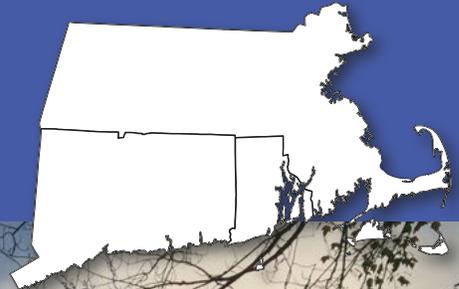![USDA logo]
United States Department of Agriculture

The Forests of Southern New England, 2012

A Report on the Forest Resources of Connecticut, Massachusetts, and Rhode Island

Abstract

This report summarizes the U.S. Forest Service, Forest Inventory and Analysis (FIA) forest inventory data, collected from 2008 to 2012, for Southern New England, defined as Connecticut, Massachusetts, and Rhode Island. In addition to providing regional and state-level summaries, the reports highlights three focus plots, one average or prototypical plot from each State, as a means to better tell the story of the forests of the region. Forests cover an estimated 5,128,000 acres or 59 percent of Southern New England—1,736,000 acres in Connecticut (56 percent of the State), 3,028,000 acres in Massachusetts (61 percent), and 364,000 acres in Rhode Island (55 percent). There was no substantial change in the area of forest land between the current, 2012, and the previous, 2007, FIA inventories. Nearly two-thirds of the forests of the region are privately owned and most of these forests are owned by families and individuals who own the land primarily for the amenity values their forests provide. Seventy-six species of trees were observed on the FIA inventory plots. Red maple is the most common species across the region, but eastern white pine, northern red oak, black oak, eastern hemlock, scarlet oak, and sweet birch are also common. Although the forests of the region are fairly healthy, there are several issues that are threatening them including: invasive plants, such as multiflora rose, oriental bittersweet, and Japanese barberry; and introduced pests, such as hemlock woolly adelgid, emerald ash borer, and Asian longhorned beetle. Human disturbances, such as development, are projected to have a substantial impact on the region and broad-scale natural disturbance, such as hurricanes, are other potential factors that will influence the future of the forests.

Cover photo: Mist over Owen's Pond on the Wentworth Farm Conservation Area in Amherst, MA. Photo by Brett J. Butler, U.S. Forest Service.

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The Forests of Southern New England, 2012

A Report on the Forest Resources of Connecticut, Massachusetts, and Rhode Island

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Introduction

View from Mount Grace fire tower, Warwick, MA. Photo by William Hill, Massachusetts Department of Conservation and Recreation, used with permission.

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This report summarizes the 2008-2012 Forest Inventory and Analysis (FIA) data for Southern New England, defined as Connecticut, Massachusetts, and Rhode Island. Instead of the traditional approach of concentrating the discussion on state-level estimates, this report highlights three prototypical or average inventory plots—one in each State—and telling the "story" of each forested plot in detail. This approach is being tested as an alternative to the traditional format for the FIA 5-year reports that may be easier to understand and more memorable and more compelling to readers. Along with simplifying and demystifying the FIA data, this approach allows the reader to reflect on how these specific plots compare to the state- and region-level statistics that are also presented.

This report begins with a general description of what FIA is and how it is implemented. Next, the ecological and socioeconomic contexts in which the forests of the region exist are presented. The criteria used to select the three "average" forested plots are discussed followed by discussions of the past, present, and possible future conditions of these plots and the forests of the region. The report concludes with some overarching findings and some additional resources that can be accessed for those who are interested in learning more about the topics discussed. The section "Statistics, Methods, and Quality Assurance," found on the DVD that accompanies this report, includes state-level tables summarizing the FIA data and data quality information.

What is FIA?

The U.S. Forest Service, Forest Inventory and Analysis program (FIA; www.fia.fs.fed.us) is the "Nation's forest census." Since the 1930s, FIA has been conducting forest inventories across the United States to monitor trends in forest area, composition, health, and other attributes. These data provide foundational information used by policy makers, conservation professionals, and others to better understand the past, current, and future state of the forest.

FIA has established a system of inventory plots across the United States in order to understand forest resources across broad areas (e.g., states and regions). There were 999 plots with one or more forested conditions inventoried as part of the 2008-2012 inventory cycle in Southern New England, including 321 plots in Connecticut, 553 plots in Massachusetts, and 125 plots in Rhode Island.

Prior to 1999, the inventory was operated in a "periodic" manner —all of the plots in a state were inventoried in, ideally, a year or two and then the inventory efforts were shifted to another state. The first periodic FIA inventory for Southern New England was conducted in 1953, followed by subsequent periodic inventories in 1972, 1985, and 1998 (Table 1).

Table 1.—Inventory years and references for previous inventories in Southern New England conducted by the U.S. Forest Service, Forest Inventory and Analysis program.

| Year | State | | |
	Connecticut	Massachusetts	Rhode Island
	-------------------------------	*Reference* -------------------------------	
2003-2007	Butler et al. 2011	Butler et al. 2011	Butler et al. 2011
1998	Alerich 2000a	Alerich 2000b	Alerich 2000c
1985	Dickson and McAfee 1998a	Dickson and McAfee 1998b	Dickson and McAfee 1998c
1972	Dickson and Bowers 1976	Peters and Bowers 1977a	Peters and Bowers 1977b
1953	Griswold and Ferguson 1957	Ferguson and Howard 1956	Ferguson and McGuire 1957

Beginning in 1999, FIA initiated an "annual" inventory system by which a subset of plots in every state was measured every year. The annual inventory for Southern New England began in 2003 with 20 percent of plots inventoried per year. Results from the first full cycle (5 years) of the annual inventory, conducted between 2003 and 2007 (referred to as the 2007 inventory), are available in Butler et al. 2011. This report presents data from the second 5-year cycle of annual inventory data conducted between 2008 and 2012, hereafter referred to as the 2012 inventory.

Each sample point is associated with an inventory plot consisting of four subplots covering a total area of approximately one-sixth acre (Fig. 1). Data are collected at three levels: plot, condition, and tree (Sidebar 1). General attributes, such as elevation and ecoregion province subsection, are collected at the plot level.
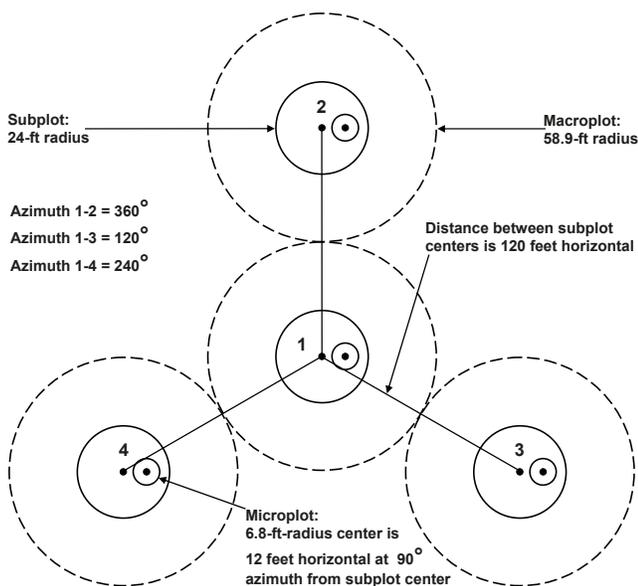
Figure 1.—U.S. Forest Service, Forest Inventory and Analysis plot layout (adapted from Bechtold and Patterson 2005). Macroplots are not used in Southern New England.

Subplot: 24-ft radius

Macroplot: 58.9-ft radius

Azimuth 1-2 = 360°
Azimuth 1-3 = 120°
Azimuth 1-4 = 240°

Distance between subplot centers is 120 feet horizontal

Microplot: 6.8-ft-radius center is 12 feet horizontal at 90° azimuth from subplot center

Sidebar 1.—Plot-, condition-, and tree-level data collected on U.S. Forest Service, Forest Inventory and Analysis inventory plots.

FIA collects forest inventory data at three different scales: plot, condition, and tree. Plot-level variables apply to the whole plot. A plot will have one or more conditions on it. The condition and tree-level data below are only collected on the forested portions of plots. Below are the major variables collected at these three levels, a full list is available in "The Forest Inventory and Analysis Database: Database Description and Users Manual" (Woudenberg et al. 2010).

Plot level
- Latitude and longitude
- Elevation
- Ecological subsection

Condition level
- Forest type
- Reserved status
- Ownership class
- Stand size
- Age of dominant trees
- Stand origin

Tree level
- Species
- Diameter
- Height*
- Tree status
- Damage*
- Volume*

* These variables are only recorded or calculated for trees greater than or equal to 5 inches in diameter.

Each plot contains one or more conditions that are determined based on land use (e.g., forest vs. nonforest) and forested areas being further subdivided based on reserved status, owner group, forest type, stand-size class, regeneration status, and tree density (these and other key terms are defined in the glossary that is found on the DVD included with this report). On each subplot, forest land uses are identified. Forest land is defined as a piece of land that is at least 1 acre in area, 120 feet wide, and either currently has 10 percent stocking by forest trees of any size or, if a timber harvest or other disturbance recently occurred, will likely have sufficient tree stocking in the near future.

Specific information is recorded for all trees on forested conditions on subplots that have diameters of at least 5 inches at breast height (defined as 4.5 feet above ground; often referred to as d.b.h.). This information includes species, diameters, heights, and general condition. Information is also recorded for trees between 1 and 4.9 inches in d.b.h. found on the 1/300-acre microplots within forested conditions.

Because of the statistical sampling procedure, the data collected on the plots can be used to estimate forest attributes for broader areas. The relatively coarse nature of the sampling grid, i.e., one one-sixth acre plot per 6,000 acres, means that the estimates are not reliable for small geographic areas, such as counties, but are reliable for larger areas, such as states. One measure of the reliability of the statistics is the sampling error that is included wherever possible. Sampling errors and error bars shown in the tables and figures in this report represent 68 percent confidence intervals for the estimated values. Other measures of data reliability, such as quality control information, are included on the DVD that accompanies this report.

For fuller descriptions of the FIA sampling procedures, estimation procedures, and database documentation, readers are referred to the "Forest Inventory and Analysis National Core Field Guide" (U.S. Forest Service 2012b), "The Enhanced Forest Inventory and Analysis Program – National Sampling Design and Estimation Procedures" (Bechtold and Patterson 2005), and "The Forest Inventory and Analysis Database: Database Description and Users Manual Version 4.0 for P2" (Woudenberg et al. 2010). All of these documents plus past inventory reports, tables, data access tools, and other information are available through the national and Northern Research Station FIA websites (www.fia.fs.fed.us and www.nrs. fs.fed.us/fia).

variables are collected on a subset of FIA plots and are related to invasive plants, down woody materials, tree crowns, soils, and, newly implemented (and not yet available for the Southern New England), tree regeneration.

FIA conducts the National Woodland Owner Survey (NWOS; www.fia.fs.fed.us/nwos) as the social complement to its biophysical inventory. The NWOS contacts a random sample of private landowners to help understand: who owns the forests; why they own them; what they have done with them in the past; and what they plan to do with them in the future. The data reported here were collected between 2011 and 2013 (Butler et al. in press).

The Timber Products Output survey (TPO; www. fia.fs.fed.us/tpo) is conducted by FIA to ascertain information on the amount of wood that is being processed. Information on the volumes and species being processed, and where the materials originate are obtained through surveys of sawmills and other primary wood processing facilities. The data reported here are from mills in Massachusetts and Rhode Island surveyed in 2010 and in Connecticut in 2011.[1]

Where applicable, this report also brings in data from other, non-FIA sources. Remotely sensed imagery (e.g., Jin et al. 2013) is an important component of the FIA program and allows for results to be spatially extrapolated and provide other insights. The forest projections incorporate FIA data, but were developed as part of the Northern Forest Futures project (Shifley and Moser, in press) and are based on numerous economic and other inputs. Information on invasive insects comes from the U.S. Department of Agriculture Animal and Plant Health Inspection Service (APHIS; www.aphis. usda.gov/wps/portal/aphis/home) and other sources.

Other FIA Data

In addition to the basic forest inventory data described above, FIA collects data on forest health, forest ownership, and timber products. The forest health

[1] Piva, R.J. Unpublished results from the 2010 Timber Products Output survey of Southern New England. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.

Ecological and Socioeconomic Context

Tree canopy in central Massachusetts. Photo by Brett J. Butler, U.S. Forest Service.

To understand the forests of a region, it is important to understand the context within which those forests exist. The broader ecological context sets the general parameters that determine the types of plants that can grow in an area and the environmental conditions in which the plants grow and compete. People have influenced the forests of Southern New England for millennia; the social and economic contexts influence the past, present, and future forest conditions.
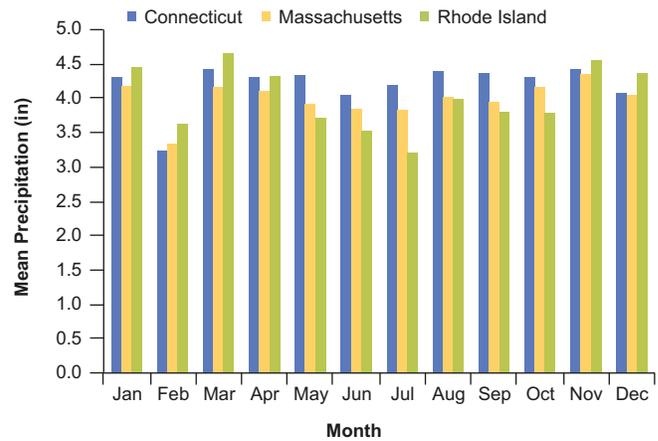

Figure 2.—Mean monthly temperatures for Connecticut, Massachusetts, and Rhode Island (NOAA, n.d.a.).

