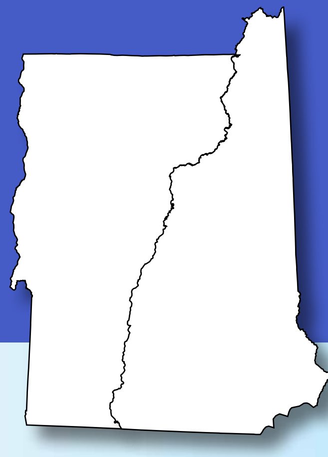
USDA United States Department of Agriculture

Forests of Vermont and New Hampshire 2012



Forest Service

Northern Research Station

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Abstract

The first full remeasurement of the annual inventory of the forests of Vermont and New Hampshire was completed in 2012 and covers nearly 9.5 million acres of forest land, with an average volume of nearly 2,300 cubic feet per acre. The data in this report are based on visits to 1,100 plots located across Vermont and 1,091 plots located across New Hampshire. Forest land is dominated by the maple/beech/birch forest-type group, which occupies 60 percent of total forest land area. Of the forest land, 64 percent consists of large diameter trees, 27 percent contains medium diameter trees, and 9 percent contains small diameter trees. The volume of growing stock on timberland has continued to increase since the 1980s and currently totals nearly 19 billion cubic feet. The average annual net growth of growing stock on timberland from 2007 to 2012 is approximately 380 million cubic feet per year. Important species compositional changes include increases in the number of red maple trees and American beech saplings which coincide with decreases in the number of eastern white pine and sugar maple trees as well as eastern white pine and northern red oak saplings. Additional information is presented on forest attributes, land use change, carbon, timber products, species composition, regeneration, and forest health. Detailed information on forest inventory methods and data quality estimates is included on the DVD accompanying this report. Tables of population estimates and a glossary are also included.

Acknowledgments

The authors would like to thank inventory crew members from Vermont and New Hampshire for their help: Aaron Clark, Robert Gregory, John Higham, Paul Kelley, Katherine Locke, Jason Morrison, Joyce Quinn, Ann Quinion, Keith Raymond, Jennifer Thompson, Bryan Tirrell, and Ashley Zickefoose. Thanks also to Karen Bennett, Jeff Briggs, George Frame, Paul Frederick, and Barbara Schultz for serving as reviewers and providing insightful, constructive comments.

Cover photo: Fishing the headwaters of the Connecticut River. Photo by New Hampshire Division of Forests and Lands, used with permission.

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Foreword

The landscapes of Vermont and New Hampshire have experienced many changes during our histories. One of the constants has been a working forest landscape that provides goods and services through stewardship, management, and conservation. We depend upon the forest for timber, maple syrup, firewood, along with values and services such as watershed protection, wildlife habitats, carbon sequestration, outdoor recreation opportunities, and scenic beauty. With forests dominating the landscapes of Vermont and New Hampshire, decisions and actions we make today need to be informed by accurate and timely data.

The Vermont Department of Forests, Parks and Recreation, and New Hampshire Division of Forests and Lands are pleased to partner with the U.S. Forest Service in the Forest Inventory and Analysis (FIA) of Vermont and New Hampshire. The more we know and understand of the resources of our forests, the better we can sustain our forests. Sustainable forests begin with healthy forests, and we encourage you to become familiar with information contained in this publication.

Steven J. Sinclair
Vermont State Forester

Brad W. Simpkins
New Hampshire State Forester

Contents

Highlights

On the Plus Side

- Vermont is the fourth most forested state and New Hampshire is the second most forested state in the United States.
- The small amount of forest land lost over the last 5 years has been offset by the forest land gained.
- Participation in Vermont's use value appraisal program and New Hampshire's current use taxation has increased, which may influence the amount of forest land converted to other uses.
- Changes in stand stocking suggest that forest management practices over the past three decades have improved the general stocking condition across both States.
- Most forest carbon in the region is found in moderately-aged stands dominated by relatively long-lived species, suggesting that forest carbon stocks will continue to increase as stands mature and accumulate carbon in aboveground and belowground components.
- Timber resources in Vermont and New Hampshire are at record levels since inventories began in 1948.
- The total value of sawtimber has increased because of an overall increase in the board-foot volume of sawtimber material in both States.
- The mortality rate (0.8 percent) in both States for the 2012 inventory is slightly lower than what was reported for the 2007 inventory.
- Tree crowns are generally healthy and stable across both States.
- Many of the wood-processing facilities in Vermont and New Hampshire are sawmills processing primarily saw logs.
- Vermont and New Hampshire both contain an abundance of large forest blocks of maple/beech/birch, spruce/fir, and aspen/birch forests which provide wildlife habitat.
- The growth-to-removals ratio remains slightly below 2.0:1.0 in both States.

Areas of Concern

- The anticipated transfer of 1.8 million acres of forest land foreshadowed by the advanced age (65+) of many owners is an important trend to monitor as the fate of forests is most likely to change when forest land is passed to the next generation of owners.
- Timber volume in both Vermont and New Hampshire has increased to record levels, but the rate of growth has leveled off as the forest matures, a trend that is likely to continue into the future.
- The presence of nonnative invasive plant species is increasing and appears to be correlated with reduced densities of desirable seedling species.
- The dominance of beech, ash, and noncommercial tree species in the sapling size class in Vermont forests and beech and noncommercial tree species in New Hampshire forests raises concerns about the future forest resource in both States.

Hikers overlooking fall color in Vermont. Photo by Vermont Department of Forests, Parks and Recreation, used with permission.

Issues to Watch

- Commercial and residential development of forest land, particularly in the Champlain Valley of Vermont and southern part of New Hampshire, could cause reductions in forest cover.
- The small parcels held by many landowners and the trend toward more landowners with smaller parcels complicate the economics of forest management and the delivery of government programs.
- The trend toward more area of large diameter and less area of small and medium diameter trees in both States needs continued monitoring.
- Although biomass continues to accumulate as the forests mature, only a fraction of the accumulated material is available for use as fuel.
- If the current species composition remains constant as saplings mature, the future forest overstory will have more red maple and balsam fir trees and less eastern white pine, eastern hemlock, and northern red oak than today.
- Although the proportion of high grade volume has remained stable in both States, changes in species composition point toward potential reductions in overall sawtimber quality into the future.
- An important consideration for those landowners actively managing their land is the ability of the primary wood products industry to retain pulp mills, sawmills, and veneer mills.
- Invasive insect pests that are likely to impact abundant tree species in Vermont and New Hampshire in the future include hemlock woolly adelgid, emerald ash borer, and Asian longhorned beetle.
- The risk of catastrophic economic and ecological loss of forest resources could increase due to forest maturity and more extreme weather-related events including hurricanes, droughts, and floods caused by a changing climatic regime.
- The two most valuable commercial species, white pine and red oak, are nearly absent in the smaller size classes in Vermont and New Hampshire.
- A maturing forest structure continues to limit pioneer and other shade intolerant species that thrive in sunnier forested conditions.
- Frequent tree damage (26 percent of trees) and internal decay (10 percent) on trees in the two States combined may be an indication of reduced tree health or timber quality.
- Pine and oak forest-type groups tend to occur in smaller, more fragmented habitat blocks in both States.
- Results from Vermont indicate that only the maple/beech/birch forest-type group is widely distributed in the highest quality habitat blocks.

Background

New Hampshire landscape. Photo by New Hampshire Division of Forests and Lands, used with permission.

Data Sources and Techniques

The forests of Vermont and New Hampshire are one of northern New England's most valuable assets due to their importance to the economy and quality of life for residents. Accurate and statistically defensible information is critical for understanding the current conditions, interpreting trends over time, and projecting future scenarios. This report highlights the current status and trends observed in the forests of Vermont and New Hampshire and is the culmination of the first complete remeasurement of the inventory for these two States using the Forest Inventory and Analysis (FIA) program's annualized forest inventory system. Data are based on visits to 1,100 plots located across Vermont and 1,091 plots located across New Hampshire. Previous forest inventories in Vermont were completed in 1948 (McGuire and Wray 1952), 1965 (Kingsley and Barnard 1968), 1973 (Frieswyk and Malley 1985b, Kingsley 1977), 1983 (Frieswyk and Malley 1985b, Frieswyk and Widmann 2000b), 1997 (Frieswyk and Widmann 2000b), and 2007 (Morin et al. 2011a). Previous forest inventories in New Hampshire were completed in 1952 (U.S. Forest Service 1954), 1960 (Ferguson and Jensen 1963), 1973 (Frieswyk and Malley 1985a, Kingsley 1976), 1983 (Frieswyk and Malley 1985a, Frieswyk and Widmann 2000a), 1997 (Frieswyk and Widmann 2000a), and 2007 (Morin et al. 2011b). The annualized system was implemented in Vermont in 2003 and in New Hampshire in 2002 to provide updated forest inventory information every year based on a 5-year cycle. The FIA program is the only source of data collected from a permanent network of ground plots from across the Nation that allows for comparisons to be made among states and regions. The most recent inventory period was conducted in 2008-2012 and hereafter is referred to as the 2012 inventory.

The FIA sampling design is based on a tessellation of the United States into hexagons approximately 6,000 acres in size with at least one permanent plot established in each hexagon. In phase 1 (P1), the population of interest is stratified and plots are assigned to strata to increase the precision of estimates. In phase 2 (P2), tree and site attributes are measured on forested plots established in each hexagon. P2 plots consist of four 24-foot fixed-radius subplots on which standing trees are inventoried. This sampling design results in 1,100 and 1,091 long-term inventory plots in Vermont and New Hampshire, respectively. The Northern Research Station FIA program is currently transitioning its forest health indicator monitoring from the phase 3 (P3) protocols of the past to the P2 plus (P2+) protocols of the future. The general approach is to decrease the amount of data collected on each plot while increasing the number of forest health plots. For example, the P3 protocols required five tree crown health variables whereas the P2+ protocols only include two crown health variables: crown dieback and uncompacted live crown ratio. Detailed information on the sampling protocols can be found in the Statistics, Methods, and Quality Assurance section found on the DVD accompanying this report.

An Overview of Forest Inventory

What is a tree?

The FIA program of the U.S. Forest Service defines a tree as a perennial woody plant species that can attain a height of at least 15 feet at maturity. Growing-stock trees include live trees of commercial species meeting specified standards of quality or vigor and having a diameter at breast height (d.b.h.) of at least 5.0 inches. The d.b.h. of a tree is the diameter measured at 4.5 feet above the ground.

What is a forest?

A forest can come in many forms depending on climate, quality of soils, and the available gene pool for the dispersion of plant species. Forest stands can range from very tall, heavily dense, and multi-structured, to short, sparsely populated, and single layered. FIA defines forest as land that is at least 10 percent stocked by trees of any size or formerly having been stocked and not currently developed for nonforest use. The area with trees must be at least 1 acre in size and 120 feet wide.

What is the difference between timberland, reserved forest land, and other forest land?

From an FIA perspective, there are three types of forest land: timberland, reserved forest land, and other forest land. In both Vermont and New Hampshire, approximately 97 percent of all forest land is classified as unreserved and productive timberland and 3 percent is reserved and productive forest land.

- Timberland is unreserved forest land that meets the minimum productivity requirement of 20 cubic feet per acre per year.
- Reserved forest land is land withdrawn from timber utilization through legislative regulation.
- Other forest land is commonly found on low-lying sites or high craggy areas with poor soils where the forest is incapable of producing 20 cubic feet per acre.

In earlier inventories, FIA measured trees only on timberland plots and did not report volumes on all forest land. Since the implementation of the new annual inventory, FIA has been reporting volume on all forest land. With the second remeasurement completed, comparison of two sets of growth, mortality, and removals data, as well as trends on forest land is now possible. However, since some of the older periodic inventories only reported on timberland, much of the trend reporting in this publication is still focused on timberland.

How many trees are in Vermont and New Hampshire?

Forest land in Vermont and New Hampshire combined contains approximately 1,776 million live trees that have a d.b.h. of at least 5 inches. The exact number of trees can not be determined because the estimate is based upon only a sample of the total population. The frequency estimates are calculated from field measurements of 1,607 forested plots (767 in Vermont and 840 in New Hampshire). For information on sampling errors, see the DVD included with this report.

How do we estimate a tree's volume?

Statistical models are used to predict volumes within a species group or for a specific species. Individual tree volumes are based upon species, diameter, and merchantable height from trees within the region. Tree volumes are reported in cubic feet or board feet based on the International ¼-inch log scale rule.

How much does a tree weigh?

Specific gravity values for each tree species or group of species were developed at the U.S. Forest Service Forest Products Laboratory (Miles and Smith 2009) and were applied to FIA tree volume estimates to determine merchantable tree biomass (weight of tree bole). Total aboveground live-tree biomass is calculated by adding the biomass for stumps, limbs, and tops (Woodall et al. 2011). Live biomass for foliage is currently not reported. FIA inventories report biomass weights as oven-dry short tons. Oven-dry weight of a tree is the green weight minus the moisture content. Generally, 1 ton of oven-dry biomass is equal to 1.9 tons of green biomass.

How do we compare data from different inventories?

New inventories are commonly compared with older datasets to analyze trends or changes in forest growth, mortality, removals, and ownership acreage over time (Powell 1985). A pitfall occurs when the comparison involves data collected under different schemes or processed using different algorithms. Recently, significant changes were made to the methods for estimating tree-level volume and biomass (dry weight) for northeastern states, and the calculation of change components (net growth, removals, and mortality) was modified for national consistency. These changes focus on improving the ability to report consistent estimates across time and space–a primary objective for FIA. Regression models were developed for tree height and percent cull to reduce random variability across datasets.

Before the Component Ratio Method (CRM) was implemented, volume and biomass were estimated using separate sets of equations (Heath et al. 2009). With CRM, determining the biomass of individual trees and forests has become an extension of FIA volume estimates, allowing biomass estimates for tree growth, mortality, and removals to be obtained not only for live trees, but also for belowground coarse roots, standing deadwood, and down woody debris.

Another new method, termed the "midpoint method", has introduced some differences in methodology for determining growth, mortality, and removals for a specified sample of trees (Westfall et al. 2009). The new approach involves calculating tree size attributes at the midpoint of the inventory cycle (2.5 years for a 5-year cycle) to obtain a better estimate for ingrowth, mortality, and removals. Although the overall net change component is equivalent under the previous and new evaluations, estimates for individual components will be different. For ingrowth, the midpoint method can produce a smaller estimate because the volumes are calculated at the 5.0-inch threshold instead of using the actual diameter at time of measurement. The actual diameter could be larger than the 5.0-inch threshold. The estimate for accretion is higher because growth from ingrowth, mortality, and removal trees is included. As such, the removals and mortality estimates will be higher than before (Bechtold and Patterson 2005).

A word of caution on suitability and availability

FIA does not attempt to identify which lands are suitable or available for timber harvesting, especially because suitability and availability are subject to changing laws and ownership objectives. Simply because land is classified as timberland does not mean it is suitable or available for timber production. Forest inventory data alone are inadequate for determining the area of forest land available for timber harvesting because laws and regulations, voluntary guidelines, physical constraints, economics, proximity to people, and ownership objectives may prevent timberland from being available for production.

Forest Features

View of the Presidential Mountain Range in New Hampshire. Photo by Randall Morin, U.S. Forest Service.

Dynamics of the Forest Land Base

Background

Vermont and New Hampshire host the transition of the maple/beech/birch forests of the northeastern United States to the spruce/fir forests of northern New England. Because forests are so important for wood products, tourism, clean water, clean air, wildlife habitat, and wood energy, evaluating changes in the status and condition of those forests is important. The amount of forest land and timberland are vital measures for assessing forest resources and making informed decisions about their management and future. Gains or losses in forest area are an indication of forest sustainability, ecosystem health, and land use practices, and they have a direct effect on the ability of forests to provide goods and services.

Forest type is determined by the stocking (relative density) that tree species contribute to a sampled area. The forest types used by FIA are based on the types presented by Eyre (1980). Related forest types are combined into groups. A modeled spatial distribution of the forest-type groups in Vermont and New Hampshire based on FIA plot attributes and ancillary data is presented in Figure 1. This dataset is available for download at http://data.fs.usda.gov/geodata/rastergateway/forest_type/index.php.

What we found

Forests are the dominant land cover across most of Vermont and New Hampshire. The percentage of forest cover generally increases from west to east in Vermont (Fig. 1), mostly due to the belt of agricultural land in the Champlain Valley in the northwestern part of the State. In 1948 when FIA completed its first inventory within Vermont, only 63 percent of the State's area was forested. Subsequent inventories showed a steady increase in forest cover as lands were reforested due to the abandonment of farmland. Vermont's forested land base increased rapidly between the 1940s and 1970s and continued to increase, although at continually slower rates, until the 1990s (Fig. 2). By contrast, the amount of farmland decreased by nearly 2.4 million acres over that period (Fig. 3). Much of the nearly 1 million acre increase in forest land is due to farmland reverting back into forest through natural regeneration, although a substantial portion of lost farmland was also developed to meet the needs of a growing population. These reverted forests have increased the total forest land area in Vermont and nearly offset losses of forest land to development. Since 2007, the amount of forest cover has remained stable (Fig. 2). Currently, Vermont is about 75 percent forested.

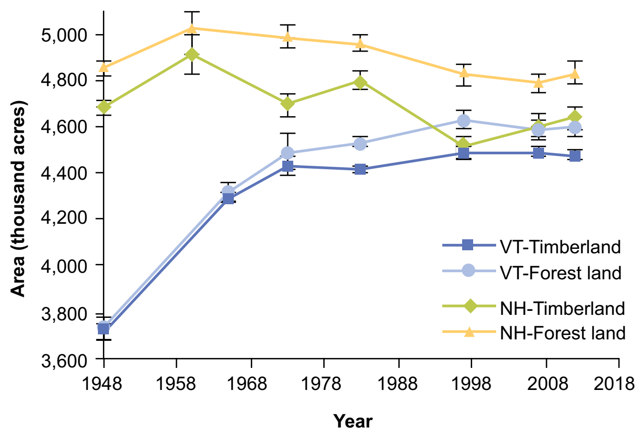


Figure 2.—Area of forest land and timberland by inventory year, Vermont and New Hampshire. Error bars represent a 68 percent confidence interval around the mean.

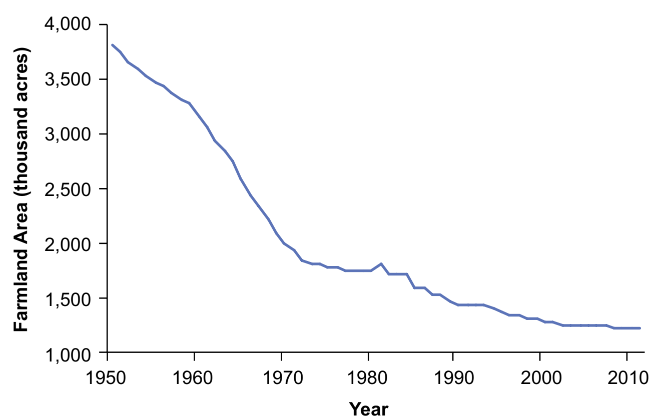
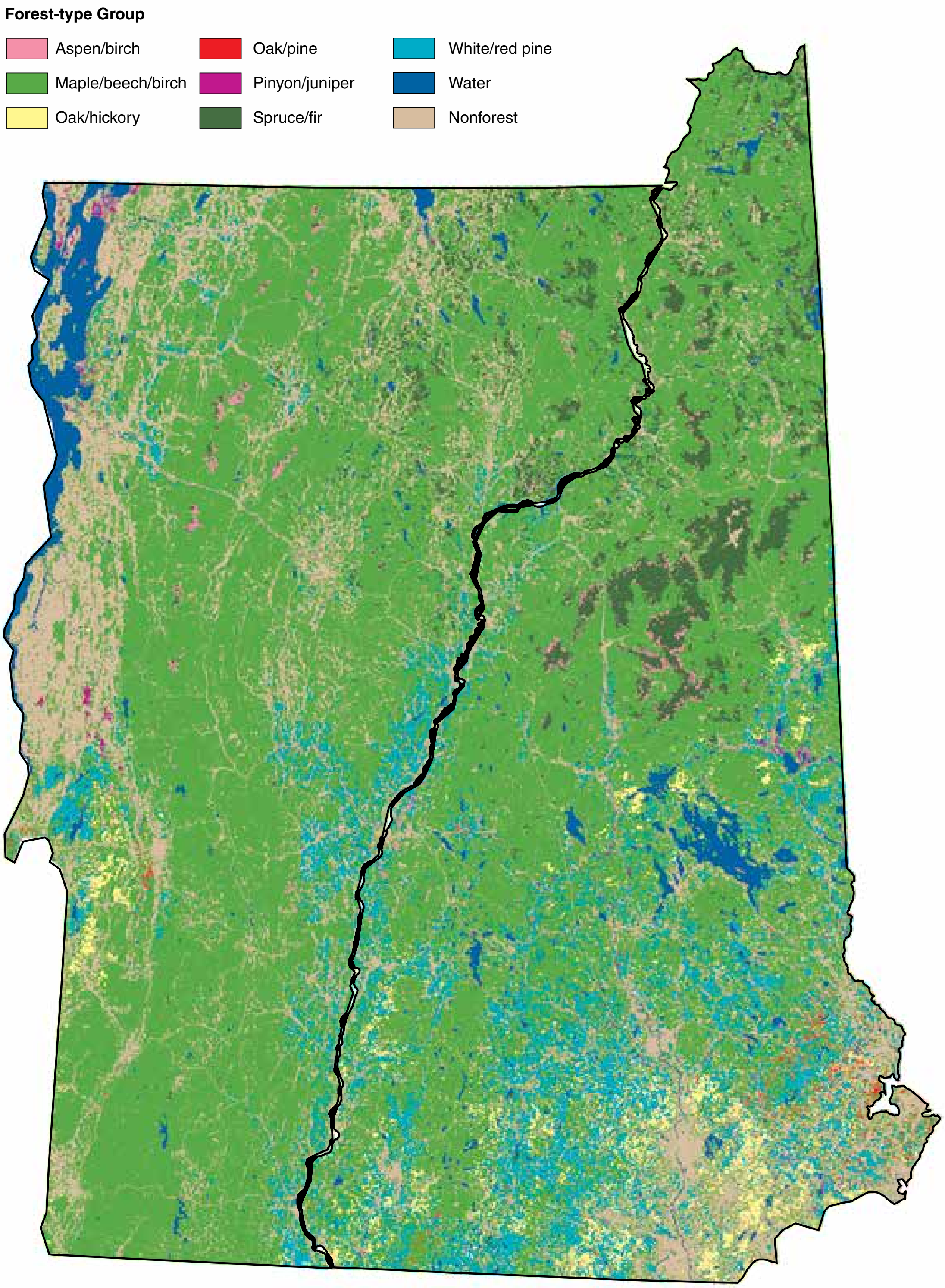


Figure 3.—Area of farmland (including farm woodlots) by inventory year, Vermont (NASS 2013).



Projection: New Hampshire State Plane, NAD83.

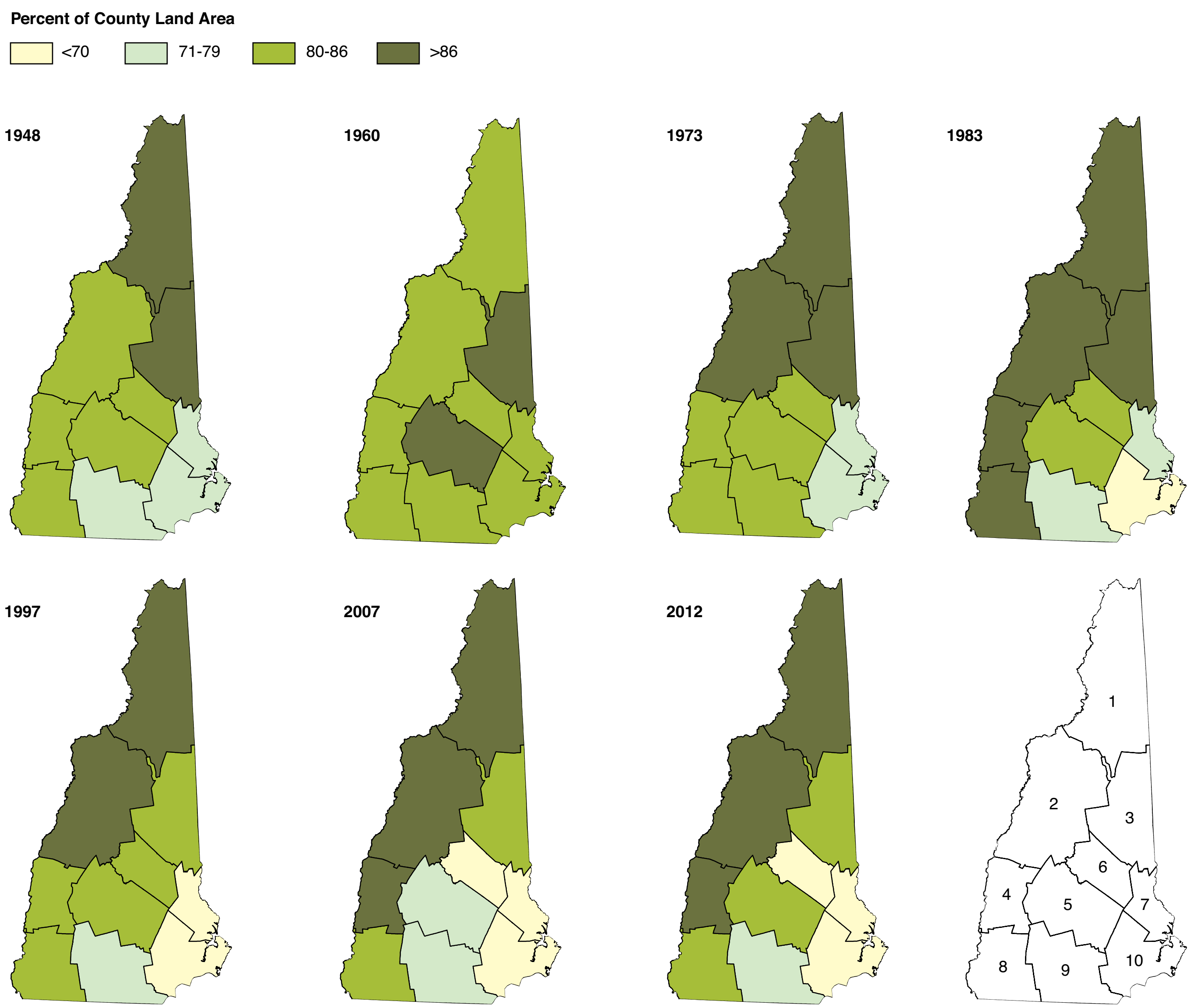
Sources: U.S. Forest Service, Forest Inventory and Analysis Program 2008; NLCD 2006.

Geographic base data are provided by the National Atlas of the USA. FIA data and Tools are available online at http://www.fia.fs.fed.us/tools-data/

Cartography: R.S. Morin. Apr. 2014

Figure 1.—Distribution of forest-type groups, Vermont and New Hampshire, 2008. Land cover data from National Land Cover Database 2006 (NLCD 2006; Fry et al. 2011).

The percentage of forest cover generally increases from south to north in New Hampshire (Fig. 1), mostly due to more urbanization in the south. In 1948 when FIA completed its first inventory in New Hampshire, 84 percent of the State's area was forested. The subsequent 1960 inventory showed a small increase in forest cover (87 percent of land area). New Hampshire's forested land base then decreased at a slow rate between the 1960s and 2000s (Fig. 2). Currently, forest covers 81 percent of New Hampshire's land base. Much of the nearly 230,000 acre decrease in forest land since 1960 is the result of the development of land to meet the needs of a growing population, particularly in the southern part of the State due to population growth north of Boston, MA (Fig. 4). Since 2007 the amount of forest cover has remained stable (Fig. 2).



Projection: New Hampshire State Plane, NAD83.

Sources: U.S. Forest Service, Forest Inventory and Analysis Program 1948,1960, 1973, 1983, 1997, 2007 and 2012. Geographic base data are provided by the National Atlas of the USA. FIA data and Tools are available online at http://www.fia.fs.fed.us/tools-data/

Cartography: R.S. Morin. Jan. 2014

County List

1	Coos	6	Belknap
2	Grafton	7	Strafford
3	Carroll	8	Cheshire
4	Sullivan	9	Hillsborough
5	Merrimack	10	Rockingham

Figure 4.—Distribution of relative area of forest land by county and inventory year, New Hampshire.

The forest land base in Vermont and New Hampshire is composed of predominately hardwood forest types. However, Vermont contains more forest area in the maple/beech/birch forest-type group (Fig. 5, VT), whereas New Hampshire contains more oak/hickory, oak/pine, and spruce/fir forest-type groups (Fig. 5, NH).

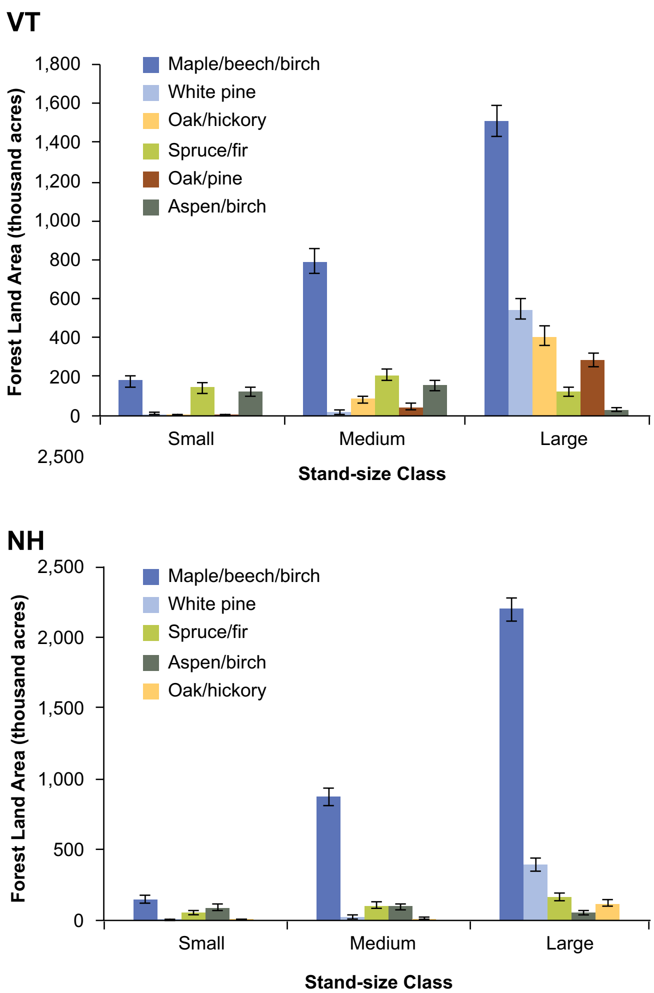


Figure 5.—Area of forest land by stand-size class for the top five forest-type groups, Vermont and New Hampshire, 2012. Error bars represent a 68 percent confidence interval around the mean.

What this means

At 75 and 81 percent, Vermont and New Hampshire are the fourth and second most forested states in the United States, respectively. Current statewide estimates of forest land have remained statistically unchanged since 1997. Future changes in Vermont's forest land base will depend on the pace of land development, particularly in the northwestern and southern parts of the State, as well as the economics of farming. Changes in New Hampshire will depend on the pace of land development, particularly in the southern parts of the State.

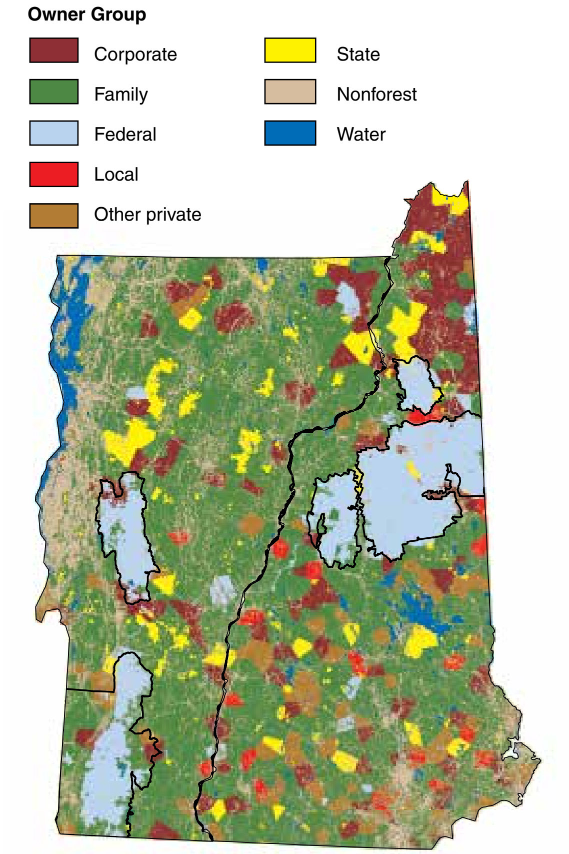
Availability and Productivity of Forest Land

Background

FIA divides forest land into three categories—timberland, reserved forest land, and other forest land—to clarify the availability of forest resources and type of forest management planning. Two criteria are used to make this determination: reserved status (unreserved or reserved) and site productivity (productive or unproductive). Forest land that is capable of accumulating wood volume at a rate of at least 20 cubic feet per year and that is not legally restricted from being harvested is classified as timberland. If harvesting is restricted on forest land by statute or administrative decision, then it is designated as reserved regardless of its productivity class. The harvesting intentions of private forest landowners are not used to determine the reserved status. The other forest land category is made up of forest land that is unreserved and low in productivity.

What we found

For Vermont and New Hampshire combined, 97 percent of the forest land meets the definition of timberland (Fig. 2), and 77 percent of that timberland is in private ownership. Estimates of the amount of timberland have remained statistically unchanged since 1997. The majority of the land in the reserved class is designated natural areas and is located on the Green Mountain National Forest in Vermont and the White Mountain National Forest in New Hampshire (Fig. 6). Other forest land (i.e., unreserved and unproductive) is rare and accounts for less than one percent of total land (Fig. 7).



