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Abstract

The third 5-year annualized inventory of Maine's forests was completed in 2013 after more than 3170 forested plots were measured. Maine contains more than 17.6 million acres of forest land, an area that has been quite stable since 1960, covering more than 82 percent of the total land area. The number of live trees greater than 1 inch in diameter are approaching 24.5 billion trees. Aboveground biomass of all live trees has increased slightly since 2008. Over the same period, the average annual volume for tree growth has increased 30 percent and tree mortality has decreased 15 percent. Tree harvest levels have remained flat since 2008.This report also includes detailed information on forest inventory methods and the quality of the estimates found in five tables (Tables A-E). A complete set of data tables and other resources can be found at http://dx.doi.org/10.2737/NRS-RB-103.

Acknowledgments

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Cover: Long Reach, a tidal inlet surrounded by Sebascodegan Island in Maine. Photo by Ken Gallager via Wiki-Commons.

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Contents

Highlights

On the Plus Side

- Maine ranks only 39th in surface area (including water) among the 50 states, but ranks 17th in the total area of forest land, which is predominantly privately owned.
- The 17.6 million acres of forest land represents 82 percent of the total area of Maine, the highest proportion in the United States. This level of forest land has been maintained for more than 50 years.
- Timberland represents more than 96 percent of the forest land in each of the four megaregions and statewide.
- Within Maine's forest types, hardwood-dominated forests cover about 10.5 million acres while softwood-dominated forests amount to 7.1 million acres.
- The numbers of saplings has increased by more than 14.5 percent or 2.3 billion trees on forest lands since 2003. Balsam fir saplings have increased 18.5 percent, red spruce has increased 28 percent, and red maple saplings have increased 12.7 percent during the same 10-year period.
- Standing volume of live trees 5.0 inches diameter at breast height (d.b.h.) or greater on Maine's forest land has increased slightly since 2003, driven by a 6-percent increase in softwood volumes. Standing volume of hardwoods has held steady since 2003.
- Growing-stock removals (harvest and others) for all species combined is less than net growth. The net growth to removals ratio (G:R) is 1.3 on timberland. Softwood removals have been less than net growth (G:R=1.5) since 2003 while hardwood removals have become balanced with net growth 1.2 since 2008.
- Maine Forest Service wood processor reports showed the annual pulpwood harvests have been largely stable since 1990 with hardwood pulpwood going from 42 percent of the tonnage to 66 percent of the share in 2013. Biomass chip harvests are down 24 percent from a high of 3.52 million green tons in 2007.
- Maine's forests are estimated to sequester 1.4 billion metric tons of carbon as of 2013, which represent a 2 percent increase over 2003 levels. Most of the gain is found in the large-diameter stands with an actual decrease in medium-diameter stands. This is especially the case in the Southern Megaregion where most of the larger trees are white pines, eastern hemlocks, and northern red oaks.

- Given the lower than expected State population growth, Maine's forests are projected to increase in volume by 2060, in lieu of a high biomass utilization scenario taking place.

Areas of Concern

- Nearly three-fourths of the family forest owners do not have a management plan nor have they recently received forest management advice.
- Although the area of forest land classified as the northern hardwoods type has increased 8.9 percent (593,000 acres) since 1995, the area in the spruce/fir forest-type group has decreased 8.5 percent (491,000 acres).
- The forest area for small- and medium-diameter hardwood stands increased while medium- and large-diameter softwood stands have decreased in area since 1982.
- The area classified as the aspen/birch forest-type group has decreased 9.2 percent (208,000 acres) since 1982.
- Balsam fir, red spruce, and red maple have dominated the sapling numbers since 1982. They now represent 76 percent of the total gain in sapling numbers for the period between 2003 and 2013. There is a lack of regeneration for eastern white pine.
- Total hardwood growing-stock volume on timberland has declined slightly since 2003. This may be due to a significant increase (38 percent) in rough cull volume for hardwoods. Specifically, red maple and yellow birch had a 65 and 55 percent increase in rough cull volume, respectively, since 2003.
- American beech volume has continued to decline since 2003, surpassed by northern red oak.
- Hardwood growing-stock removals are greater than growth in the Northern (G:R=0.78) and Western (G:R=0.92) Megaregions. This is driven by the statewide G:R of 0.66 for sugar maple.
- Red spruce G:R is 0.94 statewide and 0.74 within the Northern Megaregion.

Issues to Watch

- The smaller parcels held by many landowners complicate the economics of forest management and the delivery of government programs. The trend toward more landowners with smaller parcels will only exacerbate this problem.
- 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. The number of wood-processing mills has been steadily declining across the region.
- Given the cyclical upturn in spruce budworm activity north of Maine, monitoring this insect's activities within the State's spruce/fir forests is crucial to management of a possible major infestation.
- Invasive insect pests such as the hemlock woolly adelgid and emerald ash borer are likely to increase impacts upon abundant tree species of Maine in the future.
- Commercial and residential development of forest land, particularly around Portland and Bangor, could cause reductions in forest cover if a significant upturn in the State's economy takes place.

Introduction

Since the late 1940s, the U.S. Forest Service has conducted a periodic inventory of Maine's forests, the beginning of statewide inventories in the northeastern region of the United States. Inventories of Maine forests were completed in 1959, 1971, 1982, and 1995 (with results reported in Ferguson and Longwood 1960, Ferguson and Kingsley 1972, Powell and Dickson 1984, Griffith and Alerich 1996, respectively). The State of Maine is divided into nine inventory units. In order to stratify similar attributes on a larger scale, the nine inventory units are combined into four megaregions (Fig. 1).

In 1999, Maine and the U.S. Forest Service commenced an annual inventory program requiring 20 percent of the statewide plots to be surveyed each year, with all plots being inventoried every 5 years. These 5-year inventories were completed in 2003, 2008 (with results reported in McWilliams 2005 and McCaskill et al. 2011, respectively), and 2013. This publication presents results from the inventory completed in 2013 (hereafter referred to as the Maine 2013 inventory). Estimates presented here are based on 3,171 accessible forested plots.

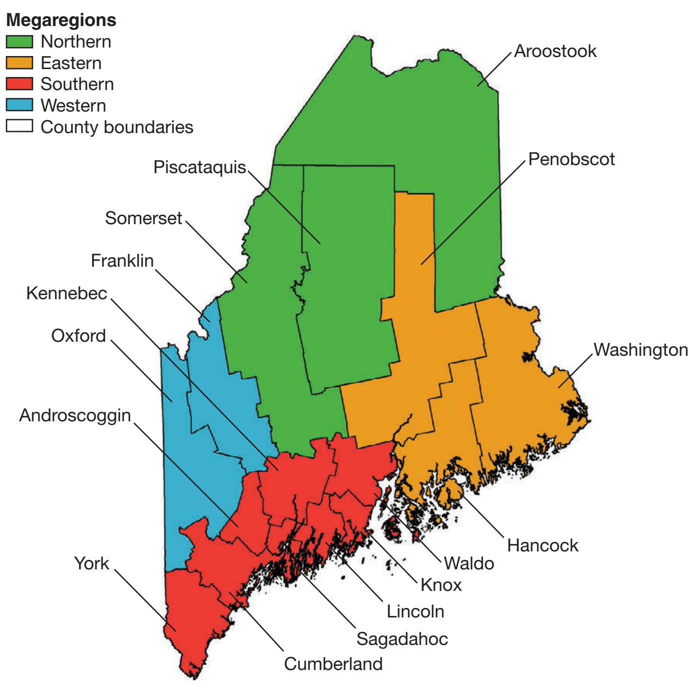


Figure 1.—Forest Inventory and Analysis (FIA) megaregions, Maine.

The Northern Research Station's Forest Inventory and Analysis (FIA) program is currently transitioning its forest health monitoring over the next few years. The approach is to decrease the data collected on each inventory plot while increasing the subset of forest health plots and the amount of data collected on forest health indicators.

This report is the first opportunity to compare the inventory periods of 1999-2003 with 2009-2013, providing a much longer 10-year "window" to observe trends. In reality, a 10-year period is closer to the time intervals between the periodic surveys than 5 years. Therefore, many of the tables and figures this report will present the periodic results of the 1982 and 1995 surveys along with the 2003 and 2013 annualized data. The 2008 data is not presented in many graphs in order to maintain at least 8 years between survey years. There will be a discussion of the trends based upon the 10-year period as well as the comparisons with the 1982 and 1995 periodic inventories.

A Guide to the FIA Forest Inventory

What is a tree?

The Forest Inventory and Analysis (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. This standard is based upon the average height at maturity for all individuals of a group (species). A complete list of the tree species measured in Maine during the 2013 inventory is included in the appendix. For a complete list of plants classified as trees by FIA, refer to the FIA field manual, version 6.0 (U.S. Forest Service 2012a).

What is a forest?

A forest is a collection of trees that can come in many forms depending on temperature, precipitation, topography, quality of soils, and the available gene pool for the dispersion of plant species. Forest stands can be very tall, heavily dense, and multi-structured or short, sparsely populated, and a single layer of trees. FIA defines forest land as land that contains at least 10 percent canopy cover by trees of any size or formally having been stocked and not currently developed for nonforest or forest 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?

FIA classifies forest land into three categories:

- Timberland is forest land that is producing or is capable of producing crops of industrial wood and is not withdrawn from timber utilization by stature or administrative regulation. These lands must be capable of producing in excess of 20 cubic feet per acre (about one-fourth of a cord) per year of industrial wood in natural stands. Inaccessible and inoperable areas can be included.
- Reserved forest land is all forest land that is withdrawn from timber utilization through statute or administrative regulation without regard to productive status, e.g., state parks, national parks, and federal wilderness areas.
- Other forest land is incapable of producing 20 cubic feet per acre per year of industrial wood in natural stands and is not restricted from harvesting. Sometimes such forest land is referred to as being "unproductive" or "less productive" with respect to wood fiber production.

In Maine, about 97 percent of all forest land is classified as timberland, 2 percent as reserved, and 1 percent is "other" forest land.

How many trees are in Maine?

Maine's forest land contains approximately 3.2 billion live trees that are at least 5 inches in diameter at breast height (d.b.h.; diameter of the tree at 4.5 feet above the ground). We do not know the exact number of trees because the estimate is based upon on a sample of the total population. The estimates are calculated from field measurements of 3,171 accessible forested plots classified by ownership. For information on sampling errors, see the Statistics, Methods, and Quality Assurance section found at http://dx.doi.org/10.2737/NRS-RB-103.

How do we estimate a tree's volume?

The volume for a specific tree species is usually determined by the use of equations developed specifically for a given tree species. Sample trees are felled and measured for length, diameter, and taper. Several volume equations have been developed by the U.S. Forest Service and others for each tree species found within the region. Tree volumes are reported in cubic-foot and in the International ¼-inch Rule board-foot scale.

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's Forest Products Laboratory and applied to FIA tree volume estimates for developing merchantable tree biomass (weight of tree bole). To calculate total live-tree biomass, we have to add the biomass for stumps (Raile 1982), limbs and tops (Hahn 1984), and belowground stump and coarse roots (Jenkins et al. 2004). We do not currently report live biomass for foliage. FIA reports 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?

Comparing current inventory data with older periodic surveys is commonly conducted to try to analyze trends or changes in forest structure, stocking, growth, mortality, removals, and ownership acreage over time (Powell 1985). The periodic inventories conducted in 1982 and 1995 used the same basic sampling frame and the same data collection procedures as the current annual inventory, and therefore are generally comparable. But, an immediate problem arises when comparing results between different surveys while dealing with a consistently smaller sampling-size encountered from the earlier inventory. The 1982 survey involved the remeasurement of 1,222 plots from the 1971 survey along with the establishment of 2,475 new ground plots. Then, the 1995 inventory utilized 2,192 remeasured plots from the 1982 survey and the establishment of 809 new ground plots. The first annualized inventory (1999-2003) included 3,001 plots from the 1995 inventory and the establishment of 181 new ground plots. Another pitfall occurs when comparing an attribute processed using different algorithms. Significant changes were made to the methods for estimating biomass (dry weight), the calculation of change components such as net growth, removals, and mortality, as well as for tree height and percent cull for trees in the northeastern states. Two examples of algorithm changes to data processing are the component ratio method (CRM) (Heath et al. 2009) utilized for biomass determination, and the mid-point method applied for many of the component of change calculations.

A word of caution on suitability and availability

FIA does not identify which lands are available for timber harvesting especially since the availability is subject to changing laws and ownership objectives. If land is classified as timberland, that does not mean it is available for timber production.

Forest inventory data are inadequate for determining availability of forests for timber harvesting since a multitude of reasons could preclude interest in wood production.

National Woodland Owner Survey (NWOS)

FIA conducts the National Woodland Owner Survey (NWOS) as the social complement to its biophysical inventory. The NWOS is based upon the responses from a random sample of private landowners to help understand: who owns the forest; why they own them; what have they done to them in the past; and what are they planning on doing in the future. The data reported here were collected between 2011 and 2013 (Butler et al. 2016a, b). Additional information about the NWOS can be found at www.fia.fs.fed.us/nwos.

Maine: A Forestry State and Its Forest Features

Spruce-fir forest of Mt. Bigelow, West Peak Maine. Photo by Petersent via Wiki-Commons.

Forest Land Area

Forests are evaluated by their extent (number of acres), ownership, composition (number of trees by species), structure (stand-size distributions), species abundance, and stand volume (tree size). This data helps to create a clear vision of the forest resources and conditions found in Maine.

Background

Determining the current acreage of forest land and timberland in Maine provides a means to evaluate not only the status of the forest resource base, but also changes in its composition and ownership. Major shifts in land use or reductions in acreage could be an indication of forest health issues or forest fragmentation concerns. Monitoring significant changes in the composition or ownership of forest land is an effective and informative way to make decisions. Maine has been a forest-dependent region for almost 400 years (Coolidge 1963). Even though it is famous for its marine resources, Maine's core economy finds its roots in the forest, and the stability of this resource is key to the State's growth (Irland 1998).

What we found

Maine is a State where forests dominate the landscape. Forests make up 83 percent of the surface area in Maine (17.6 million acres) (Fig. 2). Cities and agricultural lands (nonforest) occupy about 9.8 percent of the State. Inland waterways (census water and noncensus water) cover another 7 percent of Maine (Fig. 3). Timberland represents 80 percent of the surface area of the State (17.0 million acres) and has been quite stable since the 1958 inventory (Ferguson and Longwood 1960) (Fig. 4). Other productive (reserved) and unproductive forest land (including unproductive timberlands) make-up 2.8 percent, collectively.

Maine is the 39th largest State in surface area, but is the 17th largest in the number of forested acres. The citizens of Maine not only live amongst a vast forested landscape, but many of them heavily rely on those forests for their livelihoods.

The Northern Megaregion (Aroostook, Piscataquis, and Somerset Counties) contains 49 percent of the State's timberland or 8.3 million acres; the Eastern Megaregion (Hancock, Penobscot, and Washington Counties) has 25 percent of the timberland or 4.2 million acres; the Southern Megaregion (Casco Bay and Capital FIA units made up of eight smaller counties) consists of 13 percent or 2.3 million timberland acres; and the Western Megaregion (Franklin and Oxford Counties) also containing about 13 percent or approximately 2.2 million acres of timberland (Fig. 1).

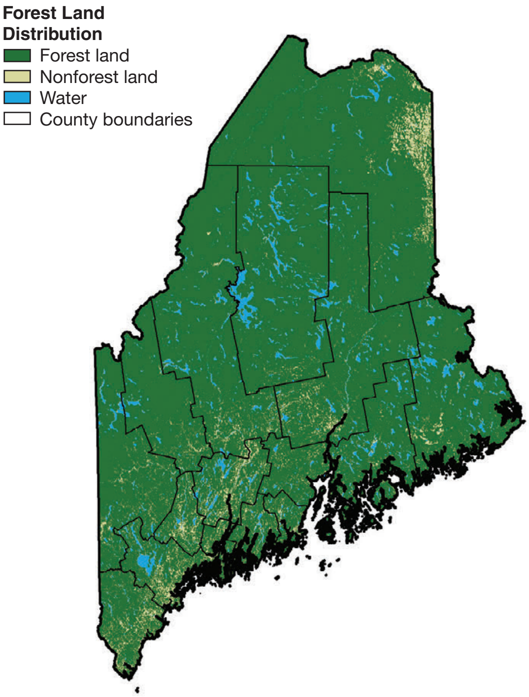


Figure 2.—Forest versus nonforest land, Maine, 2013.

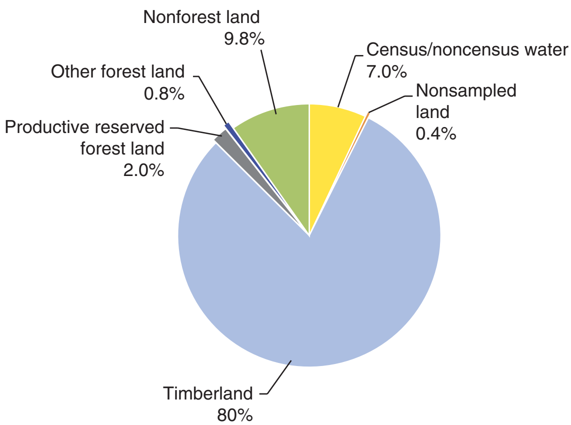


Figure 3.—Percentage of area by land-cover class, Maine, 2013.

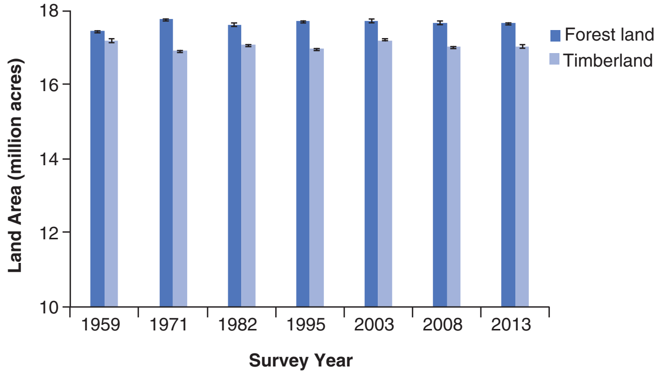


Figure 4.—Historical trends in the area of forest land and timberland in Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

What does it mean

Since the forests of Maine are very important to the livelihood of its citizens, a stable forest land base contributes to a stable economy. The area of forest land and timberlands within Maine's landscape has remained relatively stable for more than 50 years.

Maine's Forest Profile

Background

Maine's forests are in a transition zone between the boreal forests to the north and the eastern deciduous forests to the south (Hasbrouck and Connors 1987). This transition zone creates an ecotone in Maine with substantial populations of tree species from both of these forest biomes. Maine's forest resources are particularly unique having a composition of tree species which are nearly equally divided between hardwood and softwood forest types (Fig. 5). In addition, tree species composition is impacted by many watercourses and lakes distributed throughout the State. The U.S. Geological Survey (USGS) has divided most of the United States into watershed administrative units (WAUs). Maine has six major WAU drainage basins (Fig. 6), which can be further divided into 21 subunits for local applications (Watermolen 2002).

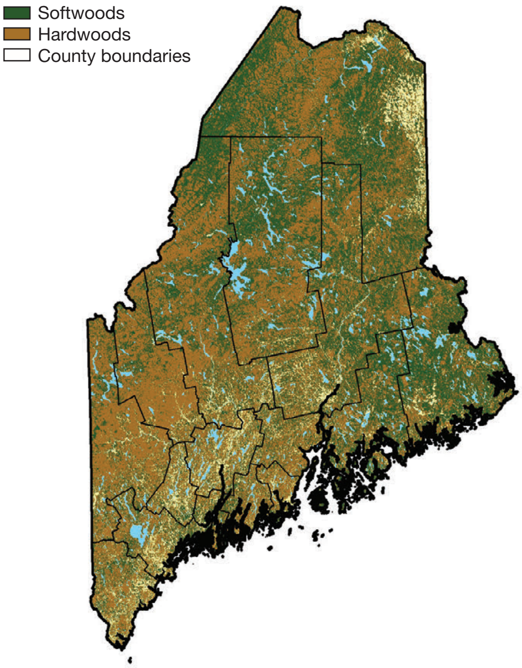


Figure 5.—Distribution of softwood and hardwood dominated forest types, Maine, 2013.

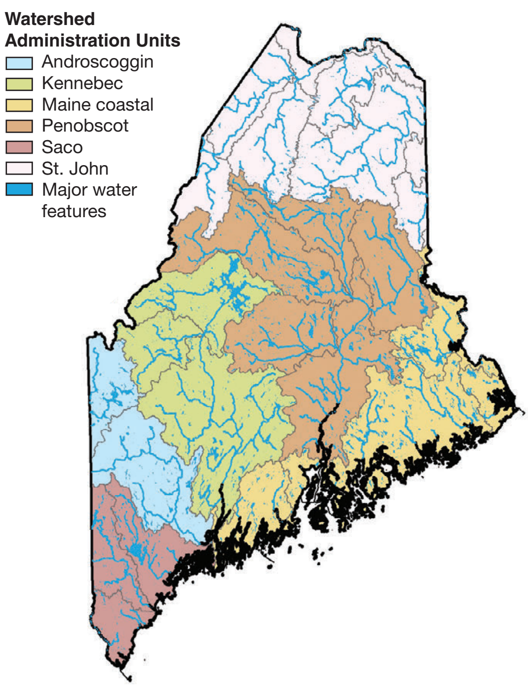


Figure 6.—Watershed Administrative Units of Maine.

What we found

Maine's forest resources are rich in species and complexity. Softwood-dominated forests contain many hardwood species, and hardwood-dominated forests are mixed with softwood species. The tree species found in Maine come from three major forest ecotypes and from some smaller groups that can be further divided into 25 recognizable forest communities (McCaskill et al. 2011). The three ecotypes are:

- Northern coniferous forests
- Northern mixed-hardwood forests
- Oak/pine forests

The northern coniferous forests are primarily composed of the spruce/fir forest-type group dominated by balsam fir (see appendix for all tree species' scientific names) red spruce, and northern white-cedar and a mixture of northern hardwood species such as aspen and paper birch. White spruce and jack pine are found in greater numbers to the north. These forests can be found upon granite parent material extending from the White Mountains toward Mt. Katahdin in north-central Maine or on well-drained soils derived from glacial till.

