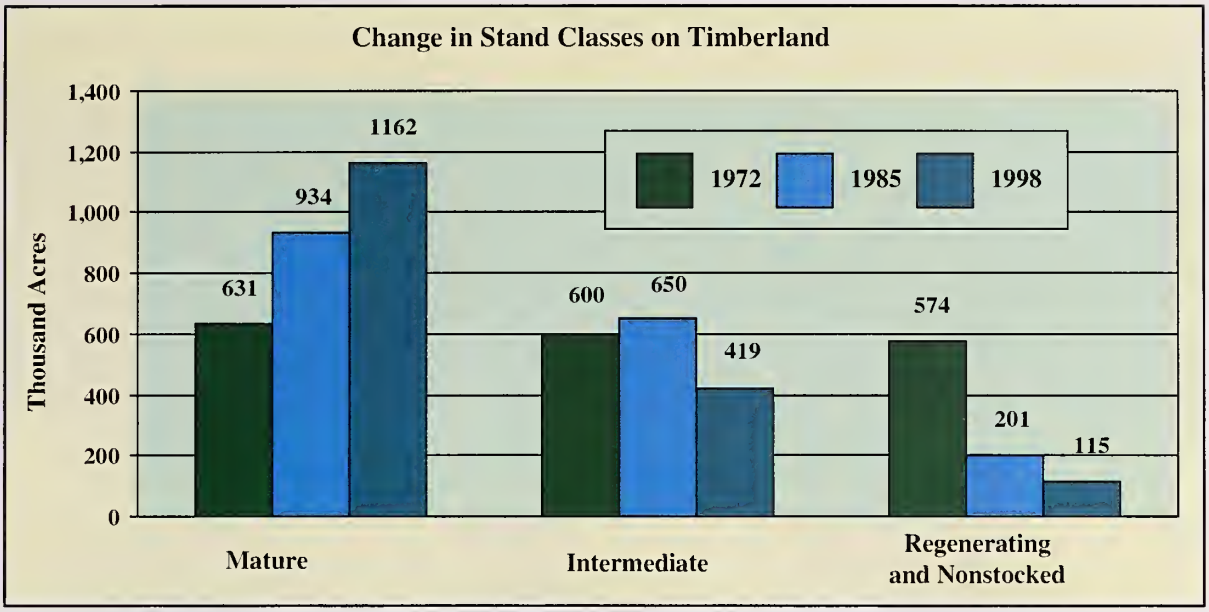
Often the number of species present is at its lowest level in the intermediate stands of a forest – between the dense vegetation of the regenerating stands and the mature stands (sawtimber-size class) dominated by large trees. The diversity of wildlife species, however, will change as these forests grow, reaching a maximum in mature, overmature, and all-age stands. Species that are more likely to be found in these stands include pileated woodpecker, porcupine, black bear, and fisher.

At one time, an even distribution of stand size classes was considered to be ideal – that is about one-third in each of the regenerating, intermediate, and mature stands. The optimal distribution for sustaining balance in forests rests in the determination of what is optimal and for whom. The nature of the forest, the needs of landowners, the demands of society, and many other factors contribute to the perception of optimal. While variable over space and time, some mix of all sizes is still considered beneficial.



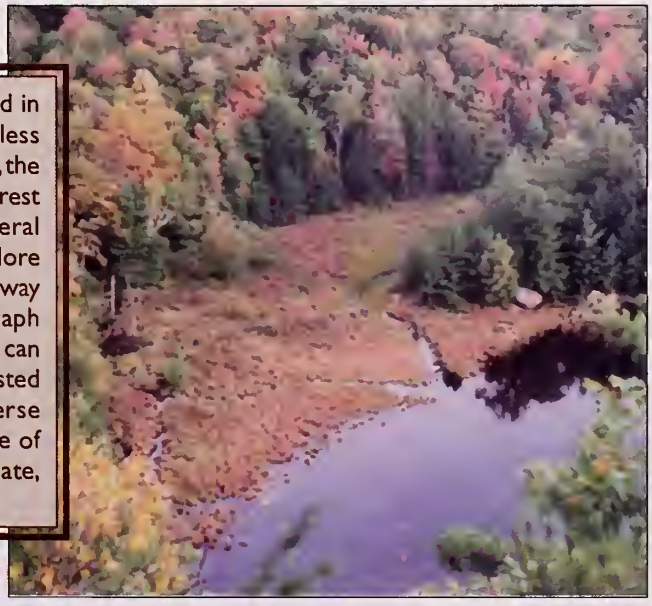

In Connecticut forests today, a beneficial mix of stand size classes may not exist. A disproportionate area – 69 percent of the timberland area – is in mature stands. In addition, there is an unusually small amount of regenerating stands, which comprise only 6 percent of timberland. The overall nature of tree growth, a decline in the abandonment of farmland, and reduced timber harvesting activities, have contributed to produce a forest comprised predominantly of mature stands and with a deficit of regenerating stands.