Projection: New Hampshire State Plane, NAD83.
Sources: PAD v4.6, 2007; NLCD 2006; ALP 2006.
Geographic base data are provided by the National Atlas of the USA. FIA data and Tools are available online at http://www.fia.fs.fed.us/tools-data/
Cartography: R.S. Morin. Jan. 2014

Figure 6.—Distribution of forest land by owner class, Vermont and New Hampshire, 2007. Proclamation boundaries are outlined for Green Mountain National Forest in Vermont and White Mountain National Forest in New Hampshire (Hewes et al. 2014).

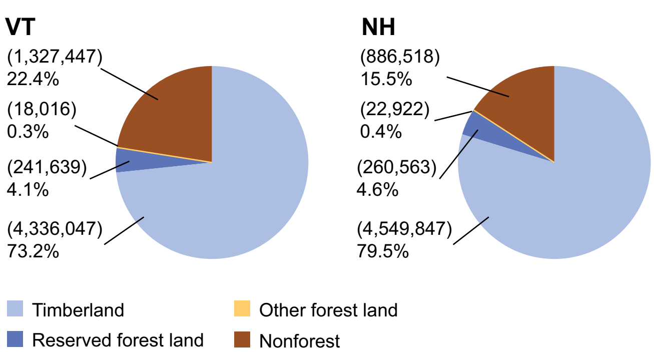


Figure 7.—Distribution of forest land by land use, Vermont and New Hampshire, 2012.

What this means

Because the vast majority of the forest land in Vermont and New Hampshire is classified as timberland, it is potentially available for harvesting timber or other forest products. It also means that trends observed on timberland are likely to apply to forest land as well. The demand for forest products will increase as the number of industries that utilize them expands. Therefore, the balance of supply and demand for these forest products needs to be closely monitored. This report provides more details on how much forest land is actively managed for forest products and a more accurate estimate of how much timberland is truly available for harvesting.

Ownership of Forest Land

Background

Forest landowners are a primary factor in determining how the distribution, composition, structure, and health of forest ecosystems will change in the future. Different types of owners (e.g., private, public) have varying objectives, opportunities, and constraints that govern decisions about forest management practices. Being interested in forest conservation means also being interested in those who control its fate, the forest owners. Working within biophysical, social, political, and economic constraints, owners make decisions related to land use and forest management that impact forest resources and influence the wealth of benefits, including timber supply, water supply, carbon sequestration, and wildlife habitat, that these forests provide. These benefits are described throughout the rest of this report.

The U.S. Forest Service, Forest Inventory and Analysis program, through the Family Forest Research Center (FFRC; www.familyforestresearchcenter.org), conducts the National Woodland Owner Survey (NWOS; www.fia.fs.fed.us/nwos/) to better understand: who owns the forests, why they own it, what they have done with it, and what they intend to do with it. The focus of the NWOS is on private ownership. The results presented are for family forest ownerships with at least 10 acres of forest land, are based on responses from 179 randomly selected family forest ownerships in Vermont and 144 in New Hampshire who participated in the NWOS between 2011 and 2013 (Butler et al., in press). The Vermont Department of Forests, Parks and Recreation has commissioned with the FFRC to increase NWOS sampling in Vermont to probe some State-specific questions; the results of these efforts will be available in 2015.

What we found

As it has been since 1948 in Vermont and 1952 in New Hampshire, the first years for which FIA reports are available for these States (McGuire and Wray 1952, U.S. Forest Service 1954), the forest ownership of Vermont and New Hampshire is dominated by private forest ownerships, and in particular, family and individual ownerships, collectively referred to here as family forest ownerships (Table 1, Fig. 6). In Vermont, family forest ownerships account for over 62 percent of the forest land, and in New Hampshire they hold 52 percent of the forest land. Other private ownerships, including corporations, nongovernmental conservation organizations, and other private groups, account for an additional 18 percent of the forest land in Vermont and 21 percent of the forest land in New Hampshire. On the public side the Federal government, and in particular the Green Mountain and White Mountain National Forests, dominate with over 1 million acres of forest land, but State government agencies in Vermont and New Hampshire, and local government agencies, especially in New Hampshire, also have substantial acreages (Fig. 8).

Table 1.—Area of forest land by ownership category, Vermont and New Hampshire, 2012

Ownership Category	Vermont Area	Vermont SE	New Hampshire Area	New Hampshire SE
	Acres	*%*	*Acres*	*%*
Private				
Family	2,857,000	4.3	2,534,000	4.7
Corporate	681,000	9.3	790,000	8.6
NGO[a]	107,000	24.0	91,000	27.0
Unincorporated	26,000	49.3	128,000	22.6
Tribal	--	--	--	--
Public				
Federal	491,000	7.9	842,000	5.6
State	386,000	13.2	212,000	15.1
Local	47,000	35.6	237,000	15.8

[a] Nongovernmental organization

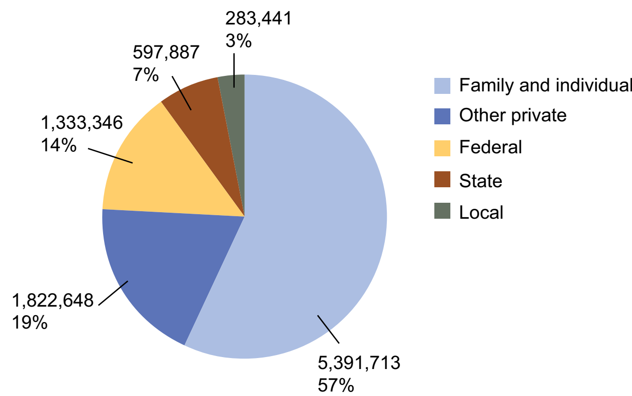


Figure 8.—Distribution of forest land area by major ownership category, Vermont and New Hampshire combined, 2012.

Although there has been relatively little change in the total area of forest land over the last 35 years (1 percent increase in Vermont and 1 percent loss in New Hampshire), relative changes by ownership category are substantial (Oswalt et al. 2014) (Fig. 9). Private forest land has dominated over this time period, but the area of public forest land has increased by over 30 percent, and the area of private forest land has decreased by over 10 percent. The nearly million-acre gain on public lands was largely by Federal and State acquisitions.

Looking more closely at family forest ownerships, the dominant ownership group, there are a diversity of reasons for owning the land, a diversity of forest uses, a diversity of forest management practices, and a variety of general land and landowner characteristics. There are an estimated 43,000 family forest ownerships in Vermont (with 10+ acres) and 40,000 family forest ownerships (with 10+ acres) in New Hampshire. These groups control an estimated 2,857,000 total acres and 2,534,000 acres of forest land, respectively.

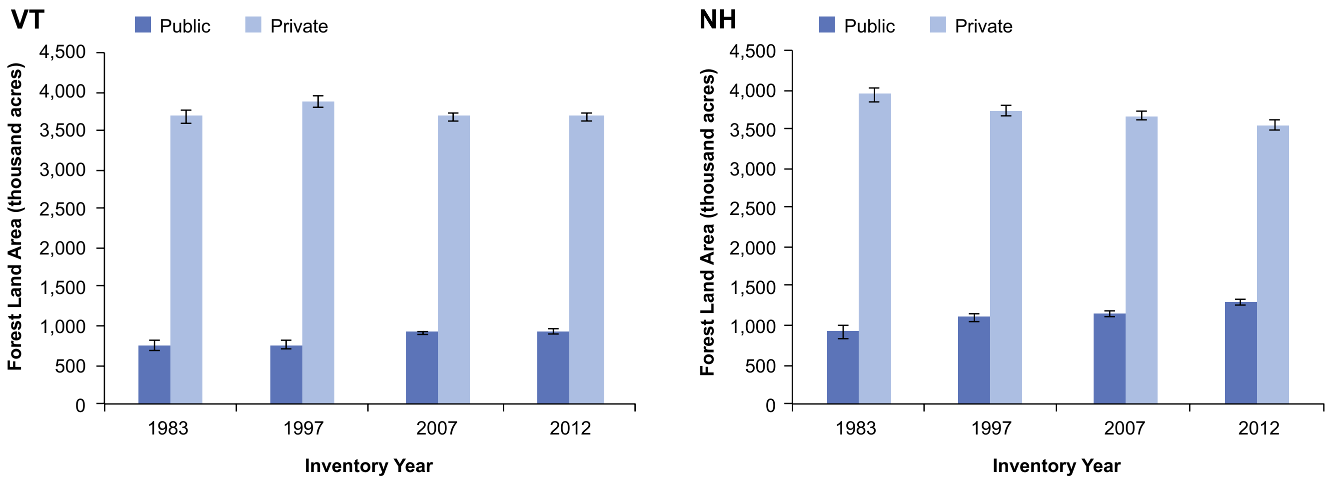


Figure 9.—Forest land area by inventory year and major ownership category, Vermont and New Hampshire. Error bars represent a 68 percent confidence interval around the mean.

The size of forest holdings is important because it influences what can be done with the land (e.g., smaller holdings may not be economically viable to manage) and is a strong indicator of many other attributes, such as reasons for owning and management practices (Butler 2008). There are two different ways to look at the ownership statistics: in terms of number of ownerships or area. In terms of number of ownerships, the vast majority are on the smaller size, ranging from 10-49 acres (Fig. 10).[1] But in terms of forest area, a majority of the family forest land is in holdings of at least 100 acres. Depending on the questions of interest, it may be appropriate to consider these statistics only in terms of ownerships or area, but often it is best to examine both. Ownerships are important because they represent the people who make the decisions and who are the recipients of the programs and services provided by the forestry community. The area is important because it represents the acreage upon which society depends for the goods and services provided.

The reasons for owning forest land are as diverse as the forests themselves. Most owners have multiple reasons for owning, with amenity-oriented objectives such as aesthetics, nature, wildlife, and privacy, dominating (Fig. 11). Some of these objectives are related to the

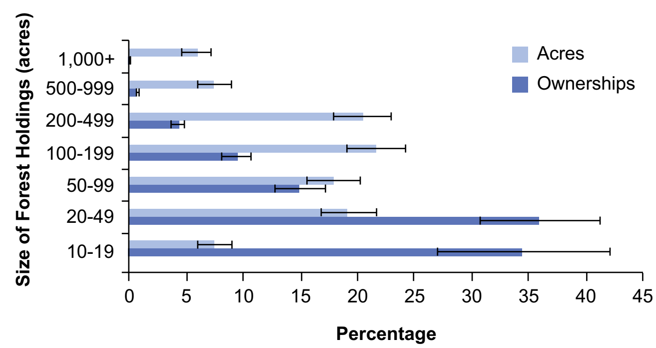
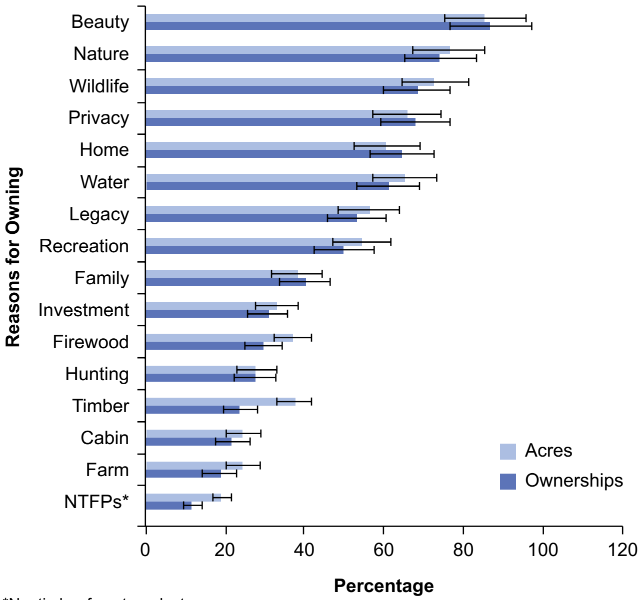


Figure 10.—Family forest ownerships (with 10+ acres) by size of forest holdings, Vermont and New Hampshire combined, 2011-2013. Error bars represent a 68 percent confidence interval around the mean.

fact that 67 percent of the ownerships, controlling 66 percent of the family forest land, have their primary homes associated with their forest land.

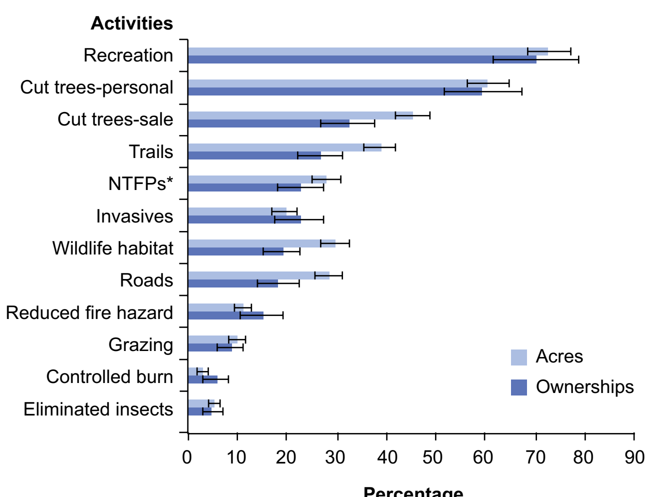
Considering just the preceding 5 years, the dominant activities on family forest ownerships were recreation and harvesting trees for personal use, such as firewood (Fig. 12). Although timber production is not a primary objective of most ownerships, 32 percent of the ownerships representing 45 percent of the family forest land acres, have commercially harvested trees. An increasing amount of family forest acres across the States (46 percent of forest land in VT and 78 percent of forest land in NH) are enrolled in one of the current use programs (NHDRED 2010, VDFPR

[1] As stated above, ownerships with 1-9 forested acres are excluded from this analysis, but these acres are included in the general forest statistics reported in Figures 8 and 9 and Table 1.



*Nontimber forest products

Figure 11.—Family forest ownerships (with 10+ acres) by reasons for owning, Vermont and New Hampshire combined, 2011-2013. Numbers include ownerships that ranked each objective as very important or important on a five-point Likert scale. Error bars represent a 68 percent confidence interval around the mean.



*Nontimber forest products

Figure 12.—Activities of family forest ownerships (with 10+ acres), Vermont and New Hampshire combined, 2011-2013. Error bars represent a 68 percent confidence interval around the mean.

2010). It is important to recognize that Vermont's use value appraisal (UVA) program is more restrictive than New Hampshire's current use taxation, also known as RSA79-A. For example, Vermont's UVA program is a working lands tax appraisal program requiring an approved forest management plan on enrolled properties 25 acres and greater, whereas the New Hampshire program has no such requirement. New Hampshire's current use taxation is an open space protection program that requires no plans but confers tiered benefits for lands 10 acres and greater based on landowner willingness to plan and manage resources or open the enrolled land for recreation. Although these programs reduce the annual property tax burden for qualifying owners, less than half of the ownerships have participated in traditional forest management practices and programs (Fig. 13). An estimated 39 percent of the family forest ownerships who own 63 percent of the family forest land in Vermont have a written forest management plan. In New Hampshire, an estimated 15 percent of the family forest ownerships who own 41 percent of the family forest land have a written forest management plan.

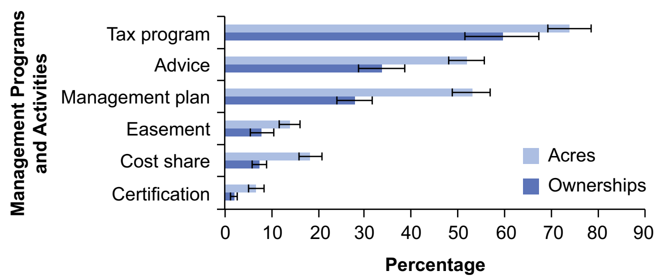


Figure 13.—Participation in forest management programs and activities by family forest ownerships (with 10+ acres), Vermont and New Hampshire combined, 2011-2013. Error bars represent a 68 percent confidence interval around the mean.

On average, family forest owners in Vermont and New Hampshire are older, more educated, and have higher incomes compared to the general population in each State (U.S. Census Bureau 2014). The mean family forest owner age is 60 years; 14 percent of the owners are 75 or over and an additional 16 percent are between 65 and 74 years of age (Fig. 14). To facilitate smoother intergenerational transfers, current owners are being encouraged to plan for the future and discuss their plans with the next generations of owners. Programs such as Ties to the Land (Oregon State University 2011) or Your Land, Your Legacy (Catanzaro et al. 2014) can help guide owners.

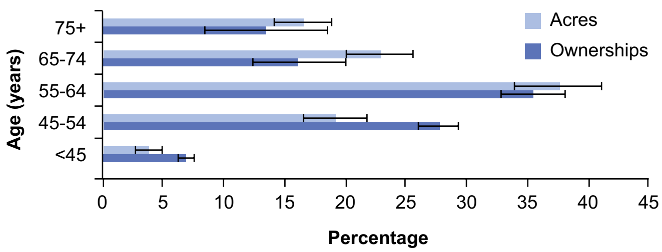


Figure 14.—Age of family forest owners (with 10+ acres), Vermont and New Hampshire combined, 2011-2013. Error bars represent a 68 percent confidence interval around the mean.

What this means

Those interested in forest conservation must understand those who own the forest. Across Vermont and New Hampshire the dominant forest owners are families and individuals, and this demographic will likely not change for the foreseeable future. Owners are engaged with their land but not in many of the traditional forestry activities such as harvesting or wildlife management. There is a general disconnect between forestry and forest owners that, if bridged, could have a major impact on the forests of these States and the people that own them. With the advanced age (65+) of many forest owners, it is anticipated that 1.8 million acres will be transferred to younger generations in the near future. This intergenerational transfer is an important trend to monitor, as the fate of forests will most likely be determined at these points of transfer.

Land Use Change

Background

FIA characterizes land area using several broad land use categories including forest, agriculture, and developed land. The conversion of forest land to other uses is referred to as gross forest loss, and the conversion of nonforest land to forest is known as gross forest gain. The magnitude of the difference between gross loss and gain is defined as net forest change. By comparing the land uses on current inventory plots with the land uses recorded for the same plots during the previous inventory, forest land use change dynamics can be characterized. Understanding land use change dynamics helps land managers make informed policy decisions.

Forest land is the dominant land area in Vermont and New Hampshire and is a critical resource that offers a wide range of benefits. Tree and vegetation cover limit the loss of fertile soils by protecting against erosion. Riparian forests serve as stream buffers, helping to protect the water resources. Forests provide habitat for forest-dwelling species and provide economic and other benefits for humans. Although the total area of forest land in Vermont and New Hampshire has remained stable between 2007 and 2012, some areas in each State have experienced forest loss, while other areas have had increases in forest land. Permanent loss of forest land is associated with urban development which is occurring at a rapid pace in the United States.

Since the late 1980s, forests in the northeast have been under pressure from urban expansion and increased population growth. There has been a great deal of concern about the effect of this growth on the forest resource and mounting concern that land use conversion to urban uses could cause significant forest loss. To a large extent, those pressures and concerns have lessened for many states in the region, including Vermont and New Hampshire. According to the U.S. Census Bureau (2011), population growth from 2010 to 2013 in Vermont and New Hampshire was 0.1 and 0.5 percent, respectively, which is well below the national average of 2.4 percent, and for the past several years, the area of forest land in the region has been stable.

What we found

Vermont and New Hampshire are dominated by forest land which covers more than three quarters of the total land area. The remaining nonforest land is primarily agricultural land located in the mid and northwestern portions of Vermont including Addison, Franklin, and Grand Isle Counties. In New Hampshire, Hillsborough, Rockingham, and Strafford Counties in the southeastern part of the State host the majority of the urban land. Most of the FIA plots in Vermont and New Hampshire have either remained forested (77 percent) or stayed in a nonforest land use (21 percent), and only the remaining 2 percent of plots experienced either a forest loss or gain from 2007 to 2012 (Fig. 15).

According to FIA remeasurement data, Vermont and New Hampshire combined lost approximately 81,000 acres (0.9 percent) of forest land from 2007 to 2012 which was offset by a gain of nearly 139,000 acres (1.5 percent) (Fig. 16, VT+NH). With these small losses being offset by gains, the result was no appreciable net change in forest land during the time period. There also was no appreciable difference in the magnitude of forest losses or gains when comparing the Vermont (Fig. 16, VT) and New Hampshire (Fig. 16, NH) estimates.

In Vermont, the majority of forest gains (56 percent) were from agricultural land converting to forest. In these cases, pasture and cropland was most likely left idle and regenerated naturally. Forest land lost (Fig. 16, VT) was converted in nearly equal proportions to agricultural and developed land (46 percent and 42 percent, respectively).

In New Hampshire, the majority of forest gains (64 percent) were from developed land converting to forest. In some cases, small sections of land had been cleared for development but no road or building construction occurred, so the land reverted to forest. Forest losses (Fig. 16, NH) primarily consisted of conversions to developed land (72 percent).

FIA data can be used to compare characteristics of forest land that has been lost and gained to forest land that remained forested to see how they differ. The forests in Vermont and New Hampshire are dominated by stands in the large diameter size class, and this class also is the most prevalent among the forested plots that were converted to nonforest land. The forest land that was gained, however, had a greater proportion of small diameter stands (33 percent) than in the overall population (7 percent). A portion of this newly acquired forest land may be the result of reforestation efforts or

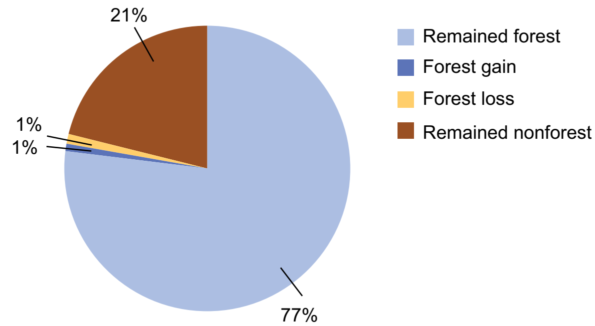


Figure 15.—Land use change, Vermont and New Hampshire combined, 2007 to 2012.

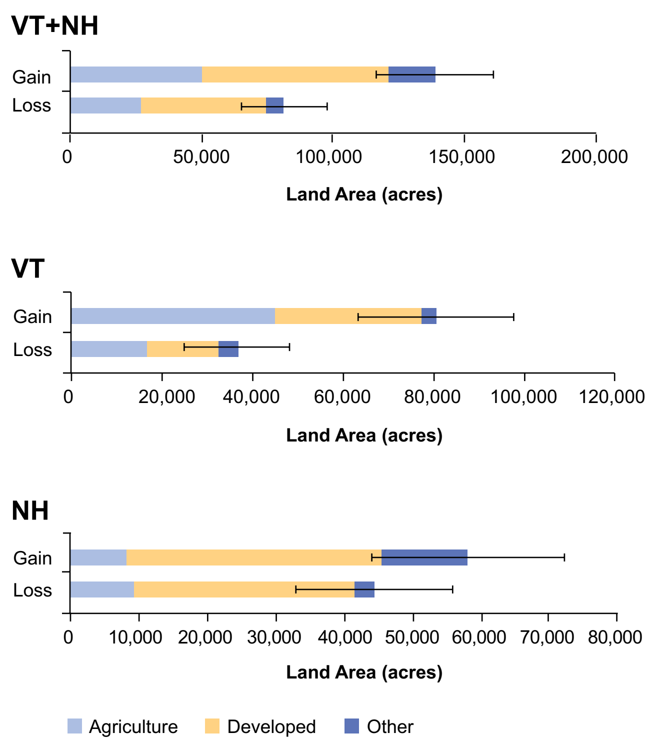
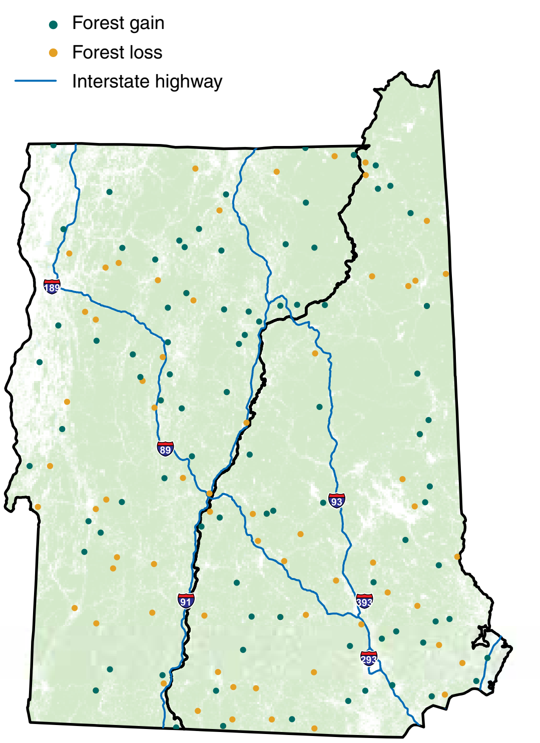


Figure 16.—Forest loss and forest gain by land use category for Vermont and New Hampshire combined and each State separately, 2007 to 2012. Error bars represent a 68 percent confidence interval around the mean.

forest succession in formerly agricultural areas. In other cases, forest land may have been gained from areas classified as being in a nonforest land use, but where trees were present. This type of forest gain most often occurs in agricultural or developed areas where the understory is initially disturbed by grazing, mowing, or other maintenance and then is left to revegetate naturally.

Figure 17 shows the distribution of forest change plots across Vermont and New Hampshire, indicating where forest land has been lost or gained. In general, there is no strong pattern in the spatial distribution of forest change plots; however, in some parts of the region change plots appear more concentrated closer to major roads, including along interstate 89 and 91. Forest gain plots are more prevalent in the northern portion of Vermont. The majority of land use change in New Hampshire occurred in the southern half of the State, with the White Mountain National Forest region changing very little.



Projection: New Hampshire State Plane, NAD83.
Sources: U.S. Forest Service, Forest Inventory and Analysis Program 2012; NLCD 2006.
Geographic base data are provided by the National Atlas of the USA. FIA data and Tools are available online at http://www.fia.fs.fed.us/tools-data/
Cartography: T. Lister. Aug. 2014

Figure 17.—Distribution of forest change plots showing forest gains and losses, Vermont and New Hampshire, 2007 to 2012. Depicted plot locations are approximate.

What this means

The small amount of forest loss that has occurred over the last 5 years has been offset by gains in forest land in other locations. Some of these gains likely come from reverting agricultural land, or from open land in developed areas that has been allowed to return to forest. Vermont's use value appraisal program and New Hampshire's current use tax are examples of legislation designed to encourage forest conservation and limit land use conversion. These incentives and other forest management and conservation programs help promote greater conservation and valuation of the forest resources of Vermont and New Hampshire.

Stand Size and Structure– A Growing, Maturing Forest

Background

To give a general indication of stand development, FIA uses tree diameter measurements to assign sampled stands to one of three stand-size classes. The category for a stand is determined by the size class that accounts for the most stocking of live trees per acre. Small diameter stands are dominated by trees less than 5 inches d.b.h. Medium diameter stands have a majority of trees with a d.b.h. of at least 5 inches but less than the large diameter stands. Large diameter stands consist of a preponderance of trees that are at least 9 inches d.b.h. for softwoods and 11 inches d.b.h. for hardwoods.

Stocking is a measure of the relationship between the growth potential of a site and the occupancy of the land by trees. The relative density (or stocking) of a forest is important for understanding growth, mortality, and yield. Five stocking classes are reported by FIA: nonstocked (0-9 percent), poor (10-34 percent), moderate (35-59 percent), full (60-100 percent), and overstocked (>100 percent). Stocking levels are examined by using all live trees and by using growing-stock trees only in order to identify the amount of growing space that is being used to grow trees of commercial value versus the amount that is occupied by trees of little to no commercial value. For a tree to qualify as growing stock, it must be a commercial species and cannot contain large amounts of cull (rough and rotten wood). The growth potential of a stand is considered to be reached when it becomes fully stocked. In overstocked stands, trees become crowded, growth rates decline, and mortality rates increase. Poorly stocked stands can result from harvesting practices or forest growth on abandoned agricultural land. In contrast to moderately stocked stands, poorly stocked stands are not expected to grow into a fully stocked condition within a practical amount of time for timber production.

What we found

In both Vermont and New Hampshire, the distribution of forest land by stand-size class continues to trend toward larger diameter stands. A substantial decrease in the area of medium and small diameter stands and a significant increase in the area of large diameter stands have occurred since 1997 (Fig. 18). The increasing trend toward large diameter trees is even more pronounced when current timberland estimates are compared with those from the 1948 inventory (U.S. Forest Service 1954). Large diameter stands now make up more than 60 percent of the timberland area in both States (Fig. 19).

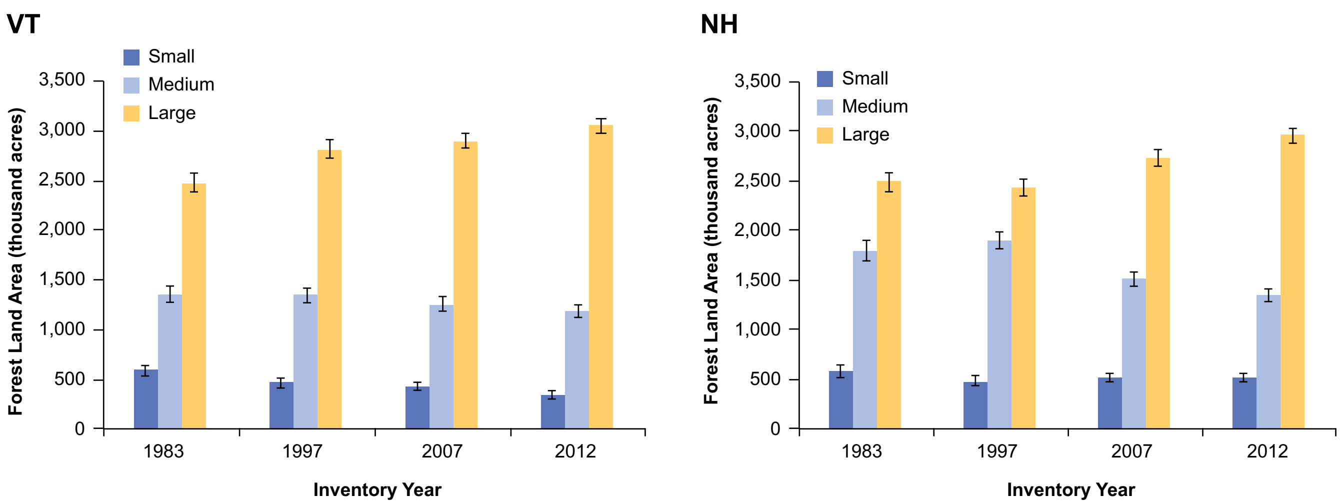


Figure 18.—Area of forest land by inventory year and stand-size class, Vermont and New Hampshire. Error bars represent a 68 percent confidence interval around the mean.

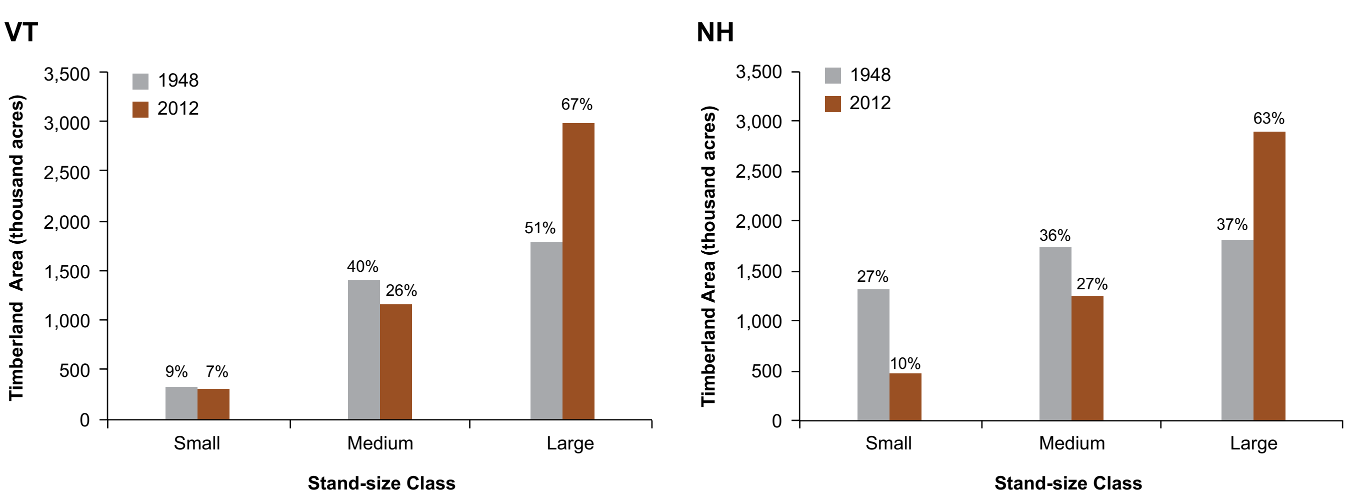


Figure 19.—Area of timberland and percentage of total by stand-size class and inventory year, Vermont and New Hampshire.

Since 1983, forest land area in the moderately and fully stocked classes for all live trees and growing-stock trees has increased, and at the same time, overstocked area has decreased in both States (Morin et al. 2011a, 2011b). However, since 2007, the distribution of forest land area among stocking classes has remained stable (Fig. 20). Only 31 and 33 percent, respectively, of stands are less than fully stocked in Vermont and New Hampshire as of 2012. A comparison of nonstocked or poorly stocked stands for all live trees (Fig. 20) and growing-stock trees (Fig. 21) in 2012 reveals that the area is 2.1 times greater for growing-stock trees in Vermont (560,000 to 271,000 acres) and 1.9 times greater in New Hampshire (517,000 to 268,000 acres). This indicates that both Vermont and New Hampshire have over one-half million acres that are poorly stocked or nonstocked with growing-stock trees, but half of those acres are moderately, fully, or overstocked when noncommercial species and cull trees are included. In Vermont and New Hampshire, nearly 30 and 35 percent of poorly or nonstocked forest land acres, respectively, are less than 40 years old and 100 and 93 percent, respectively, are less than 80 years old (Fig. 22). The distribution of age classes is explored further in a subsequent section. See Forest Habitats on page 46.