Ecology

The ecology of a region is influenced by the climate, geology, and historical factors that culminate in what are sometimes referred to as ecoregion provinces. The climate of Southern New England is temperate with mean monthly temperatures ranging from 25 to 72 °F (Fig. 2) (NOAA, n.d.a) and precipitation of about 50 inches per year distributed across the year as shown in Figure 3 (NOAA, n.d.b). The topography is characterized by rich river bottoms surrounded by hills and small mountains, particularly in the Berkshires of western Massachusetts. Elevation ranges from sea level to 3,491 feet atop Mount Greylock in Massachusetts, from sea level to 2,380 feet atop Mount Frissell in Connecticut, and from sea level to 812 feet atop Jerimoth Hill in Rhode Island (Fig. 4).
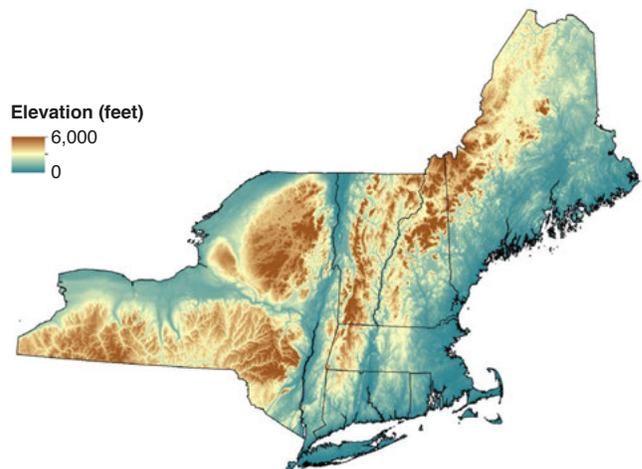
These factors contribute to the region's dominant ecoregion province, broad areas of similar climates and natural vegetation, known as the Eastern Broadleaf Forest Province across the three States (Bailey 1995) (Fig. 5). The only other ecoregion province found within the region is the Adirondack-New England Mixed Forest Province (M212), which is the dominant ecoregion province of the Berkshires of western and north-central Massachusetts and northwestern Connecticut. This ecoregion province contains 30 percent of the forest land in Massachusetts and 2 percent of the forest land in Connecticut.
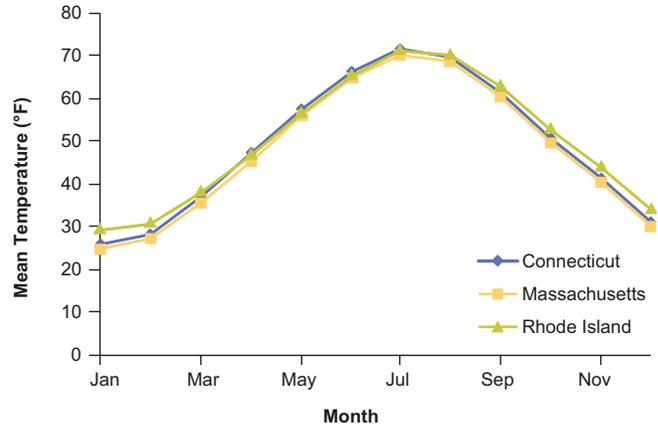
Figure 3.—Mean monthly precipitation for Connecticut, Massachusetts, and Rhode Island (NOAA, n.d.b.).

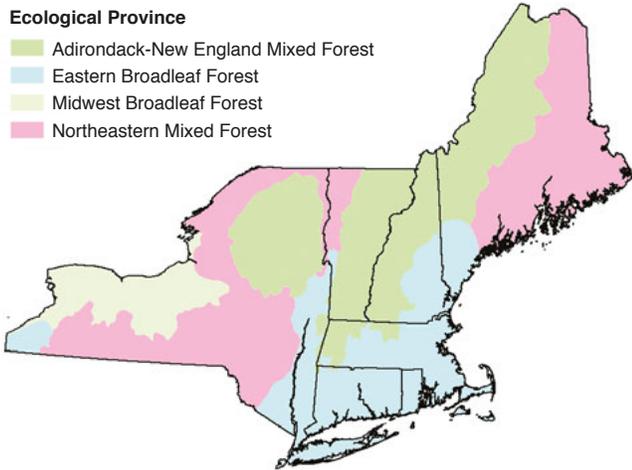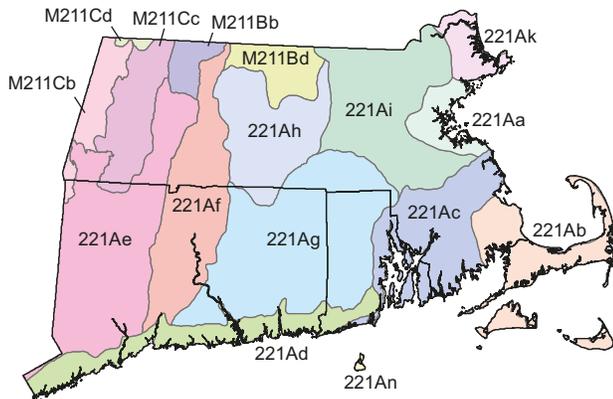**Figure 4.**—Topography of the northeastern United States (USGS 2014).

Ecological Province

Adirondack-New England Mixed Forest
Eastern Broadleaf Forest
Midwest Broadleaf Forest
Northeastern Mixed Forest

Figure 5.—Ecoregion provinces of the northeastern United States (Bailey 1995).

M211Cd M211Cc M211Bb
M211Bd
221Ak
M211Cb
221Ai
221Aa
221Ah
221Af
221Ac
221Ab
221Ae
221Ag
221Ad
221An

Ecoregion Province Subsections

Berkshire-Vermont Upland (M211Cc)
Boston Basin (221Aa)
Cape Cod Coastal Lowland and Islands (221Ab)
Gulf of Maine Coastal Lowland (221Ak)
Gulf of Maine Coastal Plain (221Ai)
Hillsboro Inland Hills and Plains (M211Bd)
Hudson Highlands (221Ae)
Long Island Coastal Lowland and Moraine (221An)
Lower Connecticut River Valley (221Af)
Narragansett-Bristol Lowland and Islands (221Ac)
Southeast New England Coastal Hills and Plains (221Ag)
Southern Green Mountain (M221Cd)
Southern New England Coastal Lowland (221Ad)
Southern Piedmont (M211Bb)
Taconic Mountains (M211Cb)
Worcester-Monadnock Plateau (221Ah)

Figure 6.—Ecoregion province subsections of Southern New England (McNab et al. 2005).

There are important differences within these ecoregion provinces. Ecoregion province subsections represent finer-scale differentiation based on areas of similar climate, potential natural vegetation, and soils. There are 16 ecoregion province subsections found across Southern New England (Fig. 6). The Southeast New England Coastal Hills and Plains (221Ag) and Hudson Highlands (221Ae) ecoregion subsections contain the greatest percentage of forest land area in the region—21 and 17 percent, respectively.

Socioeconomics

The forests we see are partially the result of people interacting with and influencing the ecological factors across the landscape. Where forests exist across the region and how they are managed are largely the intentional and unintentional result of human decisions and are critical for understanding not just the past and present forest conditions, but equally important, the future conditions.

Population

The most recent U.S. Census found that there are 11.2 million people across Southern New England (U.S. Census Bureau, n.d.); 3.6 million people in Connecticut (738 people per square mile), 6.5 million people in Massachusetts (839 people per square mile), and 1.1 million people in Rhode Island (1,018 people per square mile). The population is not evenly distributed across the region; it is concentrated in the urban areas, such as Boston, Hartford, and Providence, along the major transportation corridors, such as Interstates 95 and 91, and the coast.

Land Use and Land Cover

Land use refers to the actual use of a given parcel of land while land cover refers to what is directly observable on the land. Land use is more anthropocentric, it is defined by how people are intentionally or unintentionally

using the land. Land cover is more biocentric as it is determined by the current conditions. These two concepts can yield very different statistics. A forest area that is harvested with most of the trees removed and is likely to revert back to forest would have its land use classified as forest land, but its land cover would be classified as something else, maybe shrub land until the trees can fully reestablish. Or an area that has houses under a canopy of trees may be classified as having a forest land cover, but its land use would be residential. The terms are often confused or conflated.

Land cover is estimable using remote sensing and can be more easily mapped. Figure 7 shows the land cover across the region. From this map, it is apparent that there is a lot of forest cover across the region, but it is not evenly distributed.

FIA classifies land according to its use and that is the focus of the statistics in this report. The land use of an estimated 59 percent of the land area of Southern New England is forested. This is using the FIA definition of forest land: land at least 10 percent stocked by forest trees of any size, or land formerly having such tree cover, and not currently developed for a nonforest use; it must be at least 1 acre in size and at least 120 feet wide. Connecticut is 56 percent forested (1.74 million acres), Massachusetts is 61 percent forested (3.03 million acres), and Rhode Island is 55 percent forested (364,000 acres).

There was relatively little land use change in Southern New England between the 2007 and 2012 inventories and no substantial change in the total area of forest land (Fig. 8). Most of the region either remained forested or stayed nonforest (53 percent and 44 percent, respectively), 3 percent of the land experienced either a forest loss or gain. Southern New England lost an estimated 99,000 acres of forest land between the 2007 and 2012 inventories. This loss was offset by an estimated gain of 175,000 acres during the same period, resulting in no appreciable net change in forest land acreage. Fifty-eight percent of the gross forest loss was from forest land being converted to developed land, specifically commercial and residential development (Fig. 9).
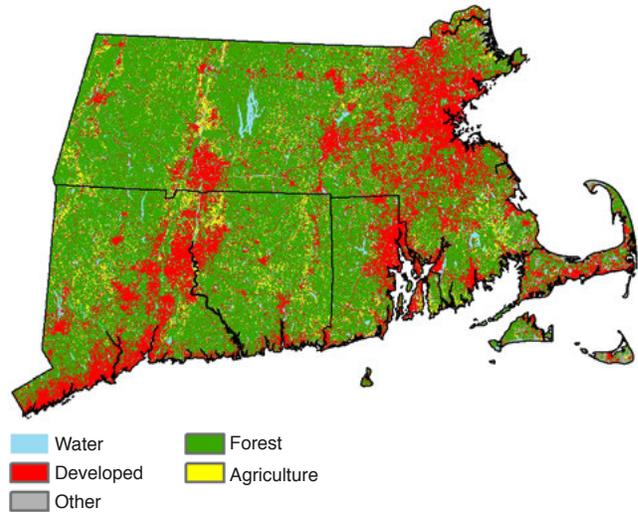
**Figure 7.**—Land cover, Southern New England, 2010 (Jin et al. 2013).
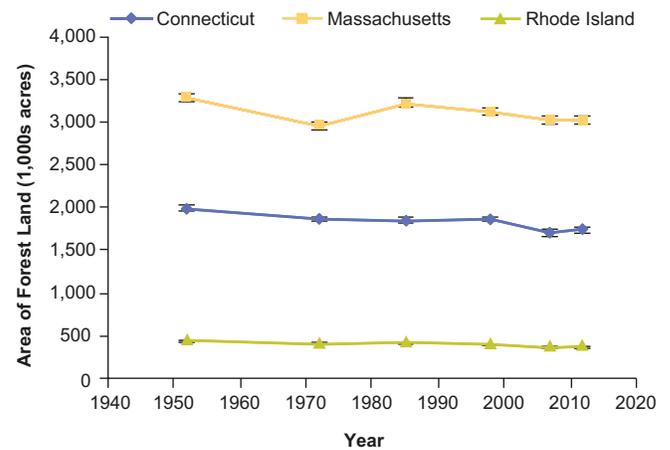
Figure 8.—Area of forest land, Connecticut, Massachusetts, and Rhode Island, 1952-2012. Error bars represent a 68 percent confidence interval around the mean.
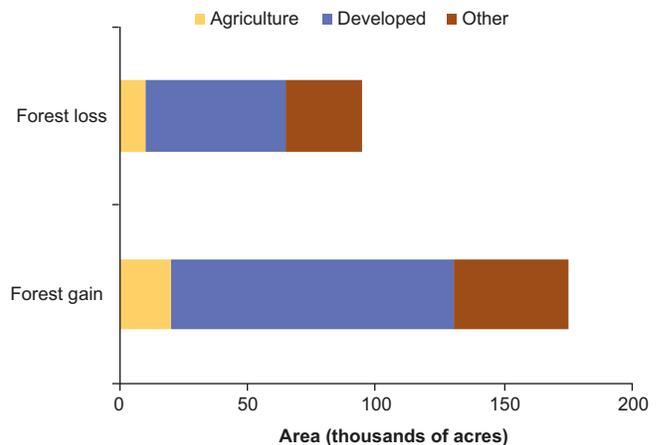
Figure 9.—Area of forest gain and loss by land use between 2007 and 2012, Southern New England.

Gains in forest land came primarily (64 percent) from developed land reverting to forest, mainly open land in residential areas and rights-of-way naturally reverting. Eleven percent of forest gain was from agricultural land uses.

The spatial distribution of plots that had forest loss or forest gain is shown in Figure 10. The plots exhibiting change are more likely to occur near persistently nonforest plots. This suggests the forest-nonforest interface areas should receive additional attention for those interested in land use change.

● Forest gain
● Forest loss
● Remained nonforest
● Remained forest
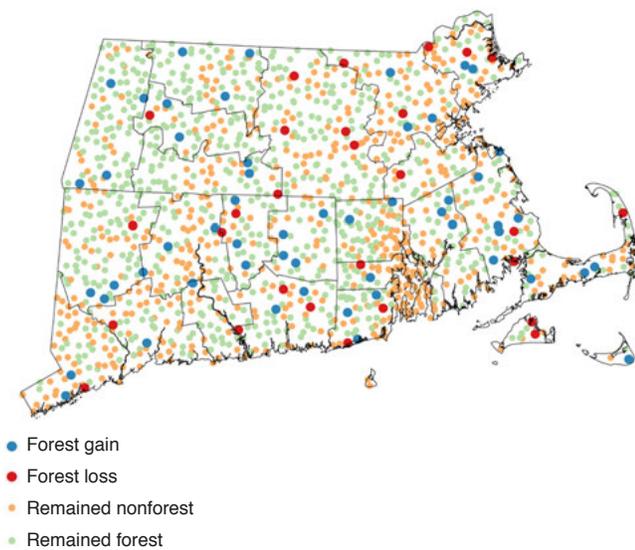
Figure 10.—Distribution of remeasured inventory plots showing forest gains and losses, as well as plots that were unchanged, Southern New England, 2007 to 2012. (Plot locations are approximate.)

Urban Forests

Not all trees are in forests. Across Southern New England, there are about 317 million trees that are in urban areas (Nowak and Greenfield 2008) and while some of these trees are in what FIA defines as forest land, many are not (e.g., they are in patches less than 1 acre in size or they have understories that are maintained lawn). Tree cover in these urban areas offers a wide range of environmental benefits, including the provision of wildlife habitat, aesthetic appeal and visual barriers, climate control, water quality improvement, and air and noise pollution abatement.