This was not always so. In 1972, the different stand sizes were virtually balanced. During the intervening years, the area in mature stands has been steadily increasing. Between 1972 and 1985, the area of intermediate stands remained essentially unchanged, declining only between 1985 and 1998. However, the area of regenerating stands has steadily declined.

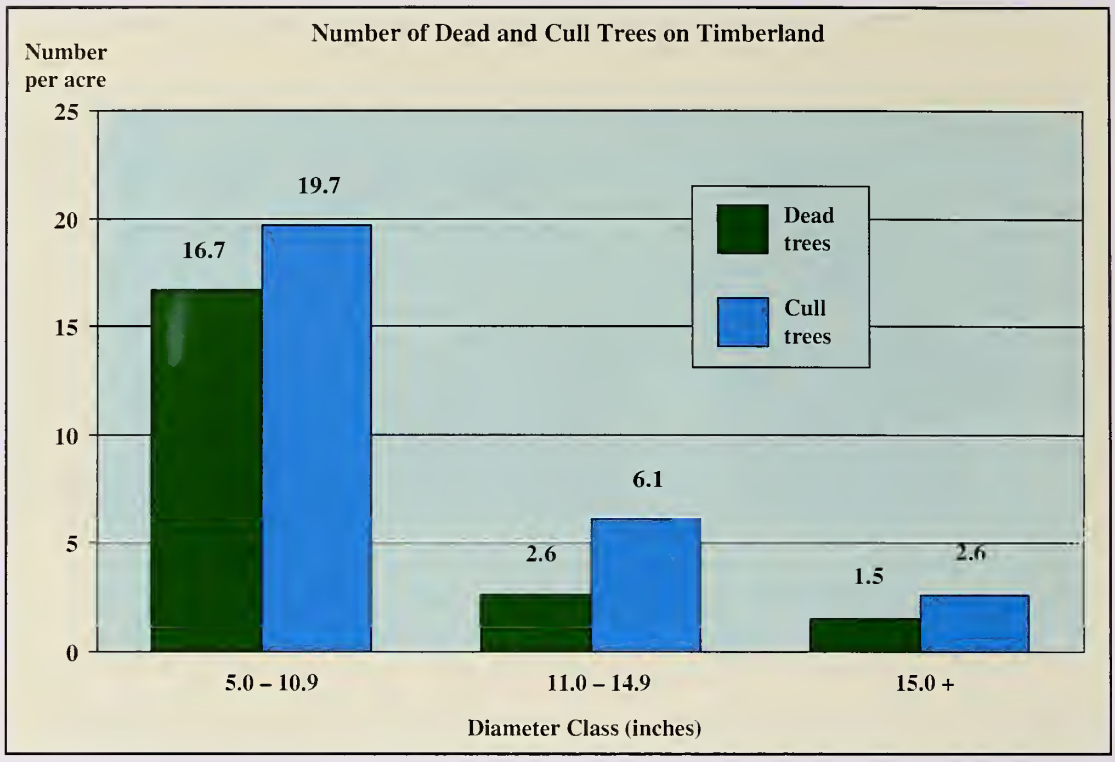



These changes can still be considered beneficial to some wildlife. The recovery and return of many woodland species has been remarkable during the last century. Black bear, wild turkey, white tail deer, and beaver have increased in number. There have even been moose sightings along the Massachusetts border. Maturing forests have made this possible. But the lack of balance between stand sizes will eventually affect other species of wildlife, and may bring about population declines. Few deny the social and environmental value of maintaining mature, old-growth forests. Yet a balance is necessary for health and diversity.

Hunting, freshwater fishing, hiking, camping, picnicking, photography, or just a day spent in the fresh air of the woods, all depend on quality wildlife habitat and clean streams and ponds. Increasingly intensive pressures resulting from high population densities in Connecticut present an interesting challenge to foresters practicing multiple-use forest management. It is a challenge that far exceeds what the State's original inhabitants could have possibly imagined when they simply burned the forest to improve their food supply.