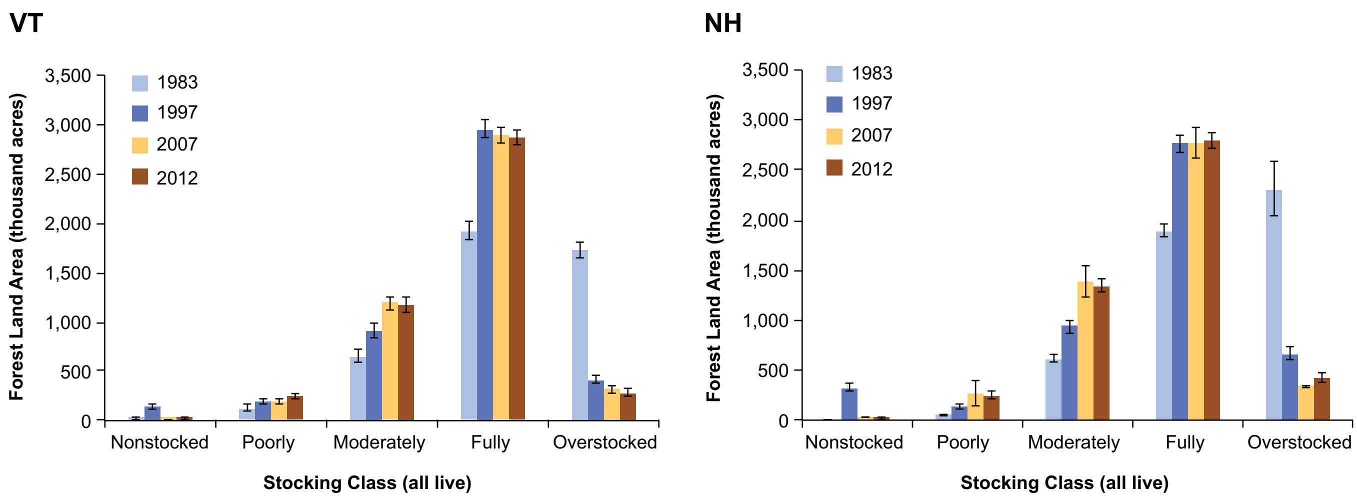


Figure 20.—Area of forest land by stocking class and inventory year for all live trees, Vermont and New Hampshire. Error bars represent a 68 percent confidence interval around the mean.

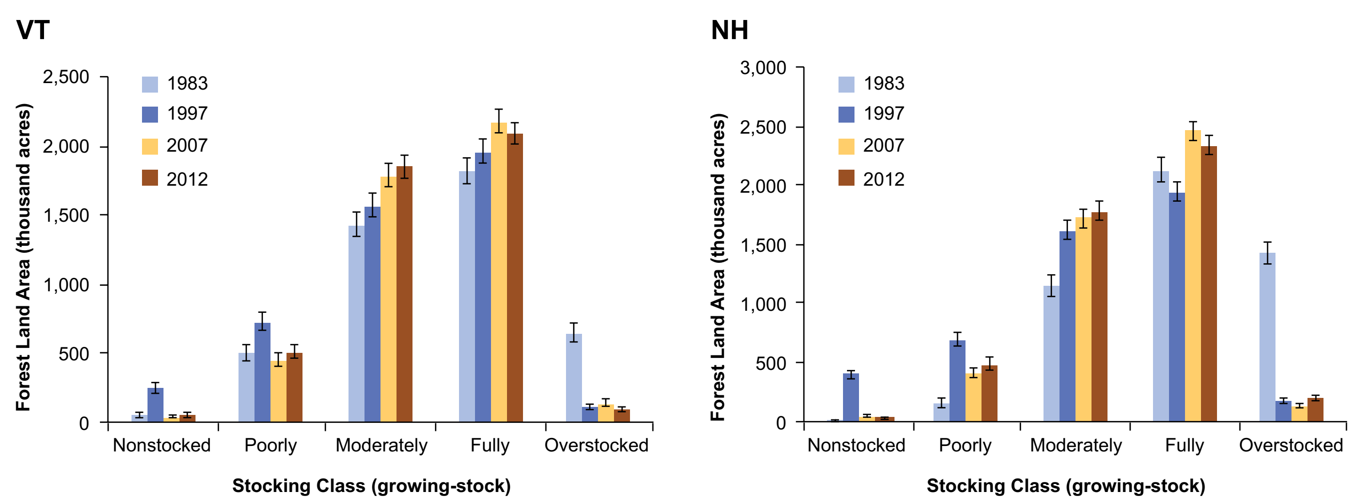


Figure 21.—Area of forest land by stocking class and inventory year for growing-stock trees, Vermont and New Hampshire. Error bars represent a 68 percent confidence interval around the mean.

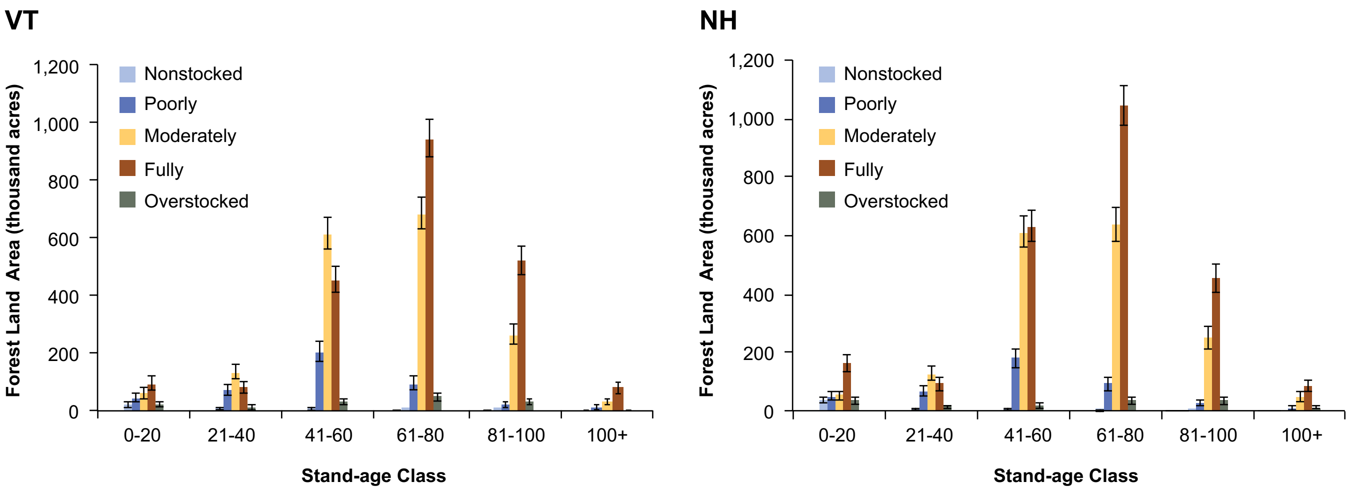


Figure 22.—Area of forest land by stand-age class and stocking class for growing-stock trees, Vermont and New Hampshire, 2012. Error bars represent a 68 percent confidence interval around the mean.

What this means

The trend of increasing forest land area in large diameter stands demonstrates clearly the continuing maturation of Vermont and New Hampshire forests to stands of larger, older trees. An important component of forest biodiversity is complex structural features. Although the area of forest in smaller diameter stands is decreasing, mature stands do provide diverse structures due to gap dynamics and the presence of shade tolerant species in the understory. The diversity of tree ages and sizes present in mature forests provides a broad range of habitats for wildlife and other organisms and makes forests more dynamic and better able to recover from disturbance.

The shifts in forest area out of nonstocked, poorly stocked, and overstocked stands into moderately and fully stocked stands are consistent with the regional trend of reforestation and maturation following the widespread land clearing that peaked in the late 1800s (Foster et al. 2004). They also indicate that forest management practices over the past three decades may have improved the general stocking condition across Vermont and New Hampshire. The majority of the forest land is well stocked with tree species of commercial importance. From a commercial perspective, continued management of these stands should keep them growing optimally by preventing them from becoming overstocked. From an ecological perspective, Vermont and New Hampshire have a low percentage of older forests, so consideration may be given to allowing some areas to continue growing beyond commercial benchmarks in order to develop some ecologically mature forests that support certain wildlife species and ecological processes. Although the nearly one-half million acres of forest land in both States that are poorly stocked or nonstocked with commercially important species represents a loss of potential growth, these forests do contribute to biodiversity. However, the higher light levels and open growing conditions in these poorly stocked and nonstocked stands may make them more susceptible to invasion by nonnative plant species such as common barberry (*Berberis vulgaris*) and multiflora rose (*Rosa multiflora*).

Number of Trees

Background

A basic component of forest inventory is the number of trees, an estimate that is easily understood, reliable, and easy to compare with past inventories. When combined with species and size, estimates of number of trees are valuable for showing the structure of forests and changes that are occurring over time. Young forests generally have many more trees per acre than older forests, but older forests usually have much more wood volume (or biomass) than younger forests.

What we found

Since 1997, the number of trees in the 12-inch and smaller d.b.h. classes has decreased while the number of trees in the larger classes has increased (Fig. 23). In general, the percentage increase in the number of trees by diameter class increased with diameter class (Fig. 24).

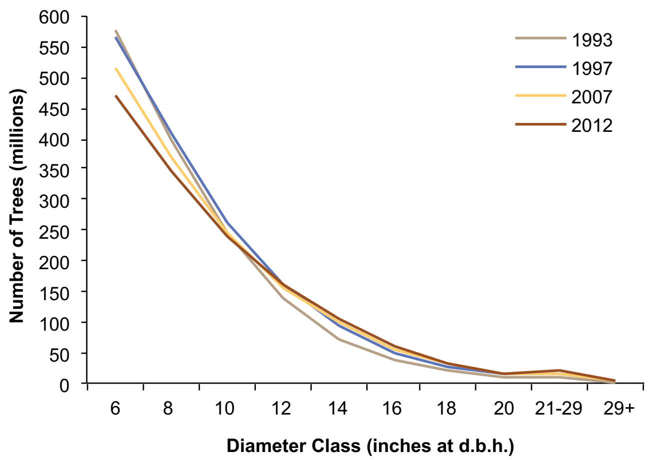


Figure 23.—Number of growing-stock trees on timberland by diameter class and inventory year, Vermont and New Hampshire combined.

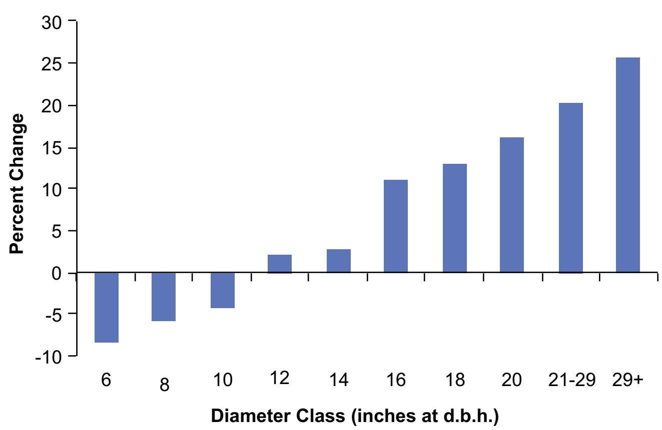


Figure 24.—Percent change in the number of growing-stock trees on timberland by diameter class, Vermont and New Hampshire combined, 2007 to 2012.

For growing-stock trees with a d.b.h. of 5 inches and larger, the most numerous tree species continue to be sugar maple[2] in Vermont and red maple in New Hampshire. The most abundant species in Vermont (sugar maple, red maple, American beech, red spruce, yellow birch, eastern white pine, paper birch, and white ash) decreased slightly in overall numbers between 2007 and 2012 while eastern hemlock and balsam fir numbers remained stable (Fig. 25, VT). Similarly the most abundant species in New Hampshire (red maple, eastern white pine, sugar maple, red spruce, paper birch, yellow birch, and American beech) decreased in number. Eastern hemlock, balsam fir, and northern red oak increased in numbers (Fig. 25, NH).

By contrast, number of sapling-size trees (1 to 4.9 inches d.b.h.) increased for some species in Vermont. All noncommercial species grouped together continue to be the most abundant saplings, although their numbers decreased by 7 percent between 2007 and 2012. American beech is the most abundant individual species in Vermont and showed a substantial proportional increase in number of saplings during that period (7 percent). The largest proportional increase in number of saplings was in white ash (8 percent). Other important species that increased in number were red spruce and yellow birch. Tree species that decreased in number of saplings were sugar maple, balsam fir, red maple, eastern hemlock, and paper birch. Most species followed the same pattern that was observed between 1997 and 2007. The exception was paper birch where the number of saplings decreased by 20 percent between 2007 and 2012 after increasing by 41 percent between 1997 and 2007 (Fig. 26, VT). Although the percentage change seems high, the actual change in numbers was relatively small.

Similarly, number of sapling-size trees increased for some species in New Hampshire. Balsam fir was the most numerous sapling species, and it continued to increase in numbers between 2007 and 2012. American beech showed the largest proportional increase in number of saplings during that period (15 percent). In general, the most abundant sapling species continued to increase in number, including balsam fir, red maple, noncommercial species, American beech, red spruce, and eastern hemlock. The major species that showed decreases in the number of saplings were yellow birch, sugar maple, eastern white pine, paper birch, and northern red oak. Most species followed the same pattern that was observed between 1997 and 2007. The exception was yellow birch

[2] Scientific names for all tree species are listed in the Appendix.

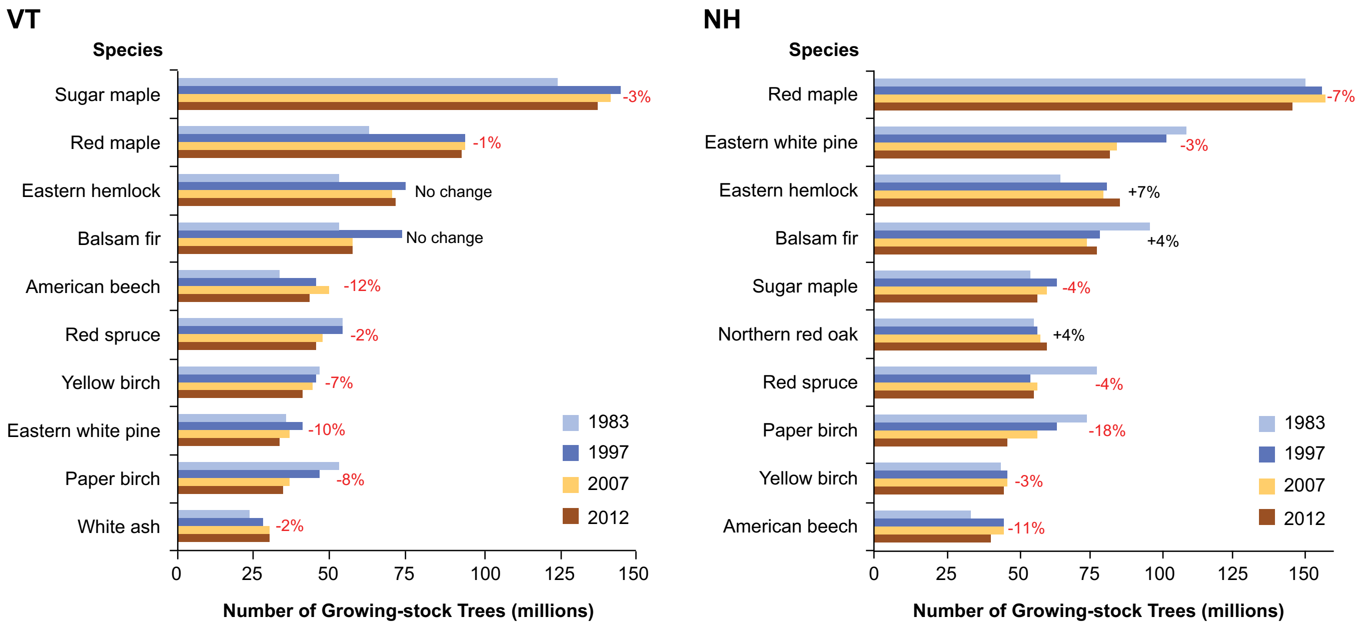
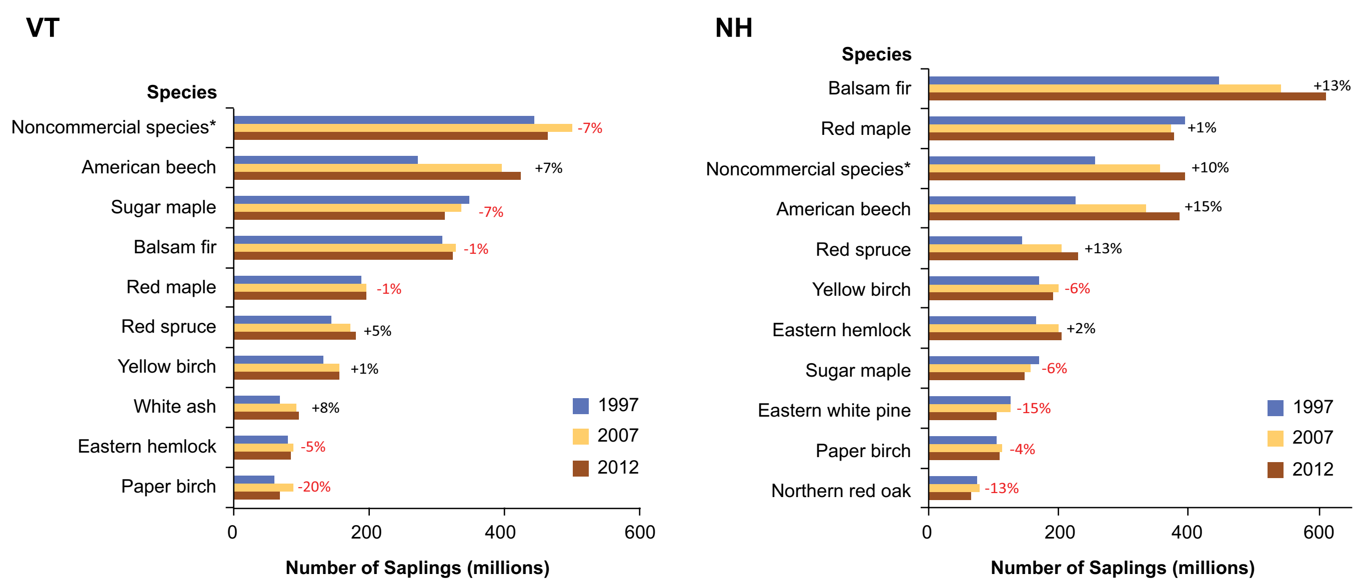


Figure 25.—Number of growing-stock trees on timberland and percent change from 2007 to 2012 by species and inventory year, Vermont and New Hampshire.



*Includes striped maple, eastern hophornbeam, pin cherry, and other species with poor form.

Figure 26.—Number of saplings (1 to 4.9 inches d.b.h.) on timberland and percent change from 2007 to 2012 by species and inventory year, Vermont and New Hampshire.

where the number of saplings decreased by 6 percent between 2007 and 2012 after increasing by 20 percent between 1997 and 2007 (Fig. 26, NH).

Since 1983, the number of large diameter trees has been increasing steadily in Vermont and New Hampshire. More recently, the number of trees in the 6- through 10-inch d.b.h. classes has been decreasing, indicating that as trees grow into larger size classes they are not being replaced by smaller trees growing into the medium diameter classes; however, the number of trees in the medium diameter category may increase when ingrowth from the small diameter classes occurs (Fig. 27).

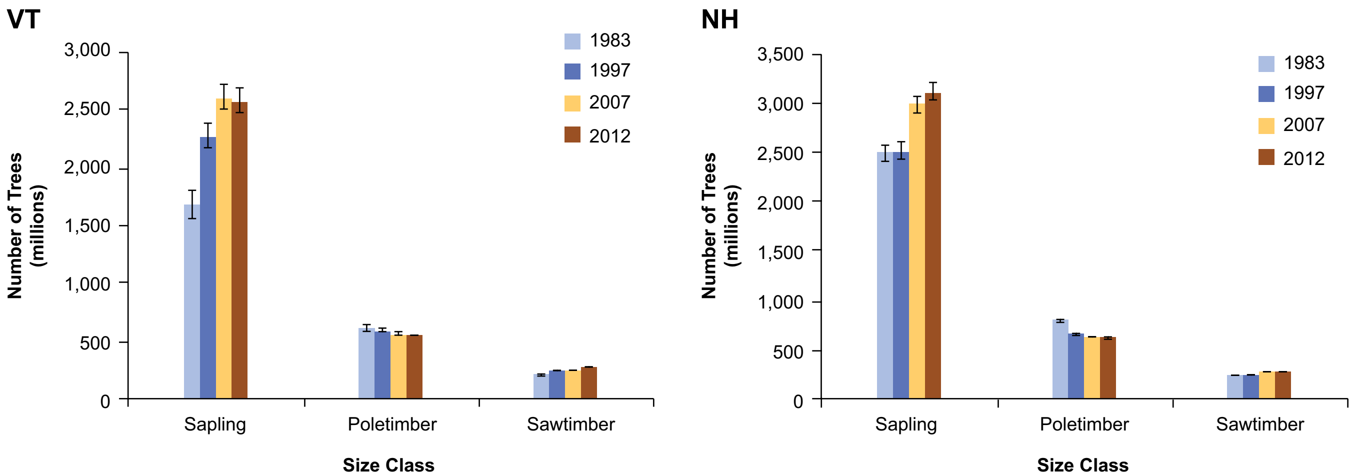


Figure 27.—Number of growing-stock trees on timberland by size class and inventory year, Vermont and New Hampshire. Error bars represent a 68 percent confidence interval around the mean.

What this means

Saplings in today's forest are a prime indicator of the composition of the future forest. Saplings eventually replace large trees that are harvested or killed by insects, diseases, or weather events. The increasing dominance of American beech in Vermont will have an impact on the future species composition of Vermont forests. Similarly, American beech and balsam fir are increasing in understory dominance in New Hampshire. The high relative sapling abundance of noncommercial species may be a concern for timber management. Additionally, with the threat of emerald ash borer (*Agrilus planipennis Fairmaire*) impacting ash survival in the future, increases in ash saplings may be an emerging issue for forest resources. Projections of future compositional changes are complicated by the potential impacts of climate change on the distributions of different tree species.

Carbon Stocks

Background

Collectively, forest ecosystems represent the largest terrestrial carbon sink on earth. The accumulation of carbon in forests through sequestration helps to mitigate emissions of carbon dioxide to the atmosphere from sources such as forest fires and burning of fossil fuels. The FIA program does not directly measure forest carbon stocks in Vermont and New Hampshire. Instead, a combination of field measurements and models are used to estimate carbon in tree and non-tree pools. Descriptions of the measurements and models used in forest carbon estimation procedures in the FIA program are described in Smith et al. (2006), Woodall and Monleon (2008), Woodall et al. (2011), and Domke et al. (2011, 2013).

What we found

Estimates of total carbon density in forests of Vermont and New Hampshire increased by an average of 1.29 tons per acre since the last inventory period (Fig. 28). On average, forests in the two States gained an estimated 0.26 tons of carbon per acre per year over the last 5 years, resulting in annual increases in carbon stocks of more than 3.4 million tons, the equivalent of offsetting the emissions of more than 1.27 billion gallons of gasoline each year (U.S. Energy Information Administration 2014). The annual rise in carbon density led to an estimated increase of nearly 17 million tons over all forest land since the last inventory period, bringing the total estimated carbon stocks in Vermont and New Hampshire to almost 805 million tons. The total forest carbon is split fairly evenly between the two States, with Vermont accounting for an estimated 397 million tons and New Hampshire accounting for an estimated 407 million tons. Live biomass (i.e., live trees and understory) represents the largest forest ecosystem carbon pool at almost 350 million tons, followed by soil organic matter (SOM) at nearly 308 million tons (Fig. 29).

Carbon stocks in the forests of Vermont and New Hampshire have increased substantially over the last decade, with the largest increases in the oak/hickory (20 percent), spruce/fir (15 percent), and white/red/jack pine (9 percent) forest types (Fig. 29). Despite similarities in forest carbon stocks in the two States, there were substantial state-to-state differences in the accumulation

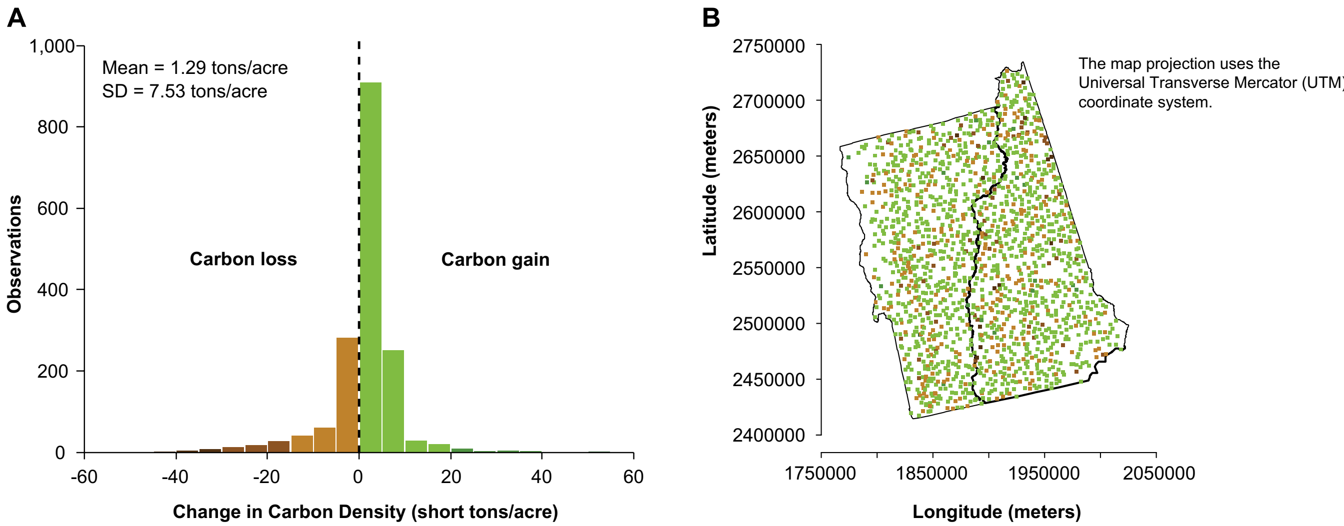


Figure 28.—Histogram (A) and map (B) of plot-level changes in carbon density, Vermont and New Hampshire combined, 2012. Point colors in map correspond to the values in the bar chart.

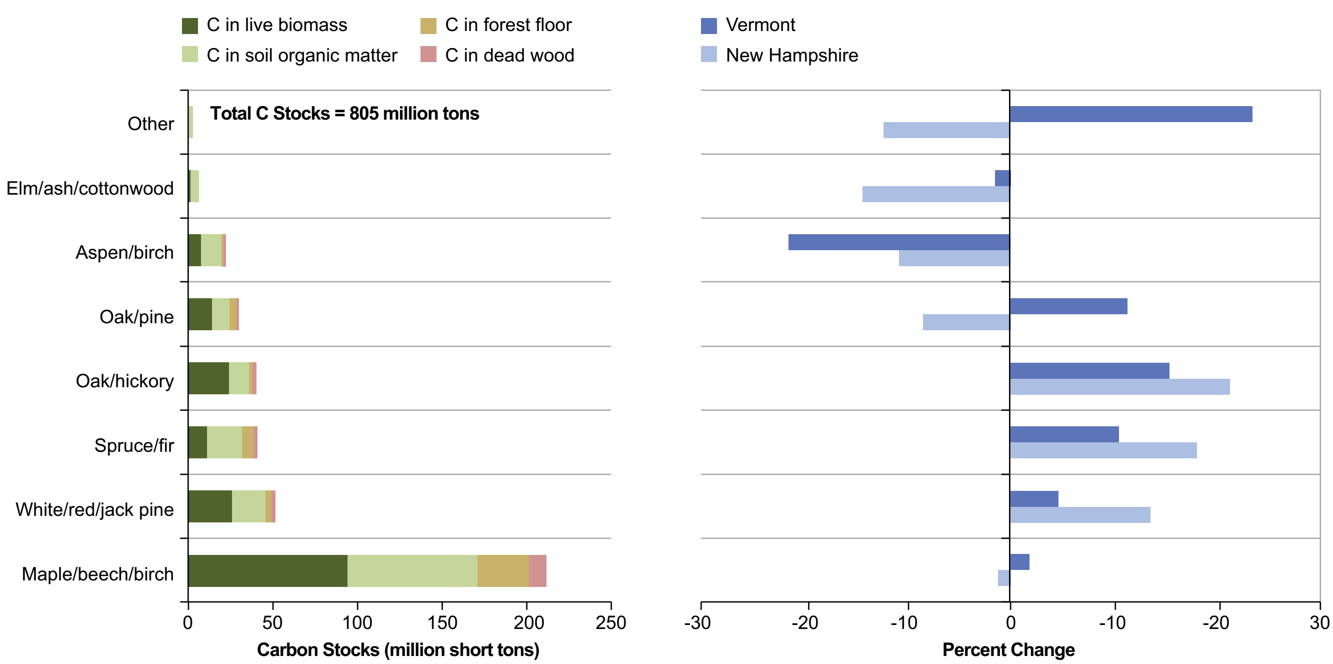


Figure 29.—Carbon stocks for Vermont and New Hampshire combined (A), and percent change of carbon stocks in Vermont and New Hampshire (B), by forest-type group, 2012.

of carbon by forest type over the last decade. In Vermont, there was a small increase in carbon stocks in the maple/beech/birch forest type which accounts for the majority of all forest carbon in the region, while in New Hampshire there was a slight decrease in carbon stocks for the maple/beech/birch forest type (Fig. 29). In the spruce/fir group, 50 percent (35 million tons) of the total estimated forest carbon is in the SOM, whereas in the maple/beech/birch group, only 36 percent is in the SOM.

The majority of the forest carbon stocks in Vermont and New Hampshire are found in moderately-aged stands of 41-100 years old (Fig. 30). Early in stand development most of the forest ecosystem carbon is in SOM and belowground tree components. As forest stands mature, the ratio of aboveground to belowground carbon shifts, and for trees in the 41-60 year age class, the aboveground components represent the majority of ecosystem carbon. This trend continues well into stand development as carbon accumulates in live and dead aboveground components.

What this means

The majority of forest carbon in the region is found in moderately-aged stands dominated by relatively long-lived species. This suggests that forest carbon stocks will continue to increase in the region as stands mature and accumulate carbon in aboveground and belowground components. Nunery and Keeton (2010) concluded that unmanaged stands will sequester more carbon than those that are actively managed. Therefore, even with slowing net growth rates (see Average Annual Net Growth and Removals on p. 34), as long as removals are less than net growth, the forests of Vermont and New Hampshire should continue to sequester more carbon than they emit. Given the age class structure and species composition of forests in the region, there may be opportunities to increase forest carbon stocks. Managing for carbon sequestration, accumulation, or both in combination with other land management objectives will require careful planning and creative silviculture.

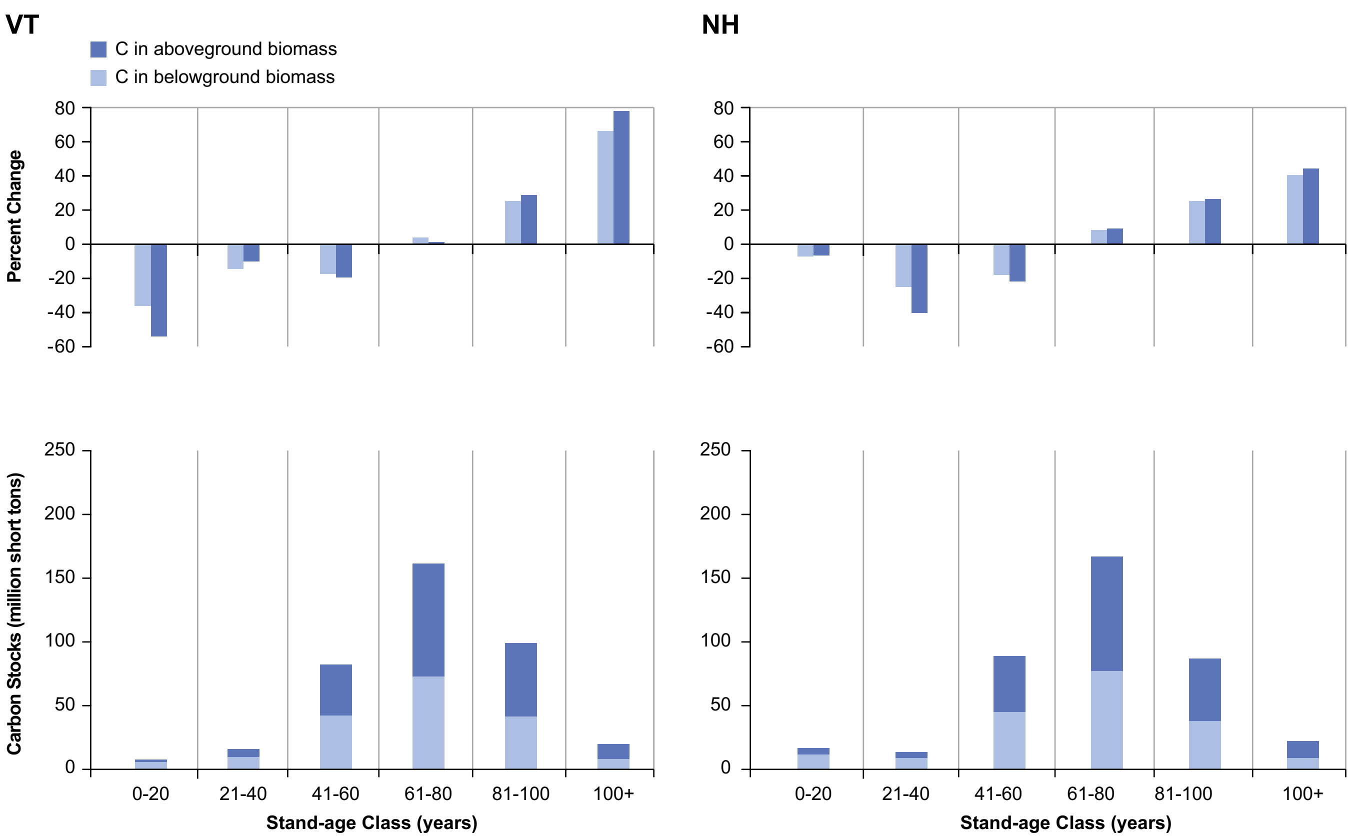


Figure 30.—Carbon stocks and percent change in carbon stocks by stand-age class, Vermont and New Hampshire, 2012.

