Maine's Forests 2008

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Abstract

The second full, annualized inventory of Maine's forests was completed in 2008 after more than 3,160 forested plots were measured. Forest land occupies almost 17.7 million acres that represents 82 percent of the total land area of Maine. The dominant forest-type groups are maple/beech/yellow birch, spruce/fir, white/red/jack pine, and aspen/white birch. Total statewide volume equals 25.5 billion ft^3, resulting in almost 590 million ft^3 of live tree volume grown each year. The report also contains additional information on sustainability, biomass, carbon, forest health, land use change, and timber products.

DVD included in this report includes detailed information on forest inventory methods and the quality of the estimates found in five detailed tables (Tables A-E). A complete set of core tables are contained on the DVD or can be found online: http://www.nrs.fs.fed.us/fia/data-tools/state-reports/default.asp.

Acknowledgments

The authors would like to thank the many individuals who contributed both to the inventory and analysis of Maine's forest resources. Rich Widmann for his expertise and guidance on Maine's forest inventory and the history of their forest industry. Primary field crew and QA staff over the 2004-2008 field inventory cycle included Mike Devine, Jeff Harriman, Ken Canfield, Melanie Duffy, Kevin Doran, Joe Bither, Greg Bjork, and other seasonal Maine Forest Service personnel. Data management personnel included Carol Alerich, Charles Barnett, Barbara O'Connell, and Mark Hatfield. Report reviewers included Ken Laustsen of the Maine Forest Service, John Gunn of the Manomet Center, Lloyd Irland of Yale University, Laura Kenefic of the U.S. Forest Service, Todd Caldwell of L.E. Caldwell Co., and Robert Seymour of the University of Maine.

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Contents

Highlights

On the Plus Side

Maine ranks 39th in land area among the 50 states, but ranks 17th in total forest-land area.

The 17.7 million acres of forest land represent 82 percent of the total land area of Maine. This level of forest land has remained constant for more than 50 years. Timberland represents more than 96 percent of forest land in each of the four megaregions and statewide.

The number of tree seedlings has increased by more than 66 percent or 42 billion trees since 2003. Balsam fir seedlings have increased by 103 percent or 15 billion. Red spruce seedlings have increased by 64 percent or 3 billion.

The volume of growing-stock trees at least 5 inches in diameter at breast height (d.b.h.) on Maine's timberland has remained stable since 2003.

Growing-stock removals (harvest and other) of all species combined is in balance with net growth (growth:removal ratio = 1.02) on timberlands. Softwood removals have decreased since 1995.

Maine's forests sequester 1.48 billion metric tons of carbon, a 2-percent increase over 2003 levels.

The number of trees at least 21 inches in d.b.h. or greater on forest land has increased by 7.3 percent or 1 million since 2003.

Since 2003, there has been an increase in the number of standing dead trees per acre in the southern FIA inventory units of Casco Bay, Capitol, Western, and coastal Hancock County.

Pulpwood harvests have increased little since 1990. Biomass chip harvests have increased by 200 percent to 1.2 million cords during the same period.

Areas of Concern

The area of forest land in the Northern Hardwoods forest type has increased by 8.4 percent (557,000 acres) while the area in the Spruce-Fir type has decreased by 9.2 percent (594,000 acres), since 1995.

Although 65 percent of family forest owners have harvested timber, only 35 percent had a written forest management plan.

Balsam fir and red maples have dominated the seedling and sapling classes since 1982; accounting for 52 percent of the total tree population compared to 32 percent in 1982.

Hardwood growing-stock volume on timberland has declined by 3.1 percent since 2003.

The volume of American beech has declined since 2003.

Hardwood growing-stock removals exceed growth on a statewide basis (0.92) and in the Northern (0.63) and Eastern (0.83) megaregions. This is driven by the statewide growth-to-removals (G:R) ratio of 0.65 for sugar maple, which has a Northern megaregion G:R ratio of 0.52. Hardwood removals have increased since 1995.

Red spruce has a G:R ratio of 0.67 on a statewide basis, and 0.56 within the Northern megaregion.

Since 2003, the number of standing dead trees per acre on forest land has decreased in Aroostook, Penobscot, and Washington Counties.

Although only 9 percent of the inventory plots contain nonnative invasive species, the number of seedlings and saplings in those plots has decreased in comparison to those plots without nonnative invasive species.

Background

Great Heath Wetland, Maine. Photo by Ralph Tiner, www.fws.gov.

Beginner's Guide to the FIA Forest Inventory

Since the late 1940s, the U.S. Forest Service has inventoried Maine's forests. Periodic forest inventories were completed in 1959, 1971, 1982, and 1995 (Ferguson and Longwood 1960, Ferguson and Kingsley 1972, Powell and Dickson 1984, Griffith and Alerich 1996). In 1999, Maine and the Northeastern Research Station began inventorying 20 percent of the statewide plots each year. Two annual inventories were completed in 2003 and 2008 (McWilliams 2005). The third annual inventory (2009-13) is in its second year of field collection.

What is a tree?

The Forest Service's Forest Inventory and Analysis (FIA) program defines a tree as a perennial woody plant species that can attain a height of at least 15 feet at maturity.

What is a forest?

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

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

FIA classifies as one of three types of forest land: timberland, reserved forest land, and other forest land. In Maine, 97 percent of all forest land is classified as unreserved and productive timberland, 2 percent is reserved and productive forest land, and the remaining 1 percent is unproductive reserved or unreserved forest land (Fig. 1).

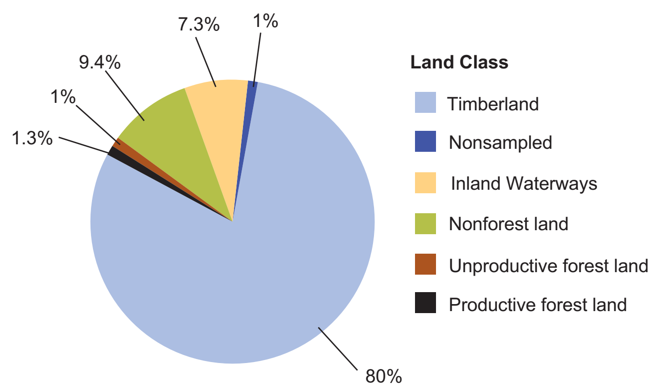


Figure 1.—Total area of Maine by land class.

- Timberland is unreserved forest land that meets the minimum productivity requirement of 20 ft^3/acre/year.

- Reserved forest land is land withdrawn from timber utilization through legislative regulation.

- Other forest land is common on low-lying sites or high craggy areas with poor soils where the forest is incapable of producing 20 ft^3/acre. In earlier inventories, FIA measured trees only on timberland plots and did not report volumes on forest land. Since the implementation of the new annual inventory in 1999, FIA has been reporting volume on all forest land.

- The third remeasurement is in its second field season and by 2013 one will be able to compare three sets of growth, mortality and removal data. Most of the trend reporting in this publication is focused on all forest land (including timberland and reserved forest land), except for the area on which measurement of individual trees are not required. Comparing current data to older periodic inventories requires timberland estimates.