The northern mixed hardwoods of central Maine are dominated by species from the maple/beech/birch forest-type group, containing sugar maple, yellow birch, American beech, red maple, and paper birch, as well as white ash, and a number of conifer species highlighted by eastern hemlock. Mixed northern hardwoods are generally found on the finer clay soils within Maine. The northern coniferous and northern mixed hardwood forests make up the larger northern forest of the New England-Acadian ecoregion (Dobbs and Ober 1996).

The oak/pine forests of southern Maine are composed of red oak, eastern white pine, red maple, eastern hemlock, white ash, and a few hickories. These forests are found primarily in southern Maine growing on sandy gravels and make up a portion of the Northeastern coastal forest ecoregion.

Forests are also abundant in Maine's wetland areas found along the coastal areas and within upland depressions. These forests consist of tamarack, northern white-cedar, and black spruce to the north. Southern Maine's wetlands contain a limited number of Atlantic white cedar, ash, hemlock, black spruce, and some scattered tupelos in the south. Most of Maine's wetlands are developed from poorly drained organic soils with a heavy clay pan.

Eastern hemlocks can also be found in isolated pure stands along the coast, or mixed with white pine or yellow birch in in the rest of the state. Jack pine grows in small isolated pure stands in the mountains along the northwestern border or mixed with red pine, quaking aspen, and white pine in central Maine. Finally, jack pine inhabits the most southeastern portion of its range within the State.

What this means

The overlapping and complex nature of Maine's forests means that if a softwood forest is harvested, the residual stand can become dominated with hardwoods within a very short time. On the other hand, if hardwood forests are left undisturbed, many stands will be eventually overtaken by softwood species. Given the strong interaction between hardwoods and softwoods, the ecotone within Maine's forests could shift dramatically in composition and structure if environmental conditions change and if land management techniques fail to include measures to control species composition (Frelich 2008, Perry 1994).

Forest Land Ownership

Background

How land is managed is primarily the owner's decision and the availability and quality of forest resources, including recreational opportunities, timber availability, and wildlife habitat conservation are determined by landowners. By understanding the priorities of forest land owners, leaders of the forest conservation community can better help owners meet their needs, and in so doing, help conserve the State's forests for future generations.

The National Woodland Owner Survey (NWOS), conducted by the U.S. Forest Service, studies private forest landowners' attitudes, management objectives, and concerns. It focuses on the diverse and dynamic group of owners that is the least understood—families, individuals, trusts, estates, and family partnerships—and collectively referred to as "family forest owners." The data reported here are based on the responses from 255 family forest ownerships in Maine that responded to the NWOS questionnaire between 2011 and 2013. This survey focused on family forest owners with 10 or more acres of forest land. More information on the NWOS can be found at http://www.fia.fs.fed.us/nwos.

What we found

Ninety-three percent of Maine's forest land (an estimated 16.4 million acres) is privately owned (Fig. 7). Of these private forests, an estimated 10.2 million acres are owned by corporations, most of which are focused on the commercial production of timber. Family forest owners control about 5.6 million acres of forest land in the State. The remaining "other private" forest land, just over half a million acres, is owned by conservation organizations, clubs, and Native American tribes.

Public agencies control almost 1.3 million acres, or 7 percent, of Maine's forest land. The Maine Department of Agriculture, Conservation, and Forests (DACF) are the State's parks and public lands, which include 880,000 acres of forest land, while local government agencies control an additional 210,000 acres. The U.S. Forest Service, the U.S. Fish & Wildlife Service, and the National Park Service control an estimated 58,000 acres each while the U.S. Department of Defense manages some small parcels within the State.

There are an estimated 86,000 family forest ownerships across Maine that each own at least 10 acres of forest land, a collective 5.3 million acres (Butler et al. 2016b). The average forest holding size of this group is 64 acres; 52 percent of these family forest

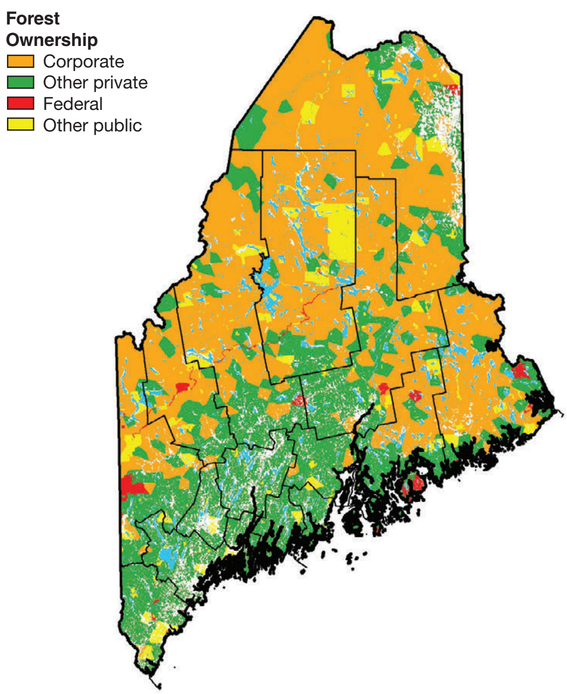


Figure 7.—Area of forest land by major ownership groups, Maine, 2013.

ownerships own less than 50 acres of forest land, and 77 percent of the collective forest land is in holdings of at least 50 acres (Fig. 8). The primary reasons for owning forest land are related to aesthetics, privacy, wildlife, nature protection, and family legacy (Fig. 9).

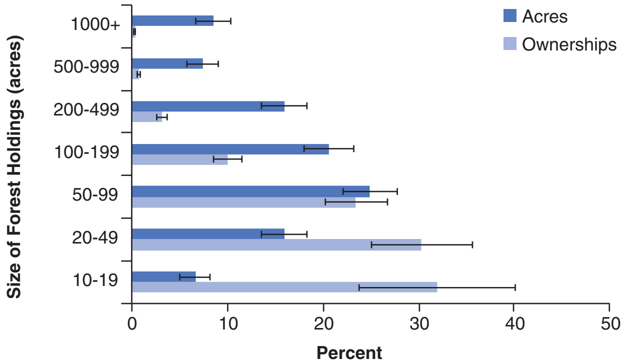
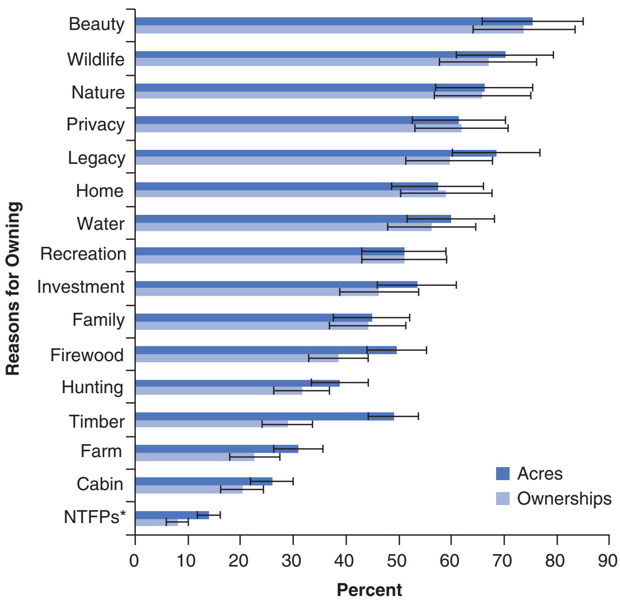


Figure 8.—Percentage of family forest ownerships and acres of forest land by size of forest land holdings, Maine, 2013. Error bars represent a 68 percent confidence interval around the estimated mean.



* Nontimber forest products

Figure 9.—Percentage of family forest ownerships and acres of forest land by reasons given for owning forest land ranked as very important or important, Maine, 2013. Categories are not exclusive. Error bars represent a 68 percent confidence interval around the estimated mean.

Recreation and cutting trees for personal use are the two most common land management objectives by the percentage of ownerships and acres. Although timber production is not a major ownership objective, one-quarter of the family forest ownerships (46 percent of the acreage) have commercially harvested trees in the last 5 years; those who have harvested tend to own larger holdings (Fig. 10).

Similarly, about one-quarter of the ownerships, owning 53 percent of the family forest land, have a written management plan (Fig. 11). The average age of family forest owners in Maine is 62 years with 44 percent of the family forest land owned by people who are at least 65 years of age (Fig. 12).

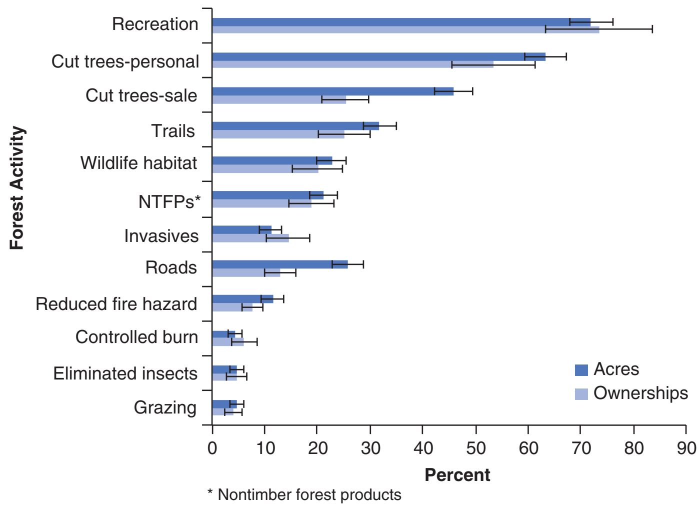


Figure 10.—Percentage of family forest ownerships and acres of forest land by forest activity in the past 5 years, Maine, 2013. Categories are not exclusive. Error bars represent a 68 percent confidence interval around the estimated mean.

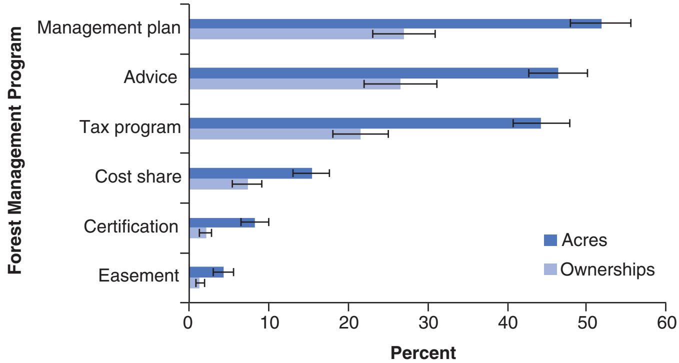


Figure 11.—Percentage of family forest ownerships and acres of forest land by participation in specific forest management programs, Maine, 2013. Categories are not exclusive. Error bars represent a 68 percent confidence interval around the estimated mean.

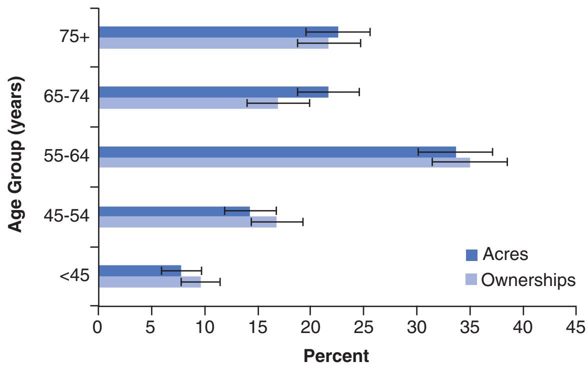


Figure 12.—Percentage of family forest ownerships and acres of forest land by age of primary owner, Maine, 2013. Categories are not exclusive. Error bars represent a 68 percent confidence interval around the estimated mean.

What this means

The forests of Maine are dominated by a variety private forest ownership groups. Aside from corporate-owned land, the fate of the forest lays primarily in the hands of families and hence it is important to understand them and what policies and programs can help them conserve the forests for current and future generations. Family forest owners are the group that is the least understood and whose ownership is arguably the most uncertain. Even though they own their land primarily for amenity reasons, many are actively managing their forests. That being said, nearly three-fourths of the owners do not have a management plan nor have they recently received forest management advice. There are significant opportunities to help these owners increase their engagement and stewardship of their lands. Programs such as Tools for Engaging Landowners Effectively (http://www.engaginglandowners.org) can help the conservation community develop and implement programs more effectively and efficiently.

Another important trend is the aging of the family forest owners. With many owners being relatively advanced in age, this portends many acres of land passing on to the next generation in the near future. There are programs such as Your Land Your Legacy (http://masswoods.net/monthly-update/your-land-your-legacy-deciding-future-your-land) and Ties to the Land (http://tiestotheland.org) that have been implemented to help owners meet their bequest goals, but it is uncertain who the future forest owners will be and what they will do with their land.

Forest Resources

Spruce-fir-maple forests near Wolfes Neck, Maine. Photo by Richard Widmann, U.S. Forest Service.

Forest-type Groups

Background

The species composition of a forest is the result of the long-term interaction of competition between tree species, soil conditions, topography, climate, and large scale disturbance, among other factors. Stand replacement disturbances in Maine can include windstorms, droughts followed by wildfires, insects and disease epidemics (i.e., spruce budworm), timber harvesting, and land clearing for development. Secondary forest succession occurs as forests recover from disturbance through stand growth, resulting in environmental conditions that favor shade-tolerant species over the early pioneering, shade intolerants. Forest management practices can intervene to perpetuate the faster-growing shade intolerants within a stand.

FIA collects information on forest composition through the number of trees by species and size, forest type, and forest-type group. Forest types describe an assembly of species that frequently grow in association with one another and dominate the stand. Similar forest types are combined into forest-type groups.

What we found

FIA has identified six major forest-type groups in Maine representing both softwood-dominated and hardwood-dominated forests (Fig. 13). The two largest forest-type groups are sugar maple/beech/yellow birch making up 7.2 million acres of forest land and spruce/fir which is found on 5.9 million acres. These two forest-type groups represent 75 percent of the forested acreage within Maine. Other major forest-type groups are the aspen/birch consisting of 2.1 million acres and white/red/jack pine comprising 1.1 million acres. The Northern Megaregion has 3.7 million acres of spruce/fir, another 3.3 million acres of sugar maple/beech/yellow birch, and 1.0 million acres of aspen/birch. The Eastern Megaregion has 1.8 million acres of spruce/fir forests, 1.1 million acres of maple/beech/yellow birch, and 623,000 acres of aspen/birch.

The Southern Megaregion has 782,689 acres of sugar maple/beech/yellow birch, 417,385 acres of the white/red pine type, and another 449,000 acres of oak/pine/hickory which combines the smaller oak/pine and oak/hickory forest-type groups. Finally, the Western Megaregion has 1.3 million acres of maple/beech/yellow birch, 306,000 acres of aspen/birch, and 312,000 acres of spruce/fir.

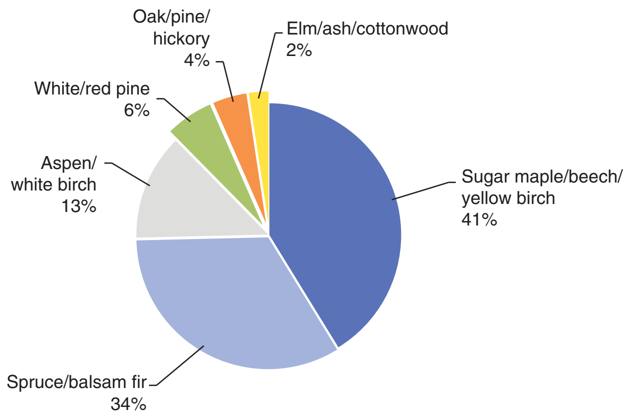


Figure 13.—Percentage of forest land area by forest-type group, Maine, 2013.

Sugar maple/beech/yellow birch forests are found widely distributed throughout the State, but are more concentrated in Oxford, Franklin, Somerset, Piscataquis Counties, and the central portion of Aroostook County (Fig. 14). In Maine, the sugar maple/beech/yellow birch forest-type group is composed of 20 percent red maple, 12 percent balsam fir, 11.8 percent sugar maple, 10 percent yellow birch, and 10 percent American beech (composition based on live trees 5.0 inches d.b.h. and greater). Balsam fir is the second most abundant species in this group but is not reflected in the group name.

Eighty percent of the spruce/fir forests (by cubic foot volume) are located in the northern counties of Aroostook, Penobscot, and Piscataquis; the northern portions of Somerset and Franklin Counties; and the northeastern coastal counties of Washington and Hancock (Fig. 15). The spruce/fir forest-type group is composed of 28 percent balsam fir, 21 percent northern white-cedar, 19 percent red spruce, and 7 percent black spruce (composition based on live trees 5.0 inches d.b.h. and greater). Again, the second most abundant species, northern white-cedar, is not reflected in the group name.

Aspen/birch forests are concentrated in Franklin, Somerset, and Piscataquis Counties, with smaller patches to the north in Aroostook County (Fig. 16). This forest-type group is composed of 22 percent balsam fir, 19 percent paper birch, 11 percent aspen, and 10.5 percent red maple (composition based on live trees 5.0 inches d.b.h. and greater). Here, balsam fir is the dominant species but is not reflected in the group name.

Finally, white/red/jack pine forests are concentrated in the southern counties of Maine, from York to Sagadahoc County, and are mixed with coastal spruce up into Washington County (Fig. 17). The white/red/jack pine forest-type group is composed of 31 percent white pine, 23 percent eastern hemlock, 10 percent red maple, and 8 percent red spruce (composition based on live trees 5.0 inches d.b.h. and greater). Eastern hemlock is the second most abundant tree species in this group while not indicated in group name.

What this means

Forest-types are composed of mixtures of hardwood and softwood species in different numbers. Depending on the disturbance regime, aspen/birch forests could easily convert to spruce/fir forests, or harvested spruce/fir forests could change back to aspen/birch. With Maine's forest regeneration being dominated by balsam fir in the north and red maple in the south, the current situation finds maple/beech/birch forests widely distributed throughout the State, while most of the spruce/fir forests are located in the Northern and Eastern Megaregions. Sixty percent of the aspen/birch acres are found with the maples in the Western Megaregion and in scattered pockets distributed throughout central Maine. White/red pine forests containing eastern hemlock are prominent along the coast and associated with minor hardwood forest types within the Southern Megaregion.

Given the strong competition that exists between hardwood and softwood tree species, it is important to keep track of changes in composition over time through consistent monitoring so the current status of the State's forest resources by forest type-group is known while updating the algorithms that determine the name for each forest type.

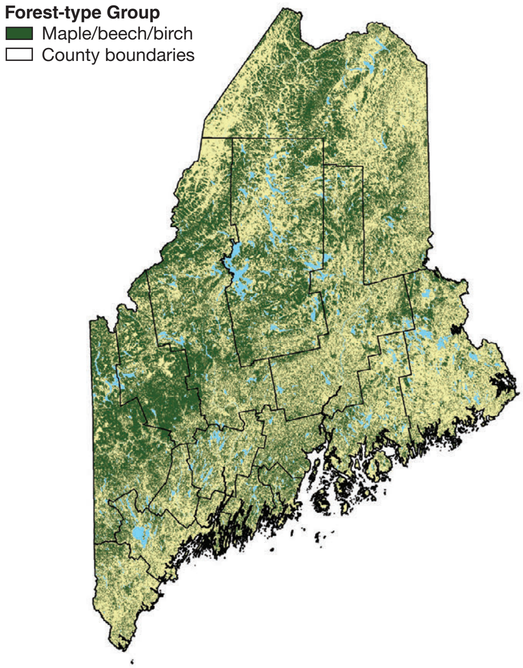


Figure 14.—Distribution of the sugar maple/beech/yellow birch forest-type group on forest land, Maine, 2013.

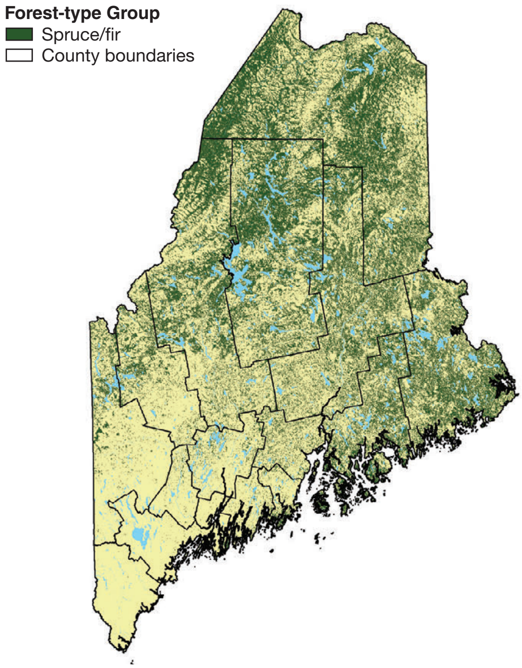


Figure 15.—Distribution of the spruce/fir forest-type group on forest land, Maine, 2013.

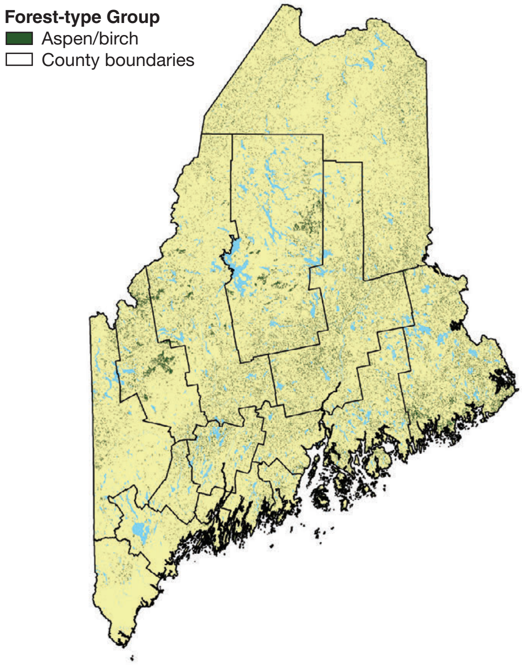


Figure 16.—Distribution of the aspen/birch forest-type group on forest land, Maine, 2013.