Forest land that lies in close proximity to developed land or in areas of high population density is strongly influenced by the surrounding urban land uses. These urban forests often differ from their rural counterparts in forest structure and function as they are exposed to unique abiotic and biotic pressures associated with their proximity to developed areas. The higher density of forest-nonforest edges near urban areas can significantly impact the flora and fauna of these areas by altering patterns of seed dispersal and by changing microclimate and site moisture dynamics. The proximity of human activity can lead to mechanical or air-pollution induced foliar damage as well. Pressures from wildlife, such as browsing from white-tailed deer (*Odocoileus virginianus*), can also differ substantially between urban and rural areas.

Connecticut, Massachusetts, and Rhode Island have the greatest proportion of urban area of any state in the United States (36, 36, and 37 percent, respectively) other than New Jersey. Twenty-four percent of the forest land across Southern New England is in areas defined by the U.S. Census as urban areas. The urban areas in the region have tree canopy cover that is substantially higher than most other states. Sixty-seven percent of the urban land area in Connecticut is covered by trees, 65 percent in Massachusetts, and 54 percent in Rhode Island; this compares to 34 percent nationally (Nowak and Greenfield 2012).

The FIA-defined forest land in the urban and rural areas are, in general, fairly similar across the region. For example, the tree diameter size class distributions are similar in the two areas. There are some potential differences in species composition, but more data are required to confirm this. Although the nonnative and invasive Norway maple and tree-of-heaven are relatively rare on forest land in Southern New England, it is interesting to note that these species are found in greater proportions in urban areas than in rural areas (1.1 percent and 0.06 percent, respectively, of trees greater than or equal to 1 inch in diameter). In terms of ownership, both the rural and urban areas are dominated by private owners, but in the urban areas

local governments control most of the public forest land compared to the rural areas where state governments are the dominant public ownership group.

The data in this report compare only FIA-defined forest land within urban and rural land. It is likely that greater differences would be found if all land with trees in rural and urban areas were compared. Much of the land with trees in urban areas is classified as nonforest land by FIA due to its existence in patches smaller than an acre and the maintenance of its understory (e.g., maintained lawn). To address this information gap, FIA, in partnership with the U.S. Forest Service's i-Tree program began the first national FIA urban inventory in 2014. Tree data within both forest and nonforest areas are being collected annually on FIA plots in certain urban areas around target cities and will eventually include urban areas in Southern New England.

Forest Fragmentation

Another consequence of human population pressures is forest fragmentation—the breaking up of contiguous areas of forest land into smaller, disconnected areas. Fragmentation can be problematic for wildlife that rely on large areas of contiguous forest and beneficial to those species that thrive on edge habitat. We adapted a spatial integrity index (SII) developed by Kapos et al. (2002) for the global forest resources assessment that integrates three important facets of fragmentation affecting aspects of forest ecosystem functioning: patch size, local forest density, and patch connectivity to core forest areas.[2] Figure 11 shows the SII of the Southern New England forests calculated at a 250 m scale. At this scale, core forest is defined as having a patch size >1,544 acres and a forest density of >90 percent within a 0.8 mile radius local neighborhood. Unconnected fragments have a patch size <30 acres, a local forest density of <10 percent, and are greater than 4.2 miles from core forest. Calculated from forest cover data only, 47 percent of the forest in Southern New England qualifies as core forest (Fig. 11). When one takes into account underlying

Forested Area

■ Core		■ Unconnected	
■ High integrity		□ Nonforest	
■ Med integrity			
■ Low integrity			
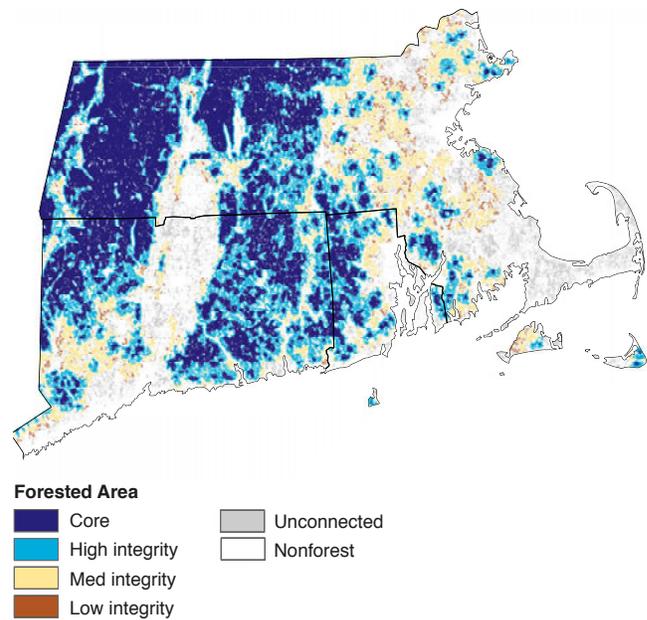
Figure 11.—Forest land by spatial integrity index (SII) at the 250 m scale, 2009. Processing note: Map was produced by calculating spatial integrity index for every forest pixel in the 250 m 2009 FIA modeled forest/nonforest dataset (Wilson et al. 2012). See text for explanation of special integrity index.

housing densities greater than 16 houses per square mile (known as the wildland-urban interface [Radeloff et al. 2005, U.S. Census Bureau 2010]) the percentage core forest drops to 23 percent.
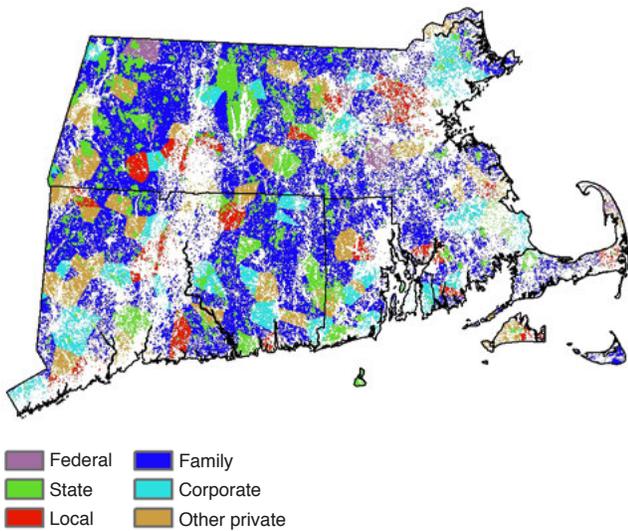
Forest Ownership

Knowing who owns the forest is important because it is the owners of the land that ultimately decide what, if anything, will happen with the forests. Private ownerships dominate the landscape of Southern New England (Fig. 12) and most of the eastern United States. Across Southern New England, 68 percent of the forest land is privately owned; 73 percent of the forest land in Connecticut is privately owned, 65 percent in Massachusetts, and 73 percent in Rhode Island.
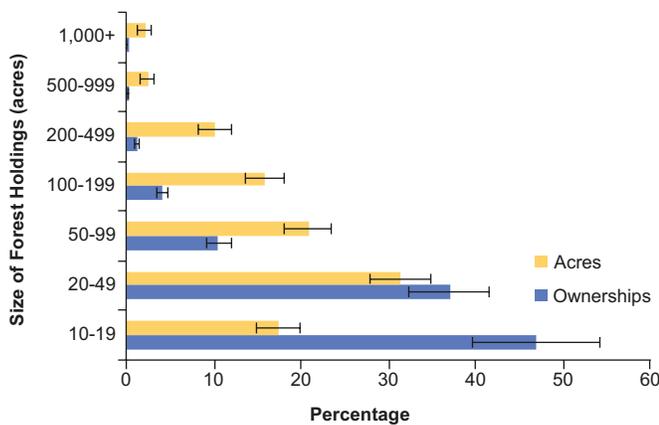
Within the private category, it is family and individuals that own the greatest proportion. Results from the FIA National Woodland Owner Survey (NWOS) for family forest ownerships with 10 or more acres of forest land (the primary focus of the NWOS), reveal 84 percent

[2] Riemann, R. 2014. Adaptation of a spatial integrity index to 30 m and 250 m scales, and its application across the northeastern United States. Unpublished.

of these ownerships have forest holdings of between 10 and 49 acres and this equates to roughly half of the forest land owned across this ownership group (Fig. 13). The average forest holding is 34 acres across the region and is 33, 39, and 17 acres in Connecticut, Massachusetts, and Rhode Island, respectively. The reasons for owning land primarily relate to amenity values, such as the beauty, nature protection, and privacy their forests provide (Fig. 14). Activities on the land tend to be oriented toward personal activities, such as recreation and cutting firewood for their own use (Fig. 15). Participation in preferential property tax programs

is fairly high across the region and this likely explains the relatively high percentage of ownerships with written forest management plans; conservation easements, participation in cost-share programs, and green certification are much less common (Fig. 16).

Figure 14.—Proportion of family forest land and ownerships (with 10+ ac) by reasons for owning, Southern New England, 2011-2103. Percentages include those who responded that the particular objective is "very important" or "important" on a five-point scale; categories are not exclusive. Error bars represent a 68 percent confidence interval around the mean.
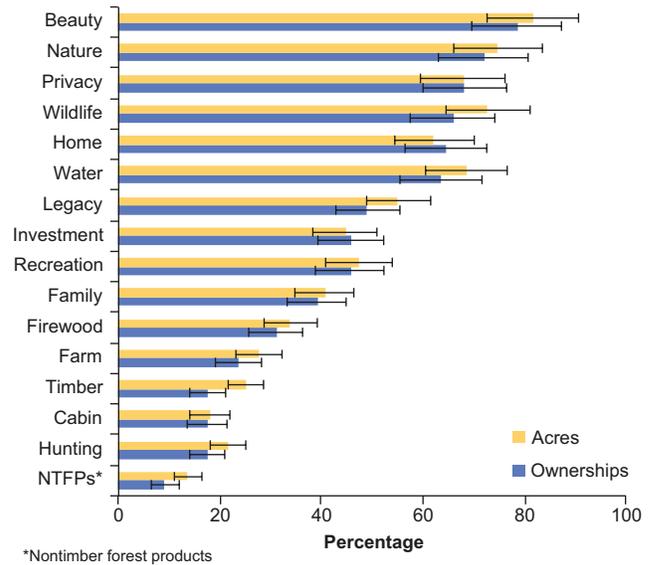

Figure 12.—Forest ownership across Southern New England, 2011 (Hewes et al. 2014).
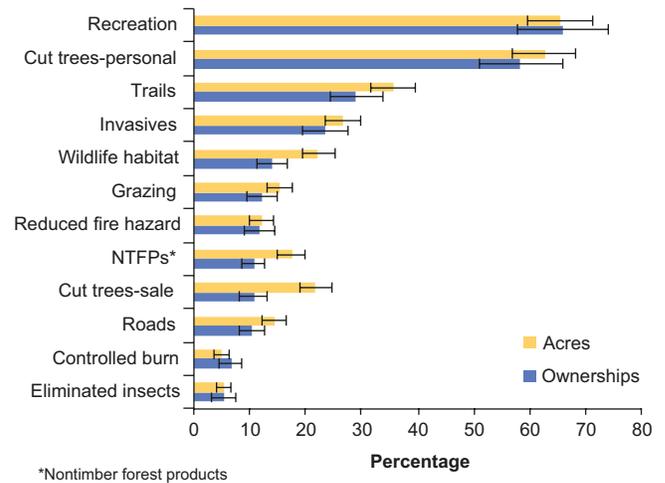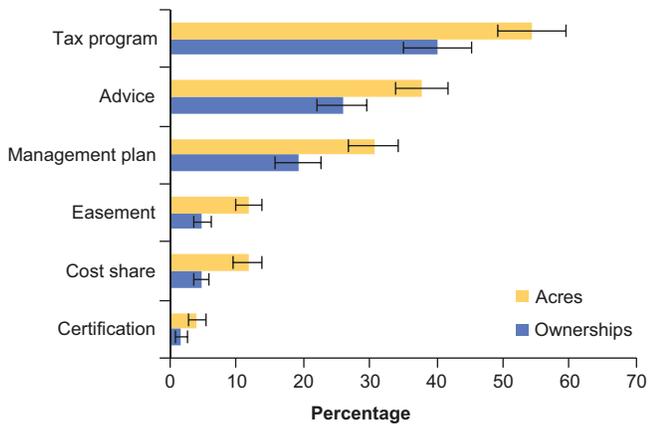

Figure 13.—Proportion of family forest land and ownerships (with 10+ acres) by size of forest holdings, Southern New England, 2011-2103. Error bars represent a 68 percent confidence interval around the mean.

Figure 15.—Proportion of family forest land and ownerships (with 10+ ac) by activity, Southern New England, 2011-2103. Categories are not exclusive. Error bars represent a 68 percent confidence interval around the mean.

Figure 16.—Proportion of family forest land and ownerships (with 10+ ac) by participation in forestry programs and management activities, Southern New England, 2011-2103. Categories are not exclusive. Error bars represent a 68 percent confidence interval around the mean.

The remainder of the privately owned forest land is controlled by corporate (11 percent) and other private entities (9 percent), including tribal groups. These organizations hold forest land for a wide variety of reasons. For some, forest land is part of land they have for other reasons, such as a manufacturing facility, with their forest land providing a buffer between them and their neighbors. For other ownerships, such as land trusts and other environmental nongovernmental organizations, they may own a specific piece of land due to unique environmental features.

On the public side, state governments control 18 percent of the forest land, local governments 12 percent, and the Federal government 2 percent. These lands are managed by various government agencies that have missions that include watershed protection, wildlife habitat, recreational opportunities, timber production, or a combination thereof. The management of these lands is largely determined through political and regulatory processes and can be constrained by budget restrictions.

Forest Products

The harvesting and processing of timber products produces a stream of income shared by forest owners, managers, marketers, loggers, truckers, and processors.

There are no regional estimates for most of these values, but the FIA Timber Products Output survey (TPO) does quantify the amount of wood that is being processed. The TPO program canvassed all active mills across the region in 2010 and 2011 (see footnote 1 on page 4). The 21 active forest product mills in Connecticut processed 21 million board feet of material. The 45 active forest product mills in Massachusetts processed 19 million board feet of material. The five active forest product mills in Rhode Island reported processing a total of 631,000 board feet of material. Eighty percent of the volume processed by the region's mills came from within the three States. New Hampshire, New York, Pennsylvania, and Vermont supplied the remaining material processed.