Biomass

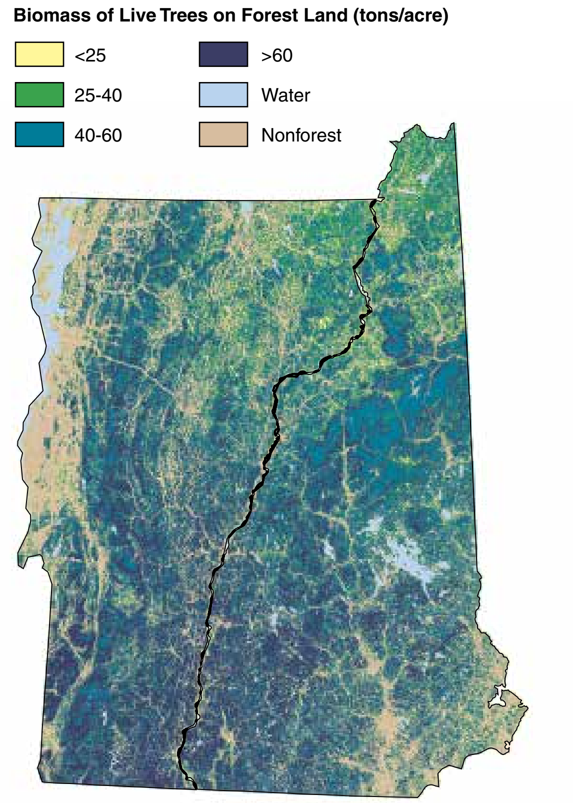
Background

The increasing interest in carbon dynamics and questions related to carbon sequestration, emission reduction targets, production of biofuels, and forest fire fuel loadings makes estimates of biomass a critical component of the FIA program. FIA defines aboveground biomass as the weight of live trees composed of the boles, aboveground portion of stumps, tops, and limbs (but excluding foliage). Due to increases in tree volume, Vermont and New Hampshire forests contribute significantly to carbon sequestration (uptake and storage).

What we found

The forest land of Vermont and New Hampshire has an estimated 569.2 million dry tons of aboveground tree biomass, with biomass per acre averaging 60.4 tons per acre of forest land. The distribution of biomass per acre on forest land is generally highest in southern Vermont and southern New Hampshire (Fig. 31). The largest portion of the aboveground biomass is in the boles of growing-stock trees (65 percent), but this is also the part of the tree resource that can be converted into valuable wood products. The other 35 percent of the biomass is in tops, limbs, stumps, cull trees, or trees of noncommercial species (Fig. 32).

Total live dry biomass on timberland in the two States combined has increased by 36 percent since 1983 (407.2 to 553.2 million dry tons), primarily due to the increasing size of sawtimber trees in Vermont and New Hampshire. Biomass also increased slightly in the sapling size class. By contrast, biomass decreased in poletimber-size trees during this time period (Fig. 33).



Projection: New Hampshire State Plane, NAD83.

Sources: U.S. Forest Service, Forest Inventory and Analysis Program 2009; NLCD 2006.

Geographic base data are provided by the National Atlas of the USA. FIA data and Tools are available online at http://www.fia.fs.fed.us/tools-data/

Cartography: R.S. Morin. Feb. 2014

Figure 31.—Live-tree biomass (dry tons) per acre of trees at least 1 inch d.b.h., Vermont and New Hampshire, 2009.

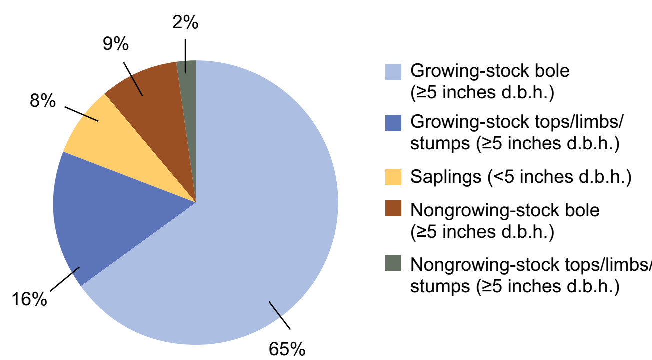


Figure 32.—Percentage of live-tree biomass (trees 1 inch d.b.h. and larger) on forest land by aboveground component, Vermont and New Hampshire combined, 2012.

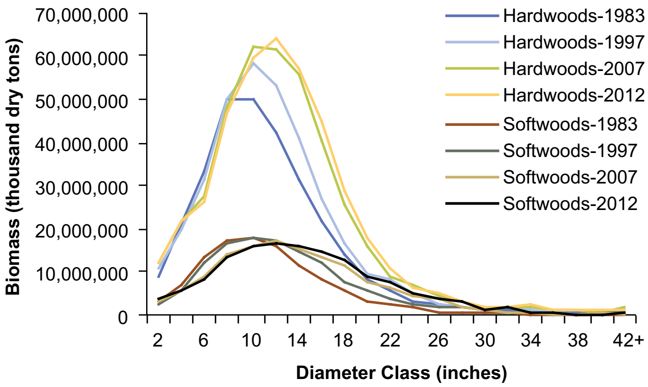


Figure 33.—Distribution of live-tree biomass (trees 1 inch d.b.h. and larger) on timberland by diameter class (2-inch intervals), species group, and inventory year, Vermont and New Hampshire combined.

What this means

The forests of Vermont and New Hampshire are continuing to accumulate biomass as the forests mature. Because most of the biomass is contained in the boles of growing-stock trees and most of the gains in biomass stocks are found in these higher value sawtimber-size trees, only a fraction of the accumulated material is available for use as whole tree chips for large wood fuel users. If the demand for biomass increases with increases in heating, power production, and (potentially) the production of liquid fuels, the wood-using market would become more competitive. This creates an opportunity for enhancing forest management practices to benefit both traditional forest products supplies and those for bioenergy. The Biomass Energy Resource Center produced a detailed report on supply and sustainability of available low grade wood for Vermont that includes the western counties of New Hampshire (Sherman 2007).

Private forest landowners are the holders of the majority of the forest biomass in Vermont (78 percent) and New Hampshire (75 percent). Thus they play an important role in sustaining this resource. Currently, forest landowners are not financially compensated for the carbon sequestration service provided by the trees on their land. However, the markets for forest carbon sequestration are growing, so this scenario could change in the future. If carbon trading and biomass production become more common, reliable estimates of biomass and carbon in forests, both in the aboveground biomass and in soils, will become more important. The future of this scenario depends on political decisions and prices for energy producing fuels including crude oil and natural gas.

Volume of Growing-stock Trees

Background

To assess the amount of wood potentially available for commercial products, the FIA program computes growing-stock volumes for trees growing on timberland that meet requirements for size, straightness, soundness, and species. Growing-stock volume includes only commercial tree species with a d.b.h. of 5 inches or larger and does not include rough, rotten, or dead trees. The forest products industry relies on this estimate of growing-stock volume as its resource base. Current volumes and changes in volume over time can characterize forests and reveal important resource trends. This is especially important with respect to trend information because many past FIA inventories have only growing-stock estimates available.

What we found

The total growing-stock volume in Vermont and New Hampshire has increased steadily since the 1960s. The 2012 estimates of 9.1 and 9.8 billion cubic feet in Vermont and New Hampshire, respectively, are substantial increases from the 1997 inventories. The rate of increase in growing-stock volume of about 0.5 percent annually is a reduction compared with the 1 to 4.5 percent annual increases in previous decades (Fig. 34). Distribution of growing-stock volumes by diameter class from the current and three previous inventories reveal a steady shift toward larger diameter trees (Fig. 35). During the most recent inventory (2012), volume increased in all d.b.h. classes greater than 10 inches, but decreased in the 6-, 8-, and 10-inch diameter classes (Fig. 36).

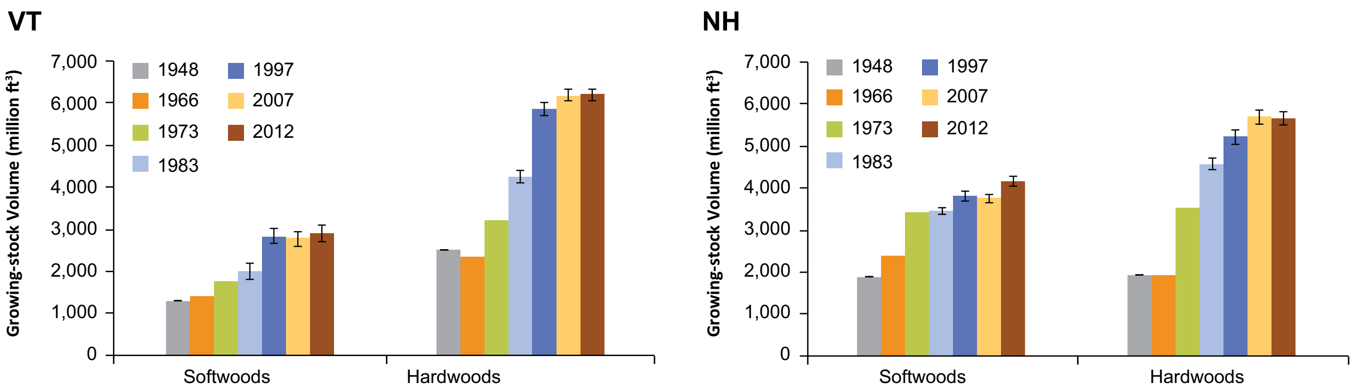


Figure 34.—Growing-stock volume on timberland by species group and inventory year, Vermont and New Hampshire. Error bars represent a 68 percent confidence interval around the mean.

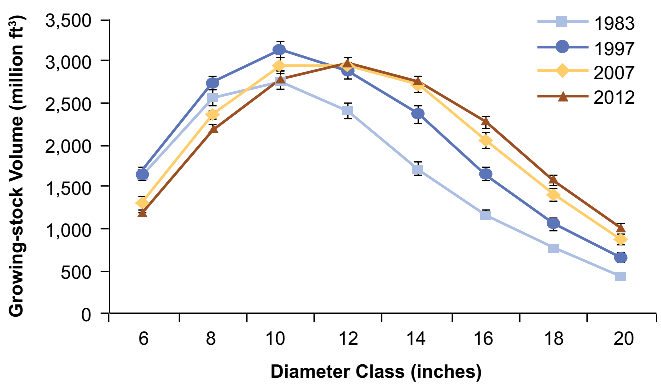


Figure 35.—Growing-stock volume on timberland by diameter class and inventory year, Vermont and New Hampshire combined. Error bars represent a 68 percent confidence interval around the mean.

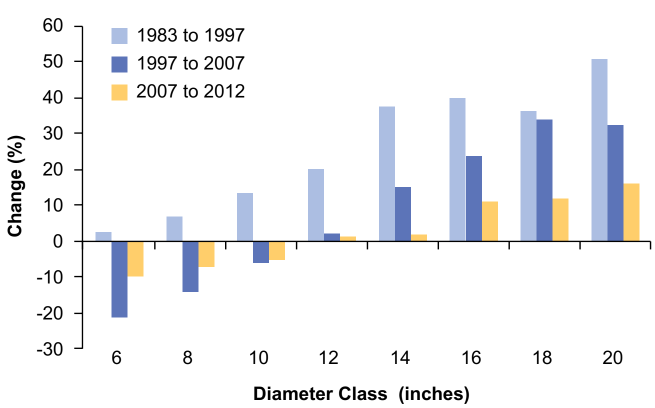


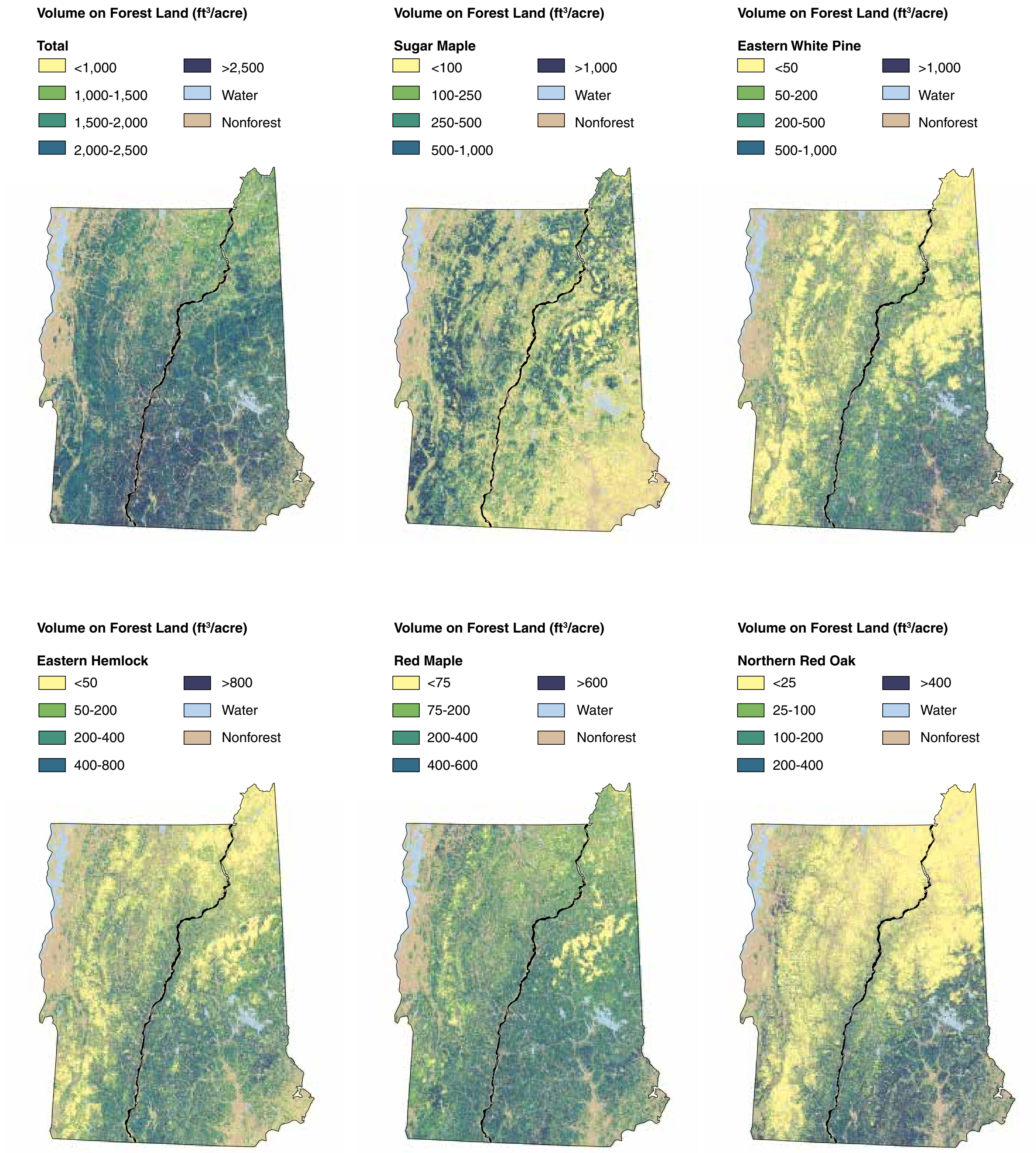
Figure 36.—Percent change in growing-stock volume on timberland by diameter class and inventory year, Vermont and New Hampshire combined.

The distributions of total growing-stock volume in New Hampshire and Vermont for five major species are shown in Figure 37. In general, total volume for each species increases from north to south, with higher volumes in the southern portion of the States and along the ridges of the White and Green Mountains to the north. Volume per acre varies spatially by species. Eastern white pine, northern red oak, and eastern hemlock are most concentrated in southern New Hampshire. Sugar maple density is highest in the Green Mountains of Vermont, and red maple is distributed throughout both States, with the highest volumes in the southern regions.

Vermont

The level of growing-stock volume on timberland in Vermont averages 2,034 cubic feet per acre. Of this volume, 68 percent is in hardwood species and 32 percent is in softwood species. Sugar maple (35 percent), red maple (18 percent), yellow birch (10 percent), and white ash (8 percent) make up over 70 percent of the hardwood growing-stock volume. Eastern hemlock (34 percent), eastern white pine (30 percent), red spruce (16 percent), and balsam fir (12 percent) account for over 90 percent of softwood growing-stock volume (Fig. 38, VT).

Overall, sugar maple has nearly twice the amount of growing-stock volume as the next most abundant species. It is followed by red maple, eastern hemlock, and eastern white pine. These species make up 56 percent of the total growing-stock volume in Vermont. Species that showed the largest increases in growing-stock volume between



Projection: New Hampshire State Plane, NAD83.

Sources: U.S. Forest Service, Forest Inventory and Analysis Program, 2009; NLCD 2006.

Geographic base data are provided by the National Atlas of the USA. FIA data and Tools are available online at http://www.fia.fs.fed.us/tools-data/

Cartography: R.S. Morin. Feb. 2014

Figure 37.—Cubic-foot volume per acre on forest land for major tree species (for trees 5 inches d.b.h. and larger), Vermont and New Hampshire, 2009.

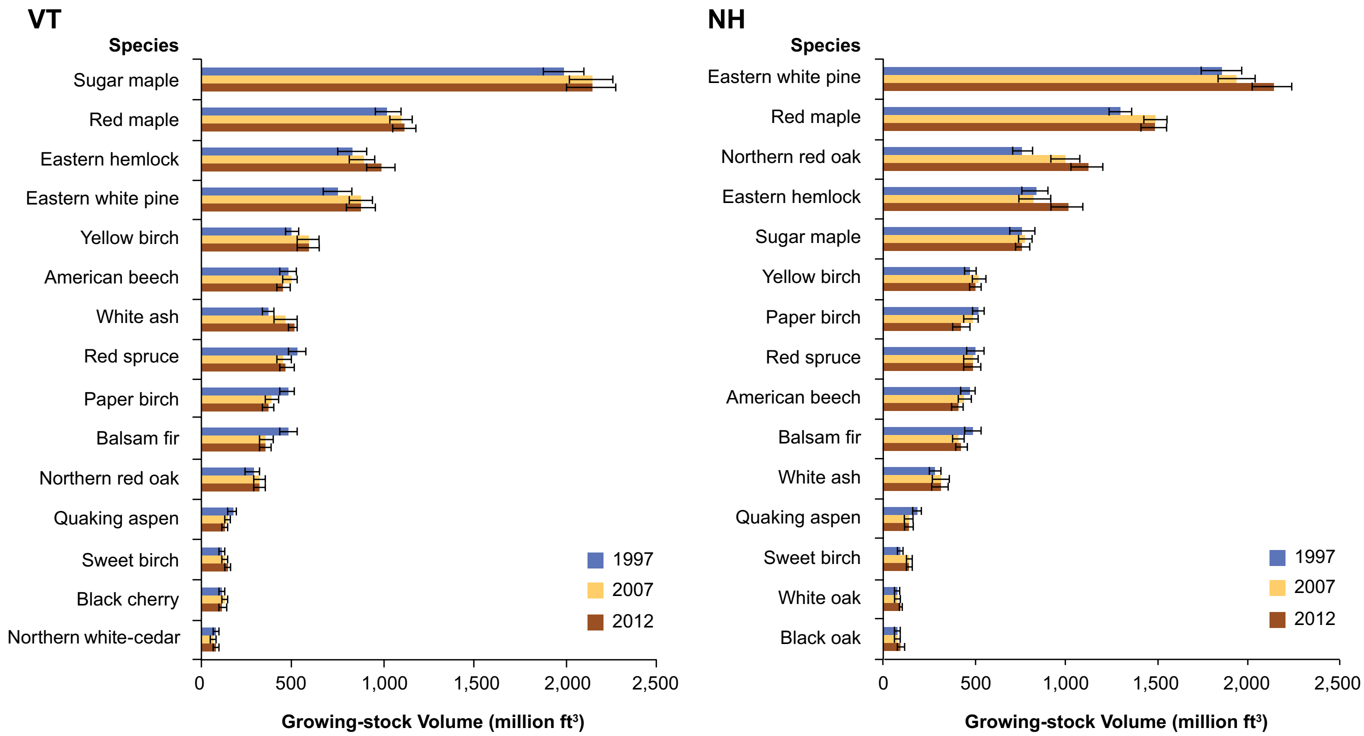


Figure 38.—Growing-stock volume on timberland by species and inventory year, Vermont and New Hampshire. Error bars represent a 68 percent confidence interval around the mean.

2007 and 2012 were northern white-cedar (15 percent), sweet birch (10 percent), and white ash (8 percent). By contrast, American beech, black cherry, and quaking aspen all decreased by 7 percent (Fig. 38, VT).

When board-foot volume is estimated, the order of the top four species by volume is slightly different from the order for growing-stock volume. Sugar maple remains the leading species by a large margin, but eastern white pine replaces red maple as the second highest. Sugar maple makes up nearly 25 percent of the total sawtimber volume in Vermont (Fig. 39, VT). Sweet birch (27 percent) and eastern hemlock (17 percent) had the largest gains in sawtimber volume between the 2007 and 2012 inventories. Total board-foot volume increased by 6 percent since 2007.

New Hampshire

There are 9.8 billion cubic feet of growing-stock volume on timberland in New Hampshire (approximately 2,118 cubic feet per acre). Of this volume, 58 percent is in hardwood species and 42 percent is in softwood species. Red maple (26 percent), northern red oak (20 percent), sugar maple (13 percent), yellow birch (9 percent), and paper birch (7 percent) make up 76 percent of the hardwood growing-stock volume. Eastern white pine (51 percent), eastern hemlock (24 percent), red spruce (12 percent), and balsam fir (10 percent) account for 97 percent of softwood growing-stock volume (Fig. 38, NH).

Overall, eastern white pine continues to have the greatest growing-stock volume followed by red maple, northern red oak, and eastern hemlock. These species make up 58 percent of the total growing-stock volume in New Hampshire. Species that showed the largest increases in growing-stock volume between 2007 and 2012 were black oak (25 percent) and white oak (21 percent), both of which are minor components of the forest, and eastern hemlock (21 percent) which is a larger component. By contrast, yellow birch and balsam fir each decreased by 4 percent (Fig. 38, NH).

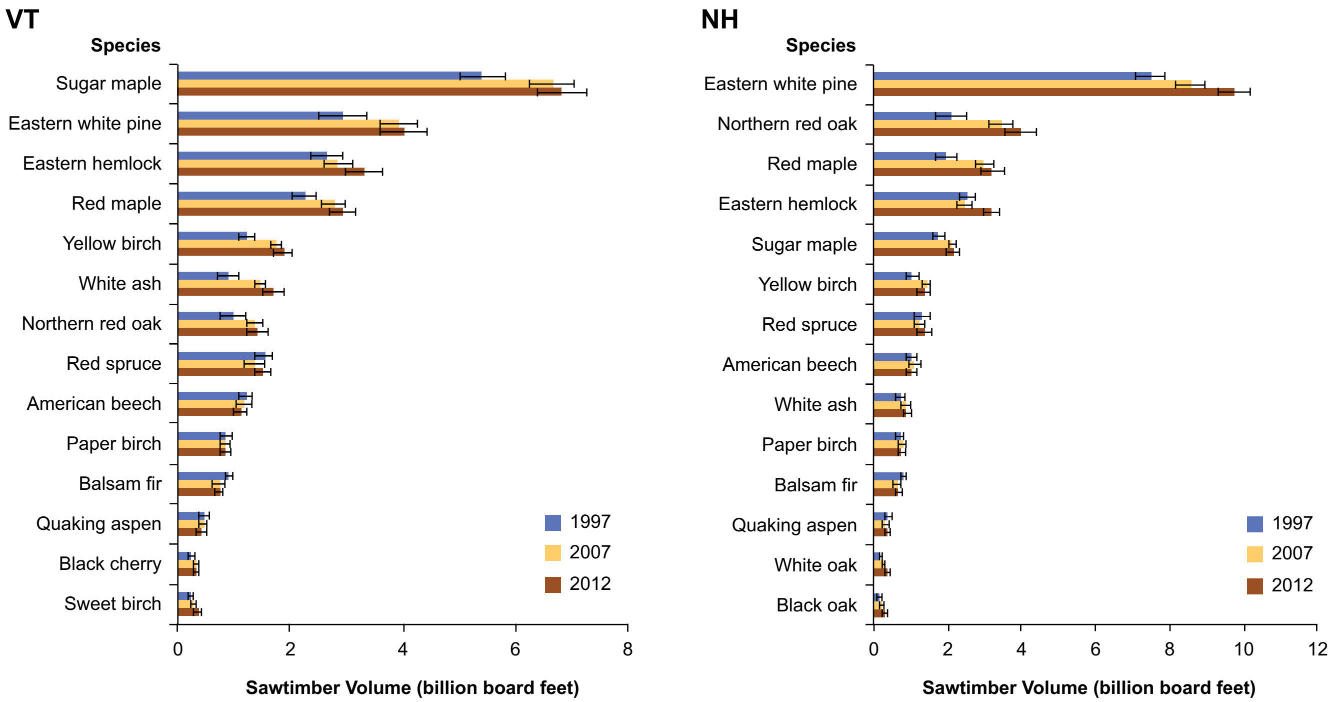


Figure 39.—Sawtimber volume on timberland by species and inventory year, Vermont and New Hampshire. Error bars represent a 68 percent confidence interval around the mean.

When board-foot volume is estimated, the order of the top four species by volume is slightly different from the order for growing-stock volume. Eastern white pine remains the leading species by a large margin, but northern red oak replaces red maple as the second highest. Eastern white pine makes up more than 31 percent of the total sawtimber volume in New Hampshire (Fig. 39, NH). Black oak, white oak, and eastern hemlock showed increases in sawtimber volume of greater than 30 percent between the 1997 and 2007 inventories. Total board-foot volume increased by 11 percent since 2007.

What this means

The volume of timber resources in Vermont and New Hampshire continues to increase, reaching record levels since FIA began doing inventories in these States in 1948. However, the rate of increase in growing-stock volumes has slowed, and growth rates may decrease further as the forest ages. Even though the rate of volume increase is leveling off, the forests of Vermont and New Hampshire are adding value at an increasing rate due to growth that is occurring on the higher valued trees. Landowners and the forest products industry can benefit from the increase in value, but care in management and harvesting practices will be important to ensure a steady supply of desirable species into the future as the population of poletimber-size trees replace the sawtimber-size trees.

Sawtimber Quality

Background

The value of a tree in the forest products market is determined by its species, size, and quality. High quality timber is generally characterized by a large diameter and the absence of defects such as knots, wounds, and form. Timber used in the manufacture of cabinets, furniture, flooring, or other millwork is the most valuable. Lower quality trees are utilized as pallets, pulpwood, or fuelwood. The quality of an individual tree can be influenced by species as well as diameter, growth rate, and management practices. According to FIA standards, hardwood trees must have a d.b.h. of at least 11 inches to qualify as sawtimber. FIA assigns tree grades to sawtimber-size trees as a measure of quality. Tree grade is based on tree diameter and the presence or absence of defects such as knots, decay, and curvature of the bole. These grades have parallels to log grades used by sawmills, but they are not identical. Quality decreases from grade 1 (high grade lumber) to grade 3. Grade 4 is assigned to tie/local use material.

What we found

The proportion of hardwood sawtimber volume in the highest quality categories (tree grades 1 and 2) remained stable in Vermont and New Hampshire between 2007 and 2012. There are currently 7.2 billion and 5.6 billion board feet, respectively, in tree grades 1 and 2 in Vermont and New Hampshire. The proportion of volume in tree grade 3 increased by 3 percent in both States (Fig. 40).

In Vermont and New Hampshire, northern red oak, eastern hemlock, red spruce, and white ash are the only species with more than 50 percent of their sawtimber volume in tree grades 1 and 2. Sugar maple, eastern white pine, yellow birch, and paper birch have at least 30 percent of their sawtimber volume in grades 1 and 2. By contrast, red maple has less than 25 percent and American beech has than less than 7 percent of their sawtimber volume in grades 1 and 2 (Fig. 41).

What this means

The quality of saw logs in New Hampshire and Vermont has remained stable since the last inventory. However, total value of sawtimber has increased because of an overall increase in the board-foot volume of sawtimber material. Board-foot volume continues to increase in many species, but changes in species composition point toward potential reductions in tree quality into the future. Many beech trees contain cankers and large amounts of rotten wood due to the impacts of beech bark disease. American beech is the species with the

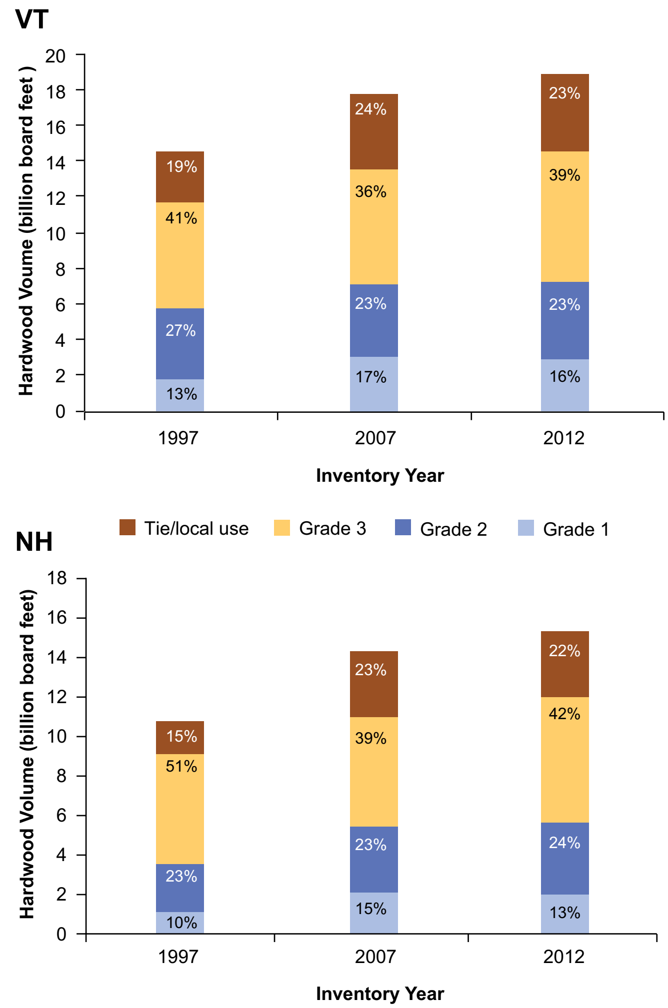


Figure 40.—Hardwood volume by inventory year and tree grade, Vermont and New Hampshire.

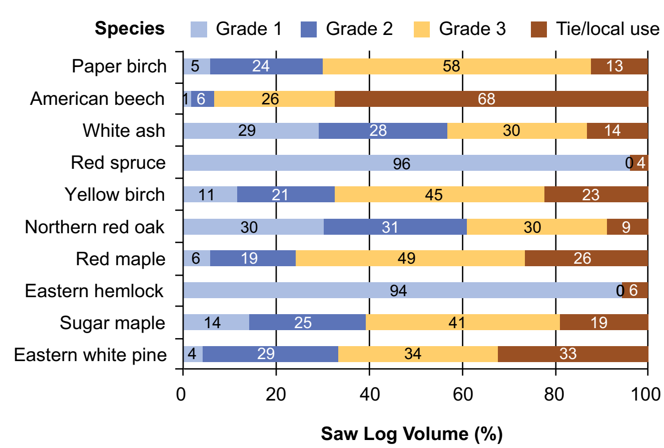


Figure 41.—Percentage of saw log volume on timberland by species and tree grade, Vermont and New Hampshire, 2012.

highest proportion of low-grade volume, and also shows the largest increase in saplings. Red maple, the species with the second highest proportion of low-grade volume, typically has more defects than other trees and is a relatively low value species.

Average Annual Net Growth and Removals

Background

Forests are a renewable resource if they are managed to provide a constant supply of useful products without impacting long-term productivity. The rate of growth is an indicator of the overall condition of a stand as well as forest health, successional stage, and tree vigor. Average annual net growth (gross growth minus mortality) is calculated by measuring trees at two points in time and determining the average annual change over the time period. Net growth is negative when mortality exceeds gross growth. A useful measure to assess growth is the percentage of annual net growth to current inventory volume. Average annual net growth estimates are based on the change in volume of growing stock on timberland between inventories. The terms average annual net growth and net growth are used interchangeably.

What we found

Vermont

Between 1983 and 2012, average annual net growth remained stable in Vermont (Fig. 42, VT). Net growth averaged 185 million cubic feet annually between 2007 and 2012, about 2 percent of growing-stock volume on timberland. In comparison to previous inventories, annual net growth to growing-stock volume increased from 2007 to 2012 (Fig. 43, VT). In 2012, about 64 percent of net annual growth was in hardwoods and 89 percent was on privately owned land.

The top nine species by growing-stock volume accounted for 85 percent of the average annual net growth of growing stock on timberland from 2007 to 2012. The growth-to-removals ratio averaged 1.9:1.0 which is a small increase from the 1.7:1.0 reported for 1997-2007. Variation between species was considerable. Net growth exceeded removals for nearly all major species except balsam fir (Fig. 44, VT). White ash, eastern hemlock, and northern red oak had the highest growth-to-removals ratios at 5.6:1.0, 5.5:1.0, and 5.0:1.0, respectively. The largest positive changes in growth-to-removals ratio between 2007 and 2012 were in white ash (2.5 to 5.6), northern red oak (2.8 to 5), and eastern hemlock (3.2 to 5.5). By contrast, changes in growth-to-removals ratio for eastern white pine (1.5 to 1.1) and balsam fir (1.1 to 0.8) were negative (Morin et al. 2011a).