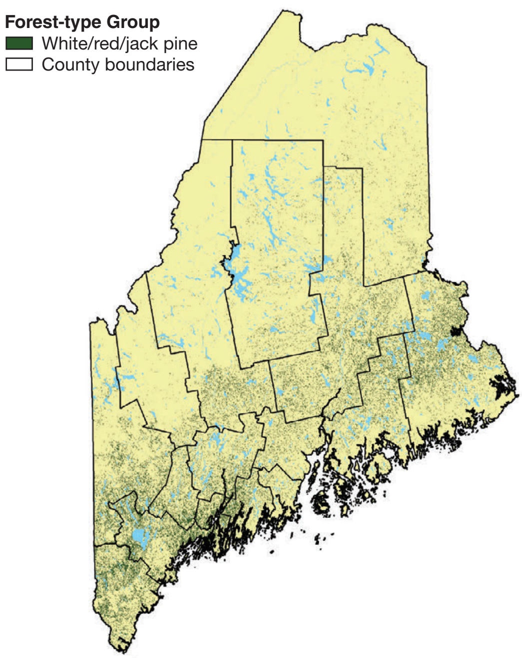


Figure 17.—Distribution of the white/red/jack pine forest-type group (with hemlock) on forest land, Maine, 2013.

Forest-type Groups by Stand Size

Background

Tree diameter measurements are used by FIA to assign a stand-size class to a sampled forested area. There are three categories of diameter-size classes determined from the majority of the stocking of live trees per acre within an area.

Sapling or small diameter stands are dominated by trees less than 5.0 inches d.b.h. but greater than 1.0 inch d.b.h. or root collar diameter (d.r.c.). Poletimber or medium diameter stands have a majority of trees at least 5.0 inches d.b.h. but less than the diameter standards for a softwood or hardwood saw log tree. Sawtimber or large diameter stands consist of a preponderance of trees at least 9.0 inches d.b.h. for softwood species and 11.0 inches d.b.h. for hardwood species.

What we found

The statewide acreage for the maple/beech/birch forest-type group is expanding. Since 2003, the area has increased by 260,000 acres. This gain is mainly in the small diameter classes (less than 5.0 inches d.b.h.), especially since the periodic surveys of 1982 and 1995 (Fig. 18). During the same period, the spruce/fir forest-type group had a shift in acreage from the large-diameter class to the medium- and small-diameter classes without a decrease in acreage (Fig. 19). The aspen/birch forest-type group decreased 311,000 acres in the small- and medium-diameter classes throughout the State (Fig. 20). White/red/jack pine forest-type group shows no significant overall change in acreage, however the area in large-diameter stands increased at the expense of the acreage for medium diameter stands (Fig. 21).

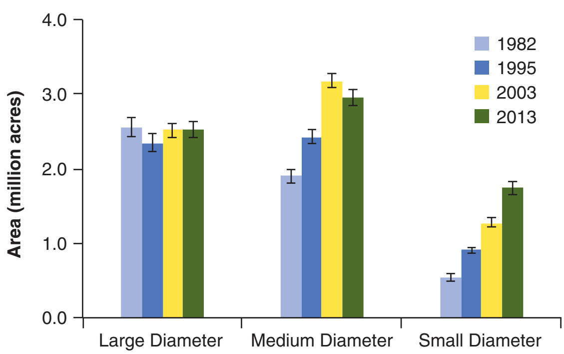


Figure 18.—Area of the sugar maple/beech/yellow birch forest-type group by stand-size class and inventory year, Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

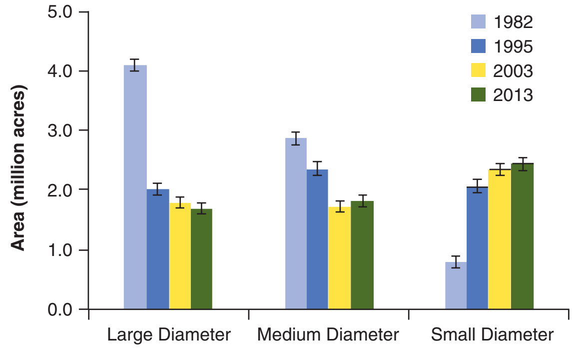


Figure 19.—Area of the spruce/fir forest-type group by stand-size class and inventory year, Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

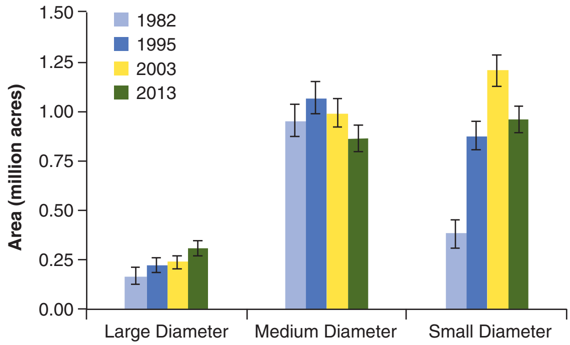


Figure 20.—Area of the aspen/birch forest-type group by stand-size class and inventory year, Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

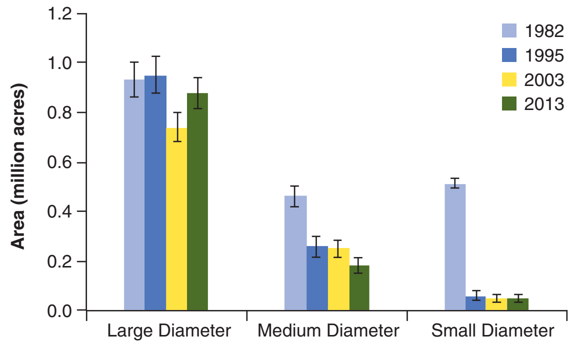


Figure 21.—Area of the white/red/jack pine forest-type group by stand-size class and inventory year, Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

What this means

The statewide gains in acreage for maple/beech/birch forest-type group occurred within the medium- and small-diameter stands at the expense of the aspen/birch acres. Spruce/fir forests had a shift from areas with larger diameter trees to smaller diameter-sized stands as a result of 15 years of harvest operations used to combat spruce budworm infestations (Solomon and Braun 1992).

The aspen/birch forests are losing acreage. The loss is in the areas containing trees with medium-and small-sized diameters. White/red/jack pine forests have a small shift from areas containing medium diameter-sized trees to areas containing large-diameter trees as these forests continue to mature.

Numbers of Trees

Background

The numbers of live and growing-stock trees, along with standing dead trees, are used to calculate volume, growth, and mortality (Powell 1985). If the numbers of growing-stock trees are increasing across diameter classes, then merchantable standing volumes should also be increasing. Hardwood and softwood tree species have comparable stocking levels, so the inventory data has been divided into softwood and hardwood species in order to effectively evaluate changes over time. The numbers of live trees in the sapling- and pole-sized diameter classes can also be used to evaluate regeneration, and follows growing-stock numbers.

What we found

There is an increase in the statewide proportion of red maple and northern white-cedar growing-stock trees (≥5.0 inches d.b.h.) established on Maine's forest land since 1982 (Table 1). More than 61 percent of the gain came from red maple. Balsam fir, red maple, and red spruce represent the greatest proportion (75 percent) of the gain in growing-stock trees on Maine's forest land since 2003. Balsam fir growing stock decreased from 23 to 16 percent of the population from 1995 through 2003, but rebounded to almost 20 percent in 2013 (Table 1). The spruces (red, white, and black spruce) decreased from 25 (in 1995) to 18 percent (2003) within the growing-stock numbers without the same level of recovery. In contrast, red maple increased to

13 percent of the total population in 1995 and has remained at that level. Northern white-cedar numbers also increased since 1982. Most of the statewide increase in the number of growing-stock trees are found within the pole-sized diameter classes (5.0 to 6.9 inches), showing a recovery between 2003 and 2008 (Fig. 22). Softwood growing-stock trees accounted for most of the statewide tree numbers in those pole-sized trees (Fig. 23). The statewide numbers for “live” hardwood trees had a significant increase in sapling numbers (3.0 to 4.9 inch diameter class) (Fig. 24). There was a small increase in the number of hardwood growing-stock trees within the pole-sized classes (5.0 to 6.9 inches diameter) driven by a 24 percent increase in sapling numbers (Fig. 24).

What this means

Throughout Maine, red maple and northern white-cedar growing-stock numbers have benefited from the spruce budworm outbreak of the 1970s through the 1980s at the expense of red spruce and balsam fir. But adult balsam fir trees produce large crops of seeds that can result in many saplings per acre. It is currently one of three tree species (along with red maple, and red spruce) dominating regeneration (60.2 percent or 12.8 billion saplings). Increased regeneration from sugar maple, yellow birch, and northern white-cedar trees would help to diversify the resource base. For hardwoods, a 24 percent increase in sapling numbers between 2003 and 2013 resulted in an average gain of 5 percent in hardwood pole-sized trees. Softwoods averaged even higher pole numbers. There should be sufficient numbers of saplings to replenish the pole-sized diameter classes if the mortality and removals of pole-sized trees are at a sustained yield level for both softwoods and hardwoods (Seymour 1992). A healthy supply of pole-sized trees can quickly grow into the saw log-sized diameter classes in the future (Fig. 25).

Table 1.—Growing-stock trees ≥5.0 inches d.b.h. by species or species group, as a percent of all trees, Maine.

Species	1982	1995	2003	2013
Spruces	25.0	18.0	19.0	17.5
Balsam fir	23.0	16.0	16.0	19.5
Red maple	9.0	13.0	13.0	13.0
Northern white-cedar	4.0	10.0	9.5	9.0
Paper birch	6.0	7.0	6.5	6.0
Eastern hemlock	5.0	5.0	6.0	6.0
Eastern white pine	4.0	5.0	5.5	5.5
Sugar maple	4.0	5.0	5.5	5.0
Yellow birch	4.0	4.0	4.5	4.5
Aspens	5.0	5.0	4.0	4.0

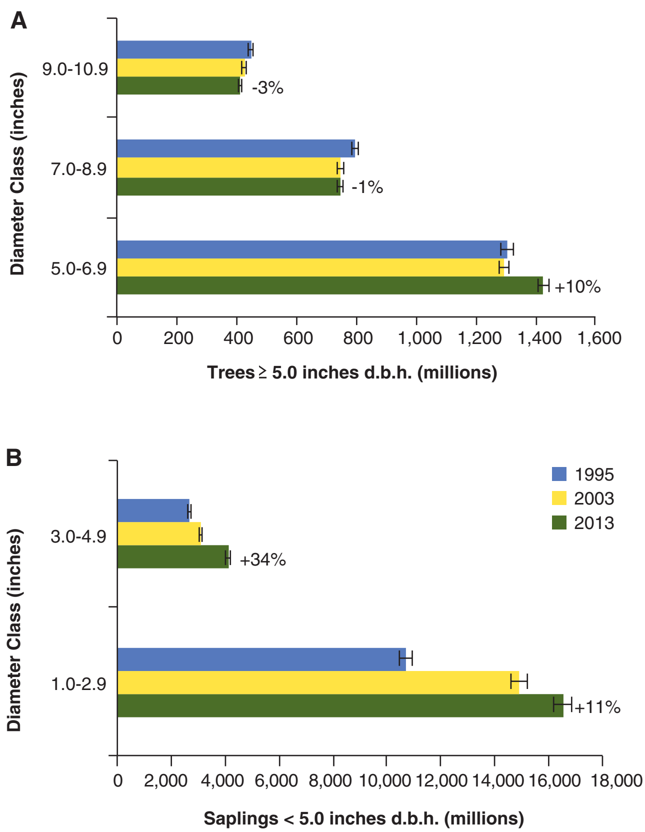


Figure 22.—Number of growing-stock trees (A) and saplings (B) for all species, Maine, 1995, 2003, and 2013. Percentages at the end of bars represent change between 2003 and 2013. Error bars represent a 68 percent confidence interval around the estimated mean.

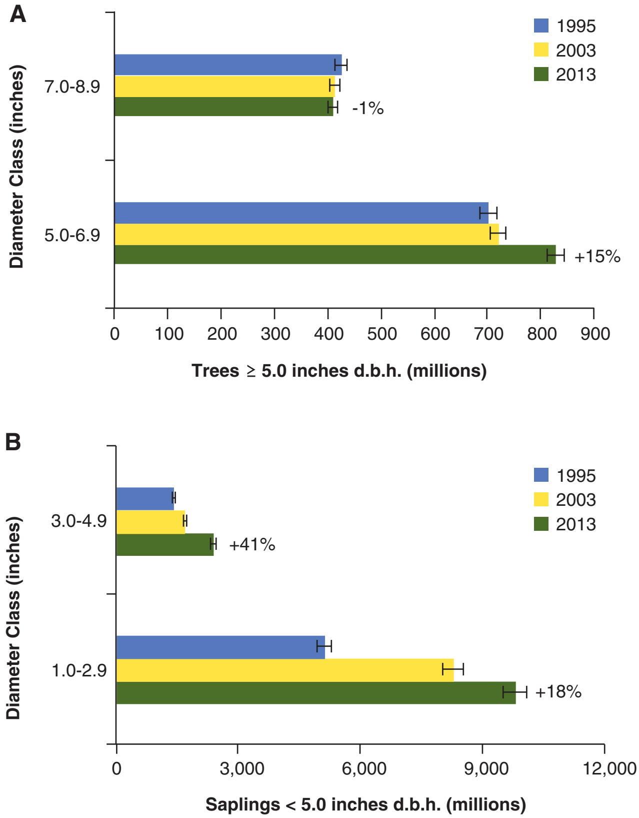


Figure 23.—Number of growing-stock trees (A) and saplings (B) for softwood species, Maine, 1995, 2003, and 2013. Percentages at the end of bars represent change between 2003 and 2013. Error bars represent a 68 percent confidence interval around the estimated mean.

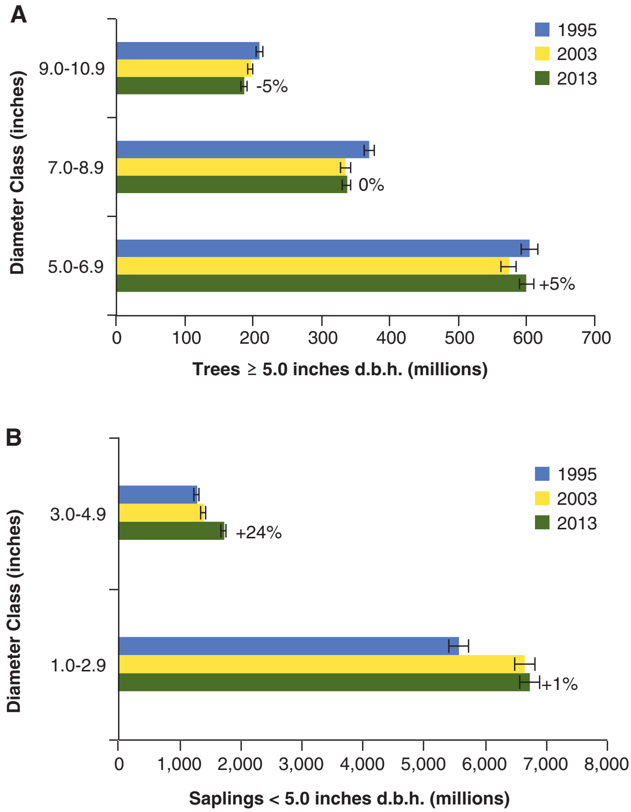


Figure 24.—Number of growing-stock trees (A) and saplings (B) for hardwood species, Maine, 1995, 2003, and 2013. Percentages at the end of bars represent change between 2003 and 2013. Error bars represent a 68 percent confidence interval around the estimated mean.

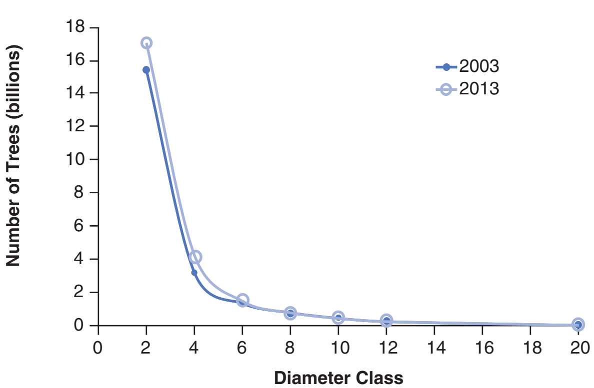


Figure 25.—Numbers of growing-stock pole-sized trees (5.0 to 6.9 inches d.b.h.) and saplings (1.0 to 4.9 inches d.b.h.) by 2.0-inch diameter classes. Numbers on the x-axis refer to the midpoint of a 2-inch class, Maine, 2013.

Seedlings and Saplings

Background

The numbers and species composition of sapling-sized trees on forest land provides an indicator for the future conditions of Maine's forest resources. Seedling numbers may be a preview of that sapling pool, depending on tree species. For example, cutting in red maple stands promotes sprouting, whereas balsam fir regenerates primarily by seeding.

What we found

Seedlings

The numbers of seedlings increased by 54 percent or 34.5 billion seedlings since 2003. The spruce/fir forest-type group had a gain of 14.4 billion seedlings with balsam fir representing 29 percent of that gain. The maple/beech/birch forest-type group had a 72 percent gain (an increase of 15.0 billion seedlings).

Saplings

There has been a statewide gain of 22 percent in the number of softwood saplings (Fig. 26). This represents an average statewide gain of 129 softwood saplings per acre. The Northern Megaregion had the largest softwood gains (194 trees per acre), while the Western Megaregion had the smallest (7 trees per acre). Balsam fir saplings alone represented more than 56 percent of the gain. Hardwood sapling numbers increased 6 percent driven by the numbers of red maple saplings. The statewide hardwood gain amounted to 26 saplings per acre (Fig. 27).The Eastern Megaregion had the largest hardwood gains (51 trees per acre), while the Western and Southern Megaregions had small losses (-5 trees per acre). Sugar maple sapling numbers increased 5 percent in the Northern Megaregion since 2003, which was in contrast to sapling losses for this species in the other three megaregions. Overall, there was a 14.5 percent gain in the number of saplings statewide since 2003. This represents more than 2.5 billion trees or an average gain of 155 saplings per acre. Northern and Eastern Megaregions had the greatest increases per acre while the Western and Southern Megaregions had the fewest.

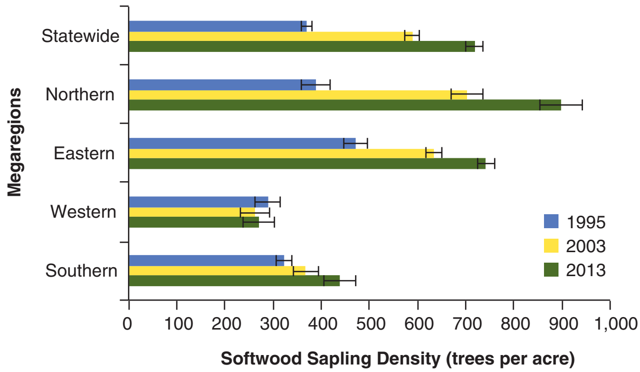


Figure 26.—Average density of softwood saplings by megaregion and inventory year, Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

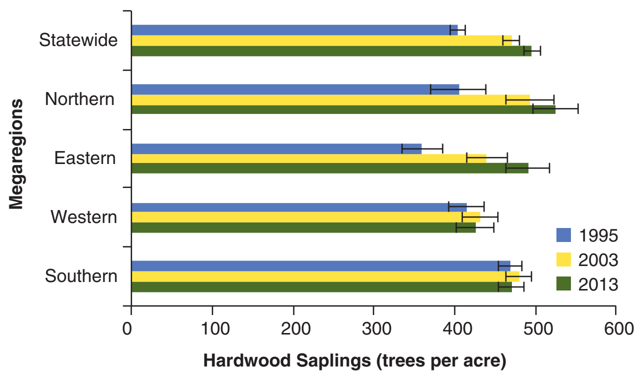


Figure 27.—Average density of hardwood saplings by megaregion and inventory year, Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

What this means

Most of the gains in saplings are found in the northern portion of the State where a softwood composition dominates. Most of the gains in the south are from red maple regeneration. Given these gains, there should be sufficient regeneration to insure adequate recruitment into desirable merchantable sizes and quality. This may not be the case for every major species or megaregion. Overall, hardwood stocking is lower than softwood stocking. Seedling numbers are good for identifying the importance of balsam fir and red maple trees to the regeneration pool within Maine.

Regeneration

Background

The composition and abundance of regeneration drives the sustainability of forests and sets the stage for future composition and stand structure within mature forests. Forests of Maine face numerous regeneration stressors: invasive plants, insects and diseases, herbivory, and environmental change brought on by weather events or climate. As forests mature and undergo stand replacement disturbances, it is imperative to know the viability of the regeneration component. Although artificial methods (planting or seeding) are an option in some stands, the region is dominated by forest ecosystems composed of species that regenerate naturally. These conditions are reflected in the fact that less than 2 percent of the harvested area was artificially planted with trees (Maine Forest Service 2014a).

In most situations, re-establishing reproduction with high-canopy tree species is the key to meeting the manager's objectives (Nyland 2002, Smith et al. 1997, Wenger 1984). Detailed information on the size and composition of regeneration will help to understand and project the future forest character that will ultimately determine the sustainability of Maine's forests.

To address the need for more detailed information on regeneration, FIA scientists added measurement protocols on a subset of NRS-FIA sample plots during the growing season (McWilliams et al. 2015). The protocols measure all established tree seedlings less than 1 inch d.b.h. and include a browse assessment for the area surrounding the sample location. These "regeneration indicator" data improve the ability to evaluate this important variable of forest sustainability.

What we found

The browse impact assessment shows that most of the plots had low or medium levels of browse on understory plants (Fig. 28). There was no distinct pattern of browse impact other than some small localized pockets. It should be noted that there are relatively few samples in the more urban southern counties.

White pine seedling. Photo by Will McWilliams, U.S. Forest Service.

The number of seedlings was estimated at 192 billion, or an average of just over

10,000 seedlings per acre. Overall seedling abundance appears somewhat uniform across Maine with no geographic pattern evident (Fig. 29). Almost half of the seedlings are less than 1 foot tall, 41 percent are 1.0 to 4.9 feet, and 12 percent are 5.0 feet and taller (Fig. 30). Balsam fir, red maple, and sugar maple comprise over half of the total seedling pool (Fig. 31). Red spruce, northern white-cedar, yellow birch, American beech, and black spruce are also prominent in the seedling pool. Species that do not grow into high canopy trees, but are in the list of top seedling counts, include striped maple, mountain maple, pin cherry, and chokecherry.