Current and Historical Conditions

Invasive buckthorn found in Leverett, MA. Photo by Brett J. Butler, U.S. Forest Service.

To tell the story of the forests of Southern New England, this report highlights three average or prototypical plots from across the region. Specifics about each of these plots are provided along with the region- and state-level summaries. There is no plot that is a perfect representation or average of all attributes across this, or any, region, but there is still much that can be learned from examining plots that are close to the average or prototypical plot. To identify a focus, or average, plot in each State, the following attributes were examined:

- Ecoregion

- Forest-type group

- Age of the dominant trees

- Stand size

- Stand origin

- Basal area

- Ownership class

- Distance to road

The average values for these attributes across each of the States are listed in Table 2.

While there were no plots that met all of the selection criteria perfectly, the plots selected were close. The selected plots had all of the same values for the categorical variables and were within 4 to 11 percent of the averages for the continuous variables. The focus plots are located in Litchfield County, Connecticut; Worcester County, Massachusetts; and Kent County, Rhode Island (Fig. 17). The Connecticut plot was measured as part of the annual inventory system in 2007 and 2012, the Massachusetts plot was measured in 2004 and 2009, and the Rhode Island plot was also measured in 2004 and 2009.
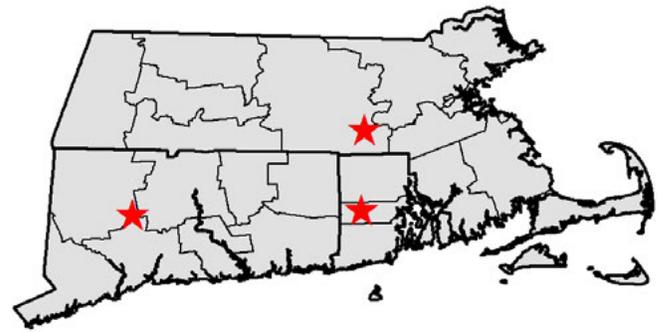
Figure 17.—Approximate location of the three FIA inventory focus plots highlighted in this report.

Table 2.—Average or plurality values for FIA forest inventory plots in Connecticut, Massachusetts, and Rhode Island, 2012.

| Attribute	State		
	Connecticut	Massachusetts	Rhode Island
	Average/plurality value		
Ecoregion province	Eastern broadleaf forest	Eastern broadleaf forest	Eastern broadleaf forest
Forest-type group	Oak/hickory	Oak/hickory	Oak/hickory
Age of dominant trees (years)	74	71	69
Size of dominant trees[a]	Large	Large	Large
Basal area (ft²)	118	132	119
Ownership group	Private	Private	Private
Distance to road category (feet)	301-1000	301-1000	301-1000

[a] Small: dominated by trees less than 5.0 inches in diameter; medium: dominated by trees 5.0 to 8.9 inches in diameter for softwoods and 5.0 to 10.9 inches in diameter for hardwoods; large: dominated by trees greater than or equal to 9.0 inches in diameter for softwoods and 11.0 inches in diameter for hardwoods.

The Past

Although we do not have extensive stand histories for the focus plots, or any FIA inventory plots, we can surmise some history based on the age of the dominant trees and a general knowledge of the region's history. A representation of the age of the dominant trees across the region is shown in Figure 18. Eighty-one percent of the forest land across the region is found in stands where the dominant trees are between 50 and 99 years old. The average age of the dominant trees, ignoring nonstocked stands, are: 74 years in Connecticut, 71 years in Massachusetts, and 69 years in Rhode Island.

The age of the dominant trees on the focus plots at the time of the most recent inventories was estimated to be 71 years for the Connecticut plot and 74 years for the Massachusetts and Rhode Island plots.

The age of the dominant trees is an important factor for understanding the stand, but it should not be confused with stand age. Stand age, meaning the number of years since the current stand was established, can be substantially higher than the age of the dominant trees unless the stand is still dominated by the initial cohort of trees that colonized the stand. The age of the dominant trees also needs to be interpreted with caution as the single value recorded for each condition is not able to capture the diversity of ages associated with mixed aged stands.
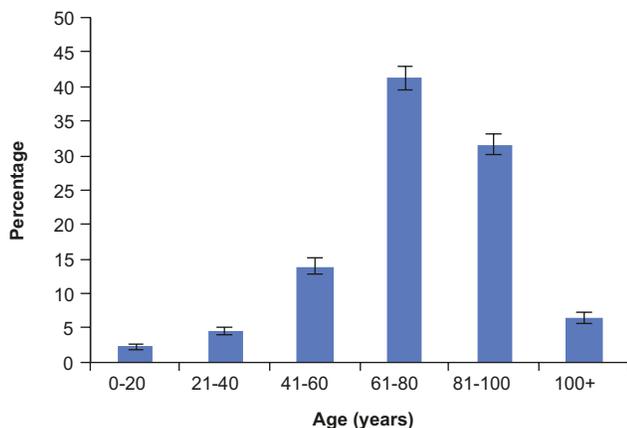
Given where the focus plots are located and knowing something about the general land use history of the area, the species and ages of the dominant trees implies that sometime during the late 1800s or early 1900s these plots were likely not forested. During this time period, most of the landscape was cleared of trees as is evidenced by the stone walls that proliferate across the landscape. It is likely the stands were from abandoned crop or pasture land at which point old-field succession commenced and a forest eventually took over. Following abandonment, the initial pioneer tree or early successional species, such as eastern redcedar, would have been the first to establish. These species are adapted to colonizing disturbed or cleared areas with ample sunlight. They are often fast growing species, but are also often not competitive with species that establish later and can shade out the pioneer species. There are no remnants of these early successional trees in the current stands that can be discerned from the inventory data, but there may be downed logs or other artifacts that could provide clues.

Although land clearing by humans was not a dominant disturbance across Southern New England 70 years ago, other disturbance could have been factors. For example, the age of the dominant trees matches fairly well with what one would expect for trees that established following the devastating hurricane of 1938 that decimated much of the forests of the region.

For those interested in understanding more about the history of forests and the New England landscapes in which they exist, "Reading the Forested Landscape: A Natural History of New England" (Wessels 1997), "Stone by Stone: The Magnificent History in New England's Stone Walls" (Thorson 2004), or one of the many other books on this topic may be of interest. Another resource is the forest dioramas at the Harvard Forest in Petersham, MA, that show an artist's rendition of forest succession from precolonial forests through the mid-1900s (Fig. 19).

Figure 18.—Percentage of forest land by age of dominant trees, Southern New England, 2012. Error bars represent a 68 percent confidence interval around the mean.

a) Circa 1700 (pre-European settlement)

b) Circa 1740 (early European settlement)

c) Circa 1830

d) Circa 1850 (farm abandonment)

e) Circa 1910 (old-field succession)

f) Circa 1915

g) Circa 1930

Figure 19.—Photographs of the dioramas from the Harvard Forest Fisher Museum showing an artist's rendition of the historical forested landscape in Southern New England. Photos used with permission of Harvard Forest Archives, Harvard University (http://harvardforest.fas.harvard.edu/dioramas).

The Present

Following the demise of the pioneer species, through natural disturbances or natural succession, the current species increased in importance and now dominate the three focus plots and much of the forests of the region.
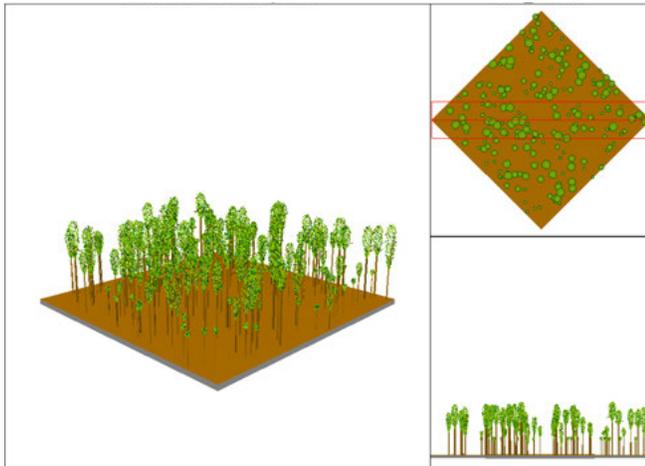
Simulations of the trees on the three focus plots using the stand visualization software (SVS) (McGaughey 2002) are shown in Figure 20. Although the graphics are simulations, they are useful for getting a better understanding of what the stands look like and provide

context for the focus plots beyond the numeric summaries.

Stand Structure

Across the one-sixth acre plot sampled on each of the focus plots, 24 trees greater than or equal to 5 inches in diameter were recorded for the Connecticut plot, 30 trees on the Massachusetts plot, and 31 trees on the Rhode Island plot. This equates to densities of 144, 181, and 187 trees per acre, respectively. The estimated number of trees, greater than or equal to 5 inches in
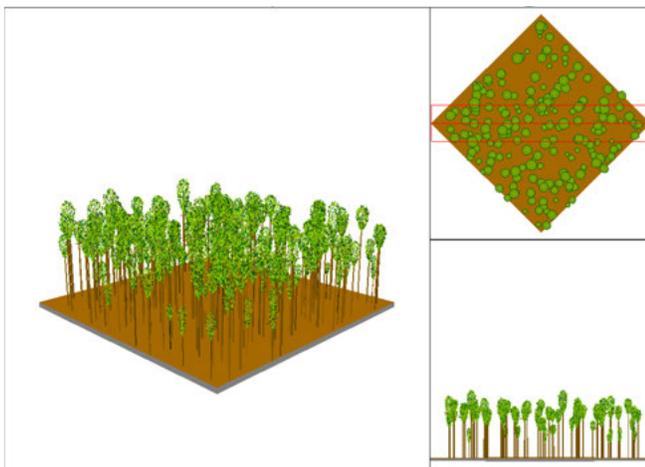
Connecticut
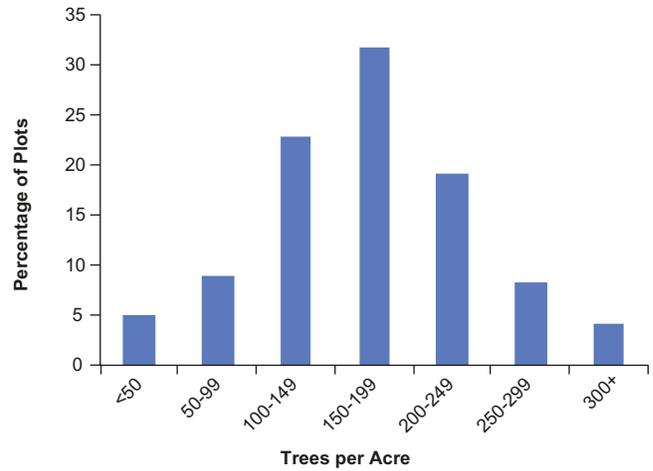

Massachusetts
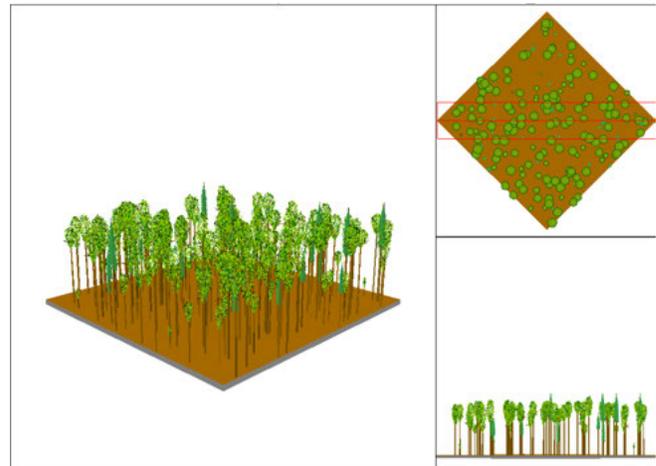
Rhode Island

Figure 20.—Simulation of the three focus plots highlighted in this report for trees greater than or equal to 5 inches in diameter generated using the Stand Visualization Software (McGaughey 2002).

diameter, varies from less than 10 to more than 400 trees per acre across all plots in the region[2] (Fig. 21), with State averages of 158, 180, and 175 trees per acre for Connecticut, Massachusetts, and Rhode Island, respectively.
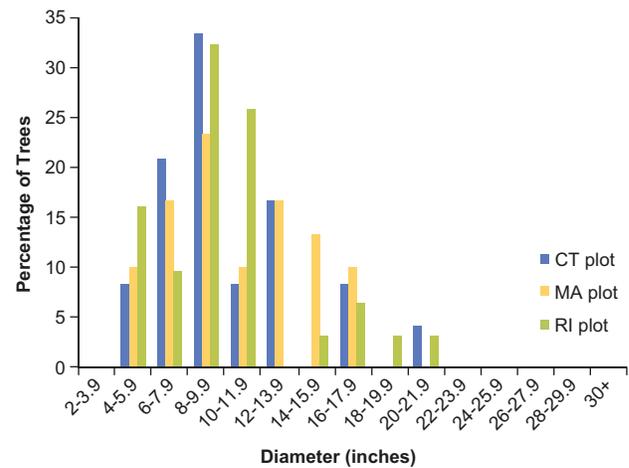
Trees with diameters between 6 and 12 inches dominate the three focus plots (Fig. 22). The Rhode Island focus plot has trees that tend to be a bit smaller, the Massachusetts focus plot has trees that tend be a bit larger, and the Connecticut focus plot trees has trees that are in between, but they all have a diversity of sizes. At the regional level, the diameter-class distribution of trees shows there are more smaller trees across the landscape than larger trees (Fig. 23).

Another way of examining stand structure is to look at basal area, which is equal to the cross-sectional area of a plane intersecting the trees at 4.5 feet above ground. The basal areas are 105, 125, and 126 ft^2 per acre for the Connecticut, Massachusetts, and Rhode Island focus plots. The average basal area for the region, excluding plots with no basal area recorded, is 126 ft^2 per acre, but there is a large range of basal area values (Fig. 24). In Connecticut, basal areas range from 5 to 327 ft^2 per acre with a mean of 118 ft^2 per acre. In Massachusetts, they range from 2 to 423 ft^2 per acre with a mean of 132 ft^2 per acre. And in Rhode Island, they range from 1 to 224 ft^2 per acre with a mean of 119 ft^2 per acre.