Hunting traditions are deeply rooted in Connecticut and each year countless hunters head to the woods. However, the economic value of Connecticut's forest habitat is even greater when general wildlife appreciation is considered. More outdoor enthusiasts are making their way into forests to view and photograph wildlife. A variety of nongame species can be found in forest habitats, but forested wetlands attract even more diverse species. While the actual dollar value of such activities is impossible to evaluate, to many it's priceless.




## The Quality of Wildlife Habitat

Two habitat characteristics that usually improve as forest stands mature are the size of mast-producing trees and numbers of standing dead and cull trees. Nuts and hard seeds produced by overstory trees is an important forage resource for Connecticut's forest wildlife. Species that depend on acorns and other hard mast include ruffed grouse, wild turkey, red-headed woodpecker, blue jay, squirrel, chipmunk, gray fox, black bear, striped skunk, and white-tailed deer.

The important mast-producing trees in Connecticut include hickory, beech, and oak. The quantity of mast produced increases with tree size, and it can be assumed that mast production has increased in the state because of increases in the number of large diameter oak and beech. Since 1985, the number of oak and beech trees 11 inches and larger in diameter increased by 39 and 18 percent, respectively.

Standing dead and cull trees are important nesting and feeding sites for wildlife. These trees have a higher probability of being used by primary cavity nesters, such as woodpeckers, as the wood is more easily excavated. These cavities, and natural cavities caused by disease or injury, are used as resting or nesting sites by various birds and small mammals.

In Connecticut, 7 percent of all standing trees in the forest are dead. Hemlock, red maple, northern red oak, and white pine are the most numerous dead trees over 15 inches in diameter, in almost equal numbers. These four species account for 62 percent of all standing dead trees of that size, and are the prime candidates for nesting activities. Cull trees are those that exceed maximum defect allowances for use as timber products due to rot or poor form – such as twisted trunks and excessive branching. The characteristics that make cull trees undesirable for timber products are beneficial to wildlife. Cavities, broken tops, pockets of rot, and boles with forks and limbs provide suitable habitat. Ten percent of all standing trees are cull.

## The Future of Connecticut's Forests

From the mid-1800s to the early 1950s, the wide-scale return of Connecticut's forests was remarkable. But for the past 50 years, new forest land from agricultural land abandonment has been offset by losses due to land development resulting in the total amount of forest land remaining stable. It is doubtful this will continue. In the future, the net loss of forest land is expected to increase because of the diminished number of farms being abandoned and increased development pressure from a growing population.

Connecticut has maturing forests dominated by hardwood species. This fact can be documented through increases in the average age, size, and volume of trees in the state. The majority of trees are healthy, with full crowns, little dieback, and few damages. One significant exception is eastern hemlock, which tends to be in poorer condition with thin crowns, higher amounts of dieback, and higher rates of damage, especially broken tops. These are likely the effects of the hemlock woolly adelgid, among other pests.

Changes in species composition naturally take place as a forest grows, but cutting practices have influenced this process, too. Low cutting rates and shaded conditions on the forest floor have promoted the growth of shade tolerant species. Red maple also has responded very aggressively to present conditions. Species that need full sunlight to reproduce, such as ash, hickory, paper birch, and aspen, will be at a disadvantage in the more shaded conditions that are now more prevalent.

Human population increases also influence how forests are used. Greater demands are now being placed on forests to produce both traditional and nontraditional benefits and values. Fragmentation of timberland into smaller holdings has made it more difficult to use the forest in traditional ways. Landowners with small holdings are less likely to manage their forests for timber products, and because many of these small holdings are home sites, these owners also might be more likely to prohibit others from using their land.

The challenge for the future is how to sustain the delivery of goods and services people expect from Connecticut's forest resource while addressing problems associated with increasing land development controlling introduced pests, diseases, and invasive exotic plants; and managing the lack of regeneration of desirable tree species such as oak.

Wharton, Eric H.; Widmann, Richard H.; Alerich, Carol L.; Barnett, Charles H.; Lister, Andrew J.; Lister, Tonya W.; Smith, Don; Borman, Fred. 2004. **The forests of Connecticut.** Resour. Bull. NE-160. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 35 p.

A report on the fourth forest inventory of Connecticut conducted in 1997-98 by the Forest Inventory and Analysis unit of the Northeastern Research Station. Explains the current condition and changes from previous inventories for forest area, timber volume, biomass, growth and removals, and harvesting. Graphics depict data at the state and geographic-unit level and, where appropriate, by county.

**Keywords:** forest inventory; volume; biomass; growth and removals.