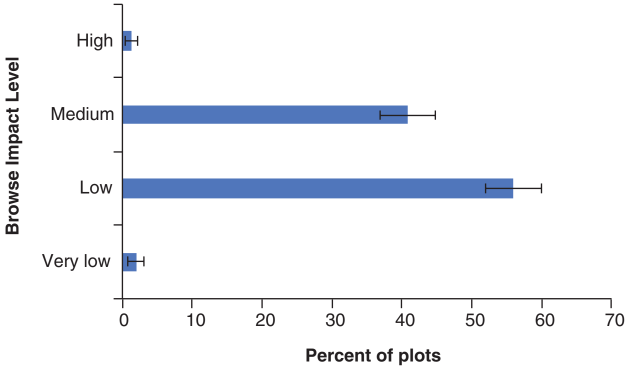


Figure 28.—Proportion of forested P2+ sample Plots by level of browse impact, Maine, 2013. Error bars represent a 68 percent confidence interval around the estimated mean.

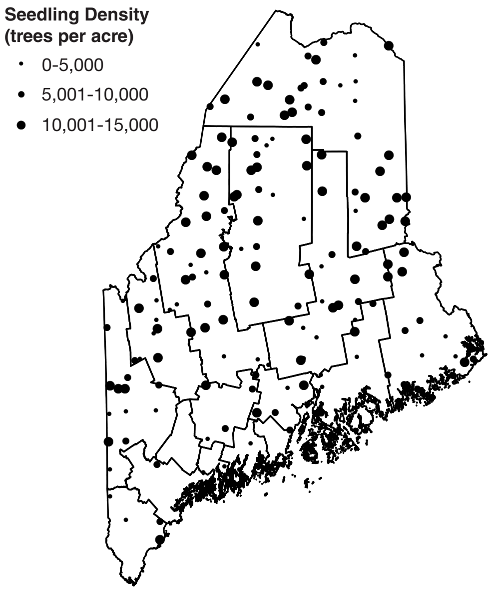


Figure 29.—Distribution of seedling density on forested P2+ sample plots, Maine, 2013. Plot locations are approximate.

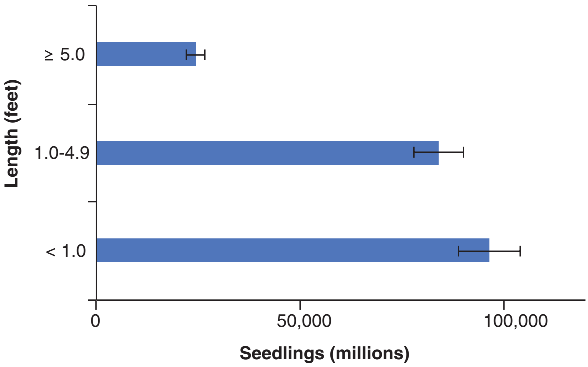


Figure 30.—Number of seedlings by length, Maine, 2013. Error bars represent a 68 percent confidence interval around the estimated mean.

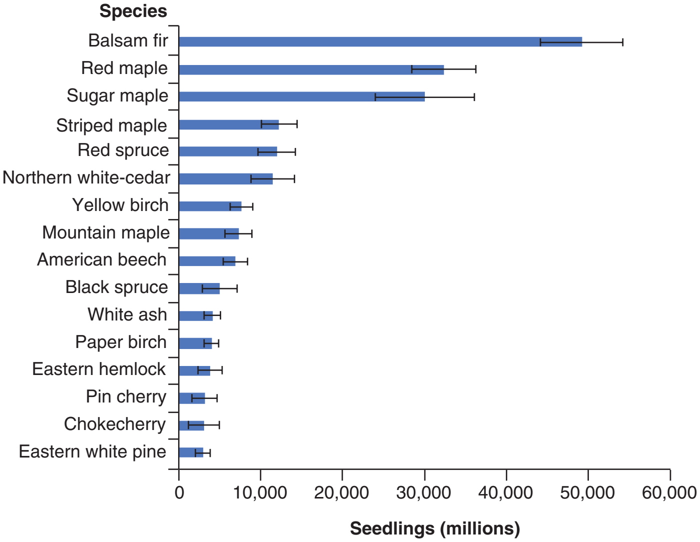


Figure 31.—Number of seedlings by species, Maine, 2013; only species with at least 1 percent of all seedlings are included. Error bars represent a 68 percent confidence interval around the estimated mean.

Comparing the numbers of seedlings with the saplings and to growing-stock trees that makeup the forest canopy illustrates the potential pathways for canopy composition development (Figs. 31, 32, 33). Red spruce, paper birch, and American beech are among the five most numerous species in the sapling pool but were absent in the "top 5" of the seedling pool; these three species typically have the ability to reach the canopy. Prospective "gainers" are those species with relatively high percentages of stems in the regeneration pool of seedlings and saplings compared to the pool of canopy dominants (Fig. 33). The potential gainers are red maple, balsam fir, red spruce, and American beech. Potential losers in the process of becoming canopy dominants are those species with lower percentages of stems in the regeneration pool: eastern white pine, eastern hemlock, northern red oak, and white spruce.

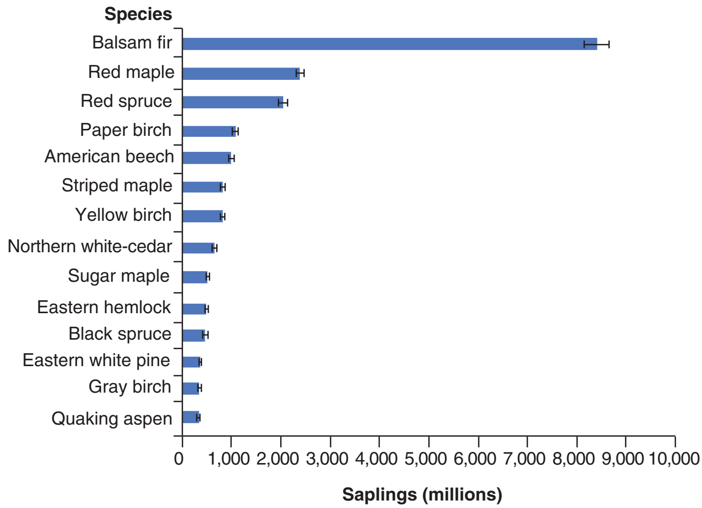


Figure 32.—Number of saplings by species, Maine, 2013; only species with at least 1 percent of all saplings are included. Error bars represent a 68 percent confidence interval around the estimated mean.

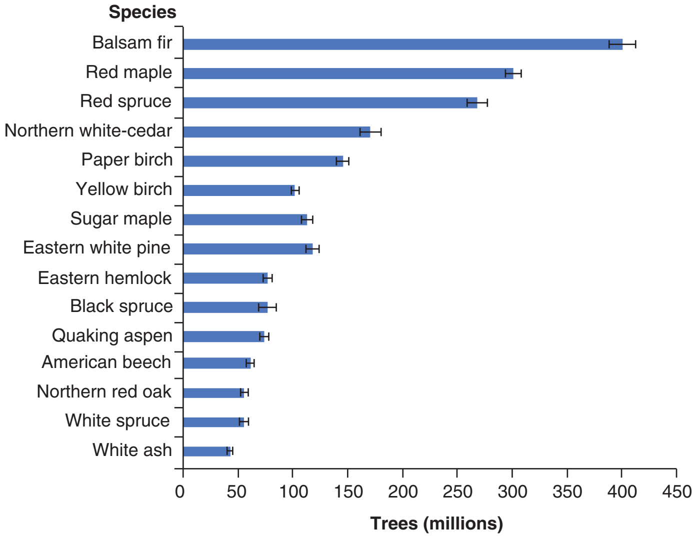


Figure 33.—Dominant and co-dominant growing-stock trees ≥5-inch d.b.h. by species, Maine, 2013; only species with at least 1 percent of all trees is included. Error bars represent a 68 percent confidence interval around the estimated mean.

What this means

Maine's forests have a well-balanced distribution of stand-size classes with 31 percent of the forested acres in saplings and seedling, 36 percent in poletimber, and 34 percent as sawtimber. This is quite different than other New England states that have a majority of their forested acreage in sawtimber-sized stands (Butler 2014, Morin and Pugh 2014). With an abundance of seedlings and saplings, Maine's forests should be resilient as existing young forests grow and are able to replace merchantable-sized forests following harvest or other stand-replacement events. Changes in the composition of canopy dominants might be expected as some major species are under- or over-represented in the regeneration pool. Based upon regeneration numbers, balsam fir, red maple, and red spruce are expected to increase their presence in the canopy. Sugar maple had large seedling numbers, but did not translate to higher sapling or canopy tree numbers. The regeneration of eastern white pine and northern red oak is an issue to watch because of the low proportion of seedlings and saplings encountered.

The results presented here for Maine reflect only two of the five panels of measurements that will eventually comprise the first full baseline data set for the regeneration indicator. Barring any extension of the inventory cycle length, the next 5-year inventory report for Maine will coincide with the completion of the baseline of this dataset. This indicator should facilitate research to evaluate plot-level regeneration adequacy for the major forest-type groups and a more complete understanding of future trends in composition, structure, and health of Maine's forests.

Growing-stock Volume of Forest Land

Background

Estimates of standing volume provide the opportunity to evaluate trends in the wood resource, potential uses of that wood, and its economic value. FIA reports tree volume as sound and net volume of live trees (cubic feet), growing-stock trees (cubic feet), sawtimber trees (board feet, International ¼-inch Rule), and as biomass (dry tons). Each of these measures characterizes the wood resource in a different way and provides insights into its use and management. Biomass estimates help to quantify the mass of trees. Because of changes in procedures, comparisons to past inventories are less consistent for some of these measures.

FIA calculates a cubic-foot volume for all trees 5 inches in diameter and larger. The sound volume of live trees includes deductions for rotten and missing wood, while net growing-stock volume makes additional deductions for tree form, including sweep, crook, and forks, but includes qualifying sections of cull trees (trees with more than two-thirds cull due to rot and form or are of a noncommercial species). The requirements to be considered growing stock (see glossary) make its volume estimates the most subjective because it includes wood quality determinations. Sawtimber is a volume determination from the saw-log portion of the larger growing-stock trees. The minimum diameter for sawtimber trees is 11 inches for hardwood species and 9 inches for softwood species. The net volume of growing-stock trees on forest land provides the baseline for determining the amount of commercial wood and most of the biomass in a forest.

What we found

Red spruce, red maple, eastern white pine, balsam fir, and northern white-cedar, represent most of the estimated live tree volume in the State (Fig. 34). Red maple volume exceeds red spruce for the first time since these data were collected. In addition, balsam fir volume now exceeds northern white-cedar volume.

Northern red oak (+164 million cubic feet), eastern white pine (+236 million), eastern hemlock (+140 million), and balsam fir (+232 million) had double-digit gains in the percentage of live tree volume since 2003 (Fig. 34). American beech (-150 million), paper birch (-65 million), sugar maple (-71 million), and red spruce (-124 million) had the greatest decreases in percentage of standing volume between 2003 and 2013. Overall, live tree volume had a slight increase of 2 percent, or 456 million cubic feet, on forest land between 2003 and 2013. This increase was driven by softwood volumes increasing (+628 million cubic feet) while hardwood volumes had a slight decrease driven by the decreases in sugar maple, American beech, and paper birch (Fig. 34). Yellow birch volume has been steady with no significant changes in live volume.

Red spruce growing-stock volume has decreased from 280 cubic feet per acre in 1982 to 164 cubic feet in 2013, with the greatest decline is in the Northern Megaregion (Fig. 35). Sugar maple has increased from 77 cubic feet per acre in 1982 to 119 cubic feet in 2003, then decreasing to 107 cubic feet in 2013 (Fig. 36). The greatest change is in the Western Megaregion.

Balsam fir growing-stock volumes have decreased from 236 cubic feet per acre in 1982 to 122 cubic feet in 2003, then increased to 140 cubic feet per acre in 2013; the greatest change is in the Northern Megaregion (Fig. 37).

Red maple and eastern white pine growing-stock volumes have increased per acre since 1982 (Figs. 38, 39). The largest gains are found in the Southern Megaregion. American beech growing-stock volumes increased from 37 cubic feet per acre in 1982 to 55 cubic feet in 1995, then decreased to 42 cubic feet per acre in 2013 (Fig. 40). This pattern of change was greatest in the Western Megaregion.

What this means

There was a 2 percent gain in the statewide live tree volume since 2003. Increases in softwood volume were partially offset by decreases in the volume for specific hardwood species. Red maple live tree volume was greater than red spruce for the first time. But red maple growing-stock volume is actually lower than for red spruce growing stock due to the deduction for rough cull. The differences between the results for live tree and growing-stock volumes can be attributed to a 38-percent increase in "rough" cull volume for specific hardwood species between the 2003 and 2013 inventory periods (see section on Tree Quality). Hardwoods represent 46 percent of the statewide growing-stock volume. In addition to losses in hardwood growing-stock volume (-6.4 percent), spruce/fir growing-stock volume also decreased (-2.1 percent) within the Northern Megaregion; this decline is attributed to ongoing harvest levels. Similar to tree abundance data, the volumes for balsam fir and red maple illustrate the statewide distribution and strong competitive interaction of these two tree species with other associated species. Their statewide growing-stock volumes are significant given their smaller-than-average tree diameters compared to other commercial tree species within Maine.

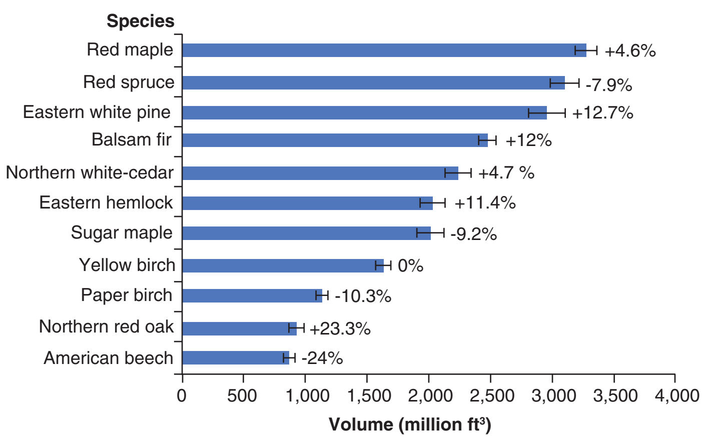
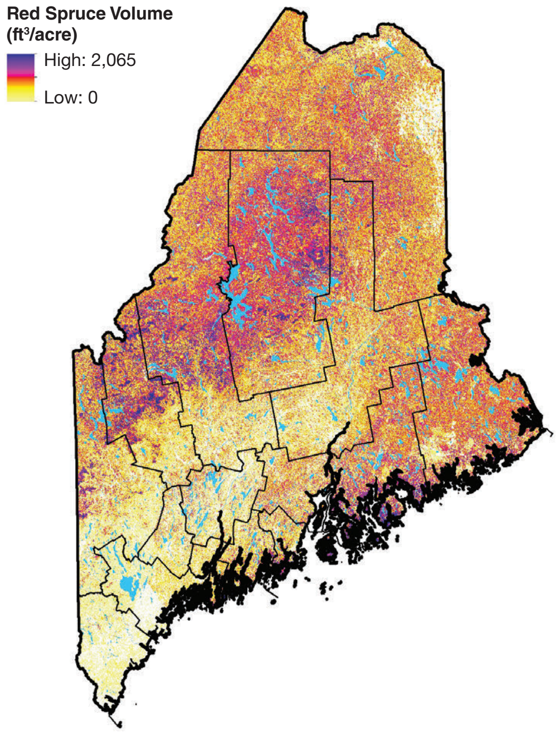


Figure 34.—Volume trees ≥5 inches d.b.h. for 10 most common species on forest land, Maine, 2013. Percentages at the end of bars represent changes in volume between the 2003 and 2013 inventories. Error bars represent a 68 percent confidence interval around the estimated mean.

A



B

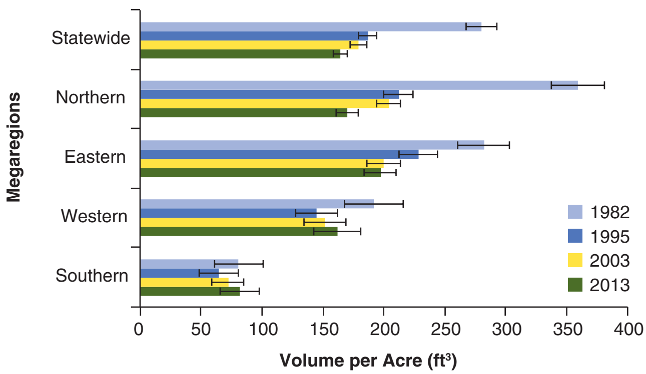
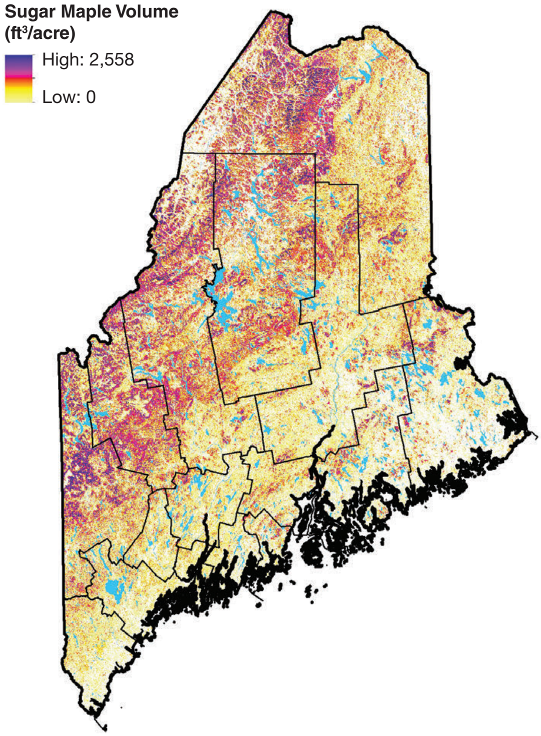


Figure 35.—Red spruce concentrations in 2013 (A), and average growing-stock volume per acre by megaregion and inventory year (B), Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

A



B

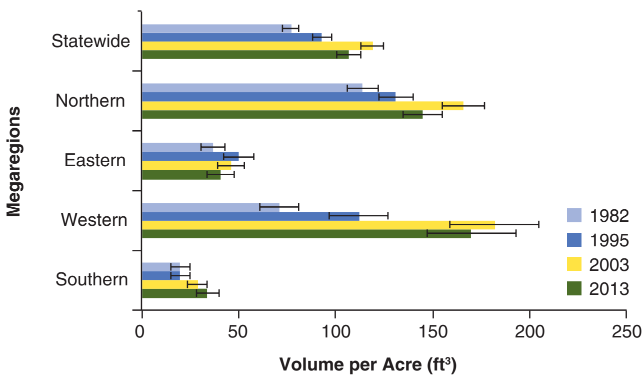


Figure 36.—Sugar maple concentrations in 2013 (A) and average growing-stock volume per acre by megaregion and inventory year (B), Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

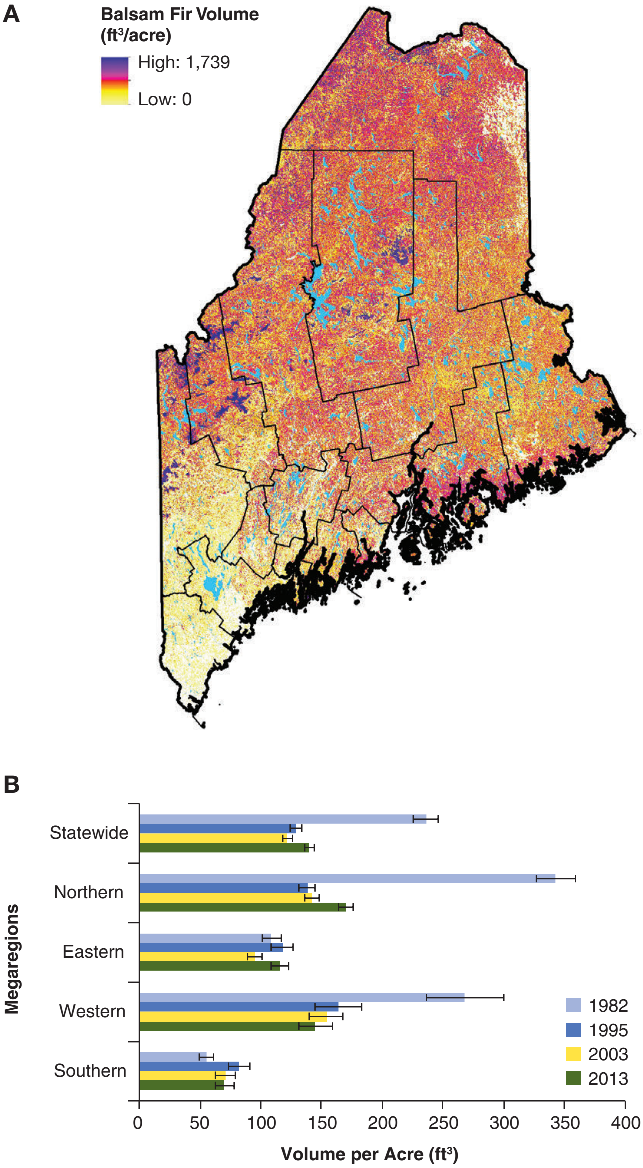


Figure 37.—Balsam fir concentrations in 2013 (A) and average growing-stock volume per acre by megaregion and inventory year (B), Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