How many trees are in Maine's forests?

Maine's forest land contains approximately 2.7 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). The estimate is based on only a sample of the total population. Area estimates are calculated from field measurement of 3,160 forested plots classified by ownership (Fig. 2). For information on sampling errors see Statistics and Quality Assurance section found on the DVD in the back of this report.

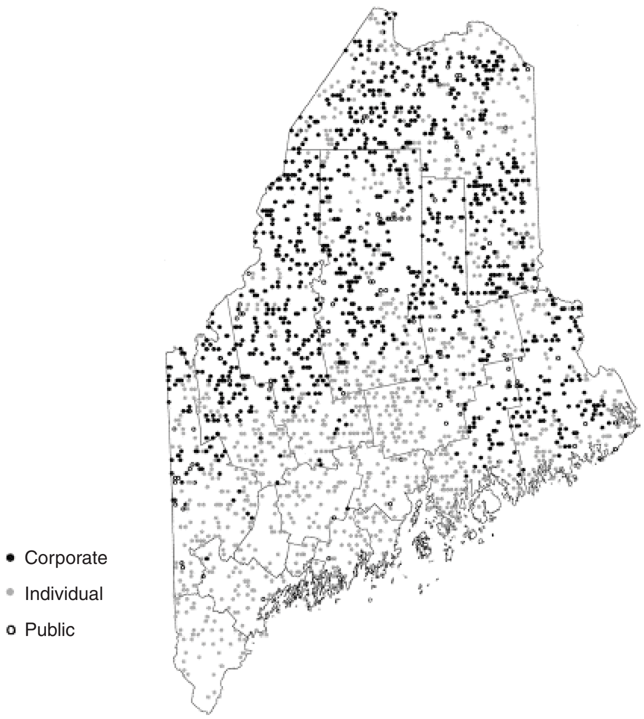


Figure 2.—Forested plot ownership categories: Corporate: (industrial forest product or timberland investment companies), Individual: (family forest, NGO trusts, or Native American), and Public: (federal, state, or local). Plot locations are approximate.

How do we estimate a tree's volume?

The volume for a specific tree species is usually determined by the use of volume equations developed for a given species. Sample trees are felled and measured for length, diameter, and taper. Several volume equations have been developed at the Northern Research Station for each tree species found within the region. Models have been developed from regression analysis to predict volumes within a species group. We can produce individual tree volumes based on species, diameter, and tree site index. Tree volumes are reported in cubic foot (ft^3) and board-foot (International ¼-inch rule).

How much does a tree weigh?

The specific gravity for each tree species or group of species was determined at the Forest Service's Forest Products Laboratory and applied to FIA estimates in developing merchantable tree biomass (weight of tree bole). To calculate total live-tree biomass, we must 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 inventories report biomass weights as oven-dry short tons. The oven-dry weight of a tree is the green weight minus the moisture content. Generally, 1 ton of oven-dry biomass equals 1.9 tons of green biomass.

How do we compare data from different inventories?

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

Prior to the implementation of the Component Ratio Method (CRM), volume and biomass were estimated using separate sets of equations (Heath et al. 2009). With the implementation of CRM, determining the biomass of individual trees and forests is simply an extension of FIA volume estimates. This allows for biomass estimates for growth, mortality, and removals of trees from forest lands, for the belowground portion of stumps and coarse roots, etc.

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

A word of caution on suitability and availability

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

Forest Features

Harper's Meadow, Lake Umbagog National Wildlife Refuge, ME. Photo by Carolina Vasconcelos, www.fws.gov.

Maine: A Forestry State

Background

Determining the current acreage of forest land and timberland in Maine provides a means to evaluate the status of the forest resource base, as well as changes in 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 any 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 nearly 400 years (Coolidge 1963).

What we found

Cities and agricultural land (nonforest) account for only 9.4 percent of Maine's land area. Inland waterways (census water and noncensus water) cover 7.3 percent of the State. Timberlands comprise 80 percent of the total area, while reserved productive forest land and unproductive forest land (including unproductive timberlands) account for 2.3 percent. One percent of the land was not sampled due to denied access or hazardous conditions (Figs. 1,3). Maine is the 39th largest state in land area but ranks 17th in the number of forested acres. Many of Maine's citizens rely on those forests for their livelihoods.

Forest land totals about 17.7 million acres or 82.4 percent of the State's total land area. Timberland accounts for more than 17.1 million acres of forest land. This area of forest land and commercial timberland has remained stable since the 1958 inventory (Fig. 4; Ferguson and Longwood 1960).

Maine is divided into nine FIA inventory units. Capitol and Casco Bay units are composed of four small counties, each. The Western unit contains Oxford and Franklin counties. The remaining five units are the counties of Aroostook, Penobscot, Piscataquis, Somerset, and Hancock. To stratify similar attributes, these units are combined into four megaregions (Fig. 5). The Northern megaregion (Aroostook, Piscataquis, and Somerset Counties) contains 49 percent of the State's timberland or 8.4 million acres; the Eastern megaregion (Hancock, Penobscot, and Washington Counties) has 25 percent or 4.2 million acres. The Southern megaregion (Casco Bay and Capital inventory units) and Western megaregion (Franklin and Oxford Counties) each contain 13 percent of the timberland, or about 2.3 million acres, respectively. Timberlands make up more than 96 percent

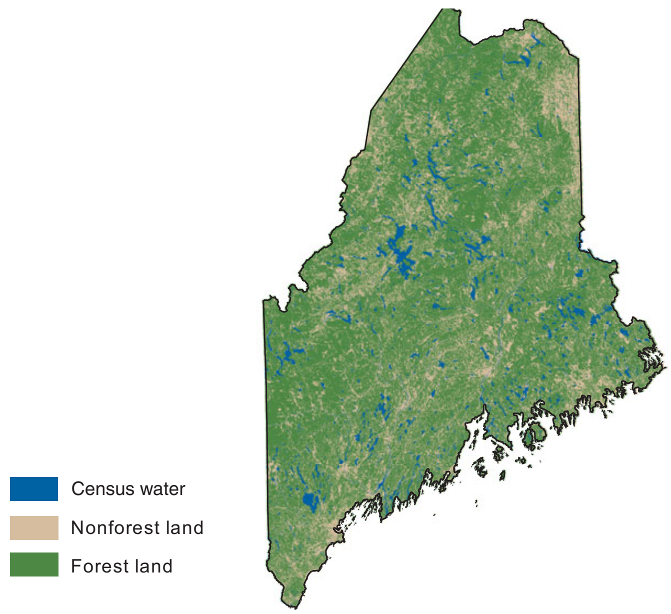


Figure 3.—Forest vs. nonforest land, Maine, 2008.