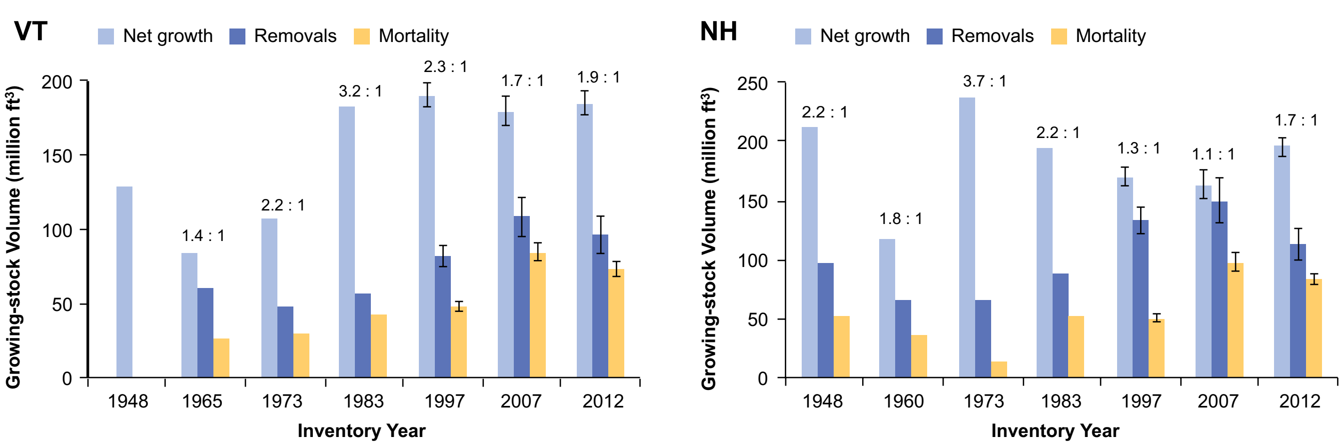


Figure 42.—Growing-stock volume and growth-to-removal ratio of growing stock on timberland by inventory year and growth category, Vermont and New Hampshire. Error bars represent a 68 percent confidence interval around the mean.

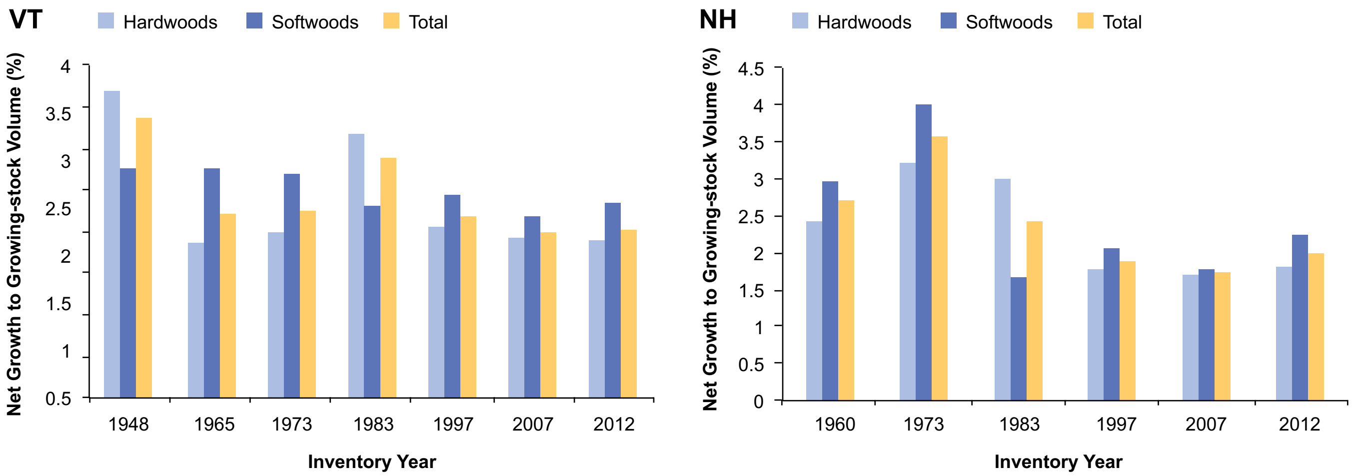


Figure 43.—Net growth of growing stock on timberland as a percent of growing-stock volume, by inventory year and forest type, Vermont and New Hampshire.

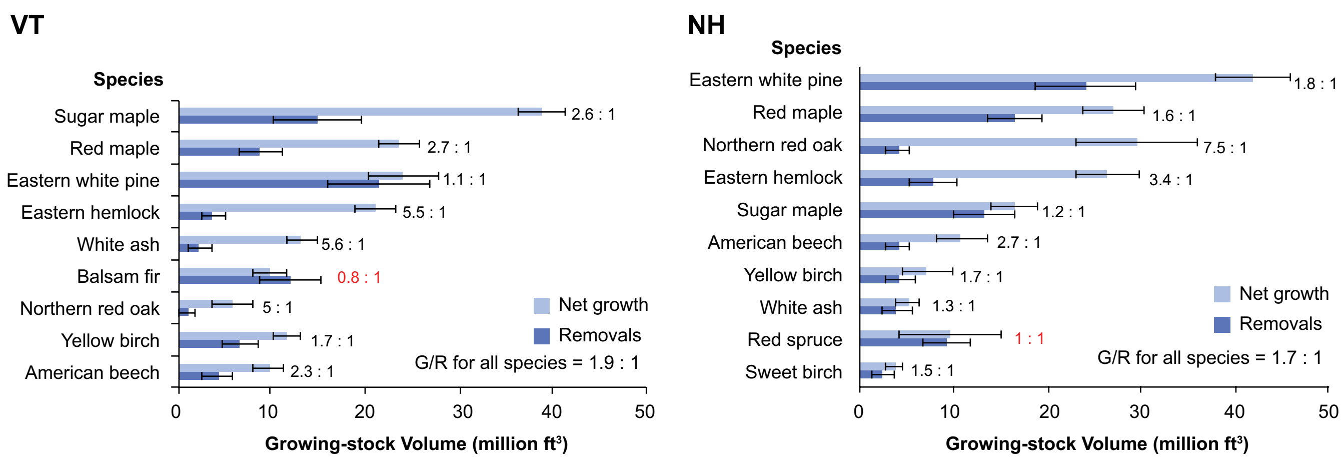


Figure 44.—Average annual net growth, removals, and growth-to-removals (G/R) ratio of growing-stock trees for major species on timberland, Vermont and New Hampshire, 2012. Error bars represent a 68 percent confidence interval around the mean.

New Hampshire

Between 1973 and 2007, average annual net growth steadily decreased in New Hampshire, but the 2012 estimate showed an increase back up to 1983 levels (Fig. 42, VT). Net growth averaged 195 million cubic feet annually between 2007 and 2012, about 2 percent of growing-stock volume on timberland. The 2012 proportion of annual net growth to growing-stock volume increased from 2007 (Fig. 43, NH). In 2012, about 52 percent of net annual growth was in hardwoods and 79 percent was on privately owned land.

The top 10 species by growing-stock volume accounted for 91 percent of the average annual net growth of growing stock on timberland from 2007 to 2012. The growth-to-removals ratio averaged 1.7:1.0 which is a substantial increase from the 1.1:1.0 reported for 1997-2007. Variation between species was considerable. Net growth exceeded removals for most major species, but red spruce removals equaled net growth (Fig. 44, NH). Northern red oak, eastern hemlock, and American beech had the highest growth-to-removals ratios at 7.5:1, 3.4:1, and 2.7:1.0, respectively. The largest positive changes in growth-to-removals ratio between 2007 and 2012 were in eastern white pine (0.8 to 1.8), northern red oak (2.4 to 7.5), eastern hemlock (1.2 to 3.4), and American beech (1 to 2.7). By contrast, sugar maple (2.3 to 1.2) and sweet birch (8.2 to 1.5) had large negative changes in growth-to-removals ratio (Morin et al. 2011b).

What this means

The well-stocked stands in the current forests of Vermont and New Hampshire developed as a result of the growth-to-removal ratios being well above 1.0:1.0 for most of the second half of the 20th century. More recently, the forests of Vermont and New Hampshire have matured and the rate of growth has slowed. At the current rates of growth, mortality, and removals, the forests of Vermont and New Hampshire are increasing in volume at a rate of roughly 2 percent per year. This rate is higher on private lands, most likely due to a larger proportion of public lands being located on high elevation, low productivity sites. Fortunately, more than 90 percent of the removals volume is due to harvesting and not land use change. Trees should regenerate as long as the land is not developed.

A comparison of the growth-to-removals ratios of individual species to the average for all species is an indicator of sustainable harvesting. The low growth-to-removals ratios of eastern white pine (0.8:1.0), red spruce (1.0:1.0), and balsam fir (0.7:1.0) suggest that these species could be decreasing in abundance. This is especially true for eastern white pine in New Hampshire which also had low numbers of saplings present in the State and a trend of decreasing numbers as evidenced by the last two inventories. By contrast, balsam fir is among the species with the highest number of saplings in both States and appears to be increasing in numbers in New Hampshire. Red spruce sapling numbers are increasing in both States.

Average Annual Mortality

Background

Mortality is a natural part of stand development in healthy forest ecosystems. Many factors contribute to mortality, including competition, succession, insects, disease, fire, human activity, and drought. Mortality is often initiated by one causal agent (inciting factor) that is followed by other contributing stress factors, making it difficult to identify the underlying cause. Although mortality is a natural event in a functional forest ecosystem, dramatic increases in mortality can be an indication of forest health problems. Average annual growing-stock mortality estimates represent the average cubic-foot volume of sound wood that dies each year between inventories. Biotic and abiotic disturbances can stress forests either as inciting factors or as contributors to mortality. The National Insect and Disease Forest Risk Assessment provides detailed maps of areas where elevated mortality is expected over the next 15 years (Krist et al. 2014).

What we found

The estimated average annual mortality rates for growing-stock trees in Vermont and New Hampshire for 2012 were 73 million cubic feet and 83 million cubic feet, respectively, which is approximately 0.8 percent of growing-stock volume. While these are some of the highest mortality rates recorded in FIA inventories of Vermont and New Hampshire, both estimates are decreases in the rates reported for 2007. In most inventory periods, softwoods have a higher mortality rate than hardwoods, but in 2012 the hardwood mortality is higher in both States (Fig. 45). The mortality rates are similar to other states in the region including 1.0 percent in Maine (McCaskill et al. 2011) and 0.9 percent in New York (Widmann et al. 2012). The rate of mortality remained stable between 2007 and 2012 for nearly all diameter classes, with the highest mortality rates generally found in the smaller diameter classes (Fig. 46).

Mortality increased across nearly all species between 1997 and 2007 in both States, but the increases were generally not statistically significant. However, between 2007 and 2012 mortality decreased back to 1997 levels for some species including: red spruce in both States, sugar maple in Vermont, and balsam fir in New Hampshire (Fig. 47). Mortality rates for white ash increased substantially in Vermont (Fig. 47, VT), and red maple and eastern white pine mortality rates increased further in New Hampshire (Fig. 47, NH). Most of

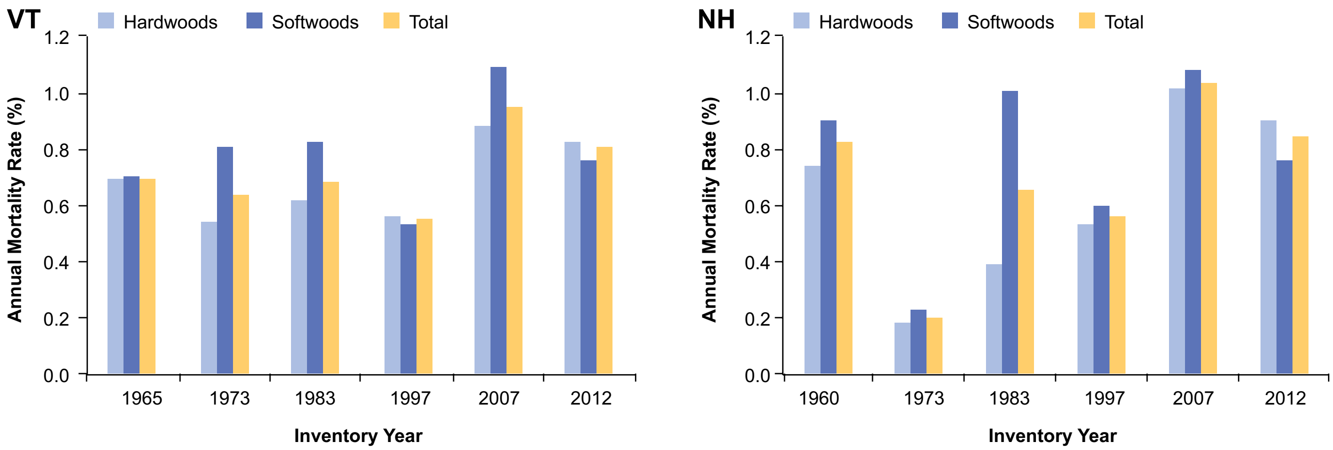


Figure 45.—Mortality of growing stock on timberland as a percent of growing-stock volume by inventory year and forest type, Vermont and New Hampshire.

the abundant species in Vermont and New Hampshire have relatively low mortality rates that are below the 0.8 percent annual average for all tree species combined. By contrast, balsam fir, paper birch, American beech, and quaking aspen have mortality rates that are more than double the statewide averages in both States (Figs. 48).

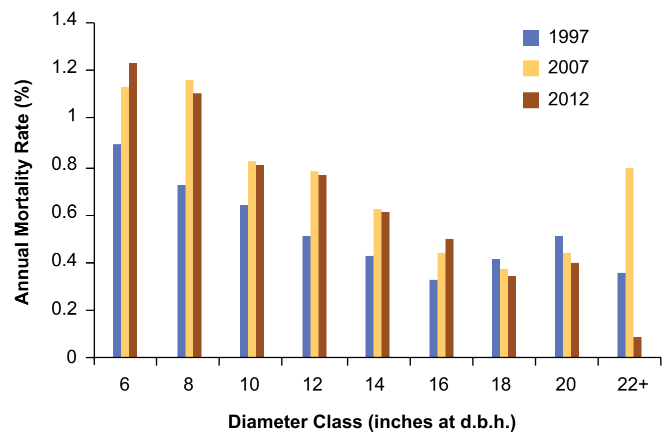


Figure 46.—Average annual mortality rate of growing-stock volume on timberland by diameter class and inventory year, Vermont and New Hampshire combined.

What this means

Tree mortality rates in Vermont and New Hampshire are comparable to those in surrounding states. Some of the mortality can be explained by stand dynamics (e.g., competition and succession) and the impacts of insects and diseases that affect specific species (e.g., beech bark

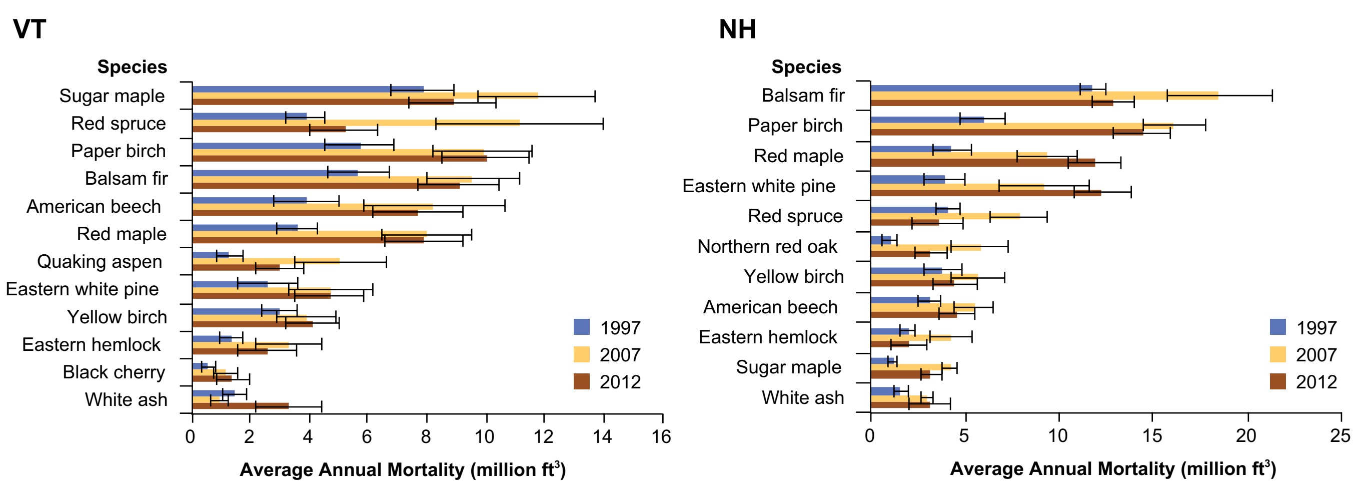


Figure 47.—Average annual mortality of growing stock on timberland for major species by inventory year, Vermont and New Hampshire. Error bars represent a 68 percent confidence interval around the mean.

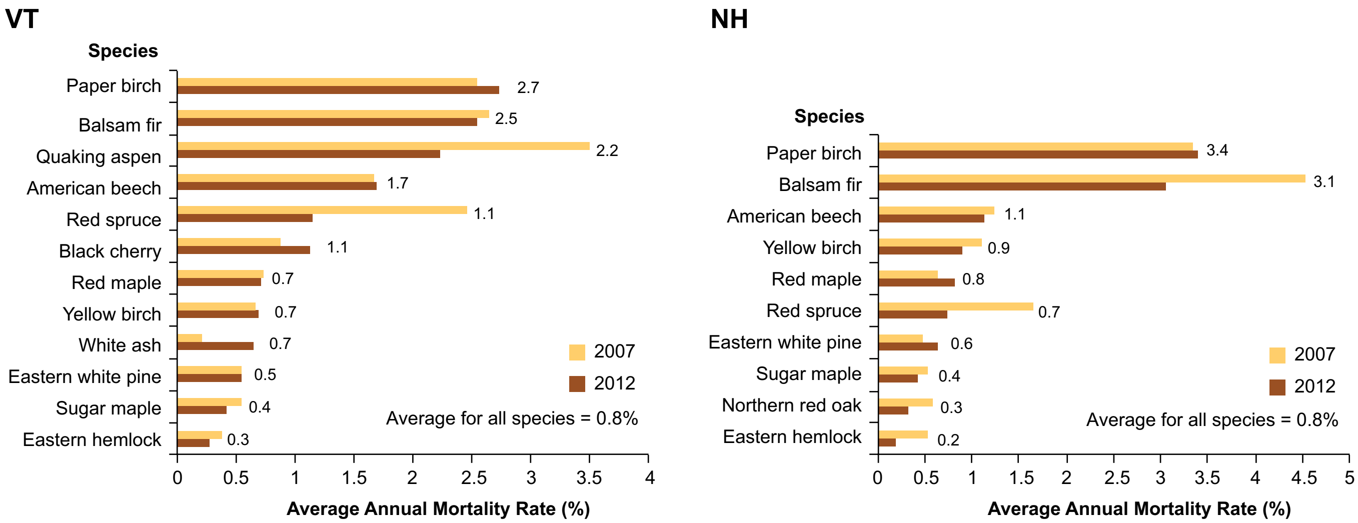


Figure 48.—Average annual mortality rate for major species by inventory year, Vermont and New Hampshire. Average for all species = 0.8%.

disease on American beech). In the normal maturation process, some trees lose vigor and eventually die from being outcompeted or succumb to insect and disease during their weakened state; this is especially apparent in trees with a d.b.h. of 12 inches or less.

Most species in Vermont and New Hampshire have low mortality rates, but some have elevated rates. Species such as balsam fir and paper birch have increased the overall mortality rates. American beech has been heavily impacted by beech bark disease for many decades. Weather-related events that significantly affected tree health during this time period include the after effects of the 1998 ice storm and droughts during 1999 and 2001. Recovery from the ice storm was particularly poor for beech and paper birch trees. Drought effects were especially significant for species with shallow root systems such as birch and beech, or for species likely growing on sites with shallow soils such as balsam fir and red spruce. Additional health problems were observed from forest tent caterpillar defoliation, spruce winter injury, and balsam woolly adelgid. Recovery following stress events is often dependent on soil fertility; trees growing on calcium rich sites are more likely to recover (Schaberg et al. 2006, Shortle and Smith 1988).

Species Composition

Background

The species composition of a forest is the result of the interaction over time of multiple factors including climate, soils, disturbance, and competition among trees species. Causes of forest disturbance in Vermont and New Hampshire include ice storms, logging, droughts, insects and diseases, and land clearing followed by abandonment. The species composition of the growing-stock volume and large diameter trees represents today's forest, while the species composition of the smaller diameter classes represents the potential future forest. Comparisons of species composition by diameter class can provide insights into potential changes in overstory species composition.

What we found

In Vermont, beech is the most numerous sapling (1 to 4.9 inches d.b.h.), accounting for 17 percent of all saplings followed by sugar maple at 12 percent (Fig. 49, VT). Noncommercial tree species combined also represent a large portion of saplings (16 percent) which is a 3 percent decrease since the 2007 inventory (Morin et al. 2011a). Striped maple is the most numerous of the noncommercial species followed by pin cherry and eastern hophornbeam. Sugar maple is the dominant species in all diameter classes of 6 inches d.b.h. and larger. Eastern white pine is poorly represented in the sapling classes (less than 1 percent), although it makes up a large portion of trees larger than 20 inches d.b.h. (Fig. 50, VT). Other species that have a lower representation in the sapling classes compared to the larger diameter classes include eastern hemlock, red maple, and sugar maple. In addition to American beech, balsam fir and red spruce make up a higher portion of total saplings relative to their share of larger trees (Fig. 49, VT).

In New Hampshire, balsam fir is the most numerous sapling accounting for 22 percent of all saplings, followed by noncommercial hardwoods and American beech at 12 percent each (Fig. 49, NH). The proportion of noncommercial hardwoods saplings increased 3 percent since the 2007 inventory (Morin et al.

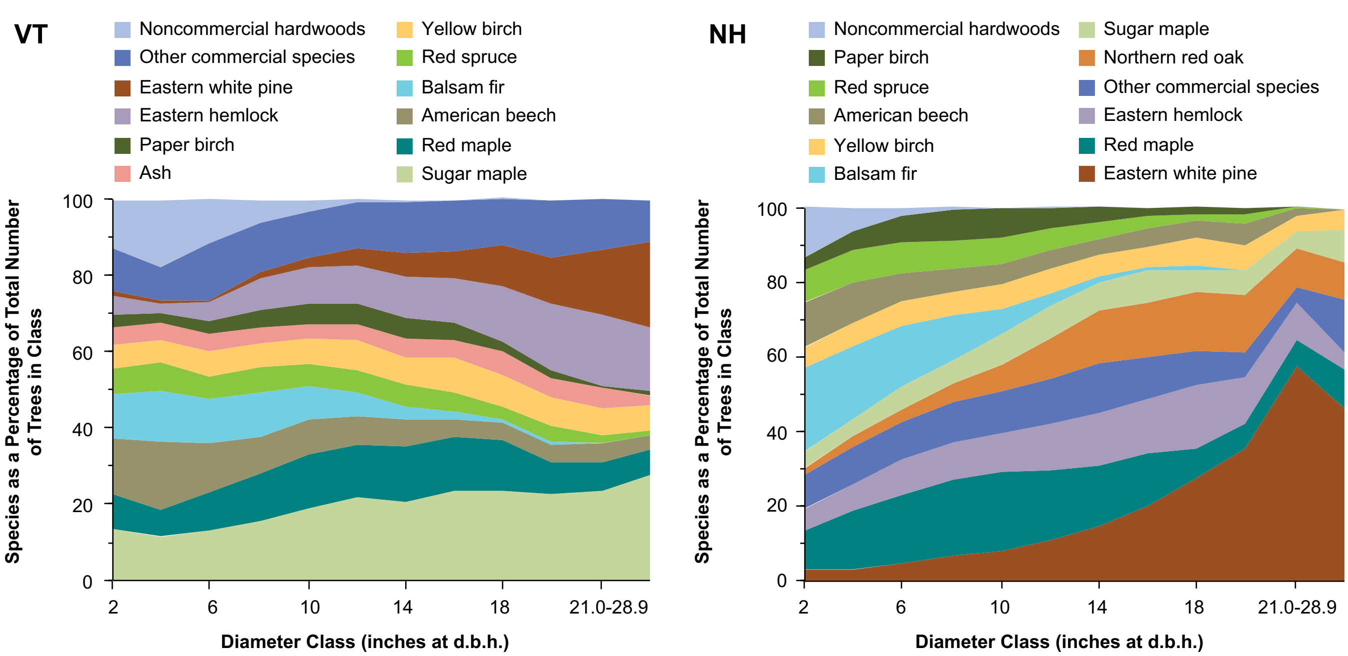


Figure 49.—Species composition by diameter class on forest land, Vermont and New Hampshire, 2012.

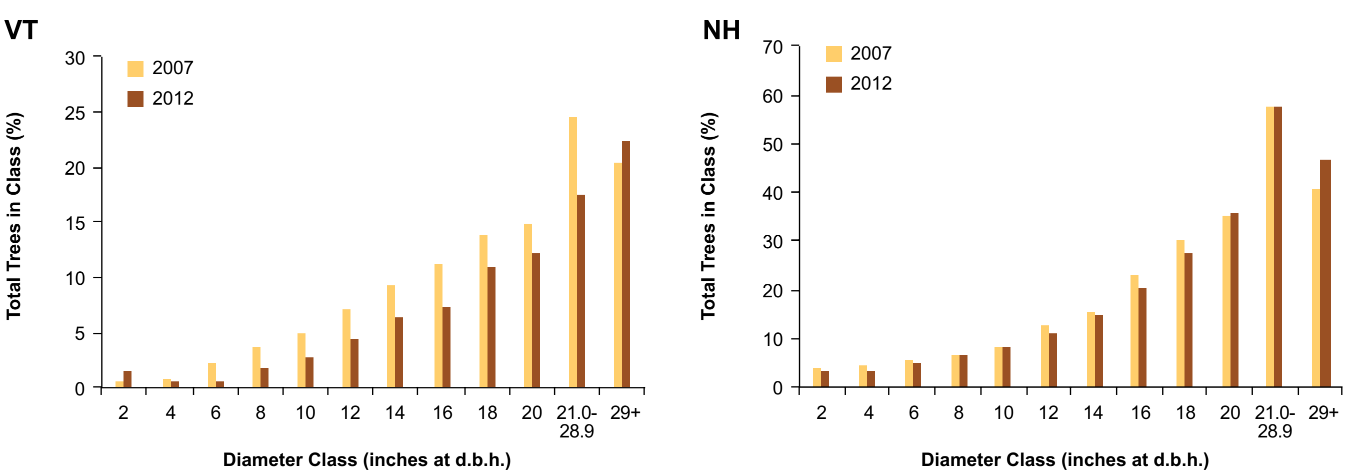


Figure 50.—Percentage of the total number of trees on forest land that are white pine by diameter class and inventory year, Vermont and New Hampshire.

2011b). Striped maple is the most numerous of the noncommercial species. Eastern white pine is the dominant species within the diameter classes with a d.b.h. greater than 16 inches, but it is poorly represented in the sapling classes (Fig. 50, NH). Other species with a lower representation in the sapling classes compared to the larger diameter classes include eastern hemlock, northern red oak, sugar maple, and paper birch. By contrast, American beech and balsam fir make up a higher portion of total saplings relative to their share of larger trees (Fig. 49, NH).

What this means

Conditions in the understory of older forests favor the reproduction of shade tolerant species as shown by the higher proportion of American beech, balsam fir, and red spruce in the sapling diameter classes compared to the larger diameter classes. However, sugar maple is a shade tolerant species that is noticeably absent from this list. Besides being shade tolerant, the large number of sapling-size American beech trees are likely the result of root sprouts following harvesting and beech bark disease. Many of these young beech trees will eventually succumb to the disease before they have the opportunity to grow into the overstory, meanwhile occupying valuable growing space and inhibiting the regeneration and growth of other more valuable species. By contrast, eastern hemlock, another shade tolerant species, makes up a lower percentage of tree numbers in the sapling diameter classes when compared to the larger diameter trees. This indicates that hemlock is not regenerating as well as it would be expected to do in the maturing forests of Vermont and New Hampshire. Noncommercial species provide habitat diversity in the understory, although they can interfere with the reproduction of commercial species if they become too numerous. Striped maple now makes up 7 percent of trees in the 2-inch diameter class. Similarly, the increase in beech regeneration may be interfering with desirable species such as sugar maple (Hane 2003). Land managers should be aware of the potential for these species to cause problems in forest regeneration.

Eastern white pine is well represented in the large diameter classes, ranking second statewide in sawtimber volume in Vermont (Fig. 39, VT) and first in New Hampshire (Fig. 39, NH). However, it continues to decrease in numbers in all but the largest diameter classes (Fig. 50), so it will probably be replaced by other species as the larger eastern white pine trees die or are harvested. Red maple and balsam fir represent large proportions of trees in diameter classes from 4 to 14 inches. Those two species are positioned to increase in dominance in forests of Vermont and New Hampshire in future decades. Trends in volume show that since the 1960s, eastern hemlock and northern red oak have increased in the proportion of total volume they represent in Vermont and New Hampshire, but increases in those species will likely slow and reverse because they are not as well represented in the sapling-size class as they are in larger trees. If the current species composition remains constant as saplings mature, these data foretell a future forest overstory with more red maple and balsam fir trees and less eastern white pine, eastern hemlock, sugar maple, and northern red oak than today. Silvicultural efforts will need to be made to regenerate some species, particularly eastern white pine and eastern hemlock. Long-term changes in forest composition will alter wildlife habitats and affect the value of the forest for timber products. Close examination of species composition changes in the future will be necessary due to the potential impacts of climate change on individual species.

Ecosystem Indicators and Services

Red pine logs cut as part of a timber salvage operation in a stand infested with red pine scale, Bear Brook State Forest, New Hampshire. Photo by New Hampshire Division of Forests and Lands, used with permission.

Tree Crown Conditions

Background

The crown condition of trees is influenced by various biotic and abiotic stressors. Biotic stressors include native or introduced insects, diseases, invasive plant species, and animals. Abiotic stressors include drought, flooding, cold temperatures or freeze injury, nutrient deficiencies, the physical properties of soils that affect moisture and aeration, and toxic pollutants.

Seasonal or prolonged drought periods have long been a significant and historical stressor in Vermont and New Hampshire. Over the past 20 years, droughts occurred in some regions during 1995, 1999, and 2001; alternatively, some of the wettest years on record were 2006 and 2008 (Fig. 51) (NCDC 2014). These extreme precipitation events can produce conditions that facilitate insect and disease outbreaks and can be even more devastating to trees that are already stressed by pest damage or other agents.

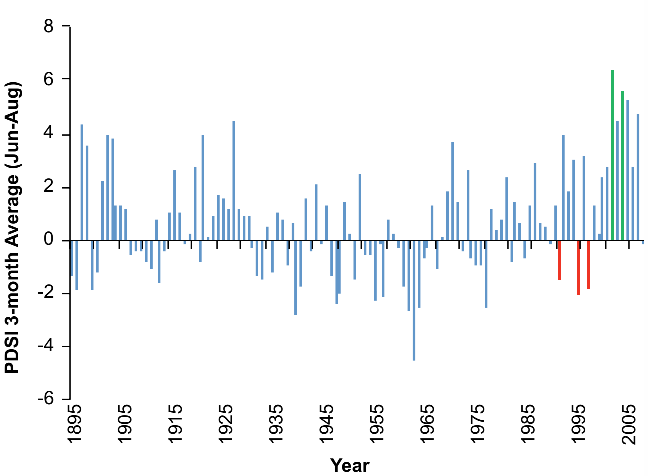


Figure 51.—Palmer Drought Severity Index 3-month average (June-August), Vermont and New Hampshire combined, 1895-2013. Drought years (red) and the wettest years (green) over the past 20 years are highlighted.

Tree-level crown dieback is collected on P2+ plots. Crown dieback, defined as recent mortality of branches with fine twigs, reflects the severity of recent stresses on a tree. A crown is labeled as poor if crown dieback is greater than 20 percent. This threshold is based on findings by Steinman (2000) that associates crown ratings with tree mortality. Additionally, crown dieback has been shown to be highly correlated with tree survival (Morin et al. 2012).

What we found

The incidence of poor crown condition is concentrated in southern Vermont and New Hampshire (Fig. 52). The species with the highest proportion of live basal area containing poor crowns is American beech at 3 percent. Conversely, other species have very low occurrence of poor crowns (Table 2). Additionally, since 2007 the proportion of basal area with poor crowns has dropped for all species except white ash and eastern white pine (Table 2).

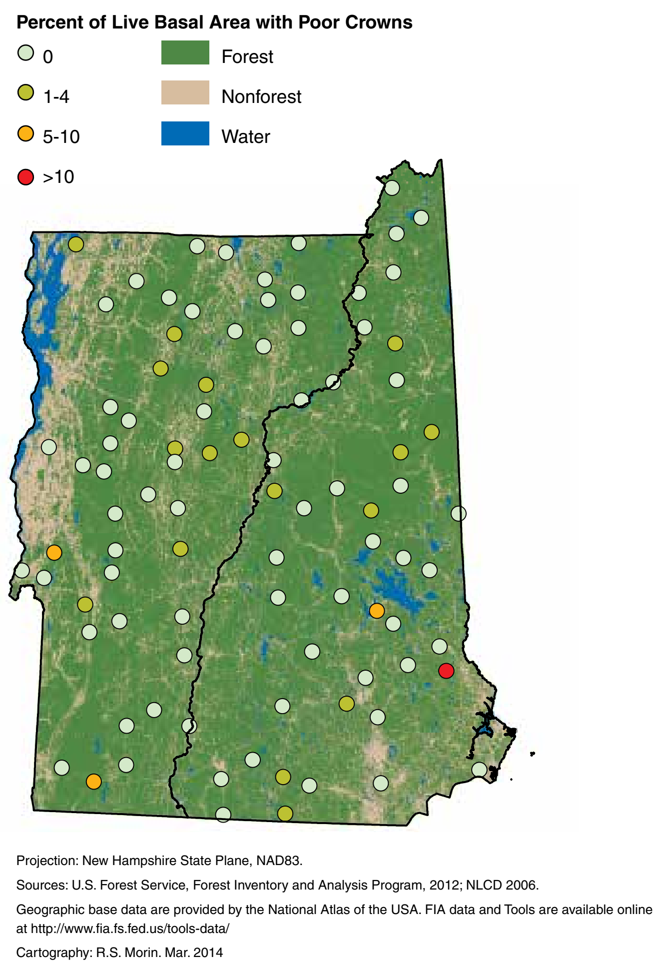


Figure 52.—Percentage of live basal area on FIA plots with poor crowns, Vermont and New Hampshire, 2012. Depicted plot locations are approximate.