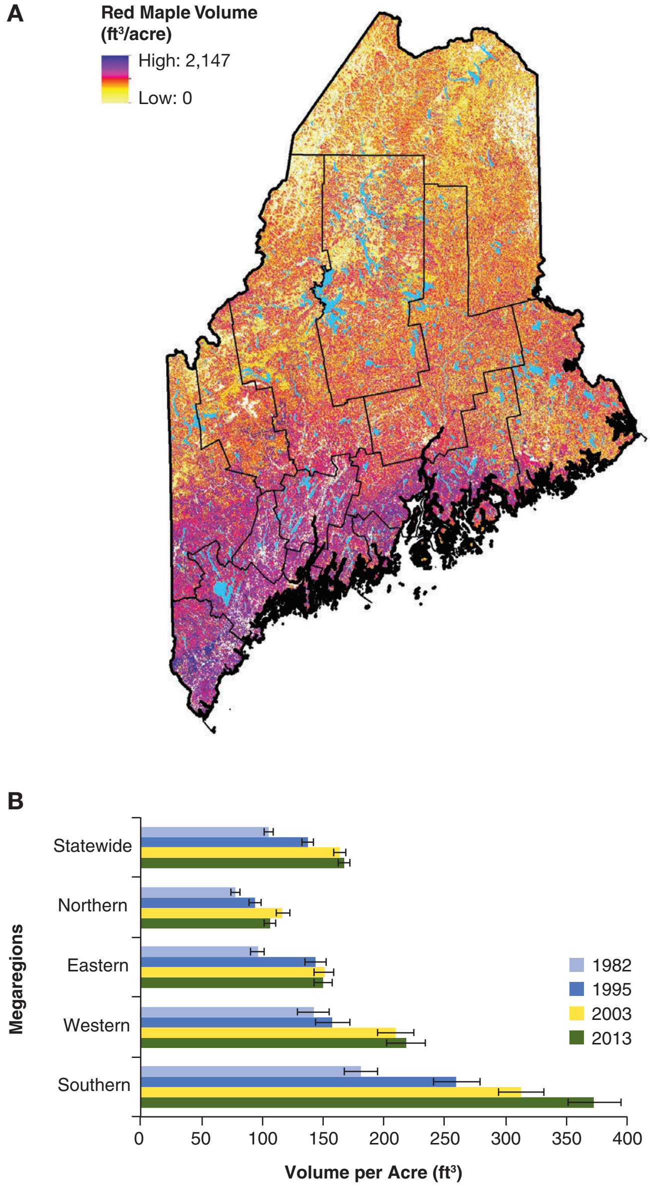
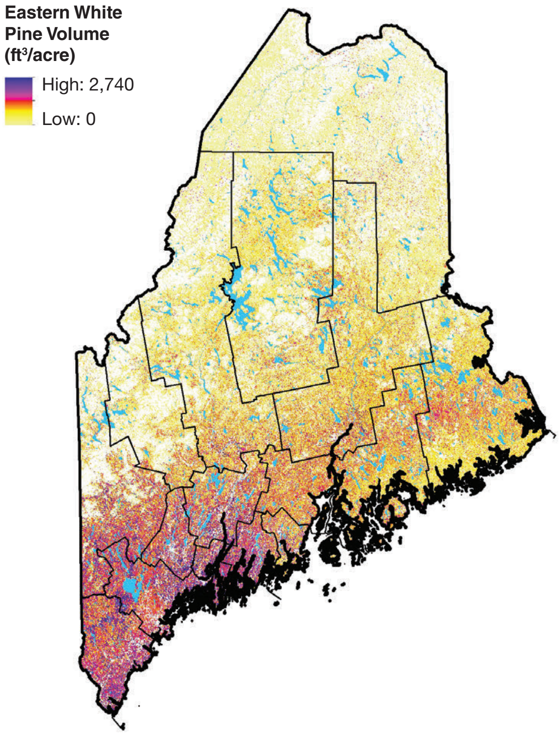


Figure 38.—Red maple concentrations in 2013 (A) and average growing-stock volume per acre by megaregion and inventory year (B), Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

A



B

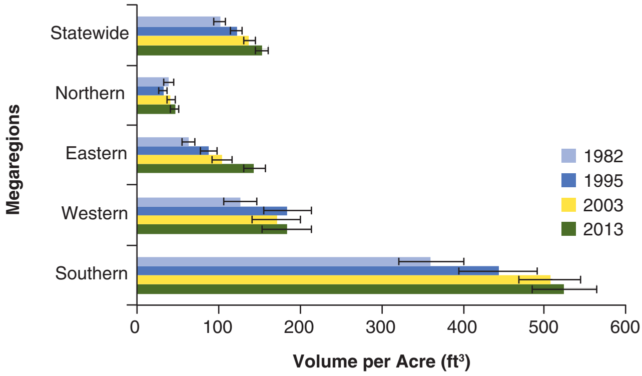
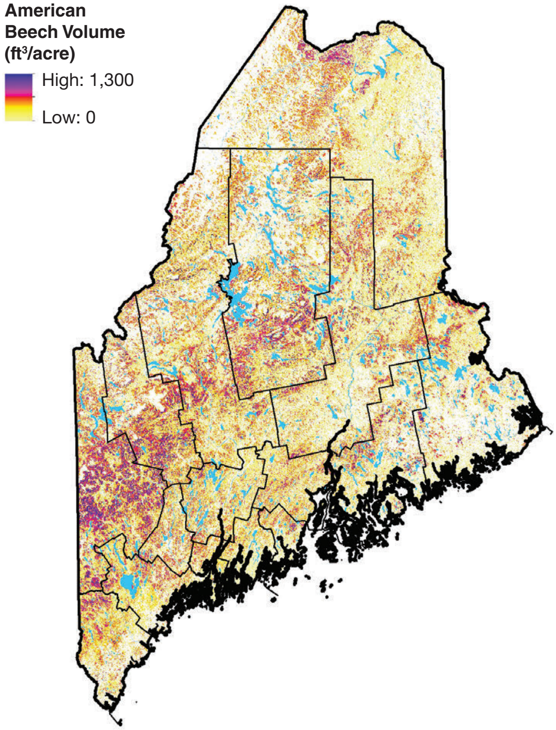


Figure 39.—Eastern white pine concentrations in 2013 (A) and average growing-stock volume per acre by megaregion and inventory year (B), Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

A



B

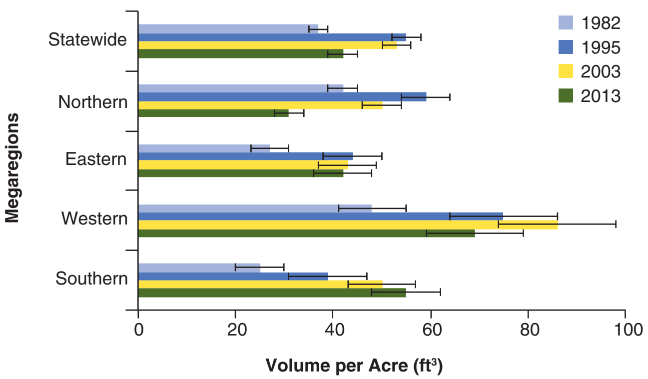


Figure 40.—American beech concentrations in 2013 (A) and average growing-stock volume per acre by megaregion and inventory year (B), Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

Components of Change: Net Growth, Removals, and Mortality

A view from Lead Mountain, eastern Maine. Photo by Fredlyfish4 via Wiki-Commons.

Background

No matter how you harvest your forest, adequate residual stocking is needed to insure harvesting is sustainable (Miller and Smith 1993). Sustained-yield forestry results from well-tended forests that supply a continuous flow of commercial products and services without impairing the long-term productivity or ecological integrity of the forest. One way to judge the sustainability of a forest is to examine the components of annual change in inventory volume: net growth, removals, and mortality. Net growth includes growth (accretion) on trees measured previously, ingrowth of trees passing the 5-inch threshold for volume measurement, deductions for mortality due to natural causes, and volume of trees on lands reverting to forest. Removals include the volume of trees harvested and the volume of trees on land no longer counted when forest land reverts to nonforest uses. Timberland removals also include tree volume on forest land that has been reclassified as reserved. Analysis of these individual components can help us better understand what is influencing net change in volume.

Net growth-to-removal (G:R) ratios give an indication of resource sustainability by comparing estimates of harvest and other removals to net growth. If an area has a G:R greater than 1.0, then the forest resource is increasing. On the other hand, if the ratio is less than 1.0, the forest resources is decreasing.

To assess the actual condition of Maine's forest resource base, one must first break this down into separate softwood and hardwood components. Major tree species can also be individually assessed accurately. Alternatively, one can analyze the growth-to-removal ratios of the individual softwood- and hardwood-dominated forest communities, leaving out removals caused by timberland withdrawal by administrative action.

What we found

The statewide G:R is 1.3. The Northern Megaregion's G:R is 1.0. The Eastern region currently is 1.5, and the Southern and Western regions are 2.4 and 1.3, respectively (Fig. 41).

Statewide, softwoods and hardwoods have positive growth-to-removal ratios for the 2013 inventory. But separating into softwood and hardwood groups provides a clearer picture of the unbalanced ratios. The statewide softwood G:R is 1.5. The Northern Megaregion has a softwood growth-to-removal ratio of 1.3.The Eastern Megaregion is at 1.8, and the Southern and Western Megaregions are 2.0 and 1.6, respectively (Fig. 42). The statewide hardwood G:R is 1.2. The Northern Megaregion's ratio is 0.93. The

Eastern Megaregion currently is 1.2, and the Southern and Western Megaregions are 3.12 and 0.93, respectively (Fig. 43).

Examining the ratios of individual species provides additional insights for those at risk. Red spruce has a statewide growth-to-removal ratio of 0.91 and a Northern Megaregion G:R of 0.64. Balsam fir has a statewide G:R of 1.11, and a Northern Megaregion ratio of 1.36. Sugar maple has a statewide G:R of 0.77 and a Northern Megaregion ratio of 0.63. Red maple has a statewide G:R of 1.4, and a Northern Megaregion ratio of 0.93.

Historical (since 1982) growth-to-removal ratios show both reduced net growth and increased salvage removals associated with the spruce budworm epidemic through the 2003 survey (Fig. 44). There began a major shift and substitution of hardwoods for softwoods in the pulp and paper industry during the early 1990s.The trends illustrate statewide G:R ratios had a maximum growth component for hardwoods recorded in the 1982 inventory, followed by a maximum softwood harvest component in the 1995 inventory, followed by a hardwood maximum harvest component in the 2008 inventory.

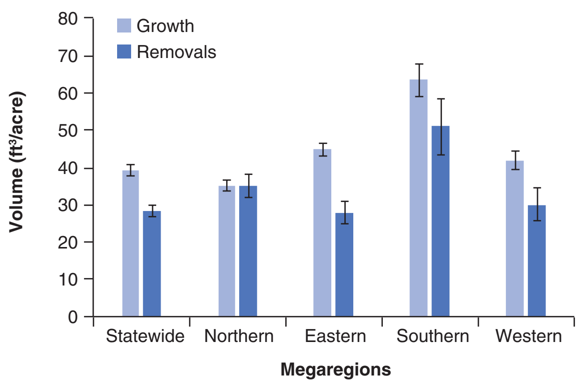


Figure 41.—Volume of growing-stock growth and removals by megaregion, Maine, 2013. Error bars represent a 68 percent confidence interval around the estimated mean.

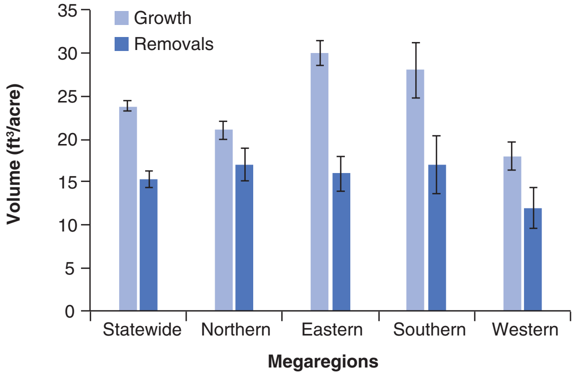


Figure 42.—Volume of softwood growth and removals by megaregion, Maine, 2013. Error bars represent a 68 percent confidence interval around the estimated mean.

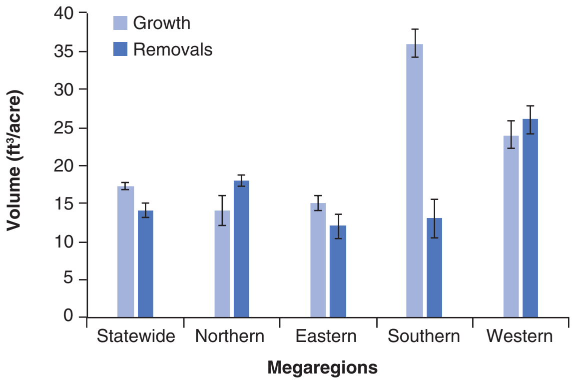


Figure 43.—Volume of hardwood growth and removals by megaregion, Maine, 2013. Error bars represent a 68 percent confidence interval around the estimated mean.

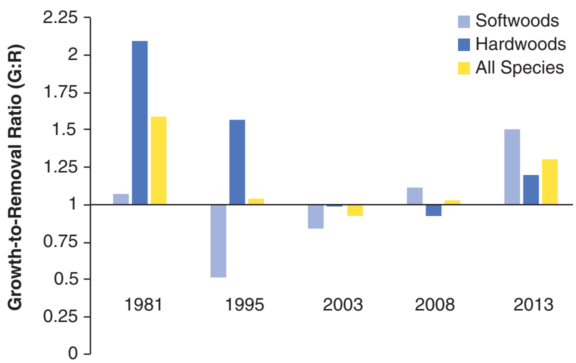


Figure 44.—Trends in growth-to-removal ratios by inventory year, Maine.

What this means

The growth-to-removal ratios for the hardwoods, softwoods, and the groups combined are positive for the first time since the 1981 inventory. These results indicate the wood supply is increasing, especially within the softwood base. Hardwood supplies are not as clear since the G:R ratios are negative for the Northern and Western Megaregions, while increasing amounts of rough cull volume may be reducing the accumulation of growing-stock volume for the hardwoods (see Tree Quality section). Specifically, the wood volume for softwoods is increasing. A 35-percent increase in rough cull levels between 2003 and 2013 for red maple, yellow birch, and sugar maple, is jeopardizing hardwood growing-stock volumes. Both softwoods and hardwoods are recovering from their lows, but these numbers are being pushed by gains from ingrowth of balsam fir, red spruce, and red maple regeneration.

Forest Products

Lumber yard in central Maine. Photo by Will McWilliams, U.S. Forest Service.

Forest Products

Background

Even with the decline in manufacturing jobs, Maine's forest products industry remains a major employer of the State (Maine Forest Products Council 2013). One out of every 20 jobs is associated with the forest products industry. It also adds a significant amount of revenue ($8 billion, or $1 out of every $16) to the State economy every year. Forestry and forest products have remained important ever since the 17th century. Major products from Maine's forests include pulpwood, saw logs, veneer, and biomass. Each year, the Maine Forest Service (MFS) collects data from wood processing facilities in the State of Maine (Maine Forest Service 2014b). The following analysis is based on those reports as well as FIA inventory data.

What we found

FIA estimates the total saw-log volume on Maine's timberlands to be 56.6 billion board feet (International ¼ inch Rule); this is no significant change from the 2003 levels. The total softwood saw-log volume on timberlands had a minor increase which was offset by a minor decrease in hardwood saw-log volume since 2003.

Saw log harvesting has been highly variable since 1990, according to the MFS processing reports. Pulpwood harvests have been steady from 3.23 million cords in 1990 to 3.16 million cords in 2013. Biomass chip harvests have recently decreased from a high of 1.4 million cords in 2010 to 1.0 million cords in 2013, as the number of mills with co-regeneration has dropped to a minimum (Figs. 45, 46). The number of primary processing mills has dropped from 438 in 1990 to only 114 mills in 2013 (Fig. 46).

Greater volumes of saw logs were produced from softwood removals than from hardwood trees. Saw log harvests have gone from 1.45 billion board feet in 1996 to only 880 million board feet in 2013 (Fig. 47). Hardwood tree volume makes up most of the pulpwood harvests since 1990 (Fig. 48).

What this means

Production levels for pulp and timber products have stabilized since the 2008 forest inventory. The consolidation of the primary processing capacity within the State also seems to have leveled off during the same time. The supply should be available for any uptick in the demand for forest products.

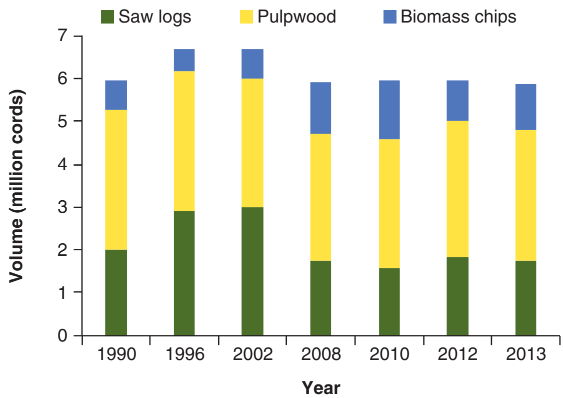


Figure 45.—Trends of harvest volumes for saw logs, pulpwood, and biomass chips by year, Maine.

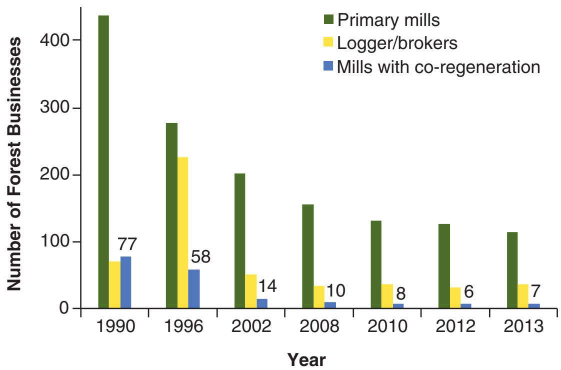


Figure 46.—Changes in the number of primary processing mills, loggers/timber brokers, and mills with co-regeneration facilities, by year, Maine.

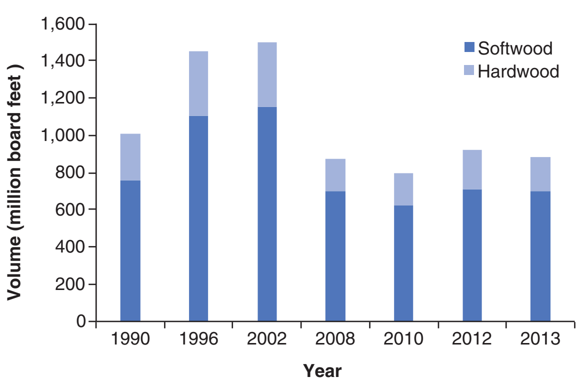


Figure 47.—Volume of saw logs harvested, by year, Maine.

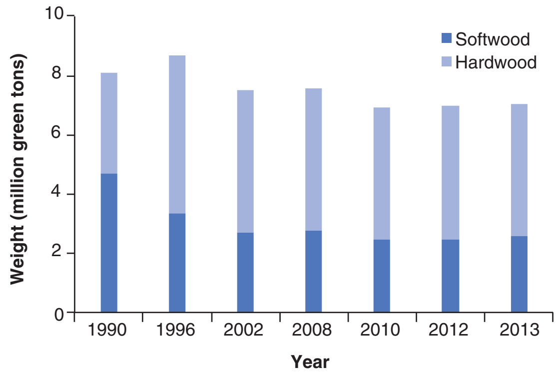


Figure 48.—Weight of pulp wood harvested, by year, Maine.

Tree Quality

Background

The quality of the trees within a forest stand has a direct impact on the amount and type of wood products that can be produced from that forest (Carpenter et al. 1989). Individually, any mature tree with a straight trunk, few limb scars, and no defect in the butt log will be a valuable tree. The quality of a stand of trees can also be altered over time utilizing timber stand improvement (TSI) practices to select for the preferred properties determining tree quality (Kenefic et al. 2014).

FIA classifies trees into one of three quality classes: rough cull (form defect), rotten cull (wood defect), or growing stock.

What we found

Yellow birch have the greatest percentage volume of cull trees (22 percent), followed by American beech (20 percent), and red maple (12 percent). Yellow birch and red maple also had 25 percent increases in the amount of cull volume since 2003. Balsam fir and red spruce have the lowest levels (1 percent) of rough and rotten cull wood in their volumes. Cull in softwood trees has been decreasing (Fig. 49). Most hardwood tree species had fewer rotten cull trees, but more rough cull trees compared to the previous inventory period (Fig. 50). Red maple and yellow birch have had a 65 and 55 percent increase in rough cull volume, respectively, since 2003. The increase in the number of yellow birch cull trees is driven by those trees classified as rough cull (Fig. 51).

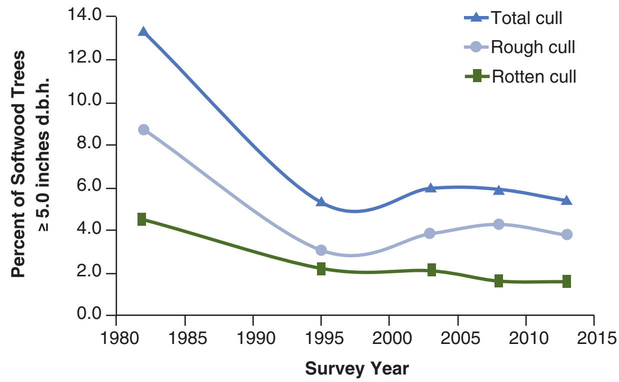


Figure 49.—Softwood trees by cull class as proportion of live trees 5.0 inches or greater d.b.h. on forest land by year, Maine.

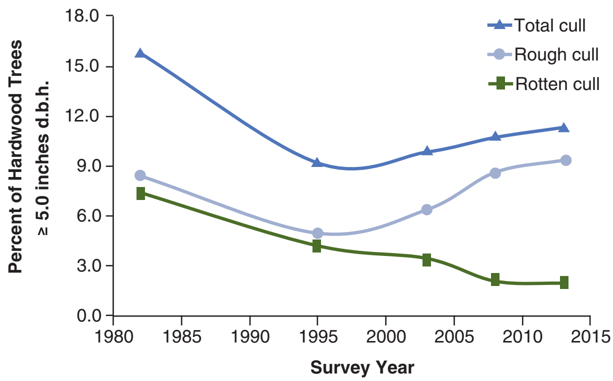


Figure 50.—Hardwood trees by cull class as proportion of live trees 5.0 inches or greater d.b.h. on forest land by year, Maine.

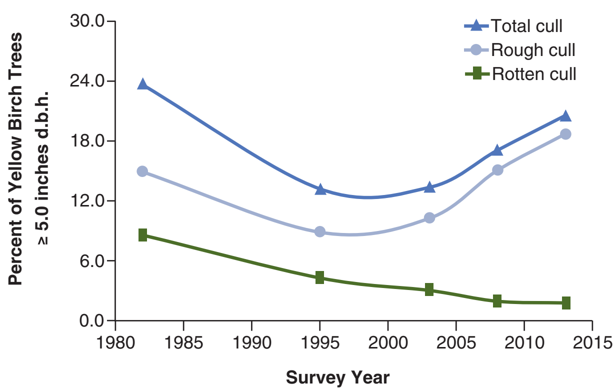


Figure 51.—Yellow birch trees by cull class as proportion of live trees 5.0 inches or greater d.b.h. on forest land by year, Maine.