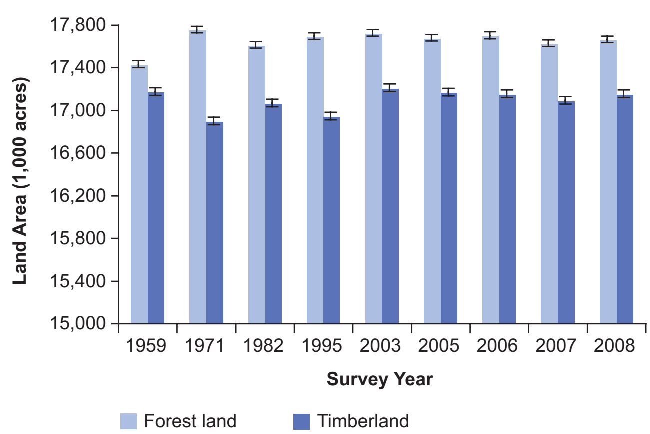


Figure 4.—Trends in forest land and timberland (error bars represent 68-percent confidence interval around estimate).

of all forest lands within each of the four megaregions. The Western and Southern megaregions are skewed with a plurality of stands assigned a size class of large and medium, whereas trees in the Northern and Eastern megaregions are distributed more equally amongst the three size classes (Fig. 6).

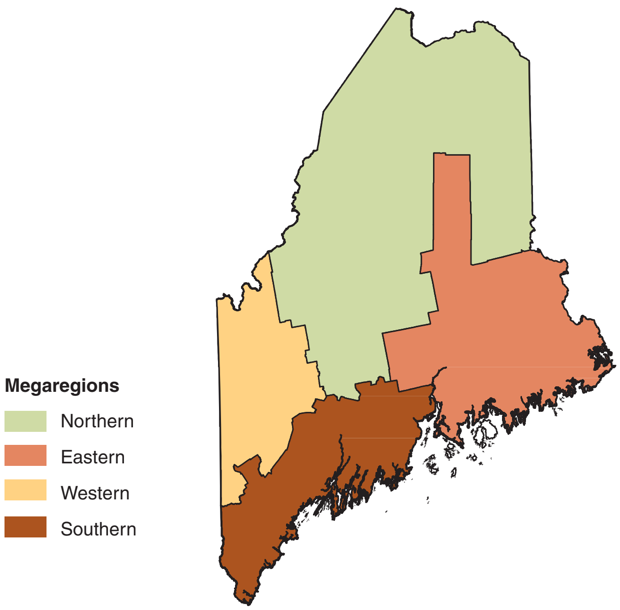


Figure 5.—Megaregions containing the nine FIA inventory units, Maine.

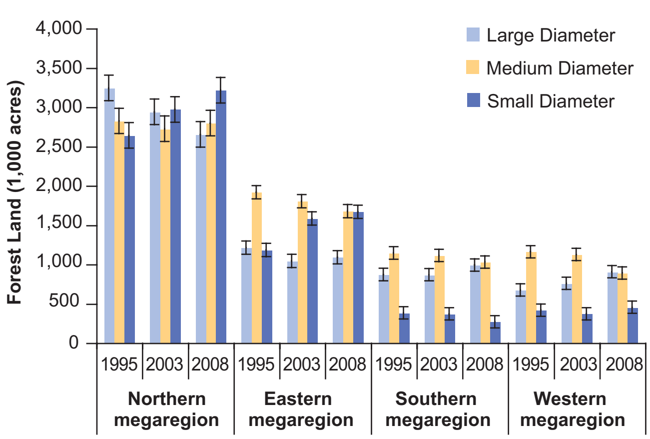


Figure 6.—Area of forest land (1,000 acres) by stand-size class and megaregion, Maine, 2008 (error bars represent 68-percent confidence interval around estimate).

What it means

The State's residents believe a stable forest-land base contributes to a stable economy. As stated, the area of forest land and commercial timberlands in Maine has remained stable for more than 50 years. Differences in the stand-size classes among megaregions may be a reflection of recent differences in harvesting intensity across the landscape.

Profile of Maine's Forests

Maine's forest land lies in a transition zone between boreal forests to the north and eastern deciduous forests to the south. The result is an ecotone containing tree species from each of these forest biomes being well represented within the State (Fig. 7). Maine's forest resources are unique in that the composition of tree species is divided nearly equally between hardwoods and softwoods (Fig. 8).

Biomes are formed by a combination of abiotic factors such as climate and regional geography and by biotic factors such as the numbers of species and their interaction with distinct vegetative cover types. Maine has been stratified into 19 biophysical regions that define the differences between the various biogeographical features within its landscape (Fig. 9). The U.S. Geological Survey has divided most of the United States into watershed administrative units (WAU; Fig. 10).

What we found

Maine encompasses three major forest regions that are divided into 25 recognized forest communities: Northern Forests which consists primarily of a spruce/fir forest-type group mixed with northern hardwoods; Mixed Northern Hardwoods of central Maine which are dominated by the maple/beech/birch forest-type group, but also contains sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), beech (*Fagus grandifolia*),

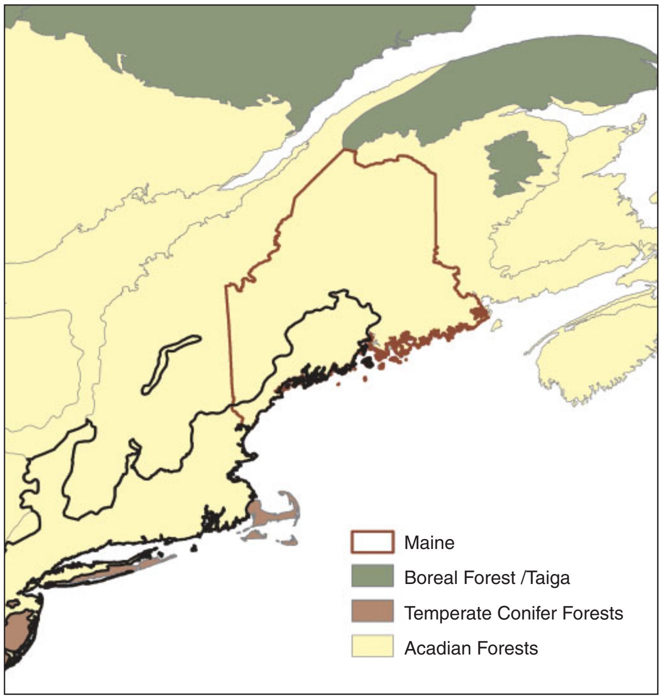


Figure 7.—Major biomes and ecoregions of the Northeast.

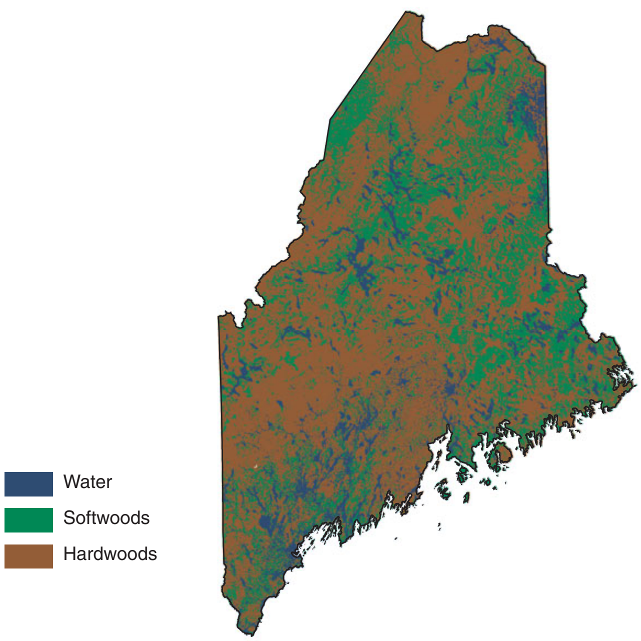


Figure 8.—Distribution of softwood and hardwood dominated forest types, Maine, 2008.