Table 2.—Percentage of live basal area with poor crowns, Vermont and New Hampshire, 2007 and 2012

	Poor Crowns (%)	
Species	**2007**	**2012**
American beech	10.5	3.0
White ash	1.2	2.4
Eastern hemlock	2.4	1.8
Paper birch	2.5	1.2
Balsam fir	2.0	1.0
Red maple	2.6	1.0
Eastern white pine	0.0	0.9
Red spruce	3.5	0.6
Sugar maple	2.5	0.0
Yellow birch	1.1	0.0
Northern red oak	0.0	0.0

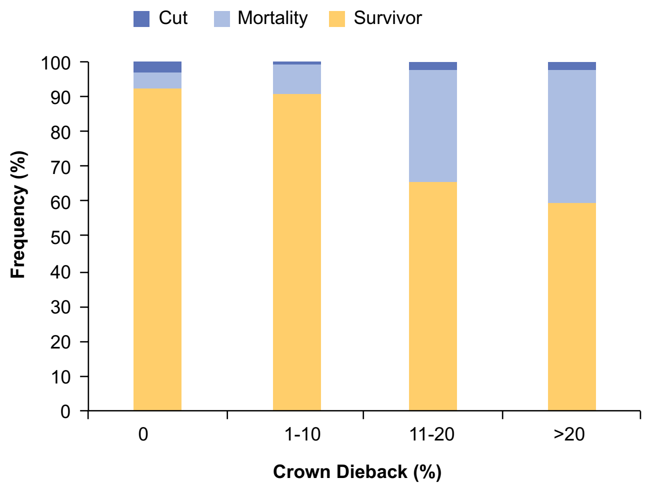


Figure 53.—Crown dieback distribution by tree survivorship for remeasured trees, Vermont and New Hampshire combined, 2007 to 2012.

Average crown dieback ranged from 1 percent for balsam fir to 5.4 for paper birch (Table 3) and did not vary substantially over time for any species. Figure 53 shows the proportion of remeasured trees that survived, died, or were cut by crown dieback classes based on the health of the crowns at the previous measurement. The proportion of the trees that die increases with increasing crown dieback. More than 38 percent of trees with crown dieback above 20 percent during the 2007 inventory were dead when visited again during the 2012 inventory.

Table 3.—Mean crown dieback and other statistics for live trees (>5 inches d.b.h.) on forest land by species, Vermont and New Hampshire, 2012

Species	Trees	Mean	SE	Min.	Median	Max.
	-number-	------------------------%------------------------				
Paper birch	140	5.4	0.8	0	5	90
White ash	121	4.5	1.0	0	0	99
Red maple	424	3.5	0.4	0	0	99
American beech	233	3.3	0.4	0	0	50
Northern red oak	111	2.7	0.3	0	5	10
Sugar maple	413	2.1	0.2	0	0	20
Yellow birch	180	1.9	0.2	0	0	10
Eastern white pine	192	1.6	0.6	0	0	90
Red spruce	147	1.4	0.3	0	0	30
Eastern hemlock	262	1.3	0.4	0	0	80
Balsam fir	179	1.0	0.2	0	0	25

What this means

American beech is a common tree species in Vermont and New Hampshire and contains a substantial volume of wood. It is an important species due to its value to wildlife and as a pulp and firewood species. American beech mortality increased substantially between the 1997 and 2007 inventories. The increase in mortality and occurrence of poor crowns is likely related to the impacts of beech bark disease (see Beech Bark Disease on page 58).

Ash is a minor component in most forests across Vermont and New Hampshire but is important for biodiversity due to its value as a food source for many insect, bird, and small mammal species. Although the mortality rate of white ash did increase in Vermont between 2007 and 2012, the rate is still low. In New Hampshire, the crowns of ash trees are generally healthier in the northern half of the State which may reflect the impact of ash yellows in the southern half (Morin and Lombard 2013). An additional concern for the health of ash trees in New Hampshire is the emerald ash borer which was discovered in Concord, NH, in March 2013 (see Emerald Ash Borer on page 59).

Tree Damage

Background

Tree damage is assessed for all trees with a d.b.h. of 5.0 inches or greater. Up to two of the following types of damage can be recorded: insect damage, cankers, decay, fire, animal damage, weather, and logging damage. If more than two types of damage are observed, decisions about which two are recorded are based on the relative abundance of the damaging agents.[3]

What we found

Damage was recorded on approximately 25 percent of the trees in Vermont and New Hampshire, but there was considerable variation between species (Table 4). The most frequent damage recorded for all species was decay (present in 10 percent of trees), ranging from less than 3 percent on conifer species up to 20 percent on red maple. Notably, cankers were present on 68 percent of American beech trees, 55 percent of white pine trees suffered branch or shoot damage from insects, and 10 percent of sugar maple trees showed signs of damage from bole borers. The high incidence of white pine damage is due to the accumulation of deformed stems caused by the native white pine weevil, *Pissodes strobi* (Peck), which typically causes stem deformities (Fig. 54). The occurrence of all other injury types was very low.

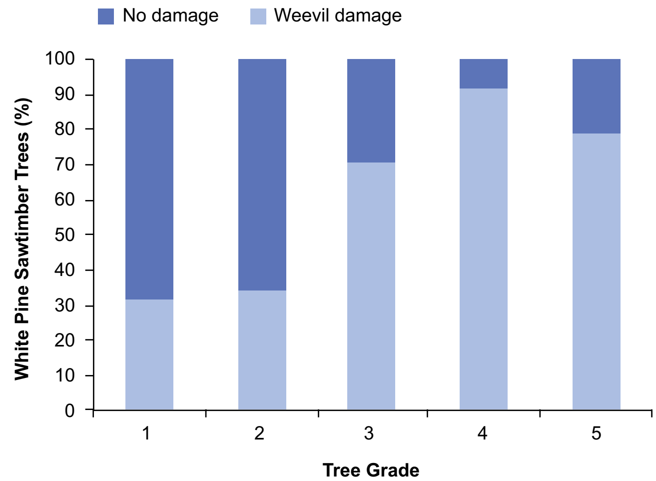


Figure 54.—Percentage of white pine sawtimber trees with and without pine weevil damage by tree grade, Vermont and New Hampshire combined, 2012.

What This Means

Decay is the most commonly observed damage, which is not unusual given that mature trees dominate the majority of Vermont and New Hampshire forests. The high frequency of cankers on American beech is due to the long history of beech bark disease (BBD) in the region (see Beech Bark Disease on page 58). Although the incidence of weevil damage on white pine is quite common, it does not typically kill trees, but the form and quality of saw logs is impacted as evidenced by the high proportion of damaged trees that fall into tree grades 3 and below. Finally, the native sugar maple borer, *Glycobius speciosus* (Say), is a common pest

Table 4.—Percentage of trees with damage by species, Vermont and New Hampshire, 2012

Damage Type	All	American beech	Eastern white pine	Sugar Maple	Red Maple	Yellow birch	Paper birch	White ash	Northern red oak	Balsam fir	Eastern hemlock	Red spruce
		%										
None	74	20	40	67	72	77	79	86	92	93	94	97
Insect damage	5	0	55	10	0	0	0	0	0	0	0	0
Cankers	6	68	0	3	1	2	1	0	0	0	0	0
Decay	10	10	2	15	20	15	8	8	5	3	2	1
Fire	0	0	0	0	0	0	0	0	0	0	0	0
Animal	1	0	0	0	2	0	0	0	0	1	1	0
Weather	3	1	2	3	4	4	11	4	2	3	1	1
Logging/human	1	1	1	3	1	2	1	2	1	1	1	1

[3] U.S. Forest Service. 2010. Forest inventory and analysis national core field guide: field data collection procedures for phase 2 plots, version 5.0. Unpublished information on file at http://www.fia.fs.fed.us/library/field-guides-methods-proc/.

of sugar maple that is the likely cause of bole borer damage. Infestations can lead to lumber defect caused by discoloration, decay, and larval galleries and may make trees more susceptible to breakage during storms.

Down Woody Materials

Background

Down woody materials in the various forms of fallen trees, shed branches, and logging slash fulfill a critical ecological niche in forests of Vermont and New Hampshire. Down woody materials provide valuable wildlife habitat, stand structural diversity, and replenishment of soil organic matter and fertility. However, they may also contribute toward forest fire hazards via woody fuels on the forest floor.

What we found

The total carbon stored in down woody materials (fine and coarse woody debris and residue piles) on forest lands within Vermont and New Hampshire exceeds 17 million tons and 14 million tons, respectively. The distribution of carbon generally increases with stand-age class (Fig. 55). The down woody carbon stocks are dominated by coarse woody debris (Fig. 56), with approximately 8 million tons in Vermont and 12 million tons in New Hampshire. Due to the relatively sparse sampling intensity, no residue piles were detected. Per acre volume of coarse woody debris was higher in the private ownership category in Vermont. By contrast, New Hampshire forests had slightly higher average coarse woody debris density on public ownerships (Fig. 57).

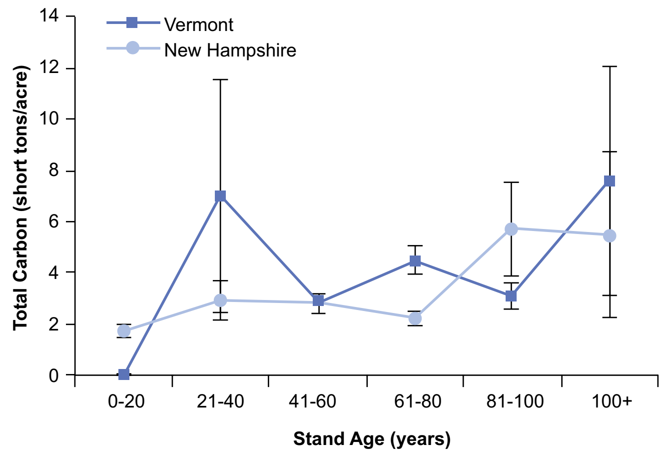


Figure 55.—Carbon per acre in down woody materials (fine and coarse woody debris and piles) by stand-age class on forest land, Vermont and New Hampshire, 2006-2010. Error bars represent a 68 percent confidence interval around the mean.

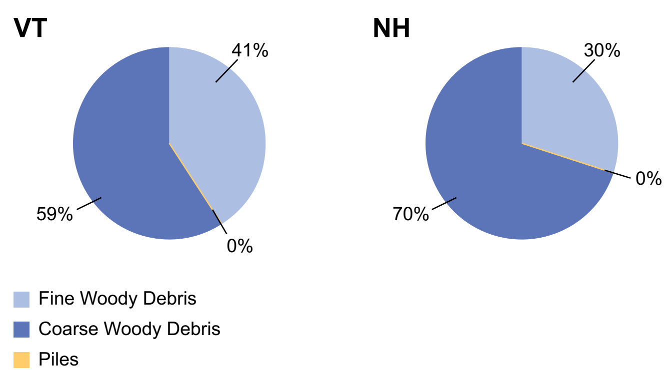


Figure 56.—Proportion of total carbon stocks by down woody material component, Vermont and New Hampshire, 2006-2010.

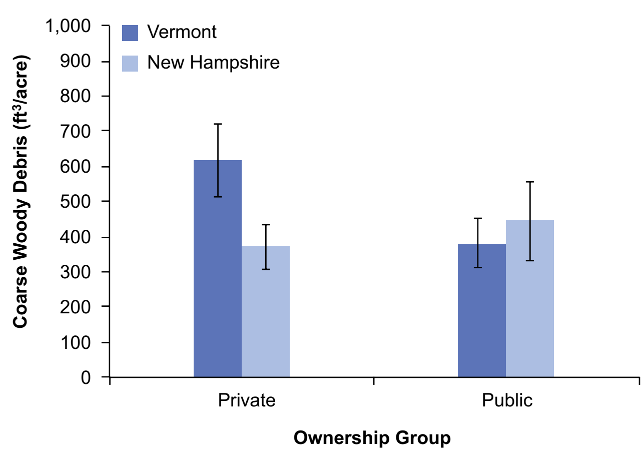


Figure 57.—Total volume per acre of coarse woody debris by ownership group, Vermont and New Hampshire, 2006-2010. Error bars represent a 68 percent confidence interval around the mean.

What this means

Although the carbon stocks of down woody materials are relatively small compared to those of soils and standing live biomass across these States, it is still a critical component of the carbon cycle as a transitory stage between live biomass and other detrital pools such as the litter. The proportions of coarse woody debris, the major contributor to replenishment of organic matter, and fine woody debris, the major contributor to replenishment of nutrients, were as expected based on the relatively high biomass of boles compared to twigs. Compared to other states where harvesting in forests is more prevalent (Woodall et al. 2013), there were no residue piles sampled in this forest inventory of Vermont and New Hampshire. Given that the vast majority of forest ownership is on private lands, it is the management of private forests in these States that may affect the future of down woody material contributions to statewide forest carbon stocks and wildlife habitat (i.e., stand structure). Overall, because fuel loadings are estimated to be quite low across Vermont and New Hampshire, the possible fire dangers associated with down woody materials may be outweighed by the numerous ecosystem services provided by them. Given the moist temperate forests across Vermont and New Hampshire, only in times of drought would down woody materials be considered a fire hazard.

Forest Habitats

Forests, woodlands, and savannas provide habitats for many species across Vermont and New Hampshire including birds (146 species), mammals (47 species), and amphibians and reptiles (25 species) (NatureServe, N.d.). At a landscape-level (coarse-filter scale of conservation), different forest types at different structural stages provide natural communities (habitats). Rare, imperiled, or wide-ranging wildlife species may not be fully served by the habitat features at this scale, so a fine filter approach is used to identify species-specific conservation needs. Representing an intermediate or meso-filter scale of conservation are specific habitat features (e.g., snags, riparian forest strips) which may serve particular habitat requirements for multiple species. This report characterizes habitats at the coarse-filter scale (forest age/size) and meso-filter scale (standing dead trees).

Vermont and New Hampshire have developed State Wildlife Action Plans (SWAPs). The "Vermont Comprehensive Wildlife Conservation Strategy" (Kart et al. 2005) identifies species of greatest conservation need (SGCN) and threats to their habitats. Similarly, the "New Hampshire Wildlife Action Plan" (New Hampshire Fish and Game Department 2005) identifies SGCN and focal habitats. These SGCN lists contain fewer species that are dependent upon mid-successional forests and more that require early or late successional forest habitats. Therefore, the condition and trends in the forest age and stand size attributes is important to assess. One of the fine scale conservation issues associated with forest habitats is the presence and abundance of snags and nest cavities, so the quantity and distribution of standing dead trees is analyzed.

Forest Age and Stand Size

Background

Some species of wildlife depend upon early successional forests that contain smaller, younger trees, while other species require older, interior forests containing large trees with complex canopy structure. Yet other species inhabit the ecotone (edge) between different forest stages, and many require multiple structural stages of forests to meet different phases of their life history needs. Abundance and trends in these structural and successional stages serve as indicators of population carrying capacity for wildlife species (Hunter et al. 2001). Historical trends in forest habitats are reported for timberland, which makes up more than 96 percent of all forest land in both Vermont and New Hampshire. Estimates for current habitat conditions are reported for all forest land.

What we found

Timberland area in the large diameter stand-size class has increased steadily in Vermont and New Hampshire since 1948 (Fig. 58). Since 1983, timberland area under 20 years of age has decreased precipitously (Fig. 59). Timberland area in the 21-40 year class increased moderately, while area in 41-100 year classes increased considerably. Timberland older than 100 years was very rare in the mid-1980s and late 1990s but is increasing notably in recent years (Figs. 59).

In Vermont, timberland area in the medium diameter stand-size class has seen a moderate decrease. By contrast, timberland area in the small diameter stand-size class quadrupled in area between 1948 and 1973, then decreased just as dramatically through the current inventory period (Fig. 58, VT).

In New Hampshire, timberland area in the medium diameter stand-size class saw a moderate increase, followed by a similar decrease. Timberland area in the small diameter stand-size class also decreased through the

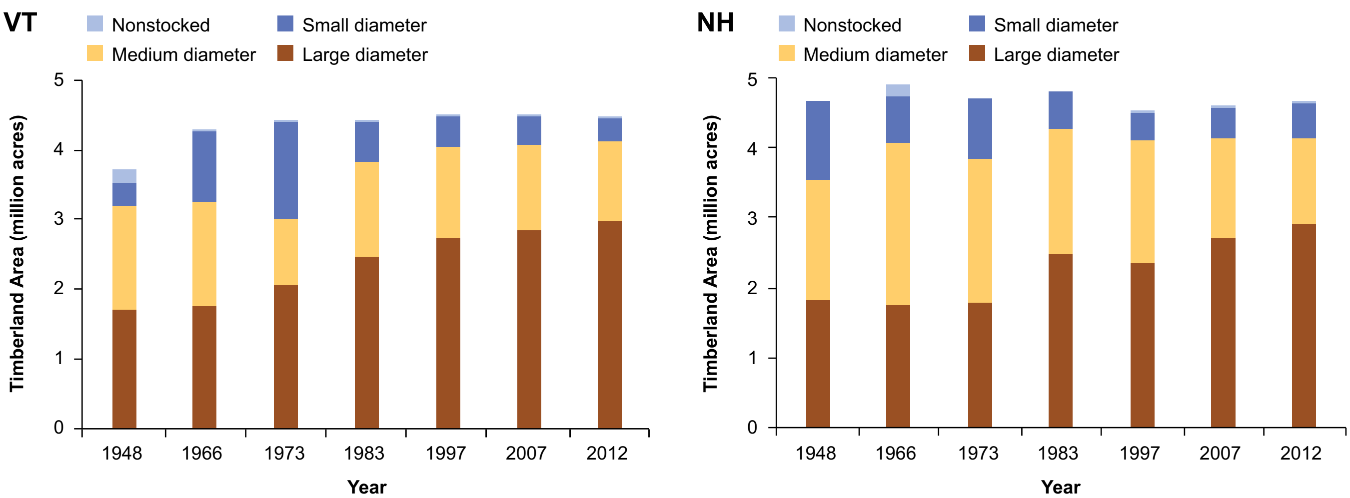


Figure 58.—Area of timberland by inventory year and stand-size class, Vermont and New Hampshire.

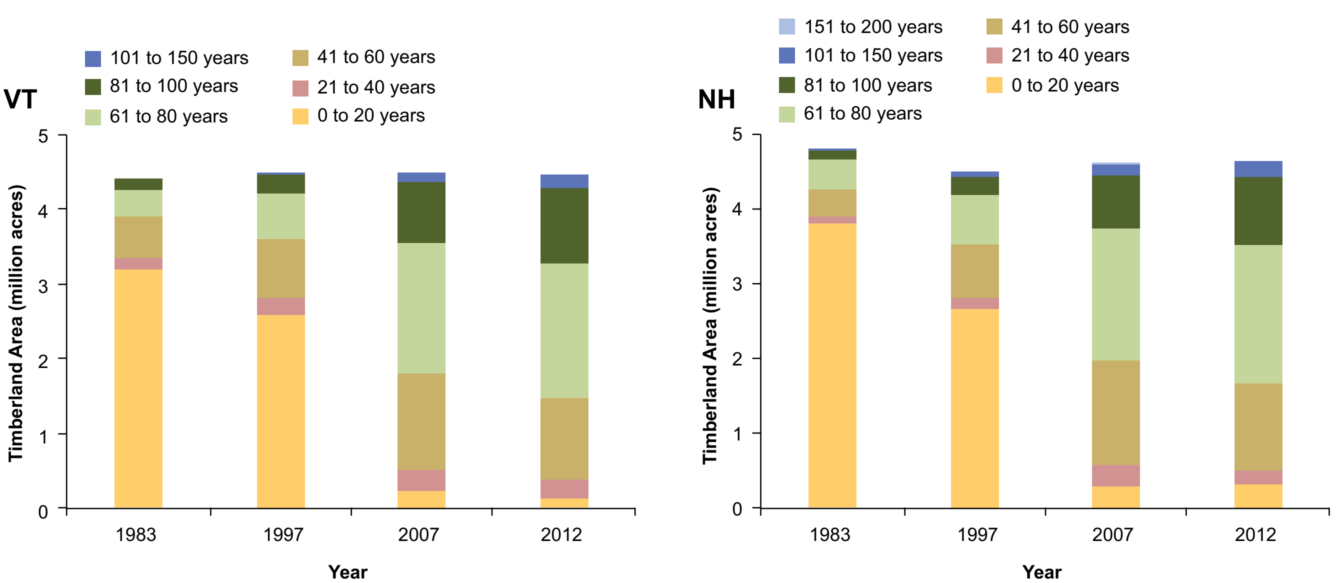
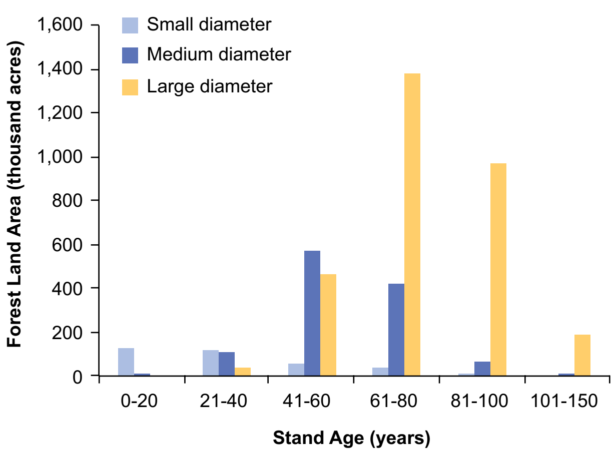


Figure 59.—Area of timberland by inventory year and stand-age class, Vermont and New Hampshire.

late 1990s but appears to be increasing slightly during the past decade (Fig. 58, NH).

In both States, all three stand-size classes are found in forests of multiple ages. The medium diameter stand-size class is predominately found in stands that are 41-80 years of age and has a lower abundance of both young and old forest. As expected, small diameter timberland comprises mostly young forests (0-40 years). Although timberland in the large diameter stand-size class is dominated by stands aged 61-100, forests with a stand age above 100 years are relatively rare (Fig. 60).

VT



NH

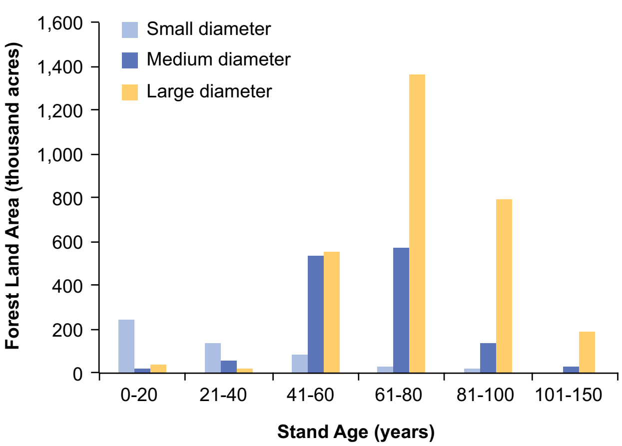


Figure 60.—Area of forest land by stand age and size class, Vermont and New Hampshire, 2012.

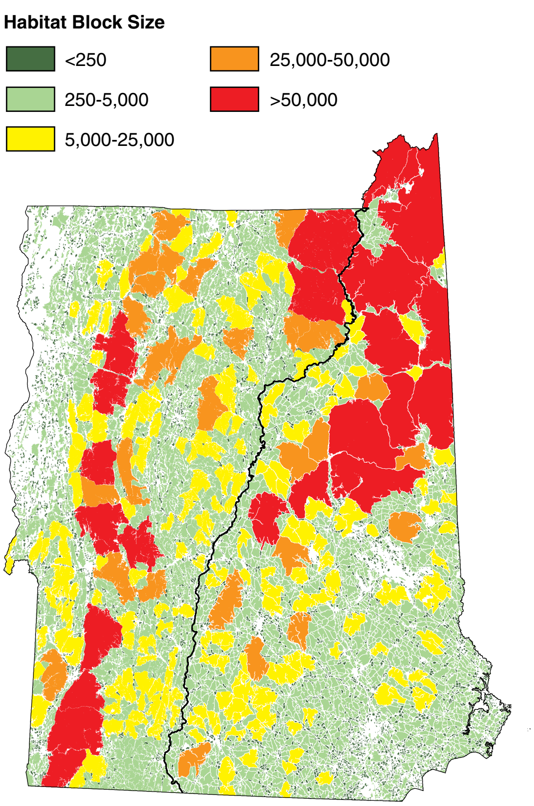
What this means

Both stand-size class and stand-age class are indicators of forest structure and successional stage. Although the amount of timberland in the large diameter stand-size class has increased markedly over the past six decades, timberland over 100 years of age has increased only in recent decades and comprises less than 5 percent of all timberland in Vermont and less than 4 percent in New Hampshire. Area of timberland in the small diameter stand-size class is nearly identical in abundance to the late 1940s for Vermont, but only half as abundant as historical estimates for New Hampshire. Such mixtures of multiple age-class and multiple size-class trees provide a vertical diversity of vegetation structure that can enhance habitat conditions for some species. Though seemingly contradictory, there is a need to maintain forest conditions in both smaller and larger structural stages to maintain both early and late successional habitats for all forest-associated wildlife species. For example, ruffed grouse (*Bonasa umbellus*), chestnut-sided warbler (*Setophaga pensylvanica*), and snowshoe hare (*Lepus americanus*) depend on early successional habitat or dense regeneration, and American marten (*Martes americana*), fisher (*Martes pennanti*), northern goshawk (*Accipter gentilis*), and pileated woodpecker (*Dryocopus pileatus*) are associated with large trees and structural complexity (Bryan 2007). Managing forest composition and structure in a variety of conditions should conserve habitat and viable populations of many forest-associated wildlife species.

Habitat Block Size and Quality

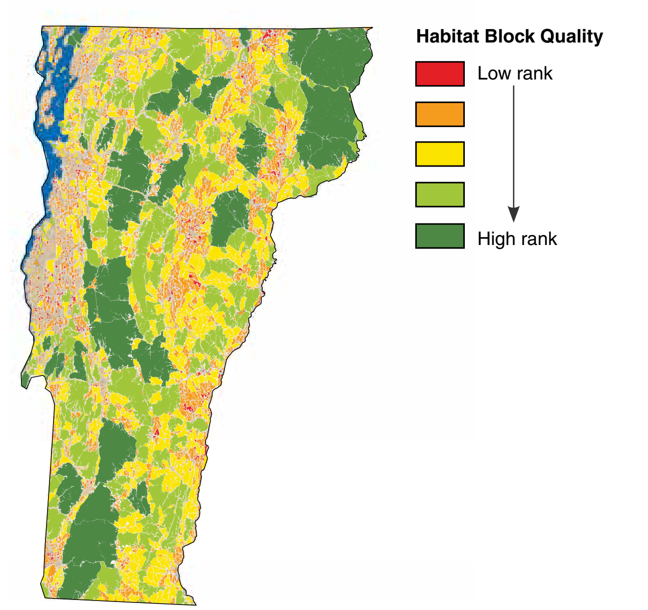
Background

Having large blocks of contiguous forest connected by protected corridors is important for many wildlife species. The habitat needs of many mammals and songbirds include large areas of forest cover that are free from human disturbance and fragmentation. In order to characterize the forest composition, successional status, and structure of different habitat block sizes and qualities, the FIA plots were overlaid in GIS with habitat block size layers from Vermont and New Hampshire (Fig. 61) and a habitat quality layer from Vermont (Fig. 62) (New Hampshire Fish and Game Department 2005, Sorenson and Osborne 2014).



Projection: New Hampshire State Plane, NAD83.
Sources: New Hampshire Fish and Game Department 2005; Sorenson and Osborne 2014.
Geographic base data are provided by the National Atlas of the USA. FIA data and Tools are available online at http://www.fia.fs.fed.us/tools-data/
Cartography: R.S. Morin. May 2014

Figure 61.—Map of habitat block size for Vermont, 2006 and New Hampshire, 2010.



Projection: New Hampshire State Plane, NAD83.
Source: Sorenson and Osborne 2014.
Geographic base data are provided by the National Atlas of the USA. FIA data and Tools are available online at http://www.fia.fs.fed.us/tools-data/
Cartography: R.S. Morin. May 2014

Figure 62.—Map of habitat block quality in Vermont, 2006.

Late successional (LS) forests provide a range of ecosystem services, including wildlife habitat and biodiversity. The area of forest land in a LS condition was estimated based on the number of large live or dead trees present (Maine Forest Service 2010). Areas that did not meet the thresholds for LS were classified as early successional (ES) or mid-successional (MS) forests.

What we found

The distribution of area by forest-type group varied by habitat block size in both States. The maple/beech/birch forest-type group is widely distributed in all habitat block sizes and generally increases in proportion of forest area as block size increases from small blocks less than 250 acres up to larger blocks of greater than 5,000 acres. The spruce/fir and aspen/birch forest-type groups also increase with block size, but they are nearly absent from the smaller habitat block size classes. By contrast, the oak and pine forest-type groups are concentrated in the smaller habitat block size classes and decrease in proportion of forest area as block size increases (Fig. 63).

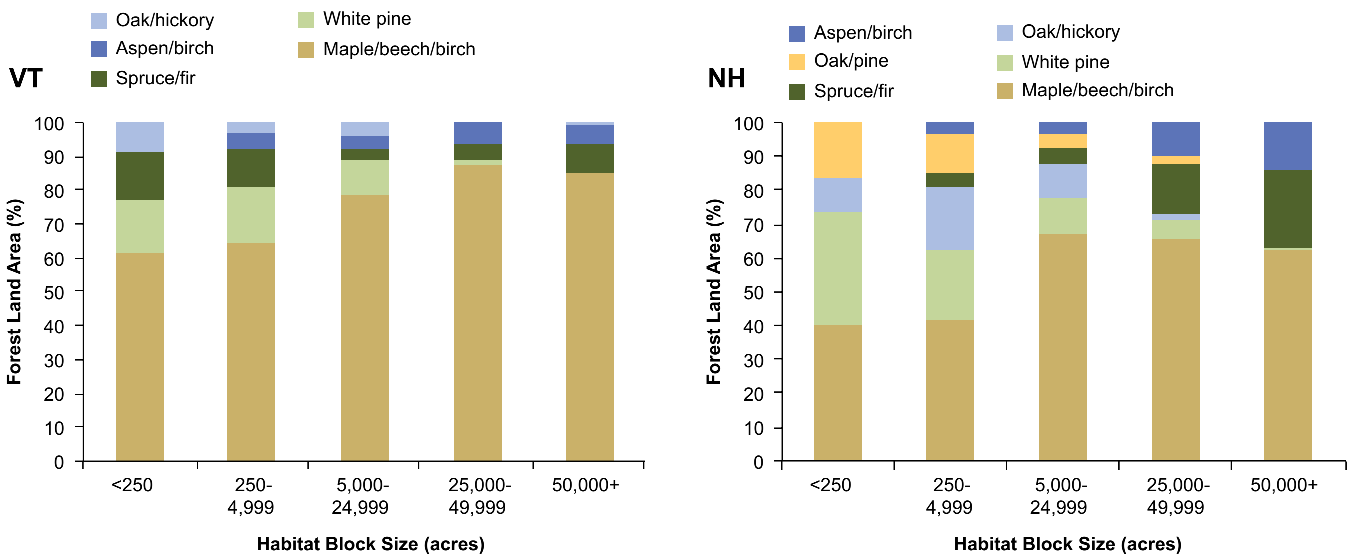


Figure 63.—Proportion of forest land by habitat block size and forest-type group, Vermont and New Hampshire, 2012.

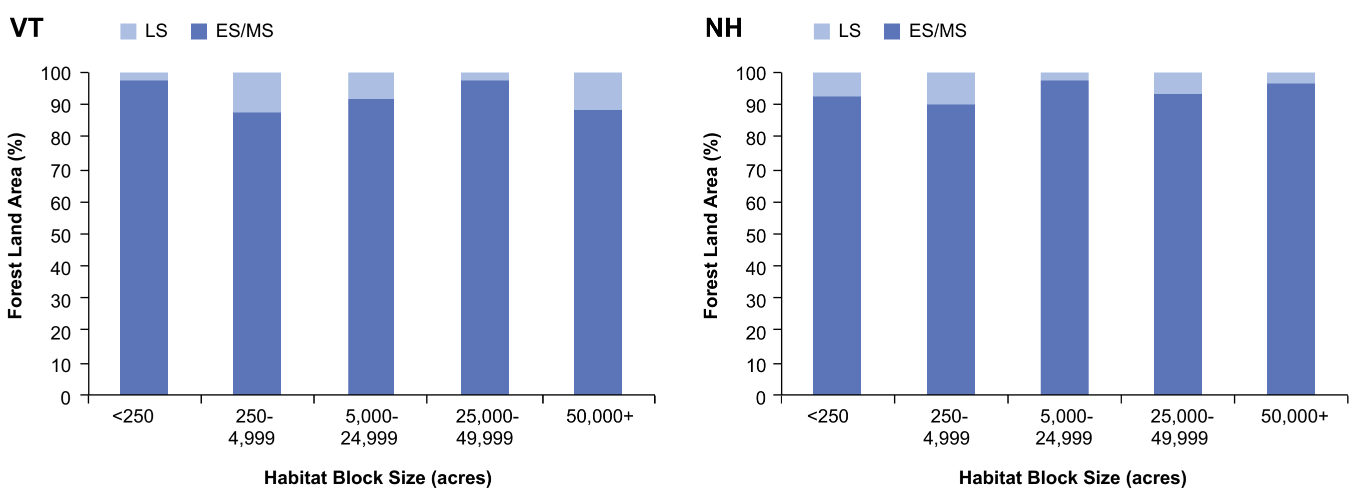


Figure 64.—Proportion of forest land by habitat block size and stand size/successional class, Vermont and New Hampshire, 2012.

Approximately 9 percent of the forest area in Vermont and 6 percent of the forest area in New Hampshire meet the criteria required to be classified as LS, but proportions vary within habitat block size classes in both States (Fig. 64). Although the majority of the forest land in Vermont and New Hampshire is in the large diameter stand-size class, very little qualifies as LS habitat. The trend between LS habitat and block size is unclear.

The distribution of area by forest-type group area also varies by habitat block quality in Vermont. The maple/beech/birch forest-type group is widely distributed in all habitat block quality classes and increases in proportion of forest area as block quality increases. The area of other forest-type groups decrease in proportion of forest area as block quality increases (Fig. 65).