What this means

Managing for tree quality in a hardwood-dominated stand has always been harder than for softwood forests (Leak and Gove 2008). The significant increase in the amount of cull wood found in hardwood trees is driven by defect determinations in "form" and not by the amount of wood rot. It is not clear how the quality of hardwood trees may have changed in Maine since 2003 to cause a 38-percent increase in rough cull volume. But what is certain is this increase will reduce the overall estimate for growing-stock volume and possibly merchantable wood.

Biomass

Background

Biomass has become increasingly important as demand for bioenergy has increased. FIA uses the component ratio method to convert cubic foot volume to biomass estimates utilizing constant specific gravity values and auxiliary information for branches, bark, and stumps (Woodall et al. 2011). This provides biomass estimates for live trees as well as for growth, mortality, and removals on forest lands. Other biomass estimates for standing dead, down woody debris, shrubs and forbs, and the belowground stump with coarse roots can also be estimated.

What we found

Aboveground live tree biomass on Maine forest land is about 694 million dry tons. The Southern Megaregion has the largest amount on a per-acre basis, 55 dry tons per acre. This area of the State has a greater concentration of large diameter trees, especially eastern white pine, northern red oak, white ash, and hickory.

The Western Megaregion has the second greatest amount of biomass, estimated at 47 dry tons per acre. This megaregion has 54,000 acres of the White Mountain National Forest located within its boundaries in addition to a higher concentration of mature sugar maples and yellow birches.

The Northern and Eastern Megaregions contain 36 dry tons per acre and 35 dry tons per acre of biomass, respectively (Fig. 52). This is in spite of Baxter State Forest containing an abundance of mature spruce/fir forests.

The component contributions of live tree biomass vary by tree species and size. The spruces, white pine, hemlock, northern white cedar, yellow birch, and sugar maple have most of their biomass in saw log-sized trees. In contrast, most of the tree biomass found within balsam fir, red maple, aspen, paper birch, the ashes, and beech are contained in pole-sized and sapling-sized trees. Since 2003, there has been an estimated 6 percent increase (35 million dry tons) of biomass.

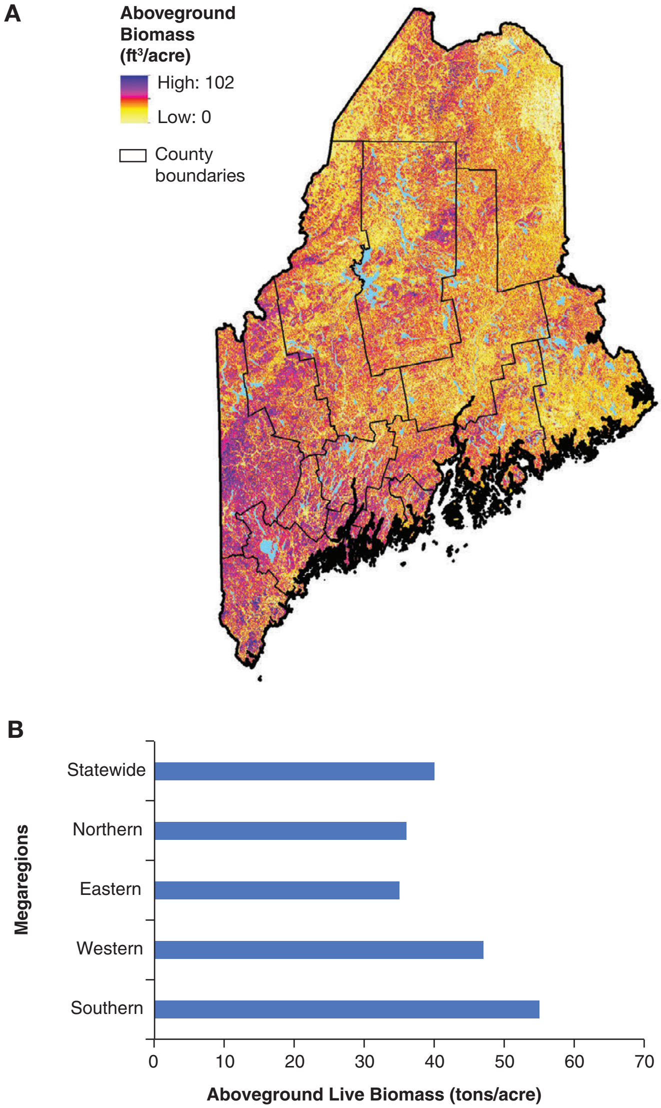


Figure 52.—Biomass concentrations in 2010 (A) and average tons per acre by megaregion (B), Maine, 2010.

What this means

Currently, Maine processes 2.4 million green tons of biomass chips every year (Maine Forest Service 2014b). Most of this material comes from logging residue or noncommercial trees during conventional timber operations. Maine's biomass markets do not permit the profit margin necessary to the average logger for obtaining biomass chips from the forest as a "stand-alone" enterprise (Benjamin et al. 2009). There are also challenges to obtaining the capital for the construction of the bioindustry processing facilities that utilize biomass chips (Timmons et al. 2007). The key to making bioenergy feasible in Maine is the continued integration of biomass chip harvesting and processing within the conventional pulpwood operations of Maine.

Forest Health Indicators

Bunchberry (*Cornus canadensis*) found near Wolfes Neck, Maine. Photo by Richard Widmann, U.S. Forest Service.

FIA measures an extended suite of forest health indicators on plots for evaluating the amount of down woody debris, tree crown condition, tree damage, insect and disease pathogens, invasive plants, forest habitats, and urbanization. These attributes, along with population projections and economic models, are used to predict different scenarios for future forest conditions. Many partners use this FIA forest health attributes to assess forest health issues at both state and regional levels.

Down Woody Material

Background:

Down woody material (DWM), in the various forms of fallen trees and shed branches, fulfills a critical ecological niche in forests of Maine. DWM provides valuable wildlife habitat in the form of coarse woody debris (CWD), stand structural diversity, a store of carbon/biomass, and contributes toward forest fire hazards via surface woody fuels. FIA inventories for DWM using transect lines placed within FIA plots (Woodall and Monleon 2008).

What we found

The DWM biomass within Maine forests is dominated by coarse woody debris (Fig. 53) at approximately 77 million tons, with fine woody material making up a little more than one-third of the total. Carbon stored in down woody materials (fine and coarse woody debris) on Maine's forest land exceeded 58 million tons (Fig. 54).

Coarse woody debris volume is highest in the private ownership category at nearly 9 billion cubic feet (Fig. 55). State and local forests had the second largest, albeit substantially lower coarse woody debris volume (517 million cubic feet) compared to private ownerships. Private forest lands also had the highest volume per acre (780 cubic feet per acre), followed closely by federal lands at 762 cubic feet per acre, while State and local lands registered only 569 cubic feet per acre. Both Aroostook and Piscataquis Counties had the greatest amount of CWD accumulation with 1,000 cubic feet per acre.

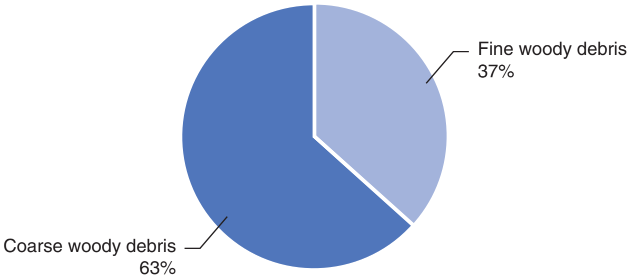


Figure 53.—Proportion of down woody material on forest land, Maine, 2010.

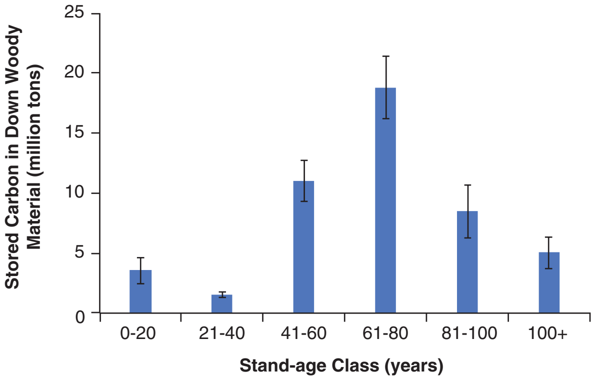


Figure 54.—Carbon in down woody materials by stand-age class on forest land, Maine, 2010. Error bars represent a 68 percent confidence interval around the estimated mean.

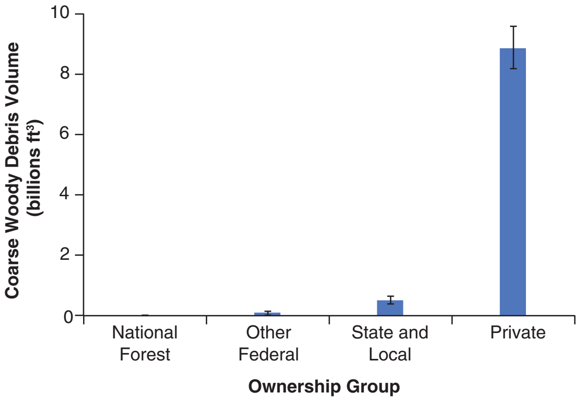


Figure 55.—Volume of coarse woody debris on forest land by ownership group, Maine, 2010. Error bars represent a 68 percent confidence interval around the estimated mean.

What this means:

Given that most of the coarse woody debris volume is estimated to be on private forest land, in contrast to what is typically found in the western United States (Woodall et al. 2013), the management of Maine's private forests will affect the future of down woody material contributions to watersheds, wildlife habitat, and biomass stocks (i.e., stand structure). Because fuel loadings are not estimated to be exceedingly high across Maine, possible fire dangers are outweighed by the numerous ecosystem services provided by down woody materials.

Only in extreme drought would the biomass within down woody materials be considered a fire hazard. Although the carbon stocks of down woody materials are relatively small compared to those of soils and the standing live biomass across Maine, 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 loss of dead wood carbon stocks could indicate the reduction of other pools in the future.

Tree Crown Conditions

Background

The crown condition of trees is influenced by various biotic and abiotic stressors. Abiotic stressors include drought, flooding, cold temperatures or freeze injury, nutrient deficiencies, soil physical properties affecting soil moisture and aeration, or toxic pollutants. Biotic stressors include native or introduced insects, diseases, invasive plant species, and animals (Liebhold et al. 1995, Pimentel et al. 2000, Vitousek et al. 1996).

Crown dieback is defined as recent mortality of branches with fine twigs and reflects the severity of recent stresses on a tree. A crown was labeled as 'poor' if crown dieback was greater than 20 percent. This threshold is based on findings by Steinman (2000), who associated crown ratings with tree mortality. Additionally, crown dieback has been shown to be the best crown-related variable for predicting tree survival (Morin et al. 2015).

What we found

Crown conditions are generally good across Maine; incidents of poor crowns are few and show no discernable spatial pattern (Fig. 56). All tree species have a very low proportion of live basal area containing poor crowns and this proportion has decreased substantially since 2008 for several species including paper birch, American beech, and yellow birch (Table 2). Mean crown dieback ranges from 1 percent for eastern hemlock to 5 percent for American beech (Table 3).

The proportion of trees that have died since the last inventory period increases with increasing crown dieback recorded during that previous period (Fig. 57). Nearly 45 percent of trees with measured crown dieback greater than 20 percent during the 2008 inventory were found dead when visited again during the 2013 inventory.

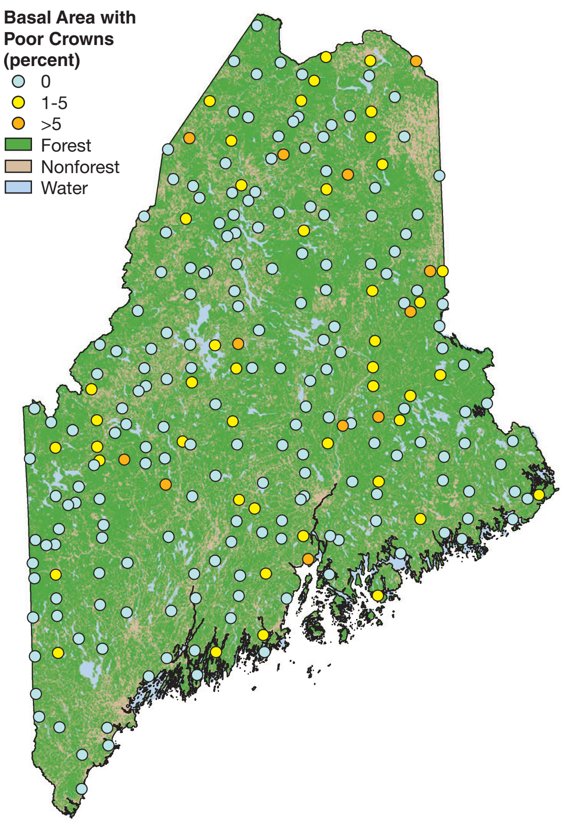


Figure 56.—Distribution of plots where trees with poor crowns were recorded, Maine, 2013. Plot locations are approximate.

Table 2.—Percentage of live basal area with poor crowns, Maine, 2008 and 2013.

Species	2008	2013
	---------------------- *percent* --------------------	
Northern white-cedar	4.5	3.2
Paper birch	7.2	2.8
American beech	14.5	1.6
Yellow birch	9.6	1.6
Northern red oak	2.9	1.3
Red maple	4.5	1.0
Balsam fir	2.8	0.8
Red spruce	1.6	0.8
Sugar maple	2.6	0.2
Eastern white pine	0.3	0.1
Eastern hemlock	1.2	0.0

Table 3.—Mean, median, and range for crown dieback of live trees (>5 inches d.b.h.) on forest land by species, Maine, 2013.

Species	Trees	Mean	SE	Median	Minimum	Maximum
	number	------------------------------	------ *percent*	------	------	------
American beech	220	5.0	0.54	5	0	80
Northern white-cedar	726	4.9	0.23	5	0	75
Paper birch	417	3.9	0.33	5	0	85
Red maple	952	3.0	0.13	5	0	45
Yellow birch	323	2.9	0.39	0	0	85
Northern red oak	51	2.8	0.63	0	0	25
Sugar maple	314	2.6	0.24	0	0	55
Eastern white pine	408	2.4	0.23	0	0	70
Balsam fir	1400	2.1	0.12	0	0	75
Red spruce	928	1.8	0.11	0	0	30
Eastern hemlock	377	1.3	0.14	0	0	15

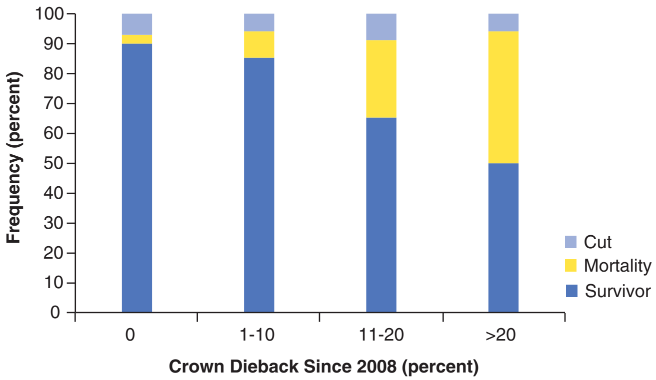


Figure 57.—Relationship between crown dieback and tree survival for remeasured trees, Maine, 2013.

What this means

Most of the tree species in the forests of Maine are generally in good health and several species show a decreasing trend in the proportion of trees with poor crowns. For American beech, this may be related to the mortality of trees that were suffering from the impacts of beech bark disease during the last survey. Similarly, the decrease in the numbers of paper birch with poor crown health could be due to mortality of senescing older trees. The health of tree crowns in ash, maple, eastern hemlock, eastern white pine, the spruces, and balsam fir should be monitored closely due to the recent invasion of hemlock woolly adelgid (*Adelges tsugae*), the likely future invasions by the emerald ash borer (*Agrilus planipennis*), Asian longhorned beetle (*Anoplophora glabripennis*), and the Sirex wood wasp (*Sirex noctilio*).

Tree Damage

Background

Tree damage is assessed for all trees 5.0 inches or greater d.b.h. on all FIA plots. Up to two of the following types of damage can be recorded for an individual tree: insect damage, cankers, decay, fire, animal damage, weather, and logging damage. If more than two types of damage are observed, the relative abundance of the damaging agents determine the two to be recorded.

What we found

Damage was recorded on approximately 18 percent of the trees in Maine, but there is considerable variation between species. The most frequent damage on all species was decay accounting for 9 percent of trees. Decay was recorded as low as 4 percent for red spruce and eastern white pine trees, but as high as 20 percent for American beech. Decay was also recorded on more than 10 percent of red maple, northern white-cedar, sugar maple, and yellow birch trees.

Insect damage was recorded for 31 percent of eastern white pine trees while cankers were observed on 49 percent of American beech trees (Table 4). The occurrence of all other injury types was very low. Figure 58 shows an example of how tree damage can affect wood quality on the larger white pine trees.

Table 4.—Percentage of trees by species with specified damage, Maine, 2013.

Species	Tree Damage						
	None	Insects	Cankers	Decay	Animal	Weather	Logging/human
	percent						
Red maple	77	2	0	18	1	1	1
Red spruce	95	0	0	2	1	1	1
Eastern white pine	65	31	0	2	1	0	1
Balsam fir	88	4	0	4	2	1	1
Northern white-cedar	74	1	0	19	3	2	1
Eastern hemlock	92	0	0	3	2	1	2
Sugar maple	78	4	1	14	0	1	2
Yellow birch	85	0	0	12	1	1	1
Paper birch	90	0	0	7	1	1	0
Northern red oak	95	0	0	4	0	0	1
American beech	29	0	49	20	0	1	1
All Species	82	3	3	9	1	1	1

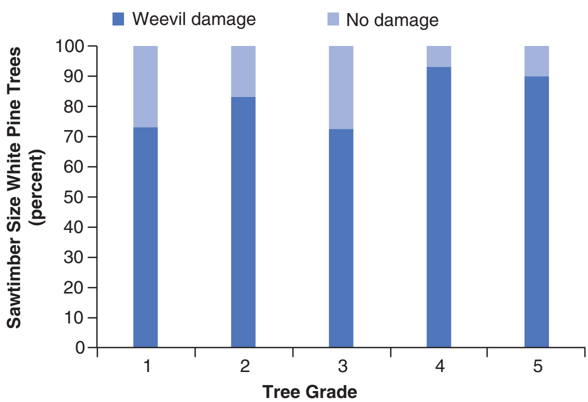


Figure 58.—Proportion of white pine trees of sawtimber size by tree grade and white pine weevil status, Maine, 2013.

What this means

Decay was the most commonly observed damage category, not unusual given the number of Maine's tree species that are suffering from epidemics such as American beech or balsam fir, the number of thin-barked maples and birches, or maturing conditions as observed in white pine, northern red oak, and northern white-cedar stands. Better management of stocking can reduce the level of decay, especially in the hardwood-dominated or overmature stands.

Insects and Disease Pathogens

Background

Insects and disease pathogens help shape the structure and composition of forest ecosystems. Between 2009 and 2013, Maine's forests have been impacted by native insect pests such as eastern spruce budworm (*Choristoneura fumiferana*) and the white pine weevil (*Pissodes strobe*), as well as exotic and invasive agents such as hemlock woolly adelgid (*Adelges tsugae*) and the beech bark disease. Maine is also threatened by the potential introduction of the emerald ash borer (*Agrilus planipennis*), which is present in neighboring states. Monitoring the status of these organisms is crucial in assessing forest health and changing trends in Maine's forests (U.S. Forest Service 2014).

Spruce budworm—Characterized as one of the most damaging native forest insects in fir and spruce forests of the eastern United States, eastern spruce budworm defoliates primarily balsam fir and white spruce during its larval stage as a caterpillar (Kucera and Orr 1981). Occasional hosts include larch, hemlock, and pine. Outbreaks of spruce budworm are periodic, with occurrences separated by an average of 30 to 40 years (Bouchard and Auger 2014, Fraver et al. 2007). With the last budworm outbreak ending in 1985, the next infestation appears eminent (Fraver et al. 2007, Hennigar et al. 2011). Average trap catches of adult moths across the State began to increase in 2011 and have continued to rise. (U.S. Forest Service 2014).

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 fungus *Neonectria galligena* Bres., which kills or injures American beech. Three phases of BBD are generally recognized: 1) the "advancing front", areas recently invaded by scale populations; 2) the "killing front", 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; 3) the "aftermath forest", areas where BBD is endemic (Houston 1994, Shigo 1972). BBD was inadvertently introduced via ornamental beech trees into North America at Halifax, Nova Scotia, in 1890, and began spreading to the south and west. By 1960, beech bark disease had been discovered in every county in Maine.

Hemlock woolly adelgid—Native to Asia, hemlock woolly adelgid (HWA; *Adelges tsugae*) was first reported in the eastern United States in the 1950s (Ward et al. 2004) and was discovered in Maine in 2003. Since then, it has slowly expanded its range. Areas with established populations often have high insect densities, which causes widespread defoliation and eventual mortality of eastern hemlock (McClure et al. 2001, Orwig et al. 2002). Mortality generally begins to increase dramatically after about 15 years of infestation (Morin and Liebhold 2015).

Emerald ash borer—Though not yet found in Maine, emerald ash borer (EAB) is an exotic wood-boring beetle that was first detected in the United States near Detroit, MI, in 2002. It is a pest of all North American ash and white fringetree (*Chionanthus virginicus*) (Cipollini 2015). The threat of EAB introduction to Maine has increased with the discovery of this pest in neighboring Massachusetts and New Hampshire, where the closest infestations are within 35 miles of the Maine border.

What we found

Spruce budworm—Half of all trees in Maine's forests, or 12.2 billion trees, are preferred hosts of spruce budworm. Balsam fir makes up 74 percent of preferred host trees, followed by red spruce, black spruce, and white spruce. Occasional hosts totaled an additional 1.3 billion trees, which were comprised mainly of eastern hemlock (51 percent). Since the end of the last outbreak period in 1985, the statewide density of balsam fir has recovered with significant increases in tree numbers for the Northern and Eastern Megaregions (Fig. 59). Red spruce showed a post-outbreak decline, but, tree numbers have not yet recovered (Fig. 60). Mortality of preferred growing-stock hosts on timberland has decreased from 138.2 million cubic feet per year in 2006 to 105.6 million cubic feet in 2013.