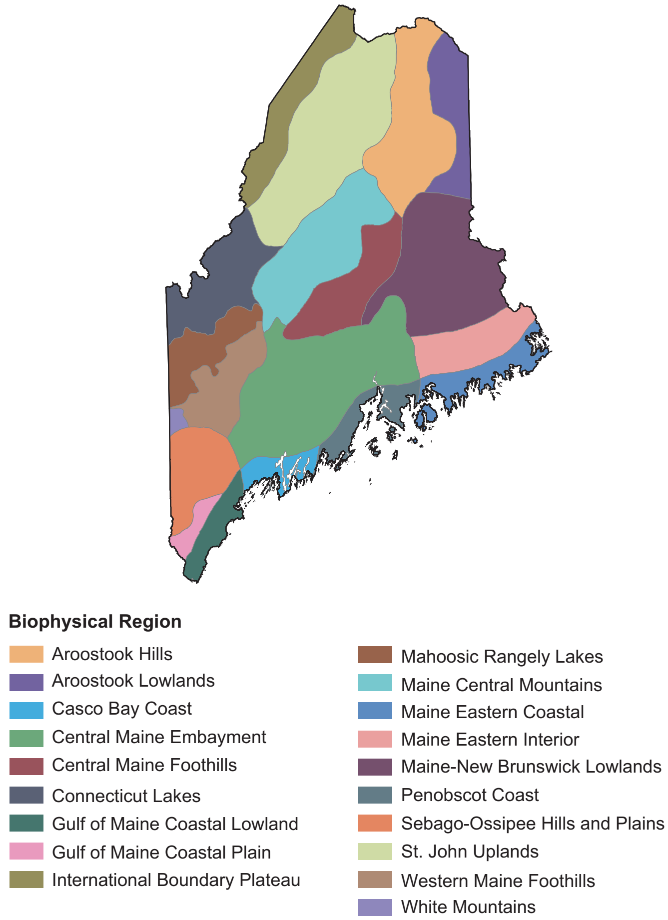


Figure 9.—Biophysical regions of Maine (Maine Department of Conservation 2008).

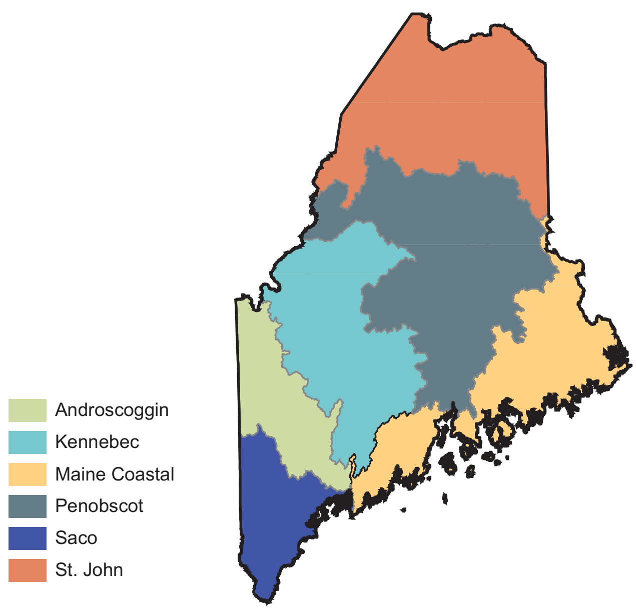


Figure 10.—Watershed administrative units of Maine (Watermolen 2002).

and numerous conifer species; and Oak-Pine Forests of southern Maine which contain red oak (*Quercus rubra*), eastern white pine (*Pinus strobus*), red maple (*Acer rubrum*), white ash (*Fraxinus americana*), and hickories (*Carya* spp.). The Northern Forests type is located on granite parent material extending from the White Mountains toward Mt. Katahdin in north central Maine and on well drained soils derived from glacial till deposited during the last Ice Age. Mixed Northern Hardwoods are found on the finer clay soils, while the oaks, white pine, ashes, and several hickory species grow on the sandy gravels. Maine's wet coastal areas and upland wetlands contain tamarack (*Larix laricina*), northern white-cedar (*Thuja occidentalis*), and black spruce (*Picea mariana*) to the north, with Atlantic white-cedar (*Chamaecyparis thyoides*), ash, hemlock, black spruce, and scattered tupelos to the south. These areas are developed from poorly drained organic soils with a heavy clay pan.

Eastern hemlock (*Tsuga canadensis*) is found in isolated pure stands along the coast or mixed with yellow birch or white/red pine. Jack pine (*Pinus banksiana*) grows in isolated pure stands in the mountains along the northwestern border or mixed with red pine, aspen (*Populus tremuloides*), and white pine in central Maine.

What this means

Maine's forest resources are rich in species and complexity. Softwood-dominated forests contain many hardwoods, and hardwood-dominated forests are mixed with softwoods. If a softwood forest is harvested, the residual stand can become dominated with hardwoods within a short time. Given the interaction between hardwoods and softwoods, the ecotone known as Maine's forests could change dramatically in composition and structure should climate change occur to the extent some scientists have predicted and if land management does not include efforts to control species composition (Iverson and Prasad 2001).

Forest Land Ownership

Background

Just as the forests of Maine are diverse and dynamic, so too are the individuals, corporations, and other groups that own them. And it is these owners who control the fate of the forests. To understand Maine's forests, we need to understand who owns the forest land, why they own it, and what they intend to do with it. Such information is collected through FIA's National Woodland Owner Survey (NWOS) as part of its biophysical survey (Butler et al. 2005).

What we found

Ninety-three percent of Maine's forests are privately owned. Most are held by a relatively small number of corporations including traditional, vertically integrated forest-products companies, timber investment management organizations (TIMOs), real estate investment trusts (REITs), and various corporations.

Public agencies manage 7 percent (1.2 million acres) of forest land in the State. Of this acreage 5 percent is controlled by state agencies such as the Maine Bureau of Parks and Lands. The 179,000 acres of federal land (1 percent) are managed primarily by the Forest Service, U.S. Park Service, and the U.S. Fish and Wildlife Service. Another 172,000 acres is managed by local government agencies (Fig. 11). Depending on the specific tract of land, these public forests are managed primarily for water protection, nature preservation, timber production, recreation, or a combination of these uses.

Ownership Dynamics

Between 2003 and 2008, the greatest change in forest ownership was a decrease in the area owned by corporations—nearly 300,000 acres. During this same period, there were commensurate increases in the areas owned by state agencies of 143,000 acres, and by families and individuals (72,000 acres) (Butler 2008).