Based on the diameters of the plurality of trees, nearly 80 percent of the forest land is classified as "large" (see definitions in the glossary found in "Statistics, Methods, and Quality Assurance" found on the DVD that accompanies this report), as are the three focus plots. The dominance of trees of this size has been increasing precipitously over the past four decades and now represents 84 percent of the forest land in Connecticut, 78 percent in Massachusetts, and 70 percent in Rhode Island (Fig. 25).

[2] Only conditions that occupied at least 25 percent of a plot were included in this and other calculations of averages. This helps to avoid anomalous values that can be caused by conditions that occupy only a sliver of a plot.

Figure 21.—Percentage of FIA inventory plots by tree density, Southern New England, 2012.
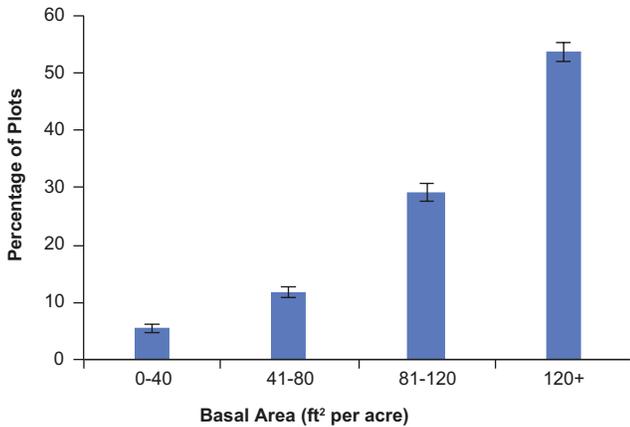

Figure 22.—Proportion of trees by diameter class on the focus plots for Connecticut, Massachusetts, and Rhode Island, 2012.
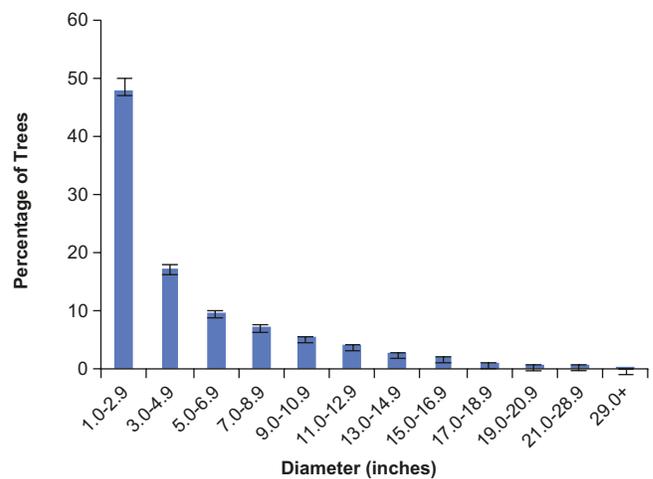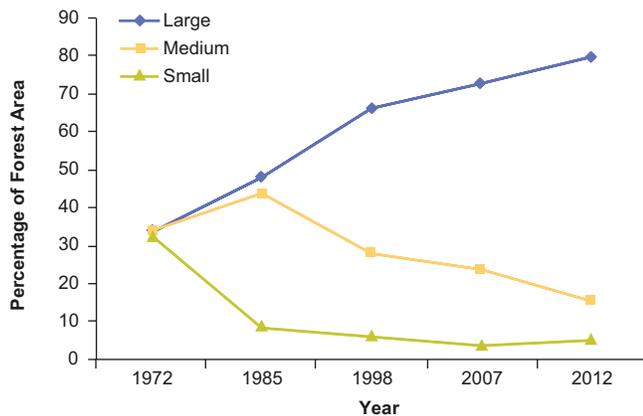

Figure 23.—Proportion of the trees by diameter class, Southern New England, 2012. Error bars represent a 68 percent confidence interval around the mean.
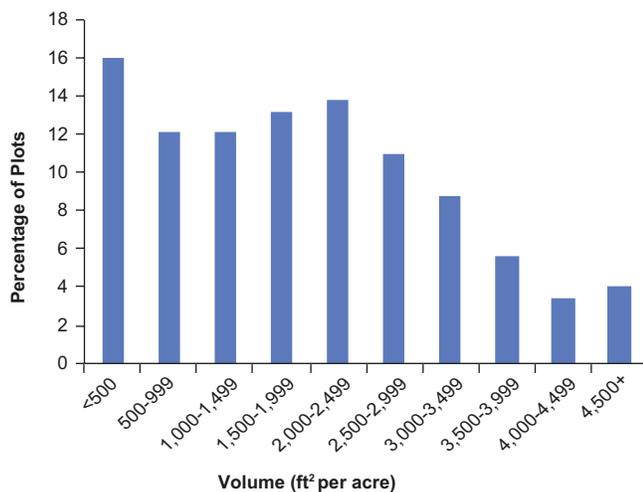
Figure 24.—Proportion of plots by basal area per acre, Southern New England, 2012. Error bars represent a 68 percent confidence interval around the mean.

Figure 25.—Percentage of forest land by size class of dominant trees, Southern New England, 2012.

Figure 26.—Proportion of plots by volume per acre, Southern New England, 2012.

Other ways of quantifying stand structure include volume, biomass, and carbon. The most appropriate metric depends on the questions being asked. For example, volumes are good for understanding the amount of timber that may be harvested, biomass is good for looking at the amount of energy that can be extracted, and carbon is good for understanding the amount of carbon that is being captured or sequestered.

The three focus plots have per acre net volumes of 1,977 ft^3, 2,897 ft^3, and 2,825 ft^3 for the Connecticut, Massachusetts, and Rhode Island plots, respectively. The average volumes are 1,913 ft^3 per acre, 2,030 ft^3 per acre, and 1,806 ft^3 per acre in Connecticut, Massachusetts, and Rhode Island plots, respectively, but there is a wide range of values (Fig. 26). Summing the volumes across all forested acres yields state-level totals of 4,387, 8,138, and 865 million ft^3, respectively. Due to biophysical and social constraints, not all of the wood in the region's forests is available for timber harvesting. The 14 percent of the wood that is in trees that are rotted or otherwise undesirable, the cull deductions, are excluded from the reported net volumes. Forty-nine percent of the wood is on lands owned by family forest owners. Butler et al. (2010) estimated that only 27 percent of the wood on family forest lands is readily available due largely to social constraints, such as owners' attitudes toward timber harvesting, experience with timber harvesting, and size of forest holdings.

The data depicted in Figure 23 changes dramatically if expressed in terms of volume (Fig. 27) because larger trees have more volume than smaller ones (and FIA does not calculate volumes for trees less than 5 inches in diameter). Half of the volume is in trees that are between 10 and 18 inches in diameter.

There are an estimated 432 million tons of carbon sequestered in the forests of Southern New England: 260 million tons in Massachusetts, 142 million tons in Connecticut, and 29 million tons in Rhode Island. Live biomass (i.e., live trees and understory plants) represents the largest proportion, 51 percent, of the forest ecosystem carbon pool, followed by soil organic matter, 35 percent

(Fig. 28). Estimates of total carbon in Southern New England forests have increased by an average of 1.81 tons per acre over the last decade (2002 to 2012) or a total increase of nearly 16 million tons across all of the forest land.

There are differences in the distribution of forest carbon stocks by forest-type group. In the oak/hickory group, for example, 59 percent of the estimated forest carbon is in live biomass, whereas in the elm/ash/cottonwood group, only 33 percent is in live biomass.
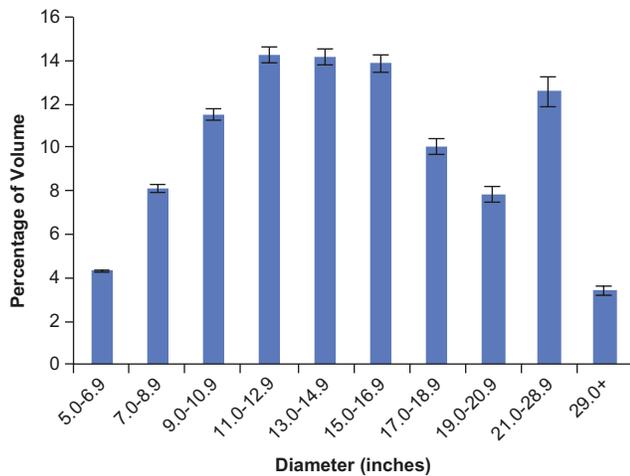
Figure 27.—Proportion of volume of trees by diameter class, Southern New England, 2012. Error bars represent a 68 percent confidence interval around the mean.
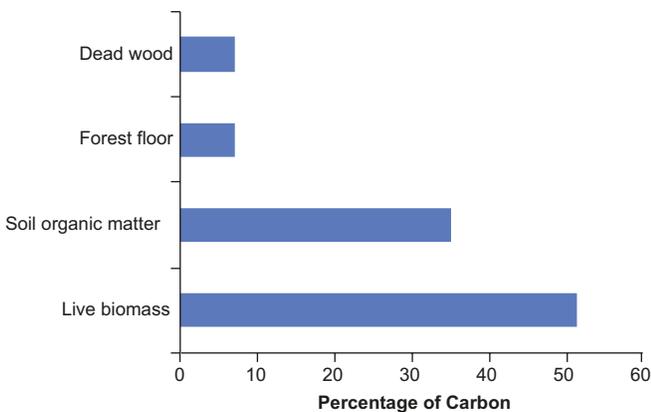
Figure 28.—Proportion of carbon on forest land by forest ecosystem component, Southern New England, 2012.

The distribution of carbon varies over the course of stand development with the most carbon being in the soil organic matter and belowground tree components of young stands until they are about 61-80 years of age when the aboveground components represent most of the ecosystem carbon. This trend continues well into stand development as carbon accumulates in live and dead aboveground components.

Downed woody material, in the form of fallen trees, branches, and twigs of all sizes, fulfills a critical ecological niche in forests. (See glossary section in "Statistics, Methods, and Quality Assurance" for definitions of terms.) This material provides valuable wildlife habitat, stand structure diversity, and carbon storage. The total carbon stored in down woody material across Southern New England's forest land exceeds 17 million tons. Most detrital carbon stocks were composed of coarse woody debris, 57 percent.

Species Composition

On the three focus plots, five species were represented by trees greater than or equal to 5 inches in diameter on the Connecticut plot, seven on the Massachusetts plot, and 13 on the Rhode Island plot (Table 3). As would be expected for forests classified within the oak/hickory forest-type group, oaks are the dominant species on these plots, but the specific oak species vary; northern red oak dominates on the Massachusetts and Rhode Island plots and a mix of white oak and northern red oak on the Connecticut plot (Table 3).

The number of species on the focus plots represent a fraction of the number of species of trees greater than or equal to 5 inches in diameter found on all of the inventory plots across the region. Fifty-six species of trees greater than or equal to 5 inches in diameter were found on Connecticut plots, 68 in Massachusetts, and 42 in Rhode Island (see appendix on page 38 for a complete list of tree species found on FIA plots). There were 76 species of trees greater than or equal to 5 inches in diameter found across all forested plots inventoried. If trees between 1.0 and 4.9 inches in diameter are included, an additional five species were found.

Table 3.—Trees, greater than or equal to 5 inches in diameter, found on the FIA focus plots in A) Connecticut, B) Massachusetts, and C) Rhode Island, by species and diameter. Each entry in the table represents one tree with the row indicating the species and the number indicating the diameter of the tree.

A. Connecticut

Species	Individual Trees by Diameter (inches)										
White oak	6	6	7	8	9	9	10	11	13	12	12
Northern red oak	9	9	13	13	16	16	20				
Red maple	5	7	8								
Sweet birch	7	9									
American beech	6										

B. Massachusetts

Species	Individual Trees by Diameter (inches)											
Northern red oak	10	10	10	10	11	12	13	14	14	16	17	17
Sweet birch	6	7	9	11	11							
Eastern white pine	7	8	9	14								
Red maple	6	6	6	14								
American beech	6	13										
White oak	14	15										
Black oak	6											

C. Rhode Island

Species	Individual Trees by Diameter (inches)									
Northern red oak	7	7	9	10	10	10	10	15	16	19
Red maple	5	5	7	9	9	11				
Pignut hickory	9	9	10							
Mockernut hickory	8	10								
Black oak	9	21								
Yellow birch	11									
Sweet birch	5									
Shagbark hickory	5									
American beech	5									
White ash	8									
Yellow-poplar	16									
Blackgum	11									
White oak	12									

Some of these tree species are fairly ubiquitous and others quite rare. Red maple is the most common species across all three States, in terms of numbers of trees greater than or equal to 5 inches in diameter (Fig. 29). Considering volume rather than number of trees, red maple is still the most voluminous species in Connecticut and Rhode Island, but eastern white pine is the most voluminous species in Massachusetts (Fig. 30). Other common species, greater than or equal to 10 percent of the number of trees or volume in a State, are northern red oak, black oak, eastern hemlock, scarlet oak, and sweet birch. At the other end of the spectrum, 22 of the species were found on no more than five of the plots.
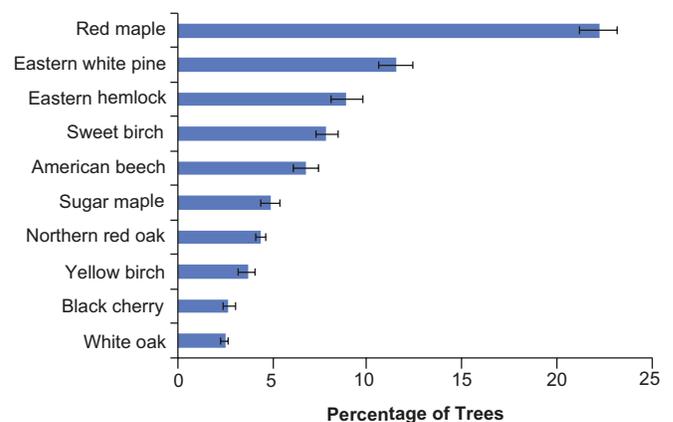
Figure 29.—Ten most common tree species as a proportion of all trees 5 inches and larger in diameter, Southern New England, 2012. Error bars represent a 68 percent confidence interval around the mean.
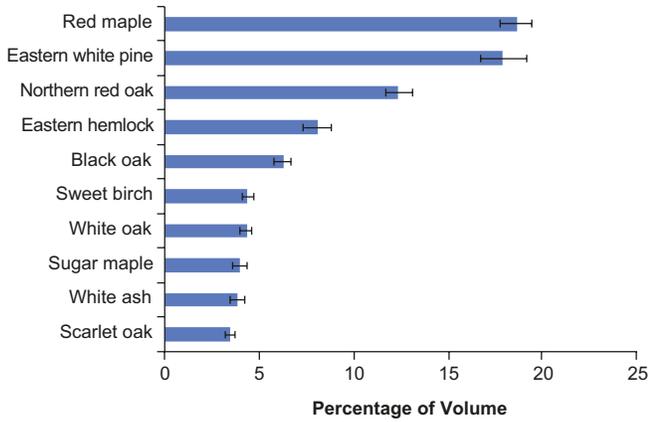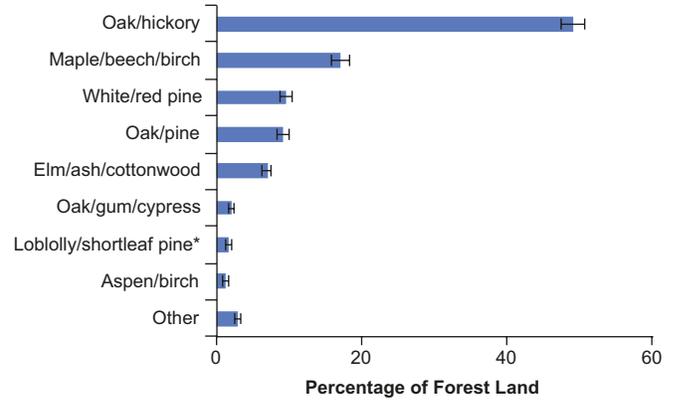
Figure 30.—Ten most voluminous tree species as a proportion of total volume of all trees 5 inches and larger in diameter, Southern New England, 2012. Error bars represent a 68 percent confidence interval around the mean.