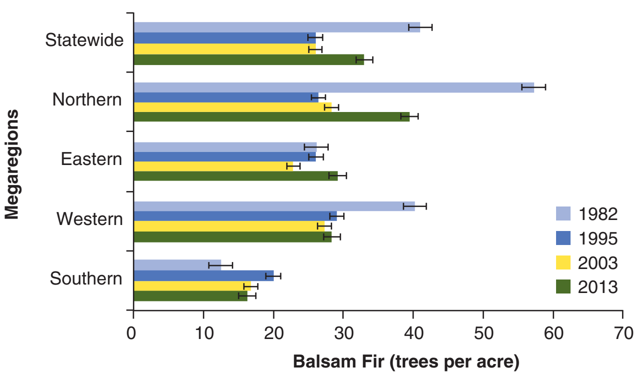


Figure 59.—Density of balsam fir growing-stock trees by megaregion and inventory year, Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

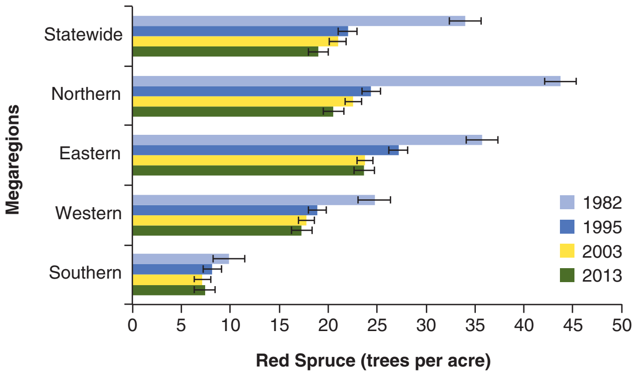


Figure 60.—Density of red spruce growing-stock trees by megaregion and inventory year, Maine. Error bars represent a 68 percent confidence interval around the estimated mean.

Beech bark disease—The impacts of BBD mortality have resulted in reductions of large diameter beech since 1995. The proportion of beech trees has been decreasing in all diameter classes 12 inches d.b.h. and greater (Fig. 61). However the number of beech seedlings increased between 2003 and 2013.

Hemlock woolly adelgid—Since its 2003 discovery in York County, HWA has spread into several other southeastern counties of Maine (Fig. 62). Unlike in many other states that have been impacted by HWA, hemlock annual mortality rates have been unaffected in Maine thus far. Additional analyses revealed no differences in the mortality rate and crown health of hemlock between infested and un-infested counties.

Emerald ash borer—Maine's forest land contains an estimated 438.0 million ash trees (greater than 1 inch d.b.h.), with white ash and black ash representing 58 and 41 percent of the ash population, respectively, and green ash making up the remaining 1 percent. Ash is widely distributed across the State though concentrated in southern Maine (Fig. 63). The net volume of live ash trees (greater than 5 inches d.b.h.) is 594.1 million cubic feet or 2.4 percent of the total tree volume. More than 75 percent of the ash volume in Maine is found in the maple/beech/birch forest-type group, while very little is found in the elm/ash/cottonwood forest-type group.

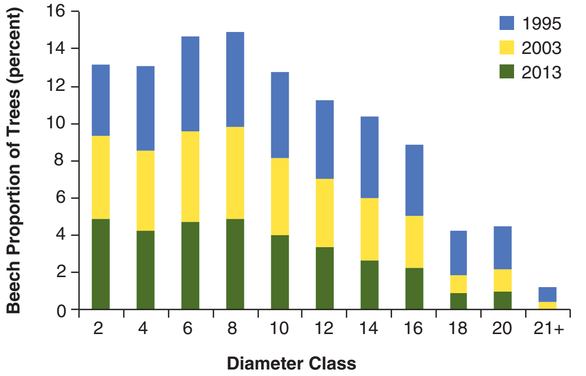


Figure 61.—Proportion of beech (percent) growing-stock trees by diameter class and survey year, Maine.

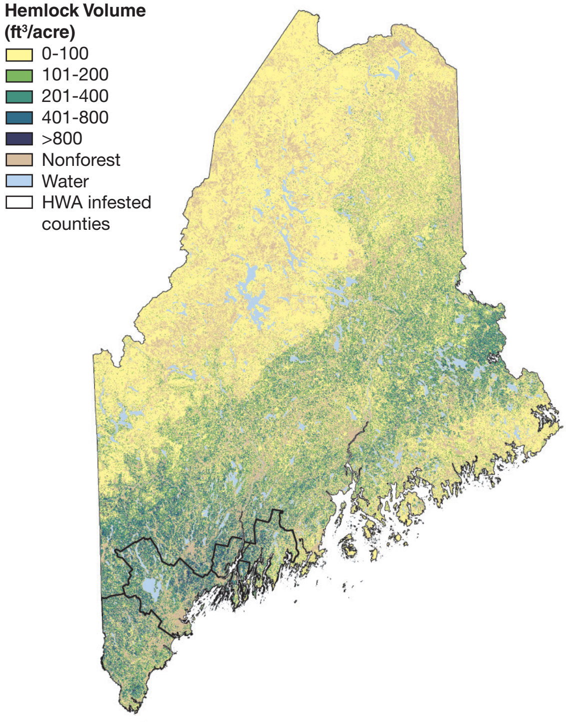


Figure 62.—Eastern hemlock concentrations (expressed as volume per acre) in Maine, 2009, and counties infested with hemlock woolly adelgid, 2011.

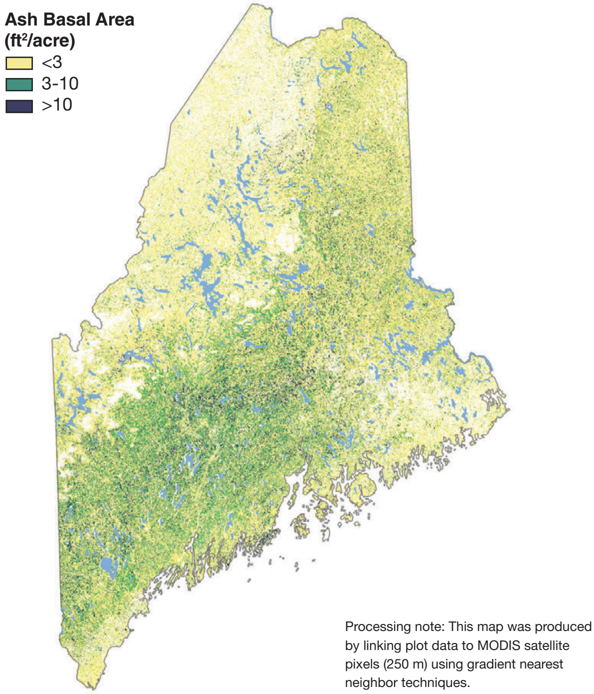


Figure 63.—Ash density expressed as basal area per acre, Maine, 2013.

What this means

Spruce budworm—Spruce budworm will continue to influence Maine's dominant spruce/fir forests and inspire innovative forest management techniques. Sustained monitoring will help to identify the impacts of spruce budworm over time.

Beech bark disease—Most of Maine's beech trees are in areas that are in the aftermath phase of BBD, which are generally comprised of 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—Hemlock woolly adelgid has already spread into the southeastern counties of Maine where eastern hemlock is the most abundant (Fig. 62). 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 (Costa et al. 2005). Therefore, the rate of spread of HWA into the rest of Maine may be limited by colder temperatures. Although the health of eastern hemlock in the forests of Maine does not appear to have been impacted by HWA, it is important to continue monitoring hemlock crown health and mortality in the future. A previous study reported that hemlock mortality increases were not substantial until HWA had infested counties for more than 20 years (Morin and Liebhold 2015), suggesting impacts in Maine may not be apparent for another 5 to 10 years.

Emerald ash borer—Even though ash is less abundant in Maine when compared to the rest of the Northeast (2.4 verses 4.9 percent), it is still an important ecological component of Maine's forests. EAB has caused extensive decline and mortality of ash throughout the eastern United States and therefore represents a threat to the forested and urban ash tree resources across the State. The spread of EAB into Maine could have a considerable impact on ash tree health and dependent wildlife, but only a minor impact on future forest composition of the various forest types.

Invasive Plants

Background

Invasive plant species (IPS) are both native and nonnative species that can cause negative ecological effects. These species can quickly invade forests and result in changes to the availability of light, nutrients, and water. An individual IPS can form dense monocultures which not only reduce regeneration but also impact wildlife quality through altering forest structure and forage availability. Aside from the ecological effects, invasive species can also impact agricultural systems. An example is common barberry (*Berberis vulgaris L.*), an alternate host for wheat stem rust (*Puccinia graminis* f. sp. *tritici*) which can cause the compete loss of grain fields. Common buckthorn (*Rhamnus cathartica*) is another troublesome IPS as it is an alternate host for the soybean aphid (*Aphis glycines*). While there are some beneficial uses for these invaders (e.g., culinary, medicinal, and soil contaminant extraction), the negative effects need to be compared with their beneficial uses (Kurtz 2013). Each year the inspection, management, and mitigation of IPS costs billions of dollars.

What we found

To aid in monitoring of plant communities, FIA assessed the presence of 40 IPS (39 species and one undifferentiated genus) on 536 Phase 2 (P2) invasive plots in Maine from 2009 through 2013. Eleven of the 40 invasive species monitored were recorded

(Table 5), with 10.4 percent of plots having one or more IPS present. Reed canarygrass (*Phalaris arundinacea*) was the most commonly observed species, recorded on 27 plots (5.0 percent of P2 invasive plots). It was found throughout the State with Aroostook County registering the most plots (Fig. 64). This aggressive grass has been bred to withstand harsh environments and is used in pastures, along roads, and for wetlands. It has become one of the most common invasive plants of the 40 monitored by the Northern Research Station (Kurtz and Hansen 2014).

Nonnative bush honeysuckles (*Lonicera* spp, 12 plots) and bull thistle (*Cirsium vulgare*, 10 plots) were the next most commonly observed species and occur on approximately 2.0 percent of plots. Japanese barberry (*Berberis thunbergii*) was the only other IPS observed on greater than 1.0 percent of the plots. Figure 65 shows the distribution of the plots where invasive plants were found. The location of plots with invasive species are fairly homogeneous throughout the State with the north-central part of the State having the fewest IPS (Fig. 65). When reviewing this information, one must remember that the inventory is of forested land so areas with less forest have fewer plots. Aside from the distribution of the monitored invasives, there are noteworthy differences between plots with and without invasive plants. Plots where IPS were detected are located closer to roads (within 1,139 feet versus 2,714 feet for plots without invasive species); less forested (85.4 percent versus 94.8 percent without invasives detected); and had fewer trees greater than or equal to 1 inch d.b.h. counted on plots (966 versus 1,581). However it is important to consider that the correlation with regeneration may be indicative of conditions favorable of their presence.

Table 5.—Number of occurrences by invasive plant species on P2 invasive plots, (NRCS 2015), Maine 2009-2013.

Name	Scientific name	Observances	Percentage of plots
Reed canarygrass	*Phalaris arundinacea*	27	5.0
Nonnative bush honeysuckles	*Lonicera*, spp	12	2.2
Bull thistle	*Cirsium vulgare*	10	1.9
Japanese barberry	*Berberis thunbergii* DC	6	1.1
Canada thistle	*Cirsium arvense*	5	0.9
Glossy buckthorn	*Frangula alnus*	4	0.7
Multiflora rose	*Rosa multiflora*	4	0.7
Common buckthorn	*Rhamnus cathartica*	3	0.6
Oriental bittersweet	*Celastrus orbiculatus*	3	0.6
Norway maple	*Acer platanoides*	2	0.4
Autumn olive	*Elaeagnus umbellata*	1	0.2

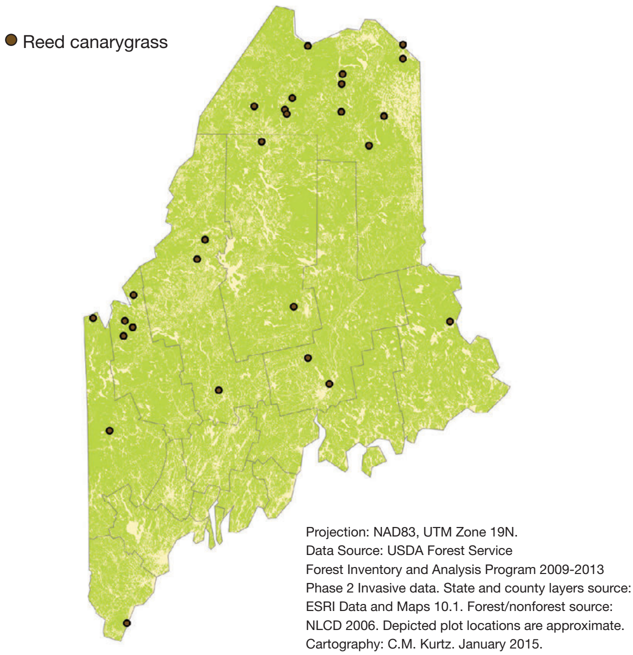


Figure 64.—Distribution of FIA plots where reed canarygrass was observed, Maine, 2013. Plot locations are approximate.

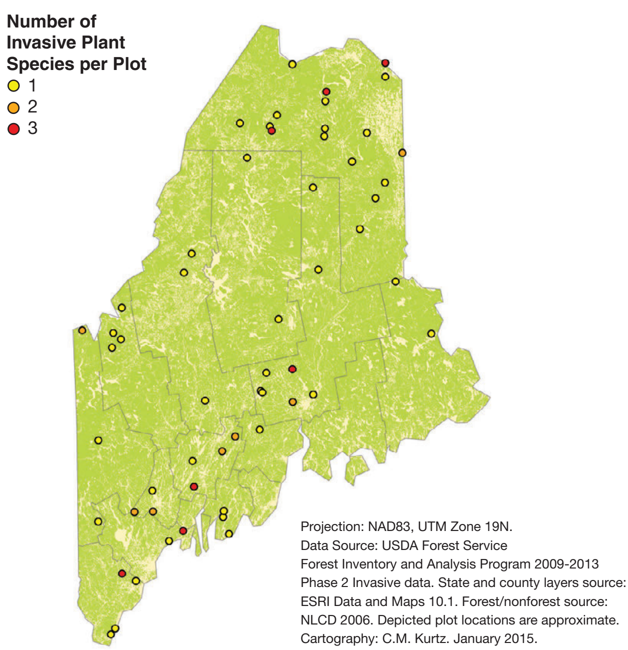


Figure 65.—Distribution of the plots where invasive plant species (IPS) were observed and the number of IPS per plot, Maine, 2013. Plot locations are approximate.

In 2008, only 2 years of invasive plant data had been reported and Morrow's honeysuckle (*Lonicera morrowii*) was the most commonly observed invasive plant species (McCaskill et al. 2011). The most commonly observed IPS in 2013 was reed canarygrass and the percentage of P2 invasive plots on which it was recorded increased from 3.2 to 5.0 percent. Over time it will be important to monitor the percentage of plots where these species are observed as well as to watch for the presence of new invasive species.

What this means

Maine forests had less plots invaded (10.4 percent) than neighboring New Hampshire where 11.2 percent of plots had one or more of the monitored invasive plant species. However, a larger number of the monitored species were observed in Maine than New Hampshire, 11 versus 8 species (Morin et al. 2015). The presence of IPS within Maine forests is troublesome and it is important that these species are monitored over time to ensure that managers and the general public are aware of their occurrence and spread.

Invasive plants are good competitors and able to alter forested ecosystems by displacing native species and impacting the fauna that depend upon them. Several factors contribute to their success: they are prolific seed producers, have rapid growth rates, can propagate vegetatively, and survive harsh conditions. Many factors contribute to forest invasion such as ungulates, development, fragmentation, and timber harvesting. When forests are invaded, they negatively affect the carbon budget by having diminished future tree cover. Furthermore, these species can cause negative economic implications by reducing timber yield and aesthetic beauty. Further investigation of the inventory data may help to reveal influential site and regional trends.

Forest Structure and Habitats

Maine's forests, woodlands, and savannas provide habitats for 146 species of birds, 46 species of mammals, and 19 species of amphibians or reptiles (NatureServe 2009). Like all states, Maine has developed a comprehensive wildlife conservation strategy, known as a State Wildlife Action Plan (MIFW 2005). Maine's plan was completed in 2005; a revision is currently in the draft stage and open for public comments (http://www.maine.gov/ifw/wildlife/reports/MWAP2015.html). Species of birds, mammals, reptiles, amphibians, plants, and invertebrates (and their forested habitats) of greatest conservation need (SGCN) are listed in the plan. The distribution of forest-associated SGCN are summarized by primary habitat:

- Deciduous and mixed forest—21 species (15 birds, 1 amphibian/reptile, 5 invertebrates)
- Coniferous forest—11 species (9 birds, 2 invertebrates)
- Mountaintop forest—2 species (1 bird, 1 mammal)
- Shrub/early successional—13 species (10 birds, 3 mammals)

A forest structural stage can be identified using a combination of age class and stand-size class data. This data can be used as a "coarse filter" scale of conservation to evaluate natural habitats for conserving ecosystems. Rare, imperiled, or wide-ranging wildlife species may require a "finer filter" approach to address species-specific habitat needs. Particular habitat features (e.g., snags, down woody logs, riparian forest strips), that can meet the habitat requirements for multiple species are assessed for mesoscale conservation. The quality of habitat can be evaluated by the total forest area for early- versus late-successional forests (coarse filter); determining the retention level of specific habitat features such as snags, cavity trees, and downed logs (mesofilter); and by monitoring the specific management prescriptions for individual species such as American marten (*Martes americana*) and ovenbird (*Seiurus aurocapilla*) (fine filter).

We report on forest structure and trends by age class and stand-size class, as well as the quantity and distribution of standing dead trees by forest type.

Forest Age and Size

Background

The survival of some species of wildlife depends on early-successional forests composed of smaller, younger trees, while other species require the protection of older, interior forests containing large trees with complex canopy structure. Another group of species inhabit the edge between these two different forest stages. For example, Maine's SGCN shrub/early successional primary habitat users include blue-winged warbler (*Vermivora cyanoptera*), American woodcock (*Scolopax minor*), New England cottontail (*Sylvilagus transitionalis*), and Canada lynx (*Lynx canadensis*).

Abundance and trends in structural attributes at different successional stages serve as indicators of population carrying capacity for wildlife species (Hunter et al. 2001). Habitat conditions from 1995 to 2013 are estimates for all forest land. Tree diameter measurements are used by FIA to assign a stand-size class to sampled stands by forest type and area.

What we found

Forests in the small diameter stand-size class make up 31 percent of Maine's forest land, an 18 percent increase between 1995 and 2013 (Fig. 66). In contrast, forests in the medium diameter stand-size class decreased by 11 percent to 35 percent of the total forest land during the same period. Forests in the large diameter stand-size class have remained fairly stable at 33 percent (Fig. 66). In Maine, all three stand-size classes contain forests from at least five age classes. As expected, medium stand-size class is predominated by forests in the 41 to 80 years of age class, with a lower abundance of both younger and older forest. Large stand-size class has a similar age distribution, but skewed slightly to the right, predominated by 61 to 100 year age class. Almost all young forests (0 to 20 years) are found in the small diameter stand-size class, but forests of the 21- to 40-year age-class contain the most acreage of forests in the small diameter class (Fig. 67).

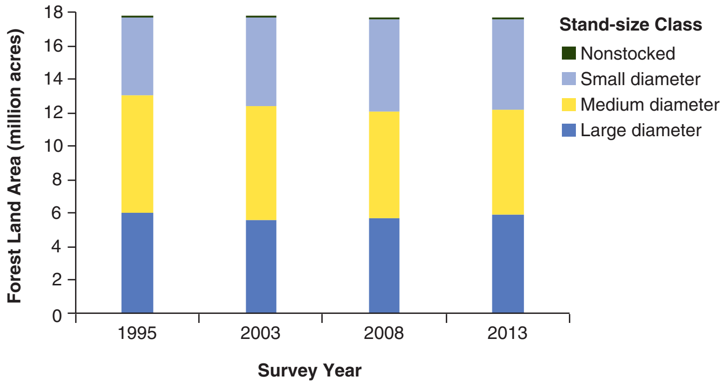


Figure 66.—Area of forest land by stand-size class and inventory year, Maine.

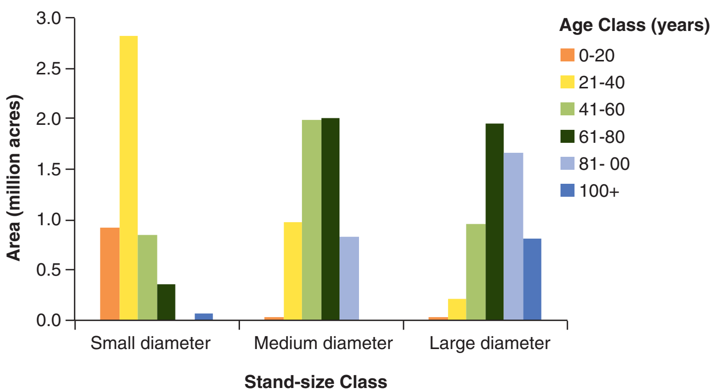


Figure 67.—Area of forest land by stand-size class and stand-age class, Maine, 2013.

What this means

Since 1995, the acreage of forest land with large diameter-sized trees has remained stable, accompanied by a decreasing area in medium diameter forests and an increasing area of forests in the small diameter stand-size class. Both stand-size class and stand-age class can be indicators of forest structural/successional stage. However, the smallest stand-size class is not predominated by the youngest stand-age class (0 to 20 years), in contrast to many states. In Maine, over 93 percent of 0- to 20-year-old forests are in small diameter stand-size class, but only 18 percent of small diameter forests are 0 to 20 years of age. As expected, almost none of 0- to 20-year-old forests occurs in medium or large diameter stand-size classes. There is almost no forest in stands dominated by small diameter trees ages greater than 80 years old. Somewhat surprisingly, there are 25 percent of small diameter trees in stands over 40 years of age. The large diameter stand-size class includes the greatest age heterogeneity, including forest land in all six age classes. Such mixtures of different aged or sized trees provide a vertical diversity of vegetation structure that can enhance habitat conditions for some species. Managing forest conditions in a variety of age and size classes will promote both early and late successional habitats for a diversity of forest-associated wildlife species.