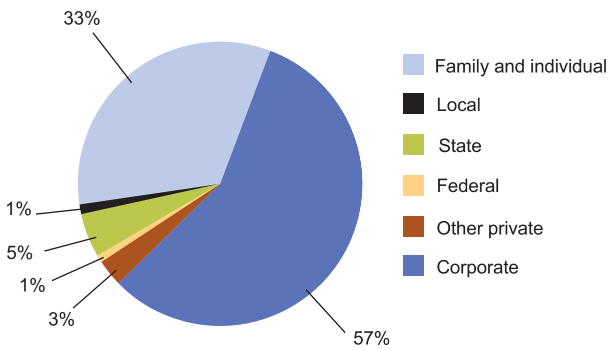


Figure 11.—Percent of forest land area by ownership class, Maine, 2006.

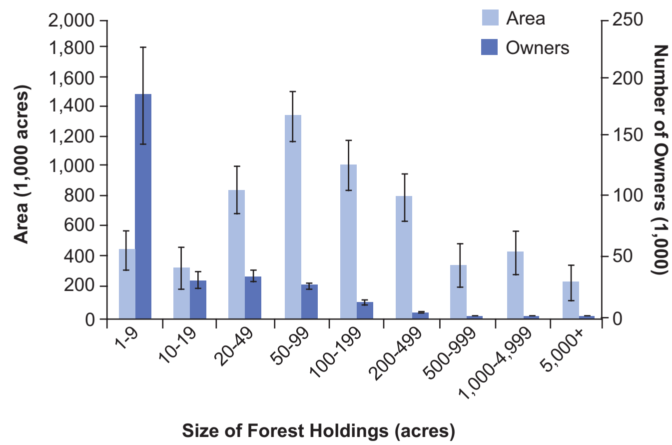


Figure 12.—Distribution of land ownership by area and number of owners, Maine, 2006 (error bars represent 68-percent confidence interval around estimate).

Since the 1980s, the major change in forest ownership was a shift of millions of acres from traditional, forest industries, such as International Paper, to the new types of owners: TIMOs and REITs. For inventory purposes, this was not a shift between FIA ownership categories as all of these commercial enterprises are classified as corporations. However there was a shift from owners who operate mills and have to ostensibly "feed" these mills, to owners whom were not motivated by keeping their mills in operation.

Of the 233,000 families and individuals who own forest land in Maine, almost two-thirds hold 1 to 10 acres. More than half of the family forest holdings are 50 to 500 acres (Fig. 12). The average family forest holding is 25 acres, a slight decrease from the average of 27 acres a decade earlier (Butler and Ma 2011, Birch 1996).

Family forests are owned for many reasons, but most reasons center around values such as aesthetics, privacy, recreation, and nature protection (Table 1). Although timber harvesting for most owners is not a primary objective, few are adverse to receiving extra income from their land. For example, almost two-thirds of the forest land is owned by people who have harvested trees commercially (Table 2). Because only one-third of the family forest land is owned by those with a written forest management plan, there may be a dearth of long-term planning.

Although most family forest owners intend to do little with their land over the next 5 years, 39,000 owners representing 1.8 million acres, plan to sell, give to heirs, or subdivide some or all of their forest land (Table 3). Legacy is important to many owners (Table 1, Table 3), and many are also worried about passing their forest land to the next generation (Table 4). Twenty percent of the family forest land is owned by people who are 75 years old or older, and 25 percent of the land is owned by people between the ages of 65 and 74 years. This indicates a large intergenerational shift of land will soon occur. This will have important ramifications for the future of Maine's forests.

What this means

The area of forest land and the number of forest landowners will continue to change as the population of Maine changes. Both of these factors need to be monitored closely to assure that landowners' needs are being met.

Between 2002 and 2006, 419 families and individuals who own forest land in Maine were surveyed as part of the NWOS. Completed questionnaires were returned by 53 percent of these owners. Survey results are included in Butler (2008) and are available at www.fia.fs.fed.us/nwos. For information on the sampling design and estimation and analysis procedures, see Butler et al. (2005).

Table 1.—Area and number of family forests in Maine by reason for owning forest land, 2006. Numbers include landowners who ranked each objective as very important (1) or important (2) on a seven-point Likert scale.

Reason[a]	Area		Owners	
	Acres	SE[b]	Numbers	SE[b]
	Thousands	*Percent*	*Thousands*	*Percent*
To enjoy beauty or scenery	3,838	4.7	185	17.2
To protect nature and biologic diversity	3,178	5.9	156	19.6
For land investment	2,560	7.3	89	26.1
Part of home or vacation home	3,530	5.8	197	20.7
Part of farm or ranch	1,253	15.3	25	29.6
Privacy	3,623	5.1	182	17.4
To pass land on to children or other heirs	3,198	5.9	129	21.6
To cultivate/collect nontimber forest products	453	32.2	7	31.1
For production of firewood or biofuel	1,571	11.3	28	18.5
For production of sawlogs, pulp-wood or other timber products	1,877	9.6	16	13.6
Hunting or fishing	1,916	9.5	70	34.8
For recreation other than hunting or fishing	2,361	7.9	95	26.8
No answer	13	314.9	<1	100.1

[a] Categories are not exclusive.
[b] SE = sampling error (68%)

Table 2.—Area and number of family forests in Maine by timber harvesting activities and reasons, 2006.

Reason[a]	Area		Owners	
	Acres	SE[b]	Numbers	SE[b]
	Thousands	*Percent*	*Thousands*	*Percent*
Trees harvested or removed				
Yes	4,179	4.2	109	16.8
No	1,452	12.1	117	23.6
No answer	96	101.1	8	64.7
Products harvested[b]				
Sawlogs	3,080	6.1	53	16.0
Veneer logs	1,296	14.9	12	43.6
Pulpwood	2,909	6.4	47	16.8
Firewood	2,818	6.7	70	23.2
Posts or poles	615	25.4	9	56.3
Other	201	63.3	7	49.6
No answer	255	51.9	22	40.5
Received professional consultation[c]				
Yes	1,880	9.7	42	36.1
No	2,200	8.4	62	16.6
Uncertain	28	196.7	1	84.6
No answer	72	139.6	5	90.6
Recent harvest/removal (within 5 years)				
Yes	2,795	6.8	61	26.5
No	2,785	6.9	160	18.5
Uncertain	14	266.8	<1	100.6
No answer	132	75.5	12	53.9
Commerical harvest[d]				
Yes	3,534	5.3	64	14.3
No	1,938	9.4	147	21.0
No answer	255	51.9	22	40.5
Reason for harvest[c]				
Part of management plan	1,798	10.2	32	46.9
Trees were mature	2,632	7.4	55	17.7
Clear land	349	40.9	22	68.3
Needed money	1,202	14.4	17	27.6
Wood for personal use	1,924	9.8	48	18.6
Price was right	501	29.9	4	28.7
Improve hunting	323	43.9	17	84.2
Improve recreation	473	31.7	24	61.3
Remove trees damaged by natural catastrophes	1,859	9.9	49	32.5
Improve quality of remaining trees	2,541	7.7	62	27.0
Other	125	91.4	7	60.3
No answer	222	57.9	14	49.5

[a] SE = sampling error (68%)

[b] Categories are not exclusive.