*Represented by the Pitch pine forest type in Southern New England.

Figure 31.—Proportion of forest land by forest-type group, Southern New England, 2012. Error bars represent a 68 percent confidence interval around the mean.

The forest-type group of all three focus plots is classified as oak/hickory, the dominant forest-type group across the region (Fig. 31). This forest-type group is very prevalent in Connecticut and Rhode Island, where it accounts for 63 and 72 percent of the forest land, respectively. It is the most common forest-type group in Massachusetts as well, but accounts for only 34 percent of the forest land; maple/beech/birch, white/red pine, and oak/pine are other relatively common forest-type groups in Massachusetts. The names of the forest-type groups are based on the prevalent species at the national level. The loblolly/shortleaf pine forest-type group contains neither loblolly nor shortleaf pine in Southern New England, but the pitch pine forest type is included in this group. The oak/hickory forest-type group contains many tree species besides oaks and hickories. The oaks are indeed among the most common species, especially northern red, black, white, and scarlet, but red maple is also prevalent (Fig. 32); there are 63 species on the plots in the oak/hickory forest-type group across the region.
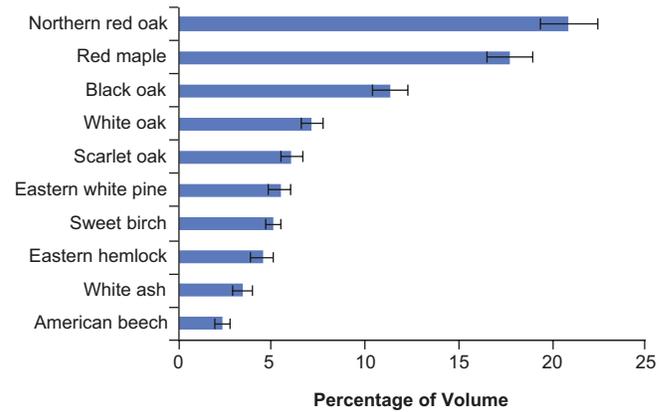
Stand Dynamics

The three focus plots showed net increases in volume. None of the trees were harvested or otherwise removed by people, but there were 13 trees that were either standing dead or otherwise died between the current and previous inventories. Two trees died on the Connecticut plot: a white oak, which is still standing (i.e., a snag),


Figure 32.—Proportion of volume of all live trees of select species in the oak/hickory forest-type group, Southern New England, 2012. Error bars represent a 68 percent confidence interval around the mean.

and a red maple. The Massachusetts plot had one standing dead tree, a northern red oak. The Rhode Island plot had 10 dead trees recorded, most of which were still standing, including red maples, white oaks, and northern red oaks.

As with the three focus plots, the overall trend for the forests of the region is an increase in volume. Between the 2007 and 2012 inventories, the net volume of trees increased from 12.6 to 13.4 billion ft^3; state-level increases were 8.5 percent in Connecticut, 5.0 percent in Massachusetts, and 11.4 percent in Rhode Island. The growth-to-removals ratio across the region is 4:1 (Fig. 33), meaning that for every four units of wood grown, one unit is harvested or removed, a broad indication of

sustainability. Seventy-six percent of the removals were due to timber harvesting with the remainder due to land clearing or other land use changes. The growth-to-removal ratios for the 10 most voluminous species indicate growth exceeds removals for these species (Fig. 33).
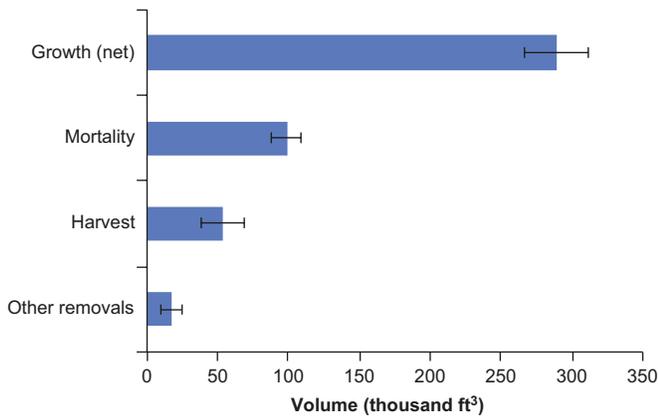

Figure 33.—Growth, mortality, and removals of trees on forest land, Southern New England, 2012. Error bars represent a 68 percent confidence interval around the mean.

Forest Health

It is important to consider not just the structure and composition of the forest, but the overall state or health of the forest as well. Tree damage and crown health are two broad measures that FIA monitors to assess forest health. While tree damage was measured on all forest plots, crown health was only measured on a subset of plots.

FIA records the presence of defoliation, foliage disease, cankers, decay, rot, fire, animal damage, weather, and logging damage on all trees inventoried that are greater than or equal to 5 inches in diameter. On the focus plots, there were 85 live trees greater than or equal to 5 inches in diameter; 12 trees showed some form of damage. On the Connecticut plot, two trees had stem decay and one of these also had weather damage. On the Massachusetts plot, six trees showed damage including four eastern white pines with damage caused by shoot/branch insects plus two trees had stem decay and one of these also exhibited weather damage. On the Rhode Island plot, four trees showed damage, three with stem decay, one of these also with weather damage, and a yellow birch with a bole canker.

Some form of damage was recorded on about 28 percent of the trees in Southern New England, but there is considerable variation among species (Fig. 34). Decay was most frequent damage on all species (12 percent of trees), but it ranged from less than 5 percent on conifer species up to 22 percent on red maple. Most of Southern New England's forests are made up of mature trees, so it isn't surprising that decay is the most common damage observed.
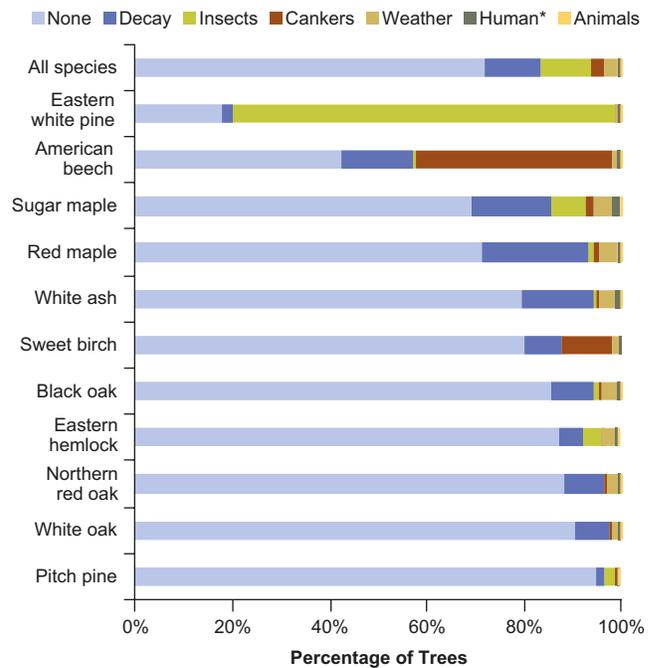

* Excluding harvests and other removals

Figure 34.—Percentage of selected tree species by damage agent, Southern New England, 2012.

Seventy-eight percent of eastern white pine exhibited branch or shoot damage from insects and 40 percent of American beech trees had cankers. The occurrence of all other injury types was low. The high incidence of damage on eastern white pine is largely due to the accumulation of deformed stems caused by the native white pine weevil, *Pissodes strobi*. Although the weevil damage does not typically kill trees, the form and quality of saw logs is negatively impacted. The high frequency of cankers on American beech reflects the long history of beech bark disease in the region (see Beech Bark Disease section on page 26).

The crown condition of trees is influenced by various biotic and abiotic stressors. Abiotic stressors include drought, flooding, cold temperatures, nutrient deficiencies, soil physical properties affecting soil moisture and aeration, and toxic pollutants. Biotic stressors include native and introduced insects, diseases, invasive plants, and animals.

Tree-level crown dieback information is collected on a subset of the FIA plots. Crown dieback is defined as recent mortality of branches with fine twigs and reflects the severity of stresses on a tree. A crown was labeled as 'poor' if crown dieback was greater than 20 percent. This threshold is based on findings by Steinman (2000), who associated crown ratings with tree mortality. Additionally, crown dieback has been shown to be the best crown variable for predicting tree survival (Morin et al. 2012).

Crown conditions are very good in Southern New England forests. No species has more than 3 percent of live basal area containing poor crowns (Fig. 35). An analysis of the trees from the 2007 inventory that were remeasured in the 2012 inventory revealed that the proportion of trees that died increases with increasing crown dieback (Fig. 36). Nearly 70 percent of trees with crown dieback above 20 percent during the 2007 inventory were dead when visited again during the 2012 inventory.
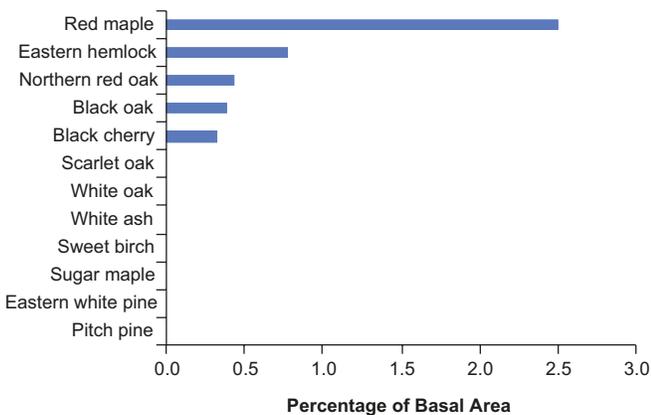
Figure 35.—Proportion of basal area of selected tree species that exhibit crown dieback of 20 percent or greater, Southern New England, 2012.
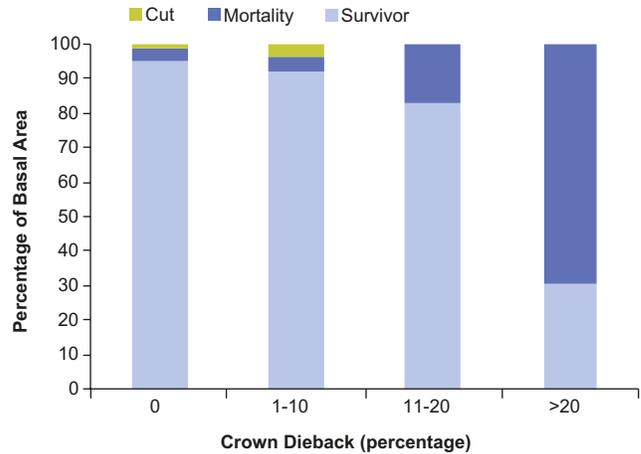
Figure 36.— Survival outcome of trees on remeasured plots (2012) based on crown dieback in 2007, Southern New England, 2012.

Invasive Insects and Diseases

Invasions by exotic diseases and insects are one of the most important threats to the productivity and stability of forest ecosystems around the world (Liebhold et al. 1995, Pimentel et al. 2000, Vitousek et al. 1996). Over the last century, Southern New England's forests have suffered the effects of native insect pests such as forest tent caterpillar (*Malacosoma disstria*) and well-known exotic and invasive agents such as Dutch elm disease (*Ophiostoma ulmi*), chestnut blight (*Cryphonectria parasitica*), European gypsy moth (*Lymantria dispar*), hemlock woolly adelgid (*Adelges tsugae*), and the beech bark disease complex. More recent invasions include emerald ash borer (*Agrilus planipennis*), Asian longhorned beetle (*Anoplophora glabripennis*), and elongate hemlock scale (*Fiorinia externa*).

Hemlock Wooly Adelgid

Hemlock woolly adelgid is native to East Asia. It was first noticed in the eastern United States in the 1950s and is now well-established across much of Southern New England (Ward et al. 2004). In areas where populations of this insect have established, they often reach high densities, causing widespread defoliation and sometimes mortality of its host species, eastern hemlock (McClure et al. 2001, Orwig et al. 2002).

Eastern hemlock is a major component of the forests of Southern New England and some of the highest densities

of eastern hemlock across its range are located in northwestern Connecticut and western Massachusetts (Fig. 37). Unlike in many other states that have been impacted by hemlock woolly adelgid, hemlock annual mortality rate, crown health, and incidence of insect damage have seemingly been unaffected in Southern New England. But it should be noted that the spread of hemlock woolly adelgid into northwestern Connecticut and western Massachusetts, where hemlock is the most abundant, is relatively recent and Morin et al. (2011) found that hemlock mortality increases were not substantial until hemlock woolly adelgid had infested counties for more than 20 years. The elongate hemlock scale is now compounding the damage to hemlocks across the region.