Standing Dead Trees

Background

Specific features, such as 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) d.b.h. and at least 6 feet (1.8 m) tall" (Society of American Foresters 1998). Standing dead trees also serve as important indicators of past mortality events, store carbon, and serve as the primary source for down woody material (discussed elsewhere in this report), which provides additional habitat features for wildlife. The number and density of standing dead trees, together with decay classes, species, and sizes, define important wildlife habitat features across Maine's forests.

What we found

FIA inventories standing dead trees at least 5 inches d.b.h. by species and diameter class and categorizes each tree into one of the five stages of decay. More than 402 million standing dead trees are present on the forest lands of Maine. This equates to an overall density of 23 standing dead trees per acre across the State, with higher densities on public (31.0 standing dead trees per acre) than on private (22.2 trees per acre) ownership. Seven of the thirteen major species groups in Maine each contributed more than 20 million standing dead trees, with the spruce and balsam fir group contributing over 162 million alone (Fig. 68). Balsam fir, a short-lived species, represents 72 percent of this group or 116.8 million dead trees.

Over 85 percent of the standing dead trees are smaller than 11 inches d.b.h., with 45 percent between 5 and 6.9 inches d.b.h. (Fig. 69). In contrast, only 2 percent of the standing dead have diameters over 17 inches, which is in line with the percentage of live trees over 17 inches. The decay class comprising most of the standing dead trees is the middle class (defined as only limb stubs present; 27 percent). The classes of least decay (all limbs and branches present) and most decay (no evidence of branches remain) comprise the smallest percentage (15 percent each). The proportion of each decay classes remains constant across all diameter classes (Fig. 69).

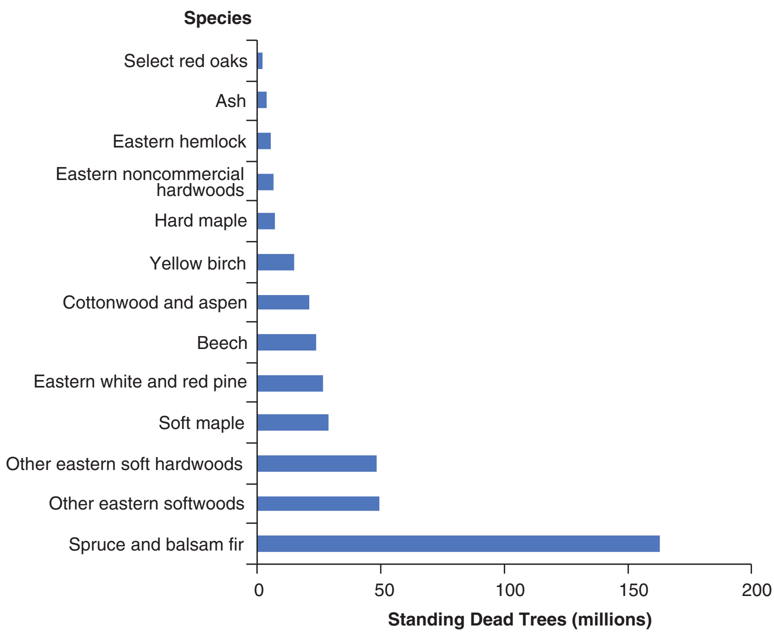


Figure 68.—Number of standing dead trees by species group, Maine, 2013.

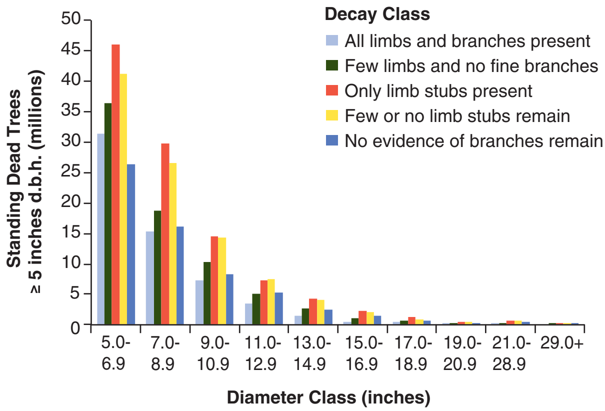


Figure 69.—Standing dead trees by diameter class and decay class, on forest land, Maine, 2013.

What this means

Snags and smaller standing dead trees result from a variety of causes, including diseases and insects, weather damage, fire, flooding, drought, and inter-competition. Dead trees are the primary source of cavities, and provide habitat for foraging, nesting, roosting, and hunting. Most cavity nesting birds are insectivores, which help to control insect populations. Since the availability of large standing dead trees (snags) may be a limiting habitat feature for some species of wildlife, retaining snags on both private and public lands can help forest managers maintain the abundance and quality of habitat for forest-associated wildlife species in Maine.

Urbanization and Fragmentation

Background

Human population growth, migration, and urbanization can transform the landscape by fragmenting some of the remaining larger tracts of forest land into smaller and disconnected parcels. Remote sensing using geographic information system (GIS) software is the primary tool for assessing the extent of landscape-level impacts of urbanization and fragmentation on forest land. The growth of population centers can pose numerous pressures on neighboring forest lands by exposing them to higher numbers of people and their associated pollutants (Nowak and Walton 2005). On the other hand, it is harder to detect forces which act to limit forest fragmentation. Two forces which limit the impacts of urbanization are the reversion of agricultural land to forest land and the emigration of residents to another region. Within New England, it has been evident that much of the loss in forest land near population centers has been effectively offset by the reversion of farms to forest; what has been less obvious are the forces of emigration on limiting urbanization.

What we found

Maine is approximately 30,865 square miles of land with 1.3 million residents, resulting in a density of 42 people per square mile. This currently ranks 38th out of 50 states. The national average is 86 people per square mile. Maine's low population density is a reflection of the State having land that is 89 percent forested. The U.S. Census Bureau (2005) projected a 10.7 percent increase in the State's population for the period of 2000 to 2030, or 136,000 persons (Table 6). Those projections are high compared to the actual change documented to date; in all likelihood the population increase will be less than 90,000 persons or about a 7.0 percent increase from 2000 to 2030. This process seems to be the trend throughout most of New England and is an example of emigration playing a positive role by limiting the expansion of urban areas and therefore lowering the levels of vulnerability to forest fragmentation (Faith and Walker 1996).

Maine's only two urbanized areas, where more than 50,000 people are concentrated, include the Portland metro area (Portland, South Portland, Westbrook, Biddeford, Old Orchard Beach, Saco, and Scarborough), and the Bangor metro area (Bangor, Brewer, Hampden, Old Town, Ellisforth, and Orono) located farther north (Table 7). The latest estimates for the 2010-2013 period shows continued slow growth throughout Maine with population gains in the southern towns being offset by losses in the northern urban centers of Maine (Portland Press Herald 2016).

Table 6.—U.S. Census interim population projections verses actual growth, 2000 to 2030 (U.S. Census Bureau 2005).

Region, division, and state	2000 Census Population	Projected change 2000 to 2010	Actual change 2000 to 2010	Projected change (%) 2000 to 2010	Actual change (%) 2000 to 2010	Projected change (%) 2000 to 2030	Revised projections (%) 2000 to 2030
New England	13,922,517	816,272	522,348	5.9	3.8	12.2	7.9
Maine	1,274,923	82,211	53,438	6.4	4.2	10.7	7.1
New Hampshire	1,235,786	149,774	80,684	12.1	6.5	33.2	12.4
Vermont	608,827	43,685	16,914	7.2	2.8	16.9	6.5
Massachusetts	6,349,097	300,344	198,532	4.7	3.1	10.4	8.3
Rhode Island	1,048,319	68,333	4,248	6.5	0.4	10.0	3.6
Connecticut	3,405,565	171,925	168,532	5.0	4.9	8.3	8.0

Table 7.—Population growth of Maine urban centers: 2010 to 2013 (Portland Press Herald Interactive 2016).

2013 Rank	City	Estimate 2013	2010 Census	Change %	County
1	Portland †	66,318	66,194	0.19	Cumberland
2	Lewiston	36,437	36,592	–0.42	Androscoggin
3	Bangor †	32,673	33,037	–1.10	Penobscot
4	South Portland	25,255	25,002	1.01	Cumberland
5	Auburn †	22,987	23,052	–0.28	Androscoggin
6	Biddeford	21,297	21,277	0.09	York
7	Sanford	20,001	20,798	–3.83	York
8	Scarborough	19,165	18,919	1.30	Cumberland
9	Augusta ††	18,793	19,132	–1.77	Kennebec
10	Saco	18,877	18,482	2.13	York
11	Westbrook	17,743	17,494	1.42	Cumberland
12	Waterville	15,962	15,722	1.52	Kennebec
13	Orono	10,585	10,362	2.15	Penobscot
14	Presque Isle	9,402	9,665	–2.72	Aroostook
15	Brewer	9,362	9,470	–1.14	Penobscot
16	Old Orchard Beach	8,666	8,624	0.49	York
17	Skowhegan †	8,552	8,589	–0.43	Somerset
18	Bath †	8,357	8,486	–1.52	Sagadahoc
19	Caribou	7,952	8,167	–2.63	Aroostook
20	Old Town	7,720	7,833	–1.44	Penobscot
21	Ellsworth †	7,875	7,784	1.17	Hancock
22	Farmington †	7,623	7,760	–1.77	Franklin
23	Rockland †	7,209	7,297	–1.21	Knox
24	Hampden	7,271	7,257	0.19	Penobscot
	State total	416,082	416,995	-0.22	

†County seat; ††State capitol and County seat.

What this means

Even though the population is expected to increase over the next two decades, the rate of change will be low compared to what the U.S. Census Bureau projected for Maine and for most of New England. The situation for New England (+7.9 percent) is in stark contrast to other regions of the country (South and West) where growth rates should be closer to 30 percent by 2030. Slower population growth will result in lower rates of urbanization and forest fragmentation, provided local governments have up-to-date urban plans that value or reserve open lands. Emigration should be given a stronger consideration as a positive force on urbanization and forest fragmentation considering the weak population projections of 2005 which have been utilized in a number of modeling projects. There are concerns of impacts upon water quality within the Lower Kennebec and Saco watersheds from increased urbanization, particularly from outside the state's southern boundary (Stein et al. 2009).

Maine's Future Forest

Background

The future of Maine's forests remains uncertain, but there are some indicators and tools that can be used for the prediction of some potential futures and impacts based upon differing future conditions.

The analysis presented here is taken from the Future Forests of the Northern United States (Shifley and Moser 2016), which makes projections of future forest conditions in the northern region from 2010 through 2060. These projections use future scenarios generated from the Resources Planning Act (RPA) 2010 assessment (U.S. Forest Service 2012b).

A major component of future forest change will be the result of normal forest growth, aging, natural regeneration, and species succession. In addition, the following external variables were imputed to drive the forest-change model:

- U.S. Census Bureau interim population projections 2000-2030 (Table 6)
- Land-use change estimation up to 310,000 acres (1.7 percent) of forest land would be converted to urban land based on the above population projections (Nowak and Walton 2005)

- Future economic forces that could increase in forest products consumption and impact production and harvest rates
- The spread of invasive species could alter species mix
- Growth in population, the economy, and energy consumption could affect climate change
- How climate change might affect patterns of forest growth and succession

The Northern Forest Futures study utilized several alternative scenarios that cover a range of different assumptions from historical too severe about population, land use, the economy, invasive species, climate, and other driving forces. The assumptions were incorporated into analytical models that predict how northern forests could change under each alternative scenario. The seven scenarios can be grouped by a climate model, storyline, and storyline variation. Two climate models, three storylines, and three variations were used to produce the seven scenarios.

All projections are estimated using two versions of a coupled global circulation model, the CGCM 3.1 (Canadian Centre for Climate Modeling and Analysis 2012a) for A1B and A2, and the CGCM2.0 (Canadian Centre for Climate Modeling and Analysis 2012b) for B2.

The three storylines:

1) A1B—Rapid economic globalization

2) A2—Consolidation into economic regions

3) B2—Trend toward local self-reliance and stronger communities

The three storyline variations (also known as scenarios):

1) C—Historical or normal range of variation

2) EAB—Variation of only the A2 storyline and incorporating the potential impact of the emerald ash borer with associated mortality of all ash trees in the affected areas: this is referred to as scenario A2-EAB.

3) BIO—Variations of the A1B, A2, and B2 storylines incorporating the potential impacts of rapid population growth and severe harvesting and utilization of woody biomass for energy, and are referred to as scenarios A1B-BIO, A2-BIO, and B2-BIO.

What we found

Over the next 50 years, forest land is projected to decline from an estimated 17.6 million acres in 2010 to 17.3 million acres (-1.9 percent) in 2060 under scenario A1B-C; to 17.4 million acres (-1.6 percent) under scenario A2-C; and to 17.5 million acres (-1.0 percent) under scenario B2-C. All three scenarios would reverse the century-long trend of increasing forest area in Maine (Fig. 70). Those storylines focused around the greatest population growth and the most robust levels of economic activity alter the area of forest land significantly, and only then in the scenarios where acute increases in population and economic activity project less future forest land. Just three scenarios are represented in Fig. 70 because the choice of a climate model and variations on the storylines did not impact the projected area of forest land. Any projected losses of forest land from 2010 to 2060 were relatively small compared to the cumulative increases in forest area since start of the 20th century. In 2060, the forests of Maine are expected to remain the dominant land cover (≥89 percent).

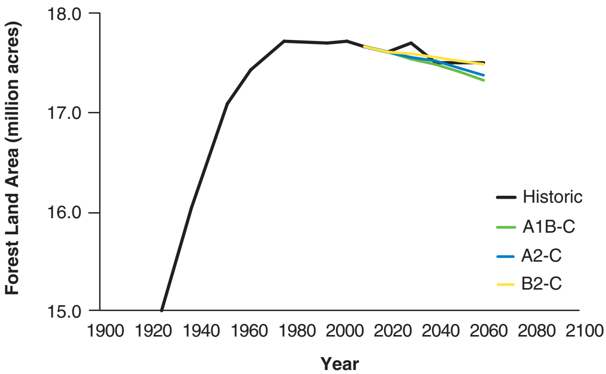


Figure 70.—Historic and projected (2010-2060) forest land area by storyline, Maine.

Emerald ash borer (EAB) was discovered within 40 miles of the southern border of Maine in December 2013. Ash species barely comprise 2 percent of the total live tree volume on forest land in Maine and only 8.4 percent of the volume in the minor elm/ash/cottonwood forest-type group. Most ash trees are found in the maple/beech/birch forest-type group, so that is where any impacts from EAB infestations would be felt.

Under scenario A2-C-EAB ash species volume is projected to decline from 550 million cubic feet in 2010 to zero cubic feet by 2050 (Fig. 71). Under scenario A2-C, ash volume is expected to increase from 550 million cubic feet in 2010 to 578 million cubic feet by 2060. A projected decline in the area for elm/ash/cottonwood forest-type group from 2010 to 2060 is projected to decrease under both scenarios A2-C (-40 percent) and A2-C-EAB (-25 percent). Any loss of the ash component in the elm/ash/cottonwood forest-type group in scenarios A2-C and A2-C-EAB is mostly offset by increases in other associated species in the maple/beech/birch forest-type group where ash trees are found in larger numbers (Fig. 71).

All three high biomass utilization scenarios (A1B-C-BIO, B2-C-BIO and A2-C-BIO) project lower levels of live tree volume in 2060 compared to the 2010 volume (Fig. 72). That is in contrast to the corresponding normal biomass utilization scenarios based upon historical patterns (A1B-C, B2-C, and A2-C). Historical patterns have the area of forest land projected to decrease with a compensating volume per acre increase for scenarios A1B-C, A2-C, B2-C, and even A2-C-EAB; as forests continue to mature.

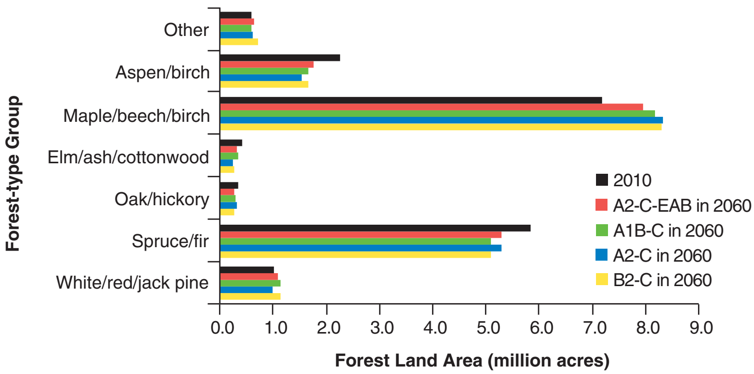


Figure 71.—Current (2010) and projected (through 2060) forest land area by scenario and forest-type group, Maine.

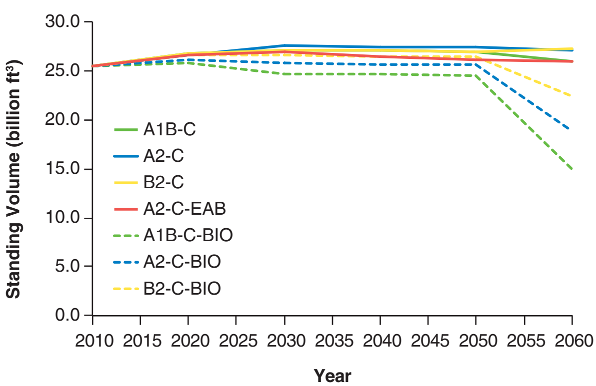


Figure 72.—Projected (2010-2060) tree volume on forest land by scenario, Maine.

What this means

Given the lower-than projected State population growth, the area of forest land is expected to decrease only slightly while the stand volume per acre is expected to increase moderately as Maine's forests mature. Overall, standing volume is expected to increase over the 2010-2060 period. Ash mortality is expected to rise with the spread of EAB, but this insect will have a minimum effect within the maple/beech/birch forest-type group where most of the ash trees are found as a minor species. The sustainability of the future wood supplies could be a risk if biomass utilization increases dramatically. Another factor that could limit projected volume increases is the possibility of a future spruce budworm outbreak.

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Appendix—List of tree species, greater than or equal to 5 inches in diameter, found on FIA inventory plots, Maine, 2013.

Common name	Genus	Species
Balsam fir	*Abies*	*balsamea*
Larch spp.	*Larix*	spp.
Tamarack (native)	*Larix*	*laricina*
Norway spruce	*Picea*	*abies*
White spruce	*Picea*	*glauca*
Black spruce	*Picea*	*mariana*
Blue spruce	*Picea*	*pungens*
Red spruce	*Picea*	*rubens*
Jack pine	*Pinus*	*banksiana*
Red pine	*Pinus*	*resinosa*
Pitch pine	*Pinus*	*rigida*
Eastern white pine	*Pinus*	*strobus*
Scotch pine	*Pinus*	*sylvestris*
Northern white-cedar	*Thuja*	*occidentalis*
Eastern hemlock	*Tsuga*	*canadensis*
Boxelder	*Acer*	*negundo*
Striped maple	*Acer*	*pensylvanicum*
Red maple	*Acer*	*rubrum*
Silver maple	*Acer*	*saccharinum*
Sugar maple	*Acer*	*saccharum*
Mountain maple	*Acer*	*spicatum*
Norway maple	*Acer*	*platanoides*
Serviceberry spp.	*Amelanchier*	spp.
Yellow birch	*Betula*	*alleghaniensis*
Sweet (black) birch	*Betula*	*lenta*
River birch	*Betula*	*nigra*
Paper birch	*Betula*	*papyrifera*
Gray birch	*Betula*	*populifolia*
American hornbeam (musclewood)	*Carpinus*	*caroliniana*
Shagbark hickory	*Carya*	*ovata*
American chestnut	*Castanea*	*dentata*
Hawthorn spp.	*Crataegus*	spp.
American beech	*Fagus*	*grandifolia*
White ash	*Fraxinus*	*Americana*
Black ash	*Fraxinus*	*nigra*
Green ash	*Fraxinus*	*pennsylvanica*
Butternut	*Juglans*	*cinerea*
Black walnut	*Juglans*	*nigra*
Yellow-poplar	*Liriodendron*	*tulipifera*
Apple spp.	*Malus*	spp.

(Appendix continued on next page.)

(Appendix continued)

Common name	Genus	Species
Eastern hophornbeam	*Ostrya*	*virginiana*
American sycamore	*Platanus*	*occidentalis*
Balsam poplar	*Populus*	*balsamifera*
Eastern cottonwood	*Populus*	*deltoides*
Bigtooth aspen	*Populus*	*grandidentata*
Quaking aspen	*Populus*	*tremuloides*
Cherry and plum spp.	*Prunus*	spp.
Pin cherry	*Prunus*	*pensylvanica*
Black cherry	*Prunus*	*serotina*
Chokecherry	*Prunus*	*virginiana*
Sweet cherry	*Prunus*	*avium*
White oak	*Quercus*	*alba*
Swamp white oak	*Quercus*	*bicolor*
Bur oak	*Quercus*	*macrocarpa*
Northern red oak	*Quercus*	*rubra*
Black oak	*Quercus*	*velutina*
Black locust	*Robinia*	*pseudoacacia*
Willow spp.	*Salix*	spp.
Mountain-ash spp.	*Sorbus*	spp.
American mountain-ash	*Sorbus*	*americana*
American basswood	*Tilia*	*americana*
Basswood ssp.	*Tilia*	ssp.
American elm	*Ulmus*	*americana*
Elm ssp.	*Ulmus*	ssp.

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The third 5-year annualized inventory of Maine's forests was completed in 2013 after more than 3170 forested plots were measured. Maine contains more than 17.6 million acres of forest land, an area that has been quite stable since 1960, covering more than 82 percent of the total land area. The number of live trees greater than 1 inch in diameter are approaching 24.5 billion trees. Aboveground biomass of all live trees has increased slightly since 2008. Over the same period, the average annual volume for tree growth has increased 30 percent and tree mortality has decreased 15 percent. Tree harvest levels have remained flat since 2008.This report also includes detailed information on forest inventory methods and the quality of the estimates found in five tables (Tables A-E). A complete set of data tables and other resources can be found at http://dx.doi.org/10.2737/NRS-RB-103.

KEY WORDS: forest resources, volume, regeneration, forest health, forest products, biomass, carbon.

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