[c] Includes only owners who have harvested.

[d] A commercial harvest is defined as the harvesting of sawlogs, veneer logs, or pulpwood.

Table 3.—Area and number of family forests in Maine by landowners' future (next 5 years) plans for their forest land, 2006.

Future plans[a]	Area		Owners	
	Acres	SE[b]	Number	SE[b]
	Thousands	*Percent*	*Thousands*	*Percent*
Leave it as is – no activity	1,243	14.2	77	27.0
Minimal activity to maintain forest land	2,393	8.1	80	25.0
Harvest firewood	2,458	7.6	47	16.3
Harvest sawlogs or pulpwood	1,961	9.3	32	41.1
Collect nontimber forest products	699	22.5	11	28.5
Sell some or all of their forest land	793	19.9	20	27.6
Give some or all of their forest land to heirs	809	19.4	17	21.3
Subdivide some or all of their forest land and sell subdivisions	210	58.1	2	40.4
Buy more forest land	838	18.7	7	24.6
Convert some or all of their forest land to another use	275	44.9	2	30.8
Convert another land use to forest land	51	147.8	<1	57.9
No current plans	722	22.1	48	40.7
Unknown	203	60.7	6	51.6
Other	108	102.3	1	45.4
No answer	74	119.3	7	79.5

[a] Categories are not exclusive.
[b] SE = sampling error (68%)

Table 4.—Area and number of family forests in Maine by landowners' sociopolitical concerns, 2006. Numbers include landowners who ranked each issue as a very important (1) or important (2) concern on a seven-point Likert scale.

Concern[a]	Area		Owners	
	Acres	SE[b]	Number	SE[b]
	Thousands	*Percent*	*Thousands*	*Percent*
Dealing with an endangered species	1,220	14.3	43	39.1
High property taxes	3,256	6.0	112	22.9
Keeping land intact for heirs	2,961	6.6	99	21.7
Lawsuits	1,510	11.9	58	40.1
Regulations that restrict harvesting	2,212	8.7	42	20.2
Development of nearby lands	1,810	10.4	106	26.3
Damage or noise from motorized vehicles	1,764	10.6	99	30.1
Trespassing or poaching	1,963	9.7	88	29.3
Timber theft	1,484	12.1	59	33.7
Misuse of forest land, such as vandalism or dumping	2,494	7.8	94	28.0
No answer	221	57.8	17	45.4

[a] Categories are not exclusive.
[b] SE = sampling error (68%)

Forest Resources

Mount Katahdin, Baxter State Park, Maine. Photo by Mark Anderson, University of Maine, used with permission.

Forest-type Groups

Background

Maine's forests are evaluated by their structure (stand-size distributions), extent (number of acres), composition (numbers of trees by species), and stand volume (size and numbers of trees). The FIA inventory has identified six forest-type groups in Maine representing softwood-dominated forests and another seven forest-type groups representing hardwoods. According to 2008 data stocking of softwoods in the spruce/fir forest-type group exceeds 87 percent verses 82 percent in the white/red pine forest-type group. Hardwood stocking in the maple/beech/birch exceeds 68 percent. Only the aspen/birch is equally stocked with hardwood and softwood species. No forest-type group is populated exclusively with hardwoods or softwoods.

What we found

The two largest FIA forest-type groups are maple/beech/birch at 7.2 million acres of forest land and spruce/fir at 5.6 million acres. Other major forest-type groups are aspen/birch (2.3 million acres) and white/red/jack pine (nearly 1 million acres); (Fig. 13). The Northern megaregion has 3.6 million acres each of spruce/fir and maple/beech/yellow birch, and 1.1 million acres of aspen/paper birch. The Eastern megaregion has 1.8 million acres of spruce/fir forests, 1.4 million acres of maple/beech/yellow birch, and 646,000 acres of aspen/paper birch.

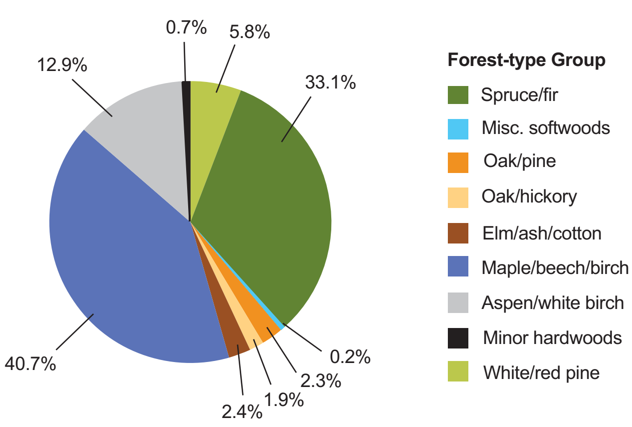


Figure 13.—Percent of forest land by forest-type group, Maine, 2008.

The Southern megaregion has 884,970 acres of maple/beech/yellow birch, 421,000 acres of the white/red pine, and 500,000 acres of oak/pine or oak/hickory. The Western megaregion has 1.3 million acres of maple/beech/yellow birch, 326,240 acres of aspen/paper birch, and 297,000 acres of spruce/fir. Maple/beech/birch forests are found widely distributed throughout the State, but have heavier concentrations in Oxford, Franklin, Somerset, Piscataquis, and Penobscot Counties, and the central portions of Aroostook County (Fig. 14, Fig. 29, Fig. 33). Eighty percent of spruce/fir forests as represented by cubic foot volumes for balsam fir and red spruce 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, Fig. 28, Fig. 30). Aspen/paper birch forests are found in Aroostook County and in portions of Oxford, Franklin and Somerset Counties (Fig. 16, Fig. 27). Finally, white pine forests are concentrated in the southern counties of Maine, and are mixed with coastal spruce up into Washington County (Fig. 17, Fig. 32).

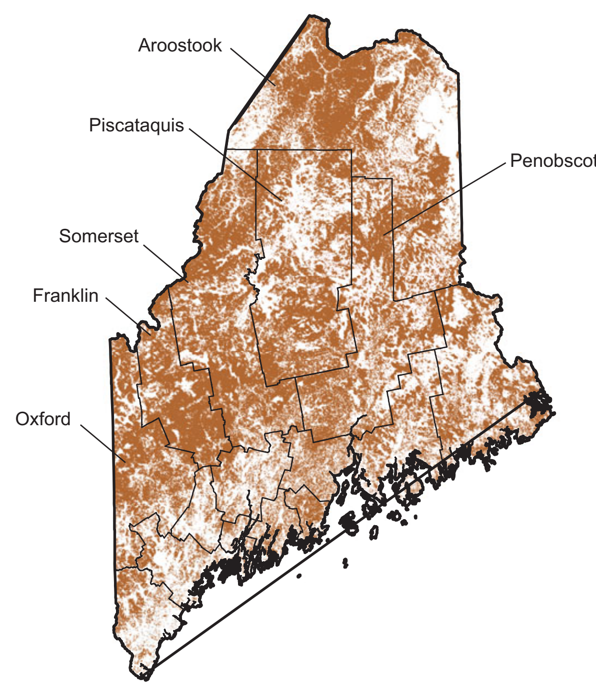


Figure 14.—Distribution of the maple/beech/yellow birch forest-type group Maine counties, 2008.