Emerald Ash Borer

The presence of emerald ash borer was first confirmed in western Connecticut and western Massachusetts in 2012. Native to Asia, this wood-boring beetle is, as its name implies, a pest of ash trees, infecting trees regardless of size and vigor (Poland and McCullough 2006). Tree mortality occurs within 1 to 4 years following infestation depending on tree size and beetle intensity. The forests of Southern New England contain an estimated 65.4 million ash trees (greater than or equal to 1 inch in

diameter), which account for 527.2 million ft^3 of volume. Though widely distributed, the highest ash densities are in the western half of the region (Fig. 38).

Asian Longhorned Beetle

The Asian longhorned beetle is an exotic, wood-boring insect that attacks a variety of hardwood species found in Southern New England. Maple (most favored), birch, willow, and elm are the preferred hosts (U.S. Forest Service 2008). Larval activity girdles the trunk, resulting in tree mortality. Asian longhorned beetle was identified in Worchester, MA, in 2008 and in Boston in 2010.

Forty-six percent of all trees in Southern New England's forests are susceptible to this pest. Maples and birches make up 62 percent and 29 percent of the available hosts, respectively. Susceptible host species account for 4.7 billion ft^3 of live-tree volume.

Asian longhorned beetle has been a significant contributor to urban tree mortality in the United States. However, with a wide range of susceptible host species, this insect could also have a substantial impact on the rural hardwood forests. Quarantines and management efforts have been initiated in Massachusetts that hope
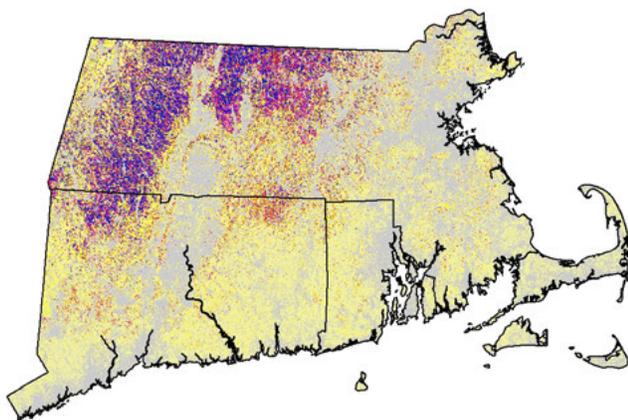
Eastern Hemlock Relative Abundance

High
Low
Nonforest

Figure 37.—Relative abundance of eastern hemlock, Southern New England, 2012.
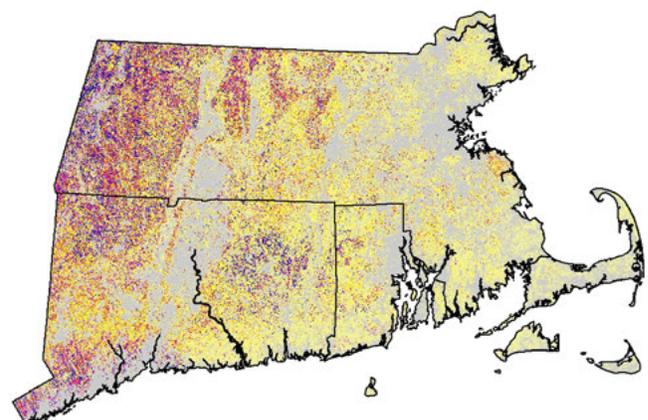
White Ash Relative Abundance

High
Low
Nonforest

Figure 38.—Relative abundance of white ash, Southern New England, 2012.

to follow the successful eradication of Asian longhorned beetle in other parts of the country. Final surveys are underway to determine if Asian longhorned beetle has been successfully eradicated in Boston (APHIS 2013).

Beech Bark Disease

Beech bark disease is an insect-fungus complex involving the beech scale insect (*Cryptococcus fagisuga*) and the exotic canker fungus *Neonectria coccinea* var. faginata. or the native *Neonectria galligena*; both species of fungi kill or injure American beech. Three phases of beech bark disease are generally recognized: 1) the "advancing front," which corresponds to areas recently invaded by scale populations; 2) the "killing front," which represents areas where fungal invasion has occurred (typically 3 to 5 years after the scale insects appear, but sometimes as long as 20 years) and tree mortality begins; and 3) the "aftermath forest," which are areas where the disease is endemic (Houston 1994, Shigo 1972).

Beech bark disease was introduced via ornamental beech trees into North America in Halifax, Nova Scotia, in 1890 and subsequently spread across New England. By 1960 all of Southern New England was generally infested. Currently, the annual mortality rate for American beech is slightly higher than that of all trees in the region (1.0 percent versus 0.8 percent). The impacts of beech bark disease on mortality of large diameter beech trees have steadily skewed the diameter distribution of beech toward smaller trees (Fig. 39); beech trees larger than 20 inches in diameter have become increasingly rare across the region.

Much of the beech forests in Southern New England, particularly the northern part of the region, have been infested by beech bark disease for decades and are in the aftermath phase of the disease complex. This phase is characterized by a lack of large beech trees from years of beech bark disease-induced mortality, and is associated with large numbers of beech seedlings and saplings. This condition, often referred to as "beech brush," can interfere with regeneration of other hardwood species, such as sugar maple (Hane 2003), and is characterized by
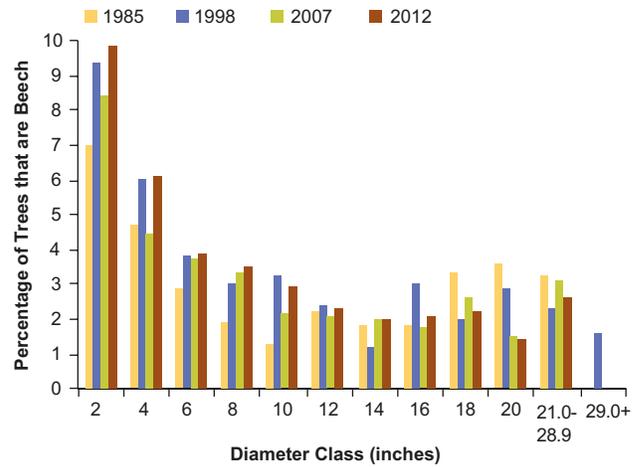
Figure 39.—Proportion of all trees that are American beech by diameter class, Southern New England, for past four inventories.

trees with low vigor and slow growth that often succumb to the disease before making it into the overstory.

Invasive Plants

Invasive plants are native and nonnative species that can cause negative ecological effects. These species can quickly invade forests and can change light, nutrient, and water availability. They can form dense monocultures, which not only reduce regeneration, but also impact wildlife quality through altering forest structure and forage availability. Each year, billions of dollars are spent across the United States on inspection, management, and mitigation of invasive plants.

FIA assesses invasive plants on a subset of inventory plots that are visited during the growing season; visiting plots during the growing season allows for better identification of annual plants that may not be easily observable other times of the year. During the 2012 inventory, 43 invasive plants and one undifferentiated genus (Table 4) were searched for on 195 forested plots distributed across the region.

Of the 44 invasive plants monitored, there were 14 species observed on plots in Southern New England; Connecticut had 10 species observed, Massachusetts had 13 species, and Rhode Island had nine species. The number of invasive plants observed per plot ranged
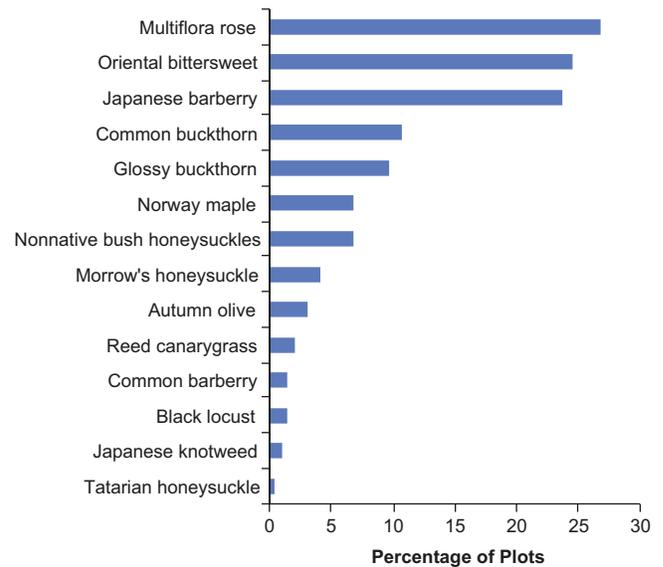
Table 4.—Invasive plants monitored for presence and absence on FIA invasive monitoring plots.

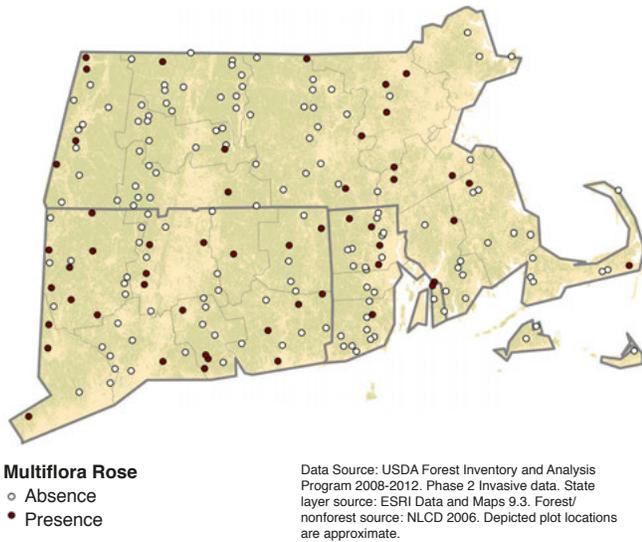| Scientific name	Common name
Acer platanoides	Norway maple
Ailanthus altissima	Tree-of-heaven
Albizia julibrissin	silktree
Alliaria petiolata	garlic mustard
Berberis thunbergii	Japanese barberry
Berberis vulgaris	common barberry
Celastrus orbiculatus	oriental bittersweet
Centaurea stoebe spp. *micranthos*	spotted knapweed
Cirsium arvense	Canada thistle
Cirsium vulgare	bull thistle
Cynanchum louiseae	Louise's swallow-wort
Cynanchum rossicum	European swallow-wort
Elaeagnus angustifolia	Russian olive
Elaeagnus umbellata	autumn olive
Euphorbia esula	leafy spurge
Frangula alnus	glossy buckthorn
Hedera helix	English ivy
Hesperis matronalis	dames rocket
Ligustrum vulgare	European privet
Lonicera spp.	nonnative bush honeysuckles
Lonicera japonica	Japanese honeysuckle
Lonicera maackii	amur honeysuckle
Lonicera morrowii	Morrow's honeysuckle
Lonicera tatarica	Tatarian honeysuckle
Lonicera x bella	showy fly honeysuckle
Lysimachia nummularia	creeping jenny
Melaleuca quinquenervia	punktree
Melia azedarach	Chinaberrytree
Microstegium vimineum	Nepalese browntop/Japanese stiltgrass
Paulownia tomentosa	princesstree
Phalaris arundinacea	reed canarygrass
Phragmites australis	common reed
Polygonum cuspidatum	Japanese knotweed
Polygonum sachalinense	giant knotweed
Polygonum x bohemicum	Japanese/giant knotweed hybrid
Rhamnus cathartica	common buckthorn
Robinia pseudoacacia	black locust
Rosa multiflora	multiflora rose
Spiraea japonica	Japanese meadowsweet
Tamarix ramosissima	saltcedar
Triadica sebifera	tallowtree
Ulmus pumila	Siberian elm
Viburnum opulus	European cranberrybush

from zero to eight (Fig. 40). Fifty-three percent of the monitored plots had one or more invasive plant species recorded. Across this region, multiflora rose was the most commonly observed invasive plant occurring on more than 25 percent of the plots (Fig. 41); it was found on plots throughout Southern New England (Fig. 42). Oriental bittersweet and Japanese barberry were also found on a large number of plots (25 and 24 percent, respectively).
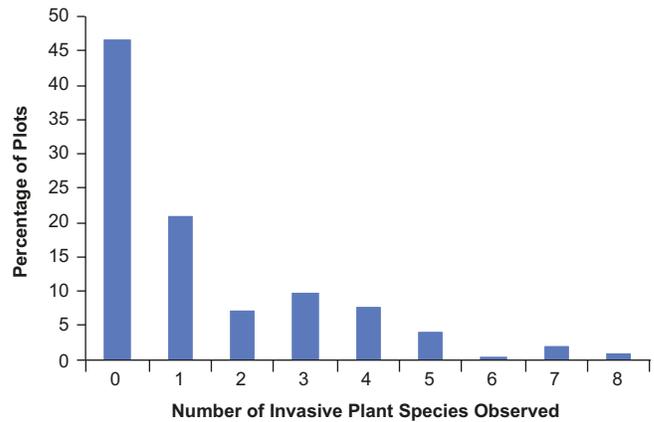
Figure 40.—Number of invasive plant species observed on FIA invasive monitoring plots, Southern New England, 2012.

Figure 41.—Proportion of FIA plots monitored for invasive plants on which select species were observed, Southern New England, 2012.

Multiflora Rose
○ Absence
● Presence

Data Source: USDA Forest Inventory and Analysis Program 2008-2012. Phase 2 Invasive data. State layer source: ESRI Data and Maps 9.3. Forest/ nonforest source: NLCD 2006. Depicted plot locations are approximate.

Figure 42.—Approximate location of FIA plots monitored for invasive plants showing the presence and absence of multiflora rose, the most commonly occurring invasive plant species of those monitored in Southern New England, 2012.

There is some overlap in the data used in the previous FIA invasive monitoring data for Southern New England, 2007-2009 (Butler et al. 2011), and the current data, 2008-2012, but some trends are still discernable. The three most commonly observed species remained the same: Japanese barberry, multiflora rose, and Oriental bittersweet. Multiflora rose increased in presence, occurring on 27 percent of plots, an increase from 19 percent in 2007-2009. The second most commonly observed species changed from Japanese barberry in 2007-2009 to oriental bittersweet in the 2012 inventory. The presence of both of these species increased in this region with Japanese barberry increasing by 5 percentage points and Oriental bittersweet increasing by 8 percentage points.