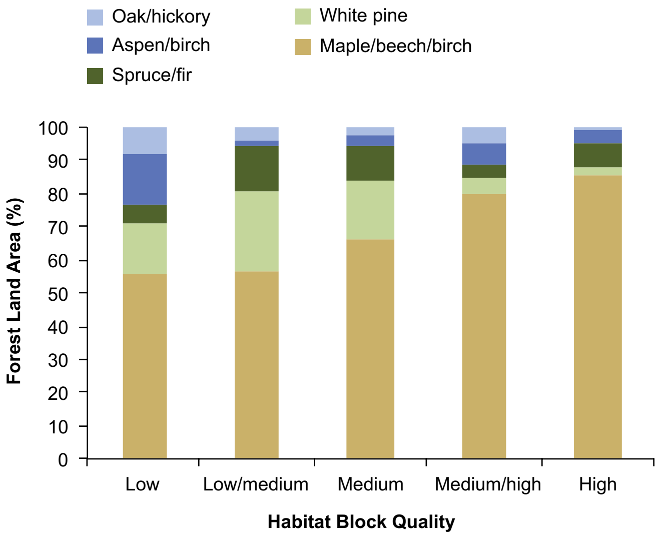


Figure 65.—Proportion of forest land by habitat block quality and forest-type group, Vermont, 2012.

What this means

Larger habitat blocks, and to some extent, higher quality blocks, are more common on publicly owned and high-elevation forest lands which are concentrated in northern and central Vermont (Figs. 61 and 62) and northern New Hampshire (Fig. 61). Therefore, high-elevation forest types like spruce/fir and aspen/birch make up a larger proportion of the forest land in the larger habitat block sizes. By contrast, pine and oak forest-type groups tend to occur in smaller, more fragmented habitat blocks. Consequently, species such as snowshoe hare, magnolia warbler (*Setophaga magnolia*), and redback salamander (*Plethodon cinereus*) that are typically found in spruce/fir forests may have larger and higher quality blocks for habitat, but species like eastern towhee (*Pipilo erythropthalmus*), pileated woodpecker, and barred owl (*Strix varia*) that depend on oak/pine forests could by limited by smaller and lower quality habitat blocks (Bryan 2007).

Standing Dead Trees

Background

Specific habitat features like nesting cavities and standing dead trees provide critical habitat components for many forest-associated wildlife species. Standing dead trees that are large enough to meet habitat requirements for wildlife are referred to as “snags.” According to one definition, “for wildlife habitat purposes, a snag is sometimes regarded as being at least 10 inches (25.4 cm) in diameter at breast height and at least 6 ft (1.8 m) tall” (Society of American Foresters 2008). Standing dead trees serve as important indicators not only of wildlife habitat, but also of past mortality events and carbon storage and are a source of down woody material (see Down Woody Materials on page 45) which also provides habitat for wildlife. The number and density of standing dead trees together with decay classes, species, and sizes, define an important wildlife habitat feature across forests of Vermont and New Hampshire.

What we found

FIA collects data on standing dead trees (at least 5 inches d.b.h.) of numerous species and sizes in varying stages of decay. According to 2012 inventory data, Vermont has more than 96 million standing dead trees and New Hampshire has 141 million standing dead trees present on forest land. This equates to an overall density of standing dead trees per acre of forest land of 20.9 in Vermont and 29.3 in New Hampshire. In both States, higher densities of standing dead trees per acre occur on public forest land (24.7 in VT; 49.6 in NH) than on private forest land (20.0 in VT; 21.9 in NH). Three species groups in Vermont and four species groups in New Hampshire each contribute more than 10 million standing dead trees. The top group in both States is spruce and balsam fir, contributing nearly 20 million in Vermont (Fig. 66, VT) and over 41 million in New Hampshire (Fig. 66, NH).

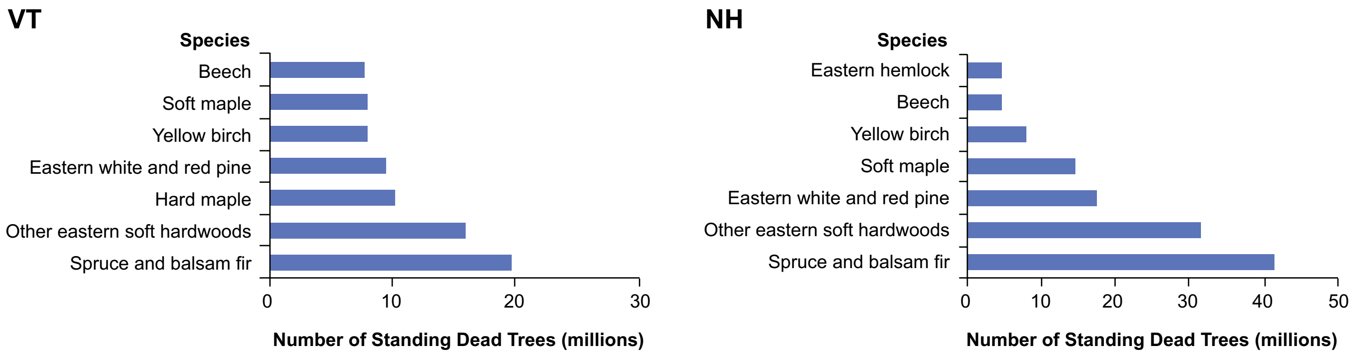


Figure 66.—Number of standing dead trees (5 inches d.b.h. and larger) by species group, Vermont and New Hampshire, 2012.

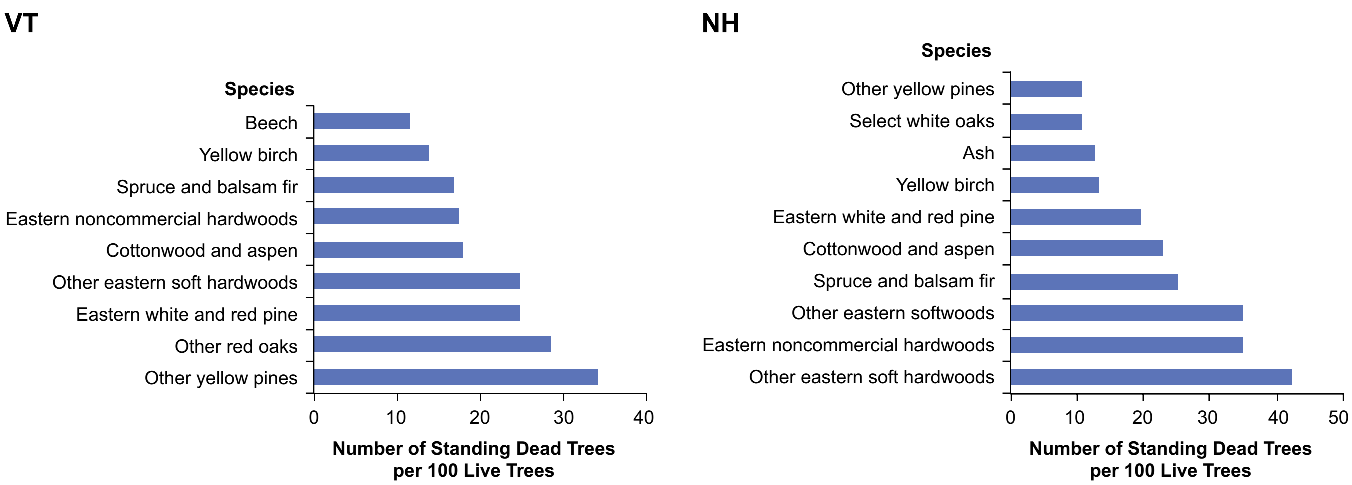


Figure 67.—Number of standing dead trees per 100 live trees (for trees 5 inches d.b.h. and larger) by species group, Vermont and New Hampshire, 2012.

Relative to the total number of live trees in each species group, 11 species groups in Vermont and 10 species groups in New Hampshire exceeded 10 standing dead trees per 100 live trees (of at least 5 inches d.b.h.). Other yellow (hard) pines species group (all of which are Scotch pines) topped the list at 34 standing dead trees per 100 live trees in Vermont (Fig. 67, VT) and other eastern soft hardwoods (predominately sweet birch) topped the list at 42 standing dead trees per 100 live trees in New Hampshire (Fig. 67, NH), although the absolute numbers of standing dead trees are among the lowest for these species groups. The majority of standing dead trees (77 percent in Vermont, 85 percent in New Hampshire) were smaller than 11 inches d.b.h., with 37 and 43 percent (Vermont and New Hampshire, respectively) falling between 5.0 and 6.9 inches d.b.h. (Fig. 68). Few standing dead trees were in the class of least decay (all limbs and branches present; 11 percent in both States) or most decay (no evidence of branches remain; 2 percent in both States). Over 41 percent of standing dead trees in both States were in the intermediate decay class (only limb stubs present) (Fig. 68).

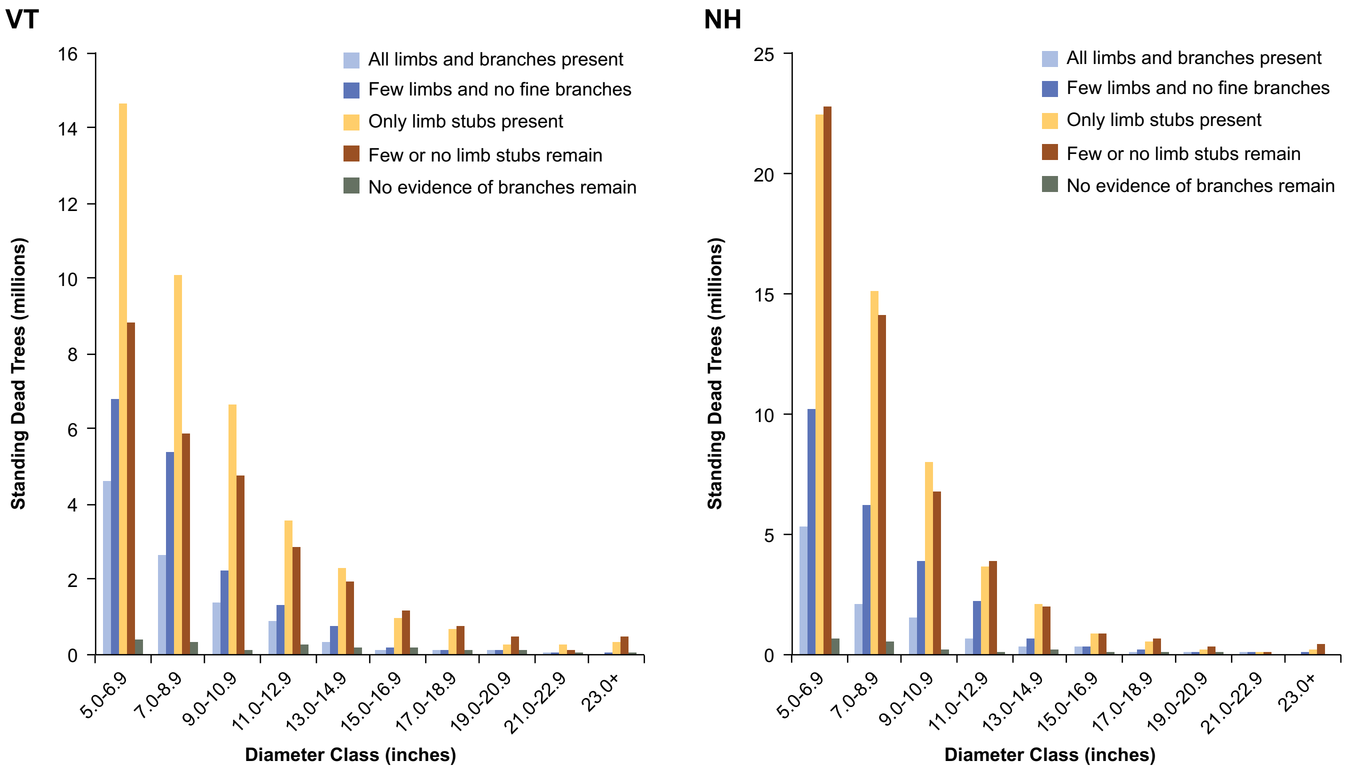


Figure 68.—Distribution of all standing dead trees (5 inches d.b.h. and larger) by diameter class and decay class, Vermont and New Hampshire, 2012.

What this means

Compared to live trees, the number of standing dead trees is small, but they may contain significantly more cavities per tree than occur in live trees (Fan et al. 2003). Standing dead trees provide areas for foraging, nesting, roosting, hunting perches, and cavity excavation for many wildlife species ranging from primary colonizers such as insects, bacteria, and fungi, to birds, mammals, and reptiles. Most cavity nesting birds are insectivores which help to control insect populations. The low availability of very large snags in Vermont and New Hampshire may be a limiting meso-scale habitat feature for some species of wildlife. Providing a variety of forest structural stages and retaining specific features like snags on both private and public lands are ways that forest managers can maintain the abundance and quality of habitat for forest-associated wildlife species in Vermont and New Hampshire. The overall average of more than 20 standing dead trees per acre in both States indicates that much of the forest land is likely to meet a general threshold of 5 to 6 snags per acre that has been recommended by previous management guides (Forest Guild 2010, Hagenbuch et al. 2011).

Watershed Protection

Background

During the 19th century, unregulated logging, overgrazing, and wildfires resulted in damaged landscapes throughout Vermont and New Hampshire. The deforested landscapes were susceptible to rapid runoff of storm water and erosion that intensified flash flooding. Flooding was a major concern as it affected the many water powered mills that were important to the economies of both States. As early as 1864, George Perkins Marsh wrote of the need for conservation of these degraded lands in his book “Man and Nature.” In 1911, after intense lobbying and public pressure for the Federal Government to buy degraded lands in the East, the Weeks Act was passed by Congress. One of the principle objectives of the bill was to recommend for purchase lands within the watersheds of navigable streams to regulate flow. The bill was introduced by Senator John Weeks of Massachusetts, a native of

Lancaster, New Hampshire. The bill allowed for the U.S. Forest Service to manage the purchased lands and resulted in the creation of the Green Mountain National Forest in Vermont and the White Mountain National Forest in New Hampshire. Recently, the impacts of Hurricane Irene highlighted the importance of forest and forest management practices for mitigating the impact of severe weather events on infrastructure.

What we found

Watersheds in Vermont and New Hampshire drain to the east through Maine, to the south through Massachusetts and Connecticut, to the north through Canada, and to the west into the Hudson River in New York. The Connecticut River drains 39 percent of the land in Vermont and New Hampshire (Fig. 69), and the watershed is 85 percent forested. Land that drains north through Lake Champlain and Lake Memphremagog to the St. Lawrence Seaway is the least forested (72 percent). This area contains much of the land that supports Vermont's dairy industry.

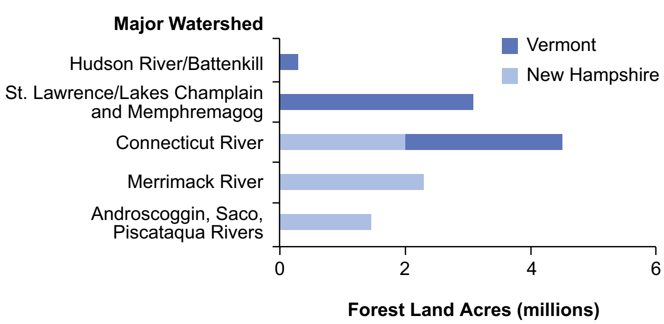


Figure 69.—Acres of forest land by major watershed, Vermont and New Hampshire, 2012.

Generally, public ownership of forest land increases with an increase in elevation. Over half the forest land in the 2,000 to 3,000 foot elevation class is in public ownership. This increases to 87 percent of forest land in the 3,000 to 4,000 foot class, and 100 percent of land over 4,000 feet (Fig. 70). Of the 2.2 million acres in public ownership in Vermont and New Hampshire, 55 percent is managed by the Green Mountain and White Mountain National Forests. The majority of national forest land is at an elevation above 2,000 feet.

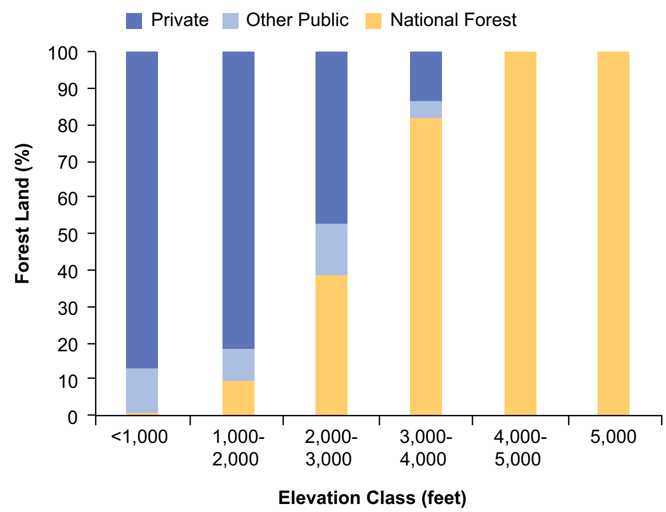


Figure 70.—Percent of forest land by elevation class and ownership class, Vermont and New Hampshire combined, 2012.

What this means

Public lands in Vermont and New Hampshire are the birthplace of many of New England's rivers. The high percentage of publicly owned high-elevation forests means that the headwaters of many watersheds are on public land, reflecting the objectives of many of the purchases. Because management of publicly owned forests is typically restricted by more rules and regulations than privately owned forest, public ownership brings a higher level of protection to these unique, and often more vulnerable and less productive, forests. Because major watersheds drain from Vermont and New Hampshire in all directions, many downstream communities in other states and Quebec, Canada benefit from their protection. Forested watersheds provide water purification, mitigation of floods and droughts, soil retention, and maintenance of habitats. Although the original intent of much of the land purchased for national forests was primarily for watershed protection, today these lands provide many additional ecological services and opportunities for recreation.

Invasive Plant Species

Background

Nonnative invasive plant species (IPS) are a concern throughout the world. Some invasive plants are alternate hosts for insects and diseases and can cause severe agricultural impacts. The presence of IPS also affects forest structure, health, and diversity. These invaders often form very dense colonies that limit light, nutrient, and water availability. While some invasive plants have beneficial characteristics, such as for medicinal purposes (common barberry; Kurtz 2013) or culinary use (garlic mustard), the negative impacts to ecosystems are problematic. Annually, nonnative IPS cost billions of dollars through monitoring and removal. Because of the vast implications caused by IPS, it is important to increase awareness through informing and educating private landowners and the general public.

What we found

During the 2012 inventory, a subset of 291 P2 plots in Vermont and New Hampshire were monitored for the presence of 43 IPS and one undifferentiated genera (nonnative bush honeysuckle) (Table 5) as a part of the invasive plant monitoring protocol. Invasive plant species were present on 51 (17.5 percent) of the plots and 16 different IPS were observed. A total of 15 different kinds of invasive species were found on plots in Vermont while 8 different species were observed in New Hampshire. The most commonly observed IPS were common buckthorn, glossy buckthorn, and Japanese barberry, each found on a total of 11 plots (3.8 percent) across both States. Figure 71 shows the presence of these three species in Vermont and New Hampshire. Common buckthorn was only observed in Vermont and glossy buckthorn and Japanese barberry were found in both States. The percentage of ground cover of the species on the plots varied, with all cover values being 10 percent or less (Table 6). Mapping all the IPS observed shows that Vermont had more plots with invasive plants and more IPS per plot than neighboring New Hampshire (Fig. 72). Overall, 24.5 percent of plots in Vermont had

Table 5.—List of 43 invasive plant species and one undifferentiated genera monitored by the Northern Research Station on Forest Inventory and Analysis P2 Invasive plots, 2007 to present

Tree Species
Black locust *(Robinia pseudoacacia)*
Chinaberry *(Melia azedarach)*
Norway maple *(Acer platanoides)*
Princesstree *(Paulownia tomentosa)*
Punktree *(Melaleuca quinquenervia)*
Russian olive *(Elaeagnus angustifolia)*
Saltcedar *(Tamarix ramosissima)*
Siberian elm *(Ulmus pumila)*
Silktree *(Albizia julibrissin)*
Tallow tree *(Triadica sebifera)*
Tree-of-heaven *(Ailanthus altissima)*
Woody Species
Amur honeysuckle *(Lonicera maackii)*
Autumn olive *(Elaeagnus umbellata)*
Common barberry *(Berberis vulgaris)*
Common buckthorn *(Rhamnus cathartica)*
European cranberrybush *(Viburnum opulus)*
European privet *(Ligustrum vulgare)*
Glossy buckthorn *(Frangula alnus)*
Japanese barberry *(Berberis thunbergii)*
Japanese meadowsweet *(Spiraea japonica)*
Morrow's honeysuckle *(Lonicera morrowii)*
Multiflora rose *(Rosa multiflora)*
Nonnative bush honeysuckle *(Lonicera* spp.*)*
Showy fly honeysuckle *(Lonicera xbella)*
Tatarian honeysuckle *(Lonicera tatarica)*
Vine Species
English ivy *(Hedera helix)*
Japanese honeysuckle *(Lonicera japonica)*
Oriental bittersweet *(Celastrus orbiculatus)*
Herbaceous Species
Black swallow-wort *(Cynanchum louiseae)*
Bohemian knotweed *(Polygonum xbohemicum)*
Bull thistle *(Cirsium vulgare)*
Canada thistle *(Cirsium arvense)*
Creeping jenny *(Lysimachia nummularia)*
Dames rocket *(Hesperis matronalis)*
European swallow-wort *(Cynanchum rossicum)*
Garlic mustard *(Alliaria petiolata)*
Giant knotweed *(Polygonum sachalinense)*
Japanese knotweed *(Polygonum cuspidatum)*
Leafy spurge *(Euphorbia esula)*
Purple loosestrife *(Lythrum salicaria)*
Spotted knapweed *(Centaurea stoebe* ssp. *Micranthos)*
Grass Species
Common reed *(Phragmites australis)*
Nepalese browntop *(Microstegium vimineum)*
Reed canarygrass *(Phalaris arundinacea)*

Table 6.—Invasive plant species (IPS) observed on Forest Inventory and Analysis P2 Invasive plots in Vermont and New Hampshire, 2012

	Number of plots with IPS present	Percentage of plots	Percent cover (standard error)
New Hampshire			
Glossy buckthorn	9	5.9	1.9 (0.6)
Oriental bittersweet	4	2.6	9.4 (5.0)
Autumn olive	3	2	0.6 (0.3)
Japanese barberry	3	2	0.3 (0.0)
Multiflora rose	3	2	6.3 (3.5)
Nonnative bush honeysuckle species	2	1.3	4.6 (0.4)
Norway maple	1	0.7	2.0 (0.0)
Reed canarygrass	1	0.7	10.0 (0.0)
Vermont			
Common buckthorn	11	7.9	5.4 (2.3)
Japanese barberry	8	5.8	0.7 (0.2)
Nonnative bush honeysuckle species	8	5.8	3.9 (1.7)
Multiflora rose	7	5	1.0 (0.7)
Common barberry	6	4.3	1.1 (0.1)
Creeping jenny	5	3.6	2.5 (2.2)
Morrow's honeysuckle	3	2.2	2.0 (1.6)
Reed canarygrass	3	2.2	1.5 (0.5)
Black locust	2	1.4	3.9 (3.6)
Bull thistle	2	1.4	0.5 (0.3)
Glossy buckthorn	2	1.4	0.5 (0.3)
Tatarian honeysuckle	2	1.4	4.1 (2.9)
Autumn olive	1	0.7	0.3 (0.0)
Japanese knotweed	1	0.7	0.3 (0.0)
Oriental bittersweet	1	0.7	3.0 (0.0)

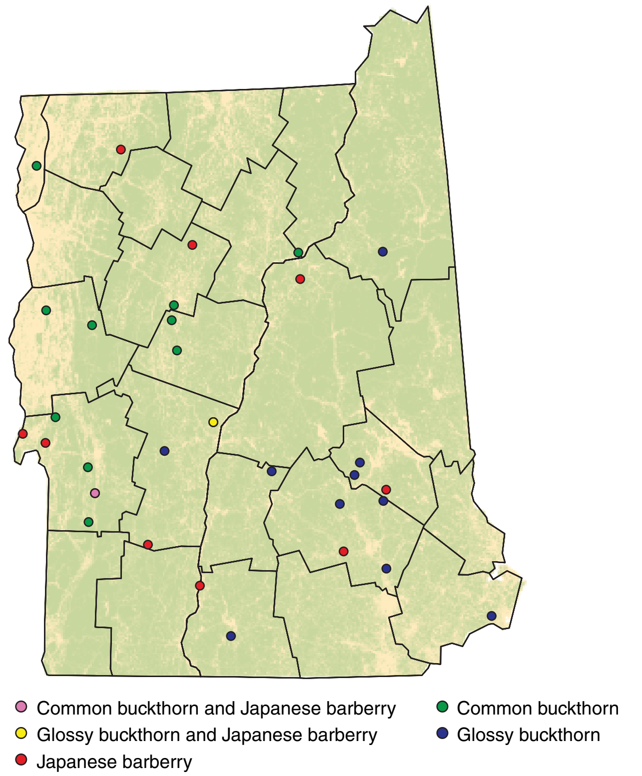
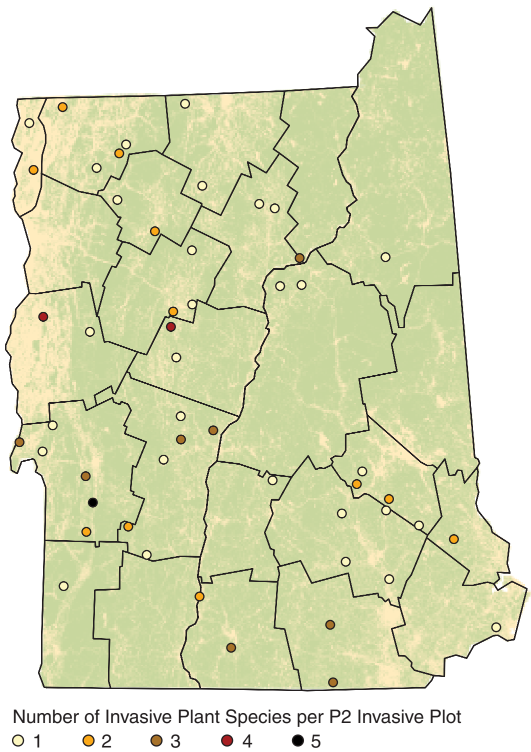


Figure 71.—Distribution of the three most common invasive plant species observed on P2 Invasive plots in Vermont and New Hampshire, 2012.

one or more invaders while 11.2 percent of plots in New Hampshire had one or more IPS (Fig. 72). No invasive plants were observed in northern New Hampshire. With few exceptions, plots with invasive plants had fewer seedlings and saplings per acre than those without invasive species (Fig. 73). Additionally, the densities of important seedling species were much lower where invasives were present in both the maple/beech/birch forest-type group (Fig. 74a) and white pine forest-type group (Fig. 74b).

In previous reports on IPS for Vermont and New Hampshire which covered the 2007–2008 P2 invasive plot data (Morin 2011a, 2011b), 10 of the invasive species monitored were observed. In the 2012 inventory, the number of IPS observed on P2 invasive plots increased to 16. In addition, the overall number of plots with one or more invasive species present increased from 12.8 percent to 17.5 percent. Common and glossy buckthorn remained among the three most frequently recorded species in both inventories; however common barberry, which was the most frequently recorded invasive plant in the 2007-2008 inventory, was now the sixth most commonly observed species. This survey again emphasized that plots with IPS have a lower number of seedlings and saplings per acre. Distribution of IPS tends to be greatest near populated areas where seed sources are concentrated. Differences observed between this inventory and the 2007-2008 data need to be carefully considered due to the variations in sample size and plot locations.



Projection: NAD83. UTM Zone 18N.

Data Source: U.S. Forest Service, Forest Inventory and Analysis Program 2008-2012 Phase 2 Invasive data.

State and county layers source: ESRI Data and Maps 9.3. Forest/nonforest source: NLCD 2006. Depicted plot locations are approximate.

Cartography: C. Kurtz Mar. 2014.

Figure 72.—Number of invasive plant species observed on P2 Invasive plots in Vermont and New Hampshire, 2012.

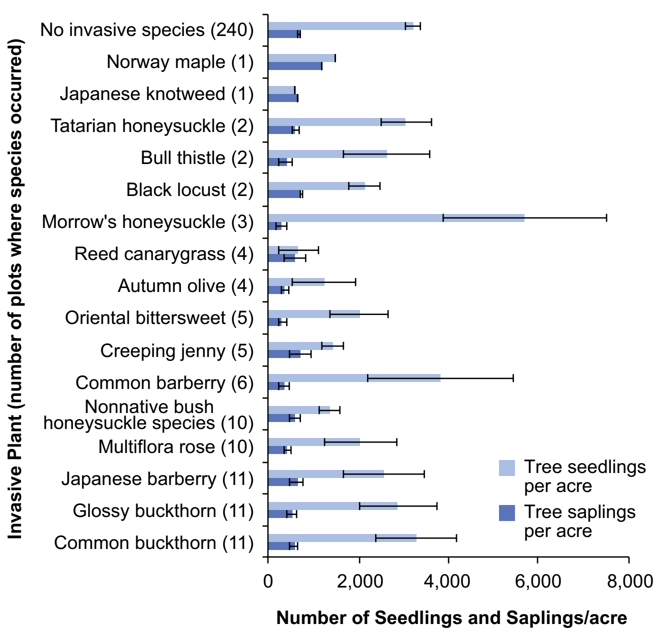


Figure 73.—Number of seedlings and saplings per acre on P2 invasive plots with or without invasive plant species in Vermont and New Hampshire combined, 2012. Error bars represent a 68 percent confidence interval around the mean.

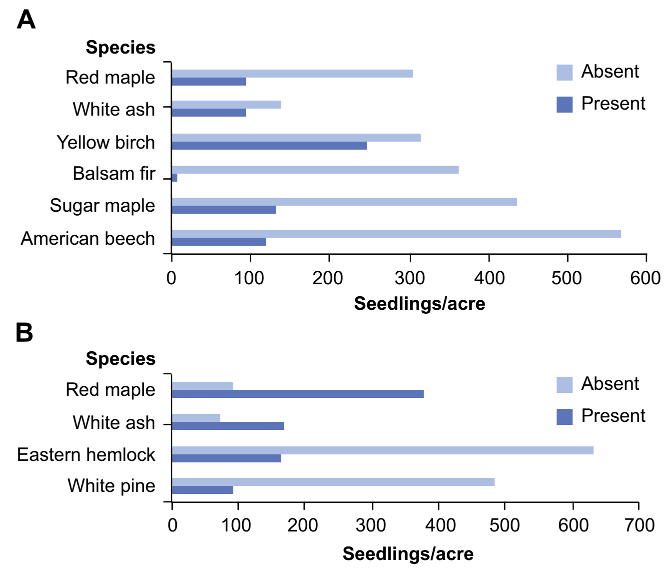


Figure 74.—Seedlings per acre by species and invasive plant presence for (A) the maple/beech/birch, and (B) white pine forest-type groups, Vermont and New Hampshire combined, 2012.

What this means

Although the percentage of plots invaded in Vermont was more than double that of New Hampshire, the presence of IPS across both States is a concern because these invaders can cause detrimental forest changes. These plants can change hydrology, displace native species, and reduce the visual aesthetics of an area. Heavily infested areas may result in a change in wildlife habitat. Once established, IPS can rapidly increase in cover and impact co-occurring native plant species. With the increased occurrence of IPS in this inventory, it is important that the presence and spread of these species are monitored. Through continual monitoring of invasive species, managers will be aware of the presence of these aggressive species and be able to make more informed management decisions. Although the densities of important seedling species were much lower where invasives were present in both the maple/beech/birch forest-type group and white pine forest-type group, the correlation may not necessarily mean that the IPS are reducing regeneration, but may instead be due to the plants establishing in areas where there is less competition and more light availability.

Forest Pests

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, forests of Vermont and New Hampshire have suffered the effects of native insect pests such as forest tent caterpillar (*Malacosoma disstri*a) and well-known exotic and invasive agents such as Dutch elm disease (*Ophiostoma ulmi*), chestnut blight (*Cryphonectria parasitica*), European gypsy moth (*Lymantria dispar*), and the beech bark disease complex. More recent invaders include hemlock woolly adelgid (*Adelges tsugae*) and emerald ash borer.[4] Additionally, the Asian longhorned beetle (*Anoplophora glabripennis*) is an impending threat that caused an extensive infestation in Worcester, Massachusetts in 2008.

Beech Bark Disease

Background

American beech is a major component of the maple/beech/birch forest-type group, which comprises 74 percent of the forest resource in Vermont and 53 percent in New Hampshire (Fig. 5). American beech is an important pulpwood and firewood species and is also important for wildlife due to the hard mast that it produces. Beech bark disease (BBD) is an insect-fungus complex involving the beech scale insect (*Cryptococcus fagisuga* Lind.) and the exotic canker fungus *Neonectria coccinea* (Pers.:Fr.) var. *faginata* Lohm. or the native *Neonectria galligena* Bres. that kills or injures American beech. Three phases of BBD 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 forests, which are areas where the disease is endemic (Houston 1994, Shigo 1972). BBD was inadvertently introduced via ornamental beech trees into North America at Halifax, Nova Scotia, in 1890 and then began spreading across New England. By 1975, all of Vermont and New Hampshire were infested.

What we found

Currently, the annual mortality rate for American beech is twice that of all trees in Vermont (1.7 percent; Fig. 48, VT) and slightly higher than that of all trees in New Hampshire (1.1 percent; Fig. 48, NH). The impacts of BBD on mortality of large diameter beech have steadily skewed the diameter distribution of beech toward smaller trees since 1983 (Fig. 75). The number of beech seedlings increased slightly between 2007 and 2012 in both States.

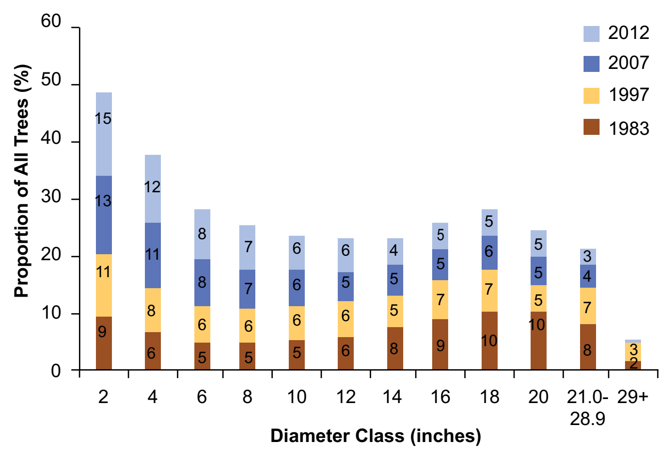


Figure 75.—Proportion of all trees on timberland that are American beech, by diameter class and inventory year, Vermont and New Hampshire combined.