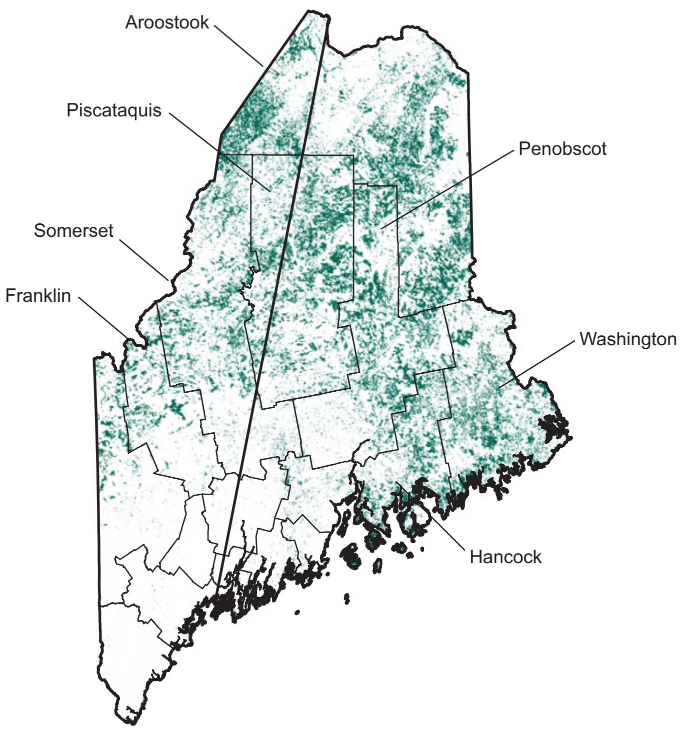


Figure 15.—Distribution of the spruce/fir forest-type group, Maine counties, 2008.

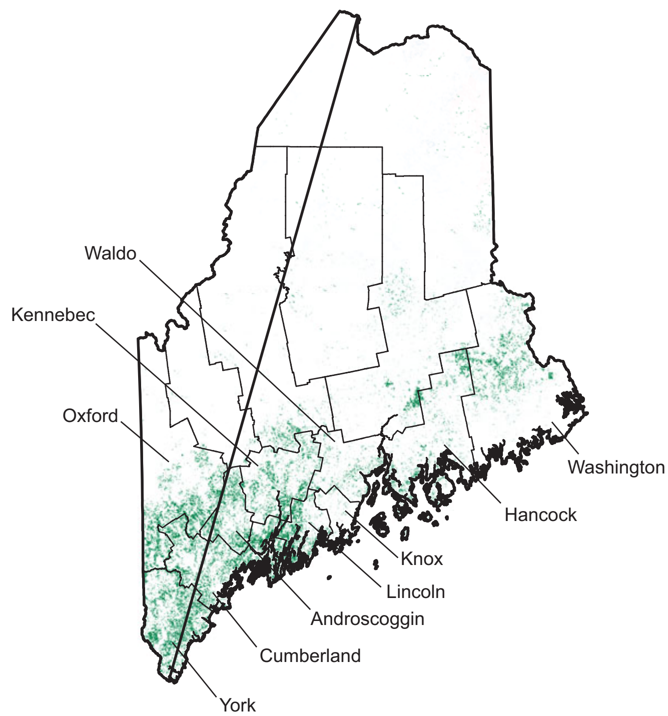


Figure 17.—Distribution of the white/red/jack pine forest-type group (with hemlock), Maine counties, 2008.

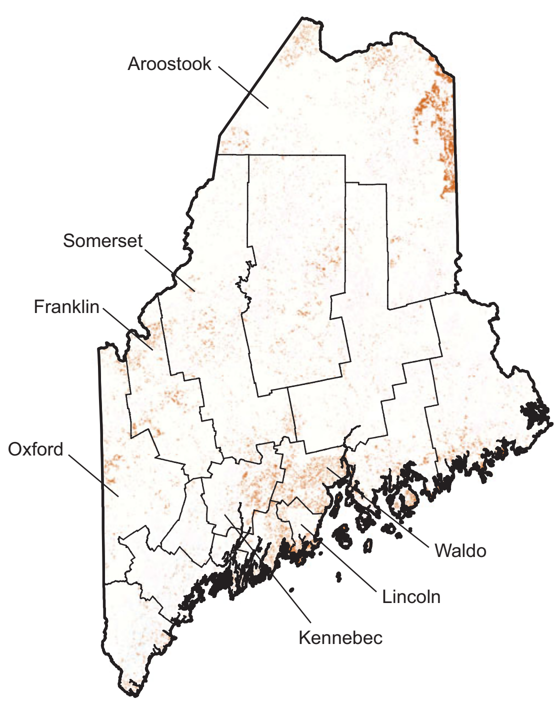


Figure 16.—Distribution of the aspen/birch forest-type group, Maine counties, 2008.

What this means

Depending on the disturbance regime, aspen/birch forests could easily succeed to spruce/fir forests, or degraded spruce/fir forests could revert to aspen/birch. Today maple/beech/birch forests are widely distributed throughout the State. Most of the spruce/fir forests are located in the Northern and Eastern megaregions as indicated by both distribution and volume per acre, while 60 percent of the aspen/birch is found with the maples in the Western megaregion and scattered throughout central Maine. About 20 percent of the aspen/paper birch volume is in Aroostook County. White/red/jack pine forests containing eastern hemlock are prominent along the coast and are associated with minor hardwood forest-type group within the Southern megaregion. Given the strong competition between hardwood and softwood tree species, monitoring changes in composition over time is important to understand the State's forest resources.

Stand Size of Forest-type Groups

What we found

Since 2003, acreage from within the maple/beech/birch forest-type group has increased primarily in the small diameter classes (Fig. 18). During the same period, the statewide acres for spruce/balsam fir growing-stock trees has remained flat, but shifted from the large-diameter classes to the small-diameter classes (Fig. 19). The acreage of aspen/birch growing-stock trees has decreased statewide and in the medium-diameter classes (Fig. 20). There was little change in the statewide area of white/red pine growing-stock (Fig. 21).

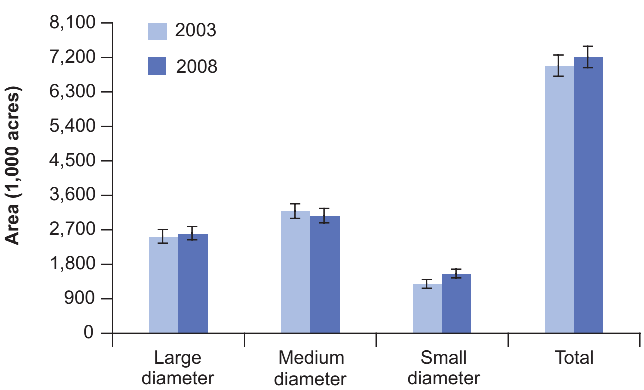


Figure 18.—Area of the maple/beech/yellow birch forest-type group (1,000 acres) by stand-size class, Maine, 2003 and 2008 (error bars represent 68-percent confidence interval around estimate).