The Future

The future of the focus plots, and the forests of the entire region, is uncertain, but there are some indicators and tools that can be used to help understand some potential futures and impacts. In the absence of disturbance, the current trees will continue to grow until senescence, individual trees will die, and gap dynamics will allow for new trees to establish and develop. Many of the new trees will be the shade tolerant seedlings and saplings that currently occupy the understory. But if large-scale disturbances do occur, like the hurricane of 1938 or the widespread infestation of a new pest, then the future forests may be very different than today.

Projection models incorporate socioeconomic, biophysical, and climate change scenarios. These modeled results are projections, not predictions, but are useful as a tool for understanding potential impacts. The projections presented here do not incorporate broad-scale disturbances such as hurricanes or the introduction of new pests. These events cannot be effectively modeled, but scientists expect that climate change and human activities are likely to increase the probability of them happening.

Projections

The analysis presented here is taken from the Future Forests of the northern United States (Shifley and Moser, in press), which makes projections of future forest conditions through 2060. These projections use the U.S. Forest assessment system (Wear et al. 2013) to project future forest conditions based on natural succession with perturbations caused by land development, timber harvesting, and climate change.

The projections are based on three scenarios that combine assumptions about the economy, population, climate, and other driving forces (U.S. Forest Service 2012a). These scenarios are based on selected International Panel on Climate Change (IPCC) scenarios that represent the breadth of potential futures, labeled A1B, A2, and B2. A1B represents "globalization [and] economic convergence" with medium levels of growth of U.S. population and gross domestic product (GDP). The A2 scenario represents "regionalism [and] less trade" with high U.S. population growth and low U.S. GPD growth. The B2 scenario represents "slow change [and] localized solutions" with low U.S. population and low GDP growth.

Under all three scenarios, there is an anticipated decline in forest land totaling hundreds of thousands of acres due to increased development across the region (Fig. 43). Specifically, over the next 50 years forest land area is projected to decline from 5.1 million acres in 2010 to 4.4 million acres in 2060 (a 13 percent decrease) under scenario A1B; 4.4 million acres (a 14 percent decrease) under scenario A2; and 4.8 million acres (a decrease of 7 percent) under scenario B2. Scenarios with greater population increases and economic activity have projections of greater forest land loss. Although there are projected decreases in forest land area under all scenarios, forests are still expected to be the dominant land use across the region, representing between 47 to 51 percent of the land in 2060.

All of the scenarios result in lower levels of live tree volume by 2060, due largely to the loss of forest land. The composition of the forests, as represented by forest-type groups, is expected to shift substantially in the next 50 years under all three scenarios (Fig. 44). The areas of oak/hickory and white/red pine forest-type groups are expected to substantially decline and the areas of elm/ash/cottonwood and the "other" forest-type groups are expected to increase. It should be noted that although not part of the name, red maple is the most common species in the elm/ash/cottonwood forest-type group.
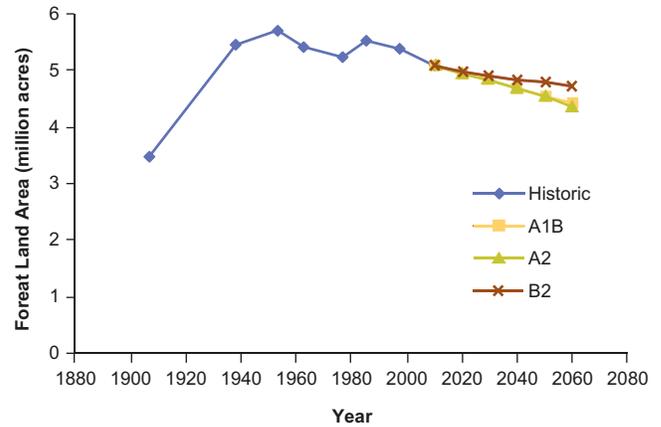

Figure 43.—Projected forest land area for Southern New England by climate change scenario, 2010-2060.
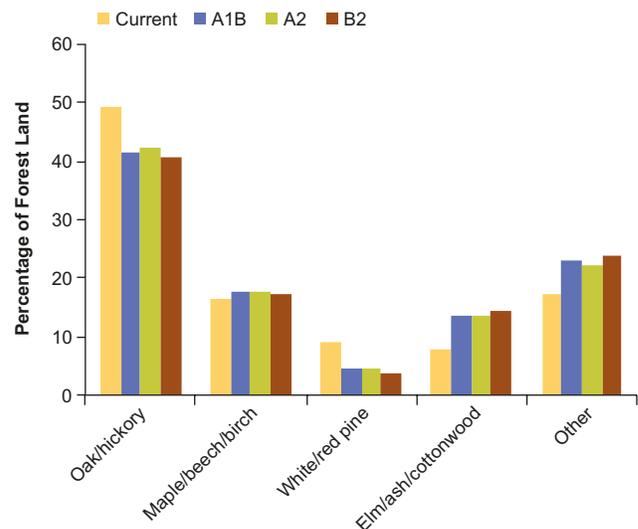

Figure 44.—Current (2010) and projected (2060) forest land area by climate change scenario and forest-type group, Southern New England.

Conclusions

Buffam Falls Conservation Area in Pelham, MA. Photo by Brett J. Butler, U.S. Forest Service.

Southern New England is blessed with hills and valleys that are flush with forests. These forests provide the people of the region with countless benefits ranging from clean air and water to recreational opportunities to aesthetics to forest products. The forests have made an impressive comeback since the large-scale abandonment of agriculture beginning in the 1800s

The current forests contain a diversity of species, but they also show a high degree of homogeneity in terms of size and age of the dominant trees. The lack of major disturbances over the past decades has led to a forest that is dominated by stands with "large" trees that are in the 55- to 99-year age range. This presents challenges for some wildlife species that rely on early successional habitat and results in forests that are potentially less resilient to threats such as insects and climate change. The lack of disturbance also makes it difficult for some species, such as oaks, to regenerate.

The future of Southern New England is likely to remain sylvan, but if human population levels increase as projected, the area of forest land will likely substantially decrease. Of equal importance to the future of the forests are the potential impacts that existing or new insects or diseases may have on the region or other broad-scale disturbances, such as hurricanes. Management can help prepare the forests for the future and continued monitoring can help us gauge the state of the forest and set a course for where we, as a society, want it to be.

More Information

Information related to topics covered in this report is available at:

- National FIA Program: www.fia.fs.fed.us

- FIA Program of the Northern Research Station: www.nrs.fs.fed.us/fia

- FIA, National Woodland Owner Survey: www.fia.fs.fed.us/nwos

- FIA, Timber Products Output Survey: www.nrs.fs.fed.us/fia/topics/tpo

- State and Private Forestry, Northeastern Area: www.na.fs.fed.us

State Forestry Agencies

- Connecticut Department of Energy and Environmental Protection, Division of Forestry: www.ct.gov/deep/forestry

- Massachusetts Department of Conservation and Recreation, Bureau of Forestry: www.mass.gov/eea/agencies/dcr/conservation/forestry-and-fire-control/forestry.html

- Rhode Island Department of Environmental Management, Division of Forest Environment: www.dem.ri.gov/programs/bnatres/forest

Other Websites

- University of Connecticut Extension: www.ctforestry.uconn.edu

- University of Massachusetts Amherst Extension: http://masswoods.net

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Appendix.

Tree Species in Southern New England

Tree species, greater than or equal to 5 inches in diameter, found on FIA inventory plots, Southern New England, 2012.

Common name	Genus	Species	Connecticut	Massachusetts	Rhode Island
Balsam fir	*Abies*	*balsamea*		X	X
Atlantic white-cedar	*Chamaecyparis*	*thyoides*		X	X
Redcedar/juniper spp.	*Juniperus*	spp.		X	
Eastern redcedar	*Juniperus*	*virginiana*	X	X	X
Tamarack (native)	*Larix*	*laricina*	X	X	
Norway spruce	*Picea*	*abies*	X	X	
Red spruce	*Picea*	*rubens*	X	X	
Red pine	*Pinus*	*resinosa*	X	X	
Pitch pine	*Pinus*	*rigida*	X	X	X
Eastern white pine	*Pinus*	*strobus*	X	X	X
Scotch pine	*Pinus*	*sylvestris*	X		X
Eastern hemlock	*Tsuga*	*canadensis*	X	X	X
Boxelder	*Acer*	*negundo*		X	X
Striped maple	*Acer*	*pensylvanicum*	X	X	
Red maple	*Acer*	*rubrum*	X	X	X
Silver maple	*Acer*	*saccharinum*	X	X	X
Sugar maple	*Acer*	*saccharum*	X	X	X
Norway maple	*Acer*	*platanoides*	X	X	
Ailanthus or tree-of-heaven	*Ailanthus*	*altissima*	X	X	
Mimosa, silktree	*Albizia*	*julibrissin*		X	
Serviceberry spp.	*Amelanchier*	spp.	X	X	
Yellow birch	*Betula*	*alleghaniensis*	X	X	X
Sweet birch	*Betula*	*lenta*	X	X	X
Paper birch	*Betula*	*papyrifera*	X	X	
Gray birch	*Betula*	*populifolia*	X	X	X
American hornbeam, musclewood	*Carpinus*	*caroliniana*	X	X	
Bitternut hickory	*Carya*	*cordiformis*	X	X	
Pignut hickory	*Carya*	*glabra*	X	X	X
Shagbark hickory	*Carya*	*ovata*	X	X	X
Mockernut hickory	*Carya*	*alba*	X	X	X
American chestnut	*Castanea*	*dentata*		X	
Northern catalpa	*Catalpa*	*speciosa*		X	
Hackberry	*Celtis*	*occidentalis*			X
Flowering dogwood	*Cornus*	*florida*	X		
American beech	*Fagus*	*grandifolia*	X	X	X
White ash	*Fraxinus*	*americana*	X	X	X
Black ash	*Fraxinus*	*nigra*	X	X	
Green ash	*Fraxinus*	*pennsylvanica*	X	X	X
Honeylocust	*Gleditsia*	*triacanthos*		X	
American holly	*Ilex*	*opaca*		X	X
Butternut	*Juglans*	*cinerea*		X	
Black walnut	*Juglans*	*nigra*		X	
Yellow-poplar	*Liriodendron*	*tulipifera*	X	X	X
Apple spp.	*Malus*	spp.	X	X	X

(Appendix Continued)

Common name	Genus	Species	Connecticut	Massachusetts	Rhode Island
Blackgum	*Nyssa*	*sylvatica*	X	X	X
Eastern hophornbeam	*Ostrya*	*virginiana*	X	X	X
American sycamore	*Platanus*	*occidentalis*	X		
Balsam poplar	*Populus*	*balsamifera*			X
Eastern cottonwood	*Populus*	*deltoides*	X	X	
Bigtooth aspen	*Populus*	*grandidentata*	X	X	X
Quaking aspen	*Populus*	*tremuloides*	X	X	X
Cherry and plum spp.	*Prunus*	spp.			X
Pin cherry	*Prunus*	*pensylvanica*	X	X	X
Black cherry	*Prunus*	*serotina*	X	X	X
Sweet cherry	*Prunus*	*avium*	X		
White oak	*Quercus*	*alba*	X	X	X
Swamp white oak	*Quercus*	*bicolor*	X	X	X
Scarlet oak	*Quercus*	*coccinea*	X	X	X
Northern pin oak	*Quercus*	*ellipsoidalis*	X		
Scrub oak	*Quercus*	*ilicifolia*		X	
Bur oak	*Quercus*	*macrocarpa*		X	
Swamp chestnut oak	*Quercus*	*michauxii*		X	
Pin oak	*Quercus*	*palustris*	X	X	
Chestnut oak	*Quercus*	*prinus*	X	X	X
Northern red oak	*Quercus*	*rubra*	X	X	X
Post oak	*Quercus*	*stellata*		X	
Black oak	*Quercus*	*velutina*	X	X	X
Black locust	*Robinia*	*pseudoacacia*	X	X	X
Willow spp.	*Salix*	spp.	X	X	X
Black willow	*Salix*	*nigra*		X	
White willow	*Salix*	*alba*		X	
Sassafras	*Sassafras*	*albidum*	X	X	X
American basswood	*Tilia*	*americana*	X	X	
American elm	*Ulmus*	*americana*	X	X	X
Slippery elm	*Ulmus*	*rubra*	X	X	

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This report summarizes the U.S. Forest Service, Forest Inventory and Analysis (FIA) forest inventory data, collected from 2008 to 2012, for Southern New England, defined as Connecticut, Massachusetts, and Rhode Island. Forests cover an estimated 5,128,000 acres or 59 percent of Southern New England—1,736,000 acres in Connecticut (56 percent of the State), 3,028,000 acres in Massachusetts (61 percent), and 364,000 acres in Rhode Island (55 percent). There was no substantial change in the area of forest land between the current, 2012, and the previous, 2007, FIA inventories. Nearly two-thirds of the forests of the region are privately owned and most of these forests are owned by families and individuals who own the land primarily for the amenity values their forests provide. Seventy-six species of trees were observed on the FIA inventory plots. Red maple is the most common species across the region, but eastern white pine, northern red oak, black oak, eastern hemlock, scarlet oak, and sweet birch are also common. Although the forests of the region are fairly healthy, there are several issues that are threatening them, including invasive plants and introduced pests. Also, human disturbances, such as development, are projected to have a substantial impact on the region and broad-scale natural disturbance, such as hurricanes, are other potential factors that will influence the future of the forests.

KEY WORDS: inventory, forest statistics, forest land, land use, ownership, volume, biomass, carbon, growth, removals, mortality, forest health

DVD Contents

The Forests of Southern New England 2012 (PDF)

The Forests of Southern New England 2012: Statistics, Methods, and Quality Assurance (PDF)

The Forests of Southern New England inventory Databases (CSV Files)

New England inventory Database (Access File)

Connecticut forest inventory summary tables (folder)

Massachusetts forest inventory summary tables (folder)

Connecticut forest inventory summary tables (folder)

Field guides that describe inventory procedures (PDF)

Database User's Guide (PDF)

The Forests of Southern New England, 2012: Statistics, Methods, and Quality Assurance

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