What this means

Since Vermont and New Hampshire have been infested by BBD for over 30 years, beech forests are in the aftermath phase of BBD. Aftermath forests are often characterized by a dearth of large beech trees due to past BBD mortality which is associated with large amounts of beech seedlings and saplings. This condition,

[4] At the time of this writing, emerald ash borer had been discovered in New Hampshire but not Vermont.

often referred to as "beech brush", can interfere with regeneration of other hardwood species such as sugar maple (Hane 2003) and includes trees with low vigor and slow growth that often succumb to the disease before making it into the overstory. These trees are also unlikely to reach sawtimber size or produce mast that is important for wildlife.

Hemlock Woolly Adelgid

Background

Eastern hemlock is a major component of the forest resources in Vermont and New Hampshire. Due to its high value as a timber species, the wildlife habitat it provides, and the unique niche it fills in riparian areas, it is an ecologically important species. Forests with the highest proportion of hemlock volume are located in southern New Hampshire and along the border with Vermont (Fig. 37). Hemlock woolly adelgid (HWA) is native to East Asia and was first noticed in the eastern United States in the 1950s (Ward et al. 2004). Since then, it has slowly expanded its range. In areas where HWA has established, populations often reach high densities, causing widespread defoliation and sometimes mortality of eastern hemlock (McClure et al. 2001, Orwig et al. 2002).

What we found

Hemlock woolly adelgid was first observed in Rockingham County, New Hampshire in 2001. By 2012, the insect had been discovered across most of the southern counties of Vermont and New Hampshire. Unlike in many other states that have been impacted by HWA, hemlock annual mortality rate (Fig. 48), crown health (Tables 2 and 3 on page 43), and incidence of insect damage (Table 4 on page 44) has seemingly been unaffected in Vermont and New Hampshire. Additional analyses revealed no differences in the mortality rate and crown health of hemlock between infested and uninfested counties.

What this means

Hemlock woolly adelgid has already spread into the counties of New Hampshire where hemlock is the most abundant. Morin et al. (2009) estimates that HWA is spreading to the north at a rate of between 9 and 10.6 miles per year. However, cold winter temperatures can cause considerable adelgid mortality and trigger dramatic population declines (Skinner et al. 2003). Therefore, the rate of spread of HWA into the rest of New Hampshire and Vermont may be impacted by temperature. Although the health of eastern hemlock in the forests of Vermont and New Hampshire does not appear to have been impacted by HWA yet, it is important to continue monitoring crown health and mortality over the coming decade. A previous study reported that hemlock mortality increases were not substantial until HWA had infested counties for more than 20 years (Morin et al. 2011c), suggesting impacts in Vermont and New Hampshire will not be apparent for another 5 to 10 years.

Emerald Ash Borer

Background

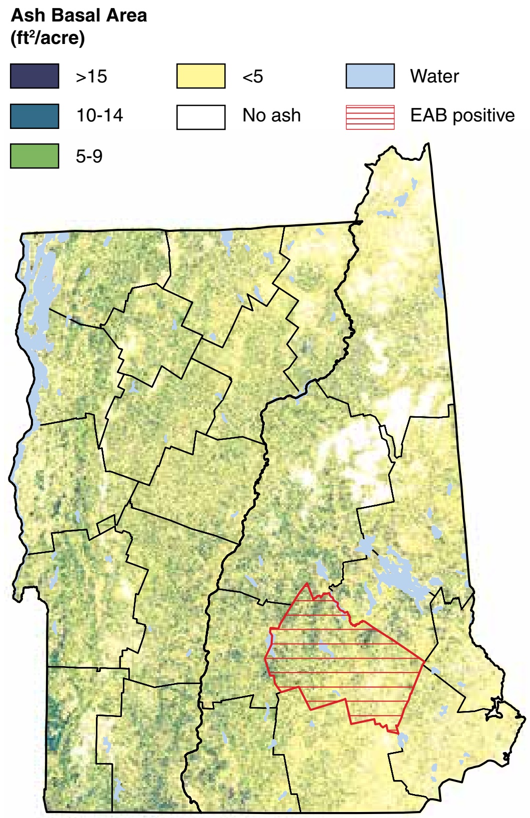
The emerald ash borer (EAB) is a wood-boring beetle native to Asia. In North America, EAB has only been identified as a pest of ash, and all major ash species are susceptible regardless of size or vigor (Poland and McCullough 2006). Tree mortality is rapid and can occur within 1 to 4 years, depending on tree size and beetle intensity. Since its 2002 discovery in southeastern Michigan, EAB has spread across the northern half of the United States and has been identified in 18 states as of the end of 2012. EAB was not identified in Vermont or New Hampshire during the 2012 inventory; however, it was found in New Hampshire in the spring of 2013.

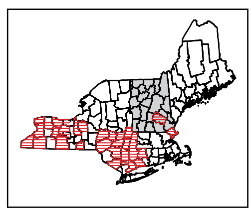
What we found

There are an estimated 254.2 million ash trees (with a d.b.h. of 1 inch or greater) on forest land in Vermont and New Hampshire, with nearly two-thirds (63 percent) of the ash being in Vermont. White ash is the most numerous ash species in the region, making up 87 percent of total ash abundance; black ash and green ash make up 9 percent and 4 percent, respectively. Ash is widely distributed, with the highest densities found in southern Vermont and central New Hampshire (Fig. 76). Ash accounts for 569.9 million and 330.9 million cubic feet of live-tree volume on forest land in Vermont and New Hampshire, respectively. Regionally, the rate of ash mortality has climbed since 1998 (Fig. 77). New Hampshire has a higher ash mortality rate, resulting in a yearly loss of approximately 1 percent of ash volume in 2012; this represents a 0.4 percent increase since 1997. The mortality rate of ash in Vermont increased sharply between 2007 and 2012.

What this means

Emerald ash borer has caused extensive ash mortality in the northeastern United States in areas where it has spread, and it represents a significant threat to the ash resource in Vermont and New Hampshire. Increasing ash mortality in the region is related to senescing trees, but could also indicate an underlying forest health issue, such as ash decline or ash yellows which occur in southern and western Vermont and southern New Hampshire, or potentially, undetected EAB infestations. The loss of ash in forested ecosystems will affect species composition and alter community dynamics. Continued monitoring of ash resources will help to identify the long-term impacts of EAB in forested settings.





Processing note:
This map was produced by linking plot data to MODIS satellite pixels (250 m) using gradient nearest neighbor techniques. The resulting image was resampled to 500 m pixels.

Figure 76.—Distribution of ash on forest land, Vermont and New Hampshire, 2012, and counties positive for emerald ash borer (as of March 11, 2013).

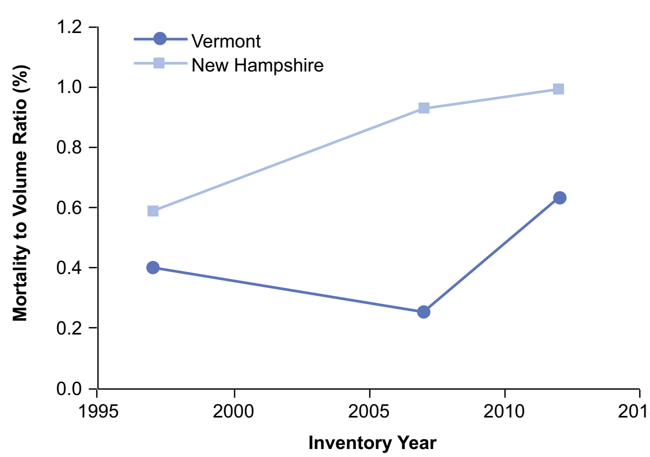


Figure 77.—Average annual mortality of ash growing stock as a percentage of ash growing-stock volume on timberland by inventory year, Vermont and New Hampshire.

Asian Longhorned Beetle

Background

The Asian longhorned beetle (ALB) is an exotic, wood-boring beetle that attacks a variety of hardwood species found in Vermont and New Hampshire. Larval activity disrupts the flow of water and nutrients, and repeated attacks will eventually girdle the trunk, resulting in tree mortality (Haack et al. 2010). Maple is the most favored host, but birch, willow, and elm are also preferred hosts. Occasional hosts include poplar and ash (U.S. Forest Service 2008). Trees are attacked regardless of vigor or size (Haack et al. 2010). Asian longhorned beetle has not yet been identified in Vermont or New Hampshire but has been present in neighboring Massachusetts since 2008.

What we found

Almost half of all trees on forest land in Vermont (49 percent) and New Hampshire (41 percent), or 3.4 billion trees, are susceptible to ALB. Maples are the most dominant across the region (61 percent), followed by birches (27 percent) and ashes (7 percent) (Fig. 78). Susceptible host species account for 10.3 billion cubic feet of total live-tree volume. County-level abundance of hosts is high throughout the region; however, the highest densities are concentrated in the northern tier (Fig. 79).

What this means

Asian longhorned beetle has caused major economic losses in China, where it is a pest of urban, windbreak, and plantation trees (Haack et al. 2010). Since its introduction to the United States, ALB has been a significant source of urban tree mortality. Due to the wide range of susceptible host species, this insect could also have a substantial impact on hardwood forests across Vermont and New Hampshire and has the potential to have serious ramifications for the maple syrup industry. Quarantine establishment and management efforts have been initiated in Massachusetts based on lessons learned during the successful eradication of ALB in Illinois and New Jersey. Continued monitoring of host species throughout the region will help to quantify potential future impacts should ALB become established in Vermont or New Hampshire.

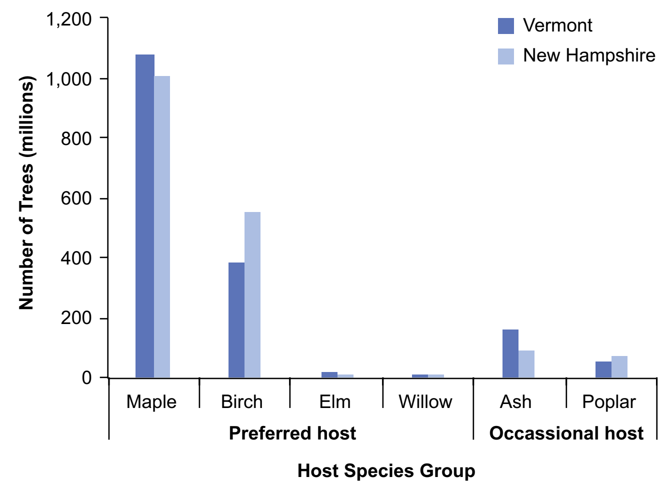


Figure 78.—Number of trees susceptible to Asian longhorned beetle on forest land by host species, Vermont and New Hampshire, 2012.

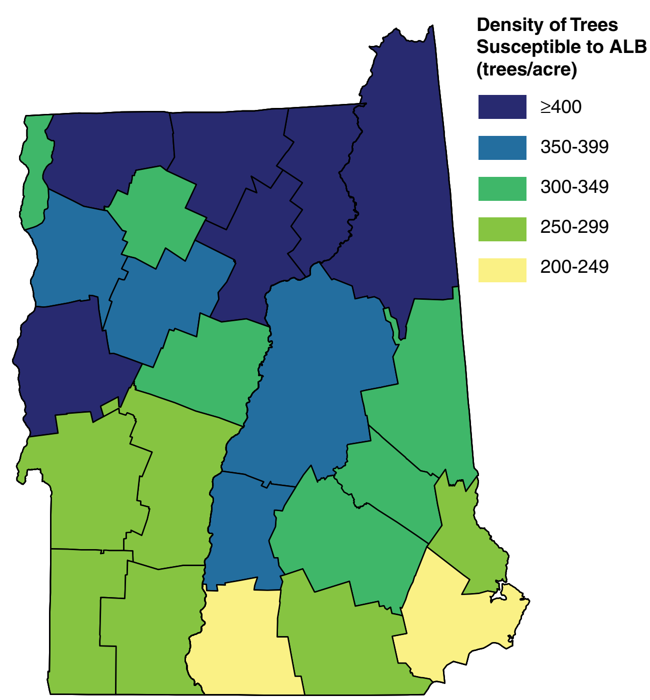


Figure 79.—Density of trees susceptible to Asian longhorned beetle (ALB) on forest land by county, Vermont and New Hampshire, 2012.

Forest Products

Background

The harvesting and processing of timber products produces a stream of income shared by timber owners, managers, marketers, loggers, truckers, and processors. The most recent reports indicate that wood products and paper manufacturing industries employ 1,588 people in Vermont and 2,030 people in New Hampshire, and the total value of shipments in Vermont is almost $230 million and more than $400 million in New Hampshire (U.S. Census Bureau 2011). To better manage these forests, it is important to know the species, amounts, and locations of timber being harvested.

What we found

Surveys of wood-processing mills in Vermont and New Hampshire are conducted periodically to estimate the amount of wood volume that is processed into products. This is supplemented with the most recent surveys conducted in the surrounding states that process wood harvested from Vermont and New Hampshire. Active primary wood-processing mills were surveyed in Vermont in 2011 and in New Hampshire in 2012 to determine the species that were processed and where the wood material came from. Mills in Vermont processed 157 million board feet of saw logs and veneer logs and 165 thousand cords of industrial fuelwood. Mills in New Hampshire processed 203 million board feet of saw logs and veneer logs and 108 thousand cords of industrial fuelwood.

A total of 68 million cubic feet of industrial roundwood (including saw logs/veneer logs, pulpwood, industrial fuelwood, and other products) was harvested from Vermont in 2011 and 74 million from New Hampshire in 2012. Saw logs accounted for 50 and 49 percent of the total industrial roundwood harvested in Vermont and New Hampshire, respectively. Pulpwood was the second most harvested product, accounting for 33 percent of the volume in Vermont and 41 percent in New Hampshire. Industrial firewood accounted for nearly all the remaining harvest in both States (Fig. 80). White pine and hard maple were the most harvested species in Vermont, both accounting for 17 percent of the State's total harvest. White pine was the most harvested species in New Hampshire, accounting for 40 percent of the State's total industrial roundwood harvest. Other important species groups harvested in both States were hemlock, balsam fir, spruce, and soft maple (Fig. 81).

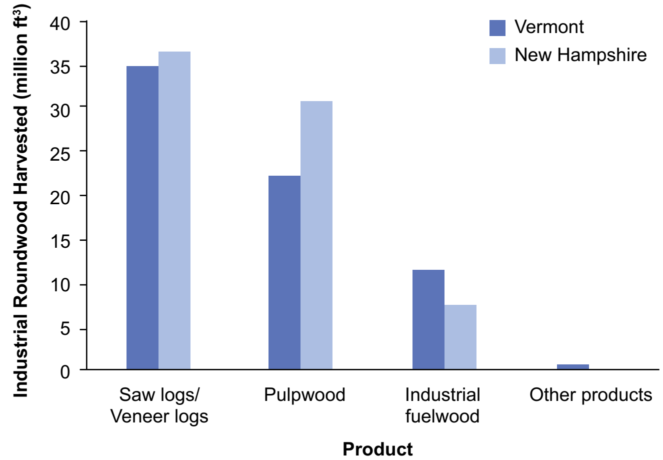


Figure 80.—Volume of industrial roundwood harvested by product, Vermont, 2011, and New Hampshire, 2012.

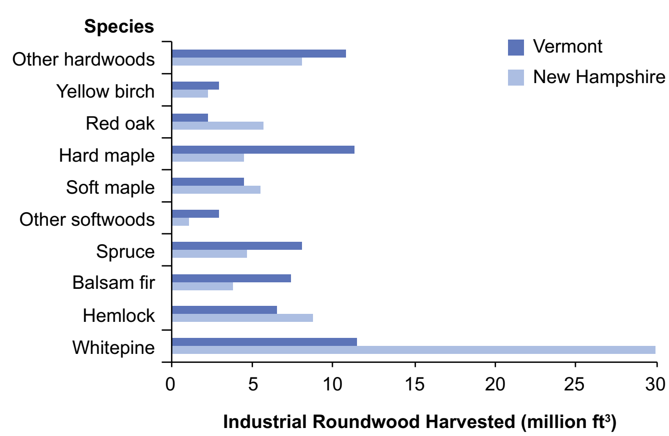


Figure 81.—Volume of industrial roundwood harvested by species group, Vermont, 2011, and New Hampshire, 2012.

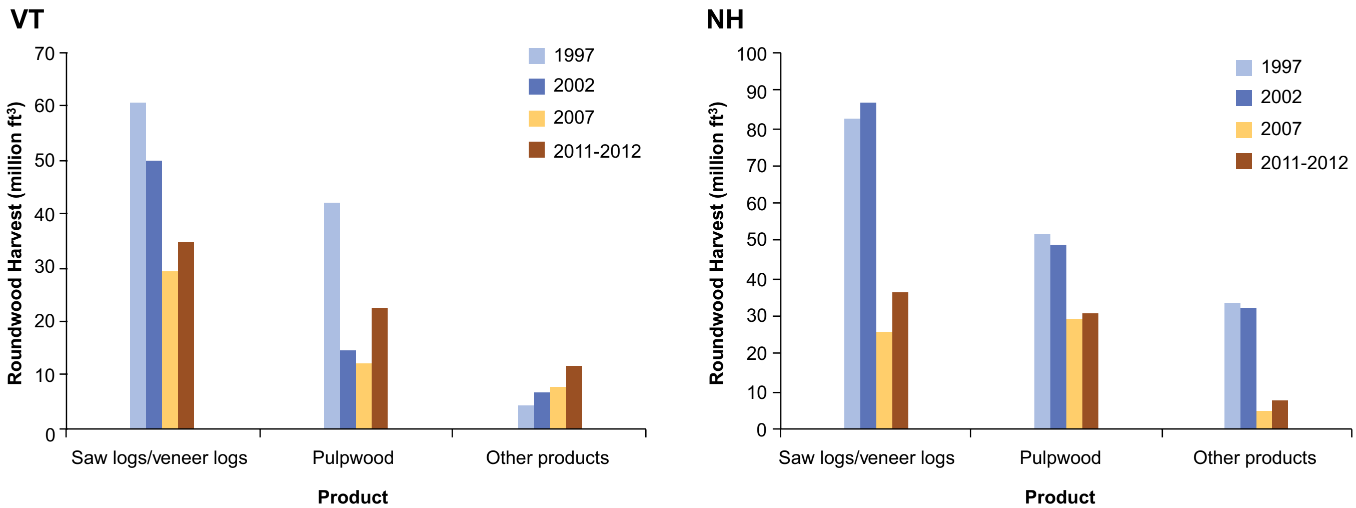


Figure 82.—Industrial roundwood harvested by product and year, Vermont, 2011, and New Hampshire, 2012.

Between 2002 and 2011, the number of employees working in the wood products and paper manufacturing industries decreased by 65 percent in Vermont and New Hampshire combined, and the total value of shipments decreased by more than 70 percent in Vermont and 65 percent in New Hampshire (U.S. Census Bureau 2011). After decreasing by 31 percent between 2002 and 2007, the harvesting of industrial roundwood in Vermont increased by 39 percent between 2007 and 2012. In New Hampshire, the harvesting of industrial roundwood decreased by more than 64 percent between 2002 and 2007 and then increased by 24 percent between 2007 and 2012 (Fig. 82).

What this means

The demand for wood products is increasing as the economy improves. The forest product mills that were able to withstand the recession have begun to increase their production. As the demand for lumber and other forest products increases, more people will need to be employed, and many part-time employees may begin working full time.

No pulp mills are currently operating in Vermont or New Hampshire. All of the pulpwood harvested in the two States is shipped to mills in surrounding states or Canada. Industrial fuelwood and industrial and residential pellets are additional markets for smaller diameter and lower quality roundwood. In addition, replacing fossil fuels used for energy and heating with biomass helps reduce the reliance on nonrenewable resources for Vermont and New Hampshire.

Projections for the Future

Fall color in New Hampshire. Photo by New Hampshire Division of Forests and Lands, used with permission.

Background

This section focuses on anticipated changes to the forests of Vermont and New Hampshire between 2010 and 2060. The Northern Forest Futures study (Shifley and Moser, in press) examined several alternative future scenarios that cover a range of different assumptions about the economy, population, climate, and other driving forces that will affect the future conditions of forests. The assumptions were incorporated into seven scenarios that consider how different alternative future climate conditions, demographic changes, and economic policies will affect forests. Additional details on methodology can be found in Shifley and Moser (in press).

Just as in the past, a large component of future forest change will be the result of normal forest growth, aging, natural regeneration, and species succession, but potential changes in regeneration were not considered in the model. However, those trends will be modified by other external forces:

- Population increases will cause roughly 0.5 million acres of forest land to be converted to urban land.
- Economic conditions will affect forest products consumption, production, and harvest rates.
- The spread of invasive species will affect forest change.
- Changes in human population, the economy, energy consumption, and energy production will affect future climate change.
- Climate change will affect patterns of forest growth and species succession.

The seven scenarios that were considered are briefly described below. The cryptic naming system is a link back to the more detailed scenario descriptions that originated from the Intergovernmental Panel on Climate Change (IPCC 2000):

1. A1B-C—Rapid economic globalization
2. A1B-BIO—Rapid economic globalization including the potential impact of increased harvest and utilization of woody biomass for energy
3. A2-C— Consolidation into economic regions
4. A2-BIO—Consolidation into economic regions including the potential impact of increased harvest and utilization of woody biomass for energy
5. A2-EAB—Consolidation into economic regions including the potential impact of continued spread of the emerald ash borer with associated mortality of all ash trees in the affected areas
6. B2-C—A trend toward local self-reliance and stronger communities
7. B2-BIO—A trend toward local self-reliance and stronger communities including the potential impact of increased harvest and utilization of woody biomass for energy

What we found

Anticipated declines in forest land under all scenarios may total in the hundreds of thousands of acres and will reverse the long-term trend of increasing forest area in Vermont and New Hampshire (Fig. 83). Specifically, over the next 50 years forest land area is projected to decline by 5.8 percent and 11.5 percent in Vermont and New Hampshire, respectively, under scenario A1B-C; by 4.1 percent and 10.7 percent under scenario A2-C; and by 3.2 percent and 8.4 percent under scenario B2-C. Only the storylines (developed around differing demographics and levels of economic activity) alter the area of forest land. Scenarios with greater increases in population and economic activity project less future forest land. Only three scenarios are represented in Figure 83 because the projected area of forest land is assumed to be unaffected by alternative climate change assumptions. The projected losses of forest land from 2010 to 2060 are relatively small compared to the cumulative increase in forest area since the start of the 20th century. In 2060, forest is expected to remain the dominant land cover in Vermont (from 70 to 72 percent) and New Hampshire (from 74 to 77 percent).

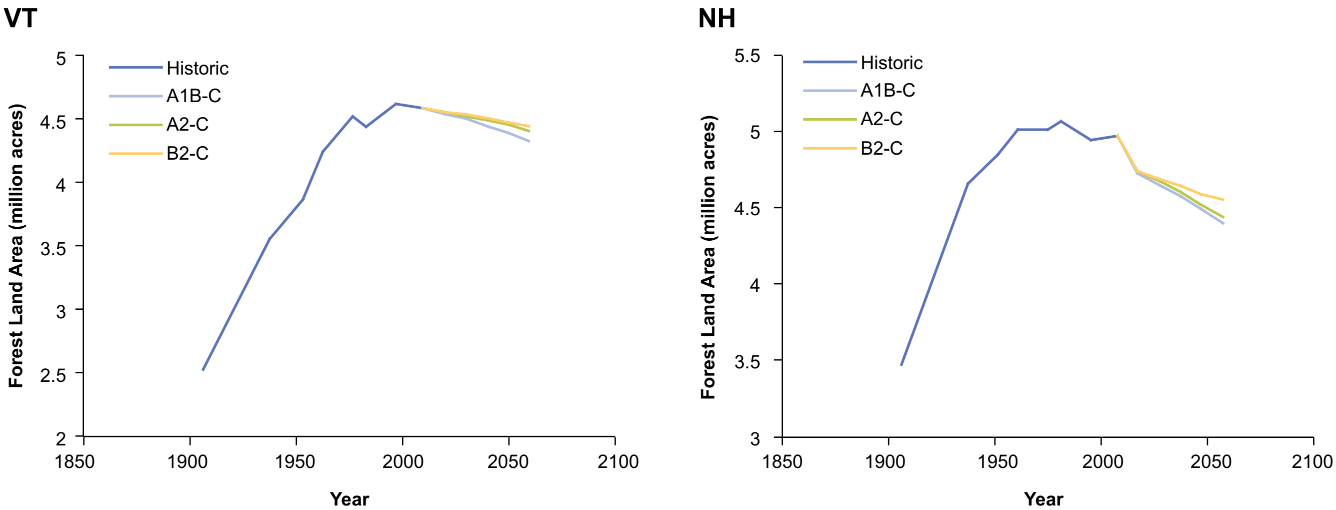


Figure 83.—Projected forest land area for 2010-2060 by scenario, Vermont and New Hampshire.

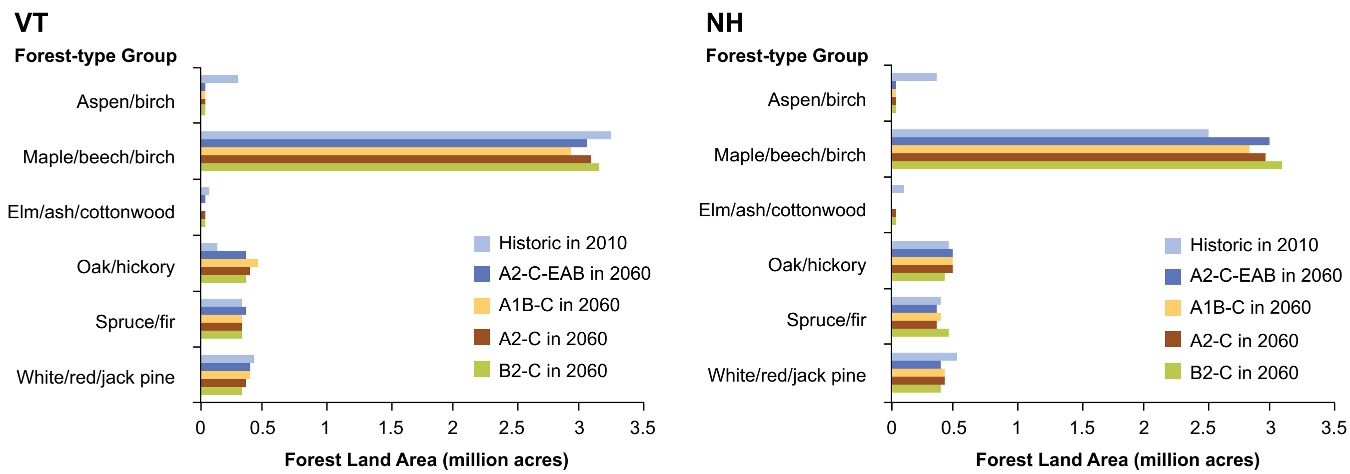


Figure 84.—Forest land area by forest-type group and scenario, Vermont and New Hampshire, 2010 and 2060.

EAB was detected near Concord, NH in March 2013. Under scenario A2-EAB there is a dip in the area of the elm/ash/cottonwood forest-type group because EAB is expected to virtually eliminate the ash tree resource in both States (Fig. 84). Ash species only make up 3 percent and 5 percent of the total live tree volume in Vermont and New Hampshire, respectively. Overall, for ash trees with a d.b.h. of at least 5 inches, about 37 million trees will be lost in Vermont and 26 million trees will be lost in New Hampshire.

The direct impacts of EAB are more pronounced when viewed in terms of forest volume rather than forest area (Fig. 85). For all scenarios, timber volume is projected to peak in 2020 or 2030 in both States. After 2020, the A2-EAB scenario is predicted to show a rapid decline in volume relative to scenario A2-C in Vermont and New Hampshire, which is the corresponding scenario modeled without projected losses to EAB. The scenarios with accelerated biomass removal for energy production (A1B-BIO, A2-BIO, and B2-BIO) show substantial declines in standing volume after 2050 in both States, comparable to or greater than declines in the EAB scenario.

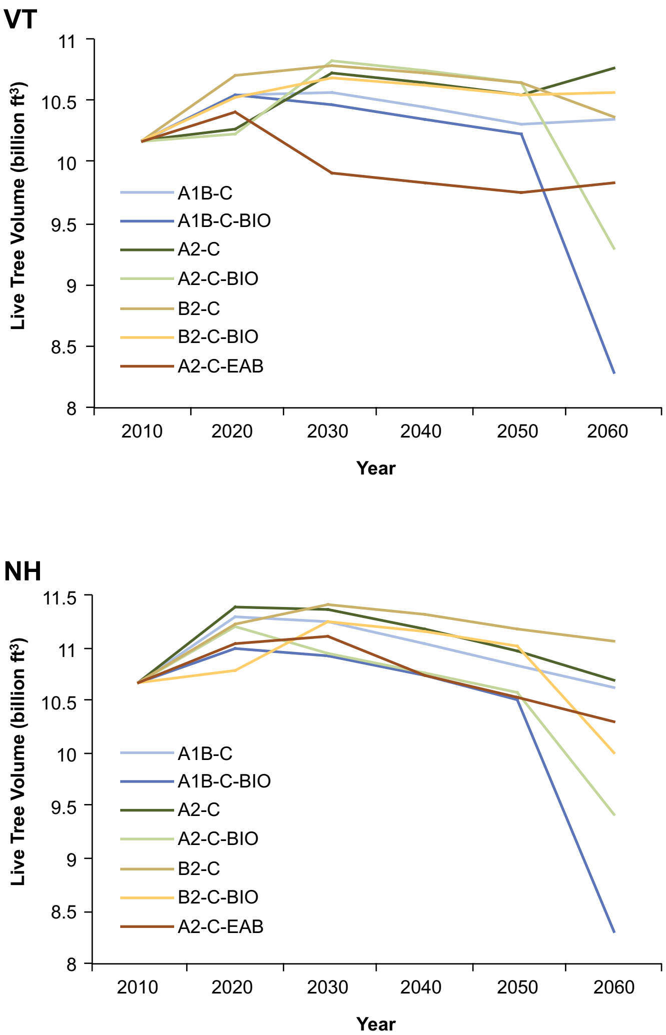


Figure 85.—Live tree volume on forest land by year and scenario, Vermont and New Hampshire.

Under the scenarios with a continuation of current removal rates (A1B-C, A2-C, and B2-C), live-tree volume is expected to increase (despite losses in forest land area) in both States until approximately 2030 and then drop to just above 2010 levels by 2060. Although the total area of forest land is expected to decrease, the volume per acre in these three scenarios is expected to increase as forests continue to mature in Vermont and New Hampshire.

What this means

The area of forest land is expected to decrease but the volume per acre is expected to increase as forests continue to mature. Nevertheless, the rate of volume increase is expected to be significantly slower than in the past. Over the past 50 years, forest managers have had the luxury of rapidly increasing forest volume with growth greatly exceeding removals. If projections hold true, that will not be the case for future generations of forest managers and wood-using industries. Changing trends result from the combined effects of gradually decreasing forest area and an aging forest resource with high volume but low net growth per acre. These projections should be considered as possible trends that will be influenced by actual future climate conditions, demographic changes, and economic policies relative to the assumptions.

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Vermont fall color. Photo by Randall Morin, U.S. Forest Service.

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Appendix. Tree Species in Vermont and New Hampshire

Scientific names of tree species mentioned in this report

Common Name	Scientific name
American beech	*Fagus americana*
Balsam fir	*Abies balsamea*
Black cherry	*Prunus serontina*
Black oak	*Quercus velutina*
Eastern hemlock	*Tsuga canadensis*
Eastern white pine	*Pinus strobus*
Northern red oak	*Quercus rubra*
Northern white-cedar	*Thuja occidentalis*
Paper birch	*Betula papyrifera*
Quaking aspen	*Populus tremuloides*
Red maple	*Acer rubrum*
Red spruce	*Picea rubens*
Sugar maple	*Acer saccharum*
Sweet birch	*Betula lenta*
White ash	*Fraxinus americana*
White oak	*Quercus alba*
Yellow birch	*Betula allegheniensis*

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The first full remeasurement of the annual inventory of the forests of Vermont and New Hampshire was completed in 2012 and covers nearly 9.5 million acres of forest land, with an average volume of nearly 2,300 cubic feet per acre. The data in this report are based on visits to 1,100 plots located across Vermont and 1,091 plots located across New Hampshire. Forest land is dominated by the maple/beech/birch forest-type group, which occupies 60 percent of total forest land area. Of the forest land, 64 percent consists of large diameter trees, 27 percent contains medium diameter trees, and 9 percent contains small diameter trees. The volume of growing stock on timberland has continued to increase since the 1980s and currently totals nearly 19 billion cubic feet. The average annual net growth of growing stock on timberland from 2007 to 2012 is approximately 380 million cubic feet per year. Important species compositional changes include increases in the number of red maple trees and American beech saplings which coincide with decreases in the number of eastern white pine and sugar maple trees as well as eastern white pine and northern red oak saplings. Additional information is presented on forest attributes, land use change, carbon, timber products, species composition, regeneration, and forest health. Detailed information on forest inventory methods and data quality estimates is included on the DVD accompanying this report. Tables of population estimates and a glossary are also included.

KEY WORDS: forest resources, forest health, forest products, volume, biomass, carbon, habitat

Beaver Brook Falls State Wayside Area, Colebrook, NH. Photo by Jennifer Weimer, New Hampshire Division of Forests and Lands, used with permission.

DVD Contents

Forests of Vermont and New Hampshire 2012 (PDF)

Forests of Vermont and New Hampshire 2012: Statistics, Methods, and Quality Assurance (PDF)

Vermont Inventory Database (CVS file)

Vermont Inventory Database (Access file)

New Hampshire Inventory Database (CVS file)

New Hampshire Inventory Database (Access file)

Field guides describing inventory procedures (PDF)

Database User Guides (PDF)

Forests of Vermont and New Hampshire 2012: Statistics, Methods, and Quality Assurance

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