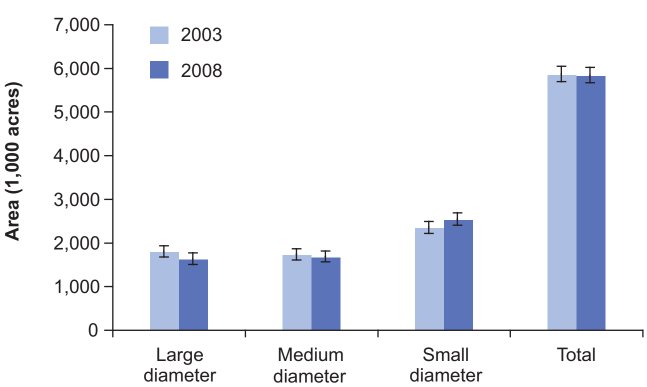


Figure 19.—Area of the spruce/fir forest-type group (1,000 acres) by stand-size class, Maine, 2003 and 2008 (error bars represent 68-percent confidence interval around estimate).

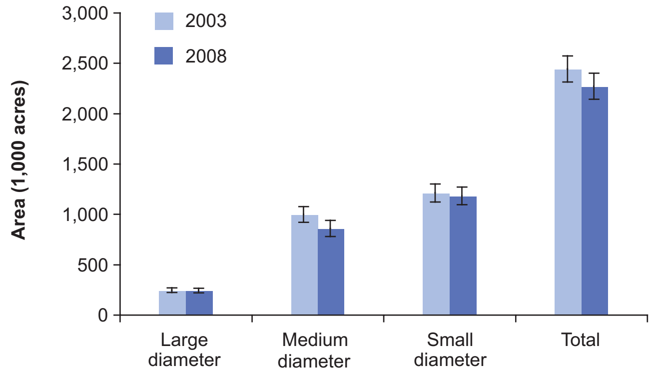


Figure 20.—Area of the aspen/white birch forest-type group (1,000 acres) by stand size class, Maine, 2003 and 2008 (error bars represent 68-percent confidence interval around estimate).

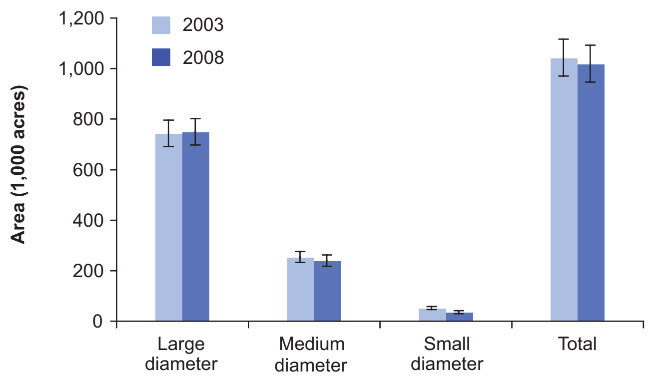


Figure 21.—Area of the white/red/jack pine forest-type group (acres) by stand size class, Maine, 2003 and 2008 (error bars represent 68-percent confidence interval around estimate).

What this means

The average stand diameters for maple/beech/birch forests are decreasing as forests are harvested for pulpwood and bioenergy supplies. Since balsam fir makes up 65 percent of the total tree numbers from within the spruce/fir forest-type group, the shift from areas with large-diameter trees to smaller diameter stands is driven by the removal of balsam fir trees before they become susceptible to spruce budworm infection. Aspen/birch forests are decreasing in general as forests succeed to more shade tolerant species. White pine forests may be suffering from a lack of regeneration.

Numbers of Live and Growing-stock Trees on Forest land

Background

The number of live and growing-stock trees is the basis for calculating volume, growth, mortality, and removals. If growing-stock trees increase across diameter classes, stocked acres and stand volumes should also be increasing.

What we found

There has been a significant increase in the number of live trees (including seedling counts) within Maine's forest land since 1982 (Table 5), particularly in the seedling and sapling classes. Balsam fir (*Abies balsamea*), red maple, and the spruces (*Picea* spp.) rank first, second, and third as a percent of the total tree numbers (> 5 inches d.b.h.) growing on Maine's forest land. Since 1982 growing-stock trees of balsam fir have decreased to 18 percent from 23 percent of the population while the spruces have been reduced to 17 percent from 25 percent. In contrast, red maple has increased to 12 percent of the total population (Table 6). Balsam fir trees, in the sapling and the poletimber-size diameter classes, greatly exceeded the numbers from the other genuses. This dominance was observed statewide and in three of the four megaregions (Fig. 22).

There has also been a decrease in the number of growing-stock trees in pole-size diameter classes (5.0-10.9 inches d.b.h.; Fig. 23). Growing-stock softwood trees mirrored statewide numbers increasing significantly in sapling size class (1.0-4.9 inches d.b.h.) and a decreasing in pole-size class (5.0-10.9 inches d.b.h.; Fig. 24). Live hardwood trees increased slightly especially in the 3.0 to 4.9-inch diameter class. There was a substantial decrease in the number of hardwood growing-stock trees within the pole-size (5.0 to 10.9 inch) diameter classes (Fig. 25), but no significant change in the number of hardwood growing-stock trees within the 13.0 to 18.9-inch diameter classes.

What this means

Statewide regeneration is currently dominated (50.4 percent or 10.2 billion saplings) by two species, balsam fir and red maple (Fig. 23). Increasing the numbers of red spruce and sugar maple saplings would help diversify the future resource. There should be sufficient numbers of saplings to replenish the pole-size diameter classes if the mortality and removals of pole-size trees is limited to the levels of ingrowth for both softwoods and hardwoods. Healthy pole-size trees are important for populating future saw log diameter classes (Fig. 26).

Table 5.—Number of seedlings (in millions) and live trees (≥1.0-inch d.b.h.) by number of trees per species. "Top Ten" refers to 10 most common species.

Order	"Top Ten" Species	1982	2008 Order	2008
1	Balsam fir	24.8	1	37.0
2	Red maple	10.2	2	12.0
3	Sugar maple	8.9	3	10.5
4	Striped maple	6.4	6	6.6
5	Spruces	6.0	4	9.9
6	Yellow birch	4.7	8	5.2
7	American beech	4.4	7	6.0
8	Mountain maple	4.0	10	4.4
9	No. white-cedar	3.9	5	8.7
10	Paper birch	3.8	9	4.5
	Total	77.0		104.8

Table 6.—Number of growing-stock trees (≥ 5.0-inch d.b.h.) per species, as a percent of total trees. "Top Ten" refers to 10 most common species or genus.

	1982	1995	2008
Spruces	25	18	17
Balsam fir	23	16	18
Red maple	9	13	12
No. white-cedar	4	10	6
Paper birch	6	7	6
Eastern hemlock	5	5	6
Eastern white pine	4	5	5
Sugar maple	4	5	5
Yellow birch	4	4	4
Aspens	5	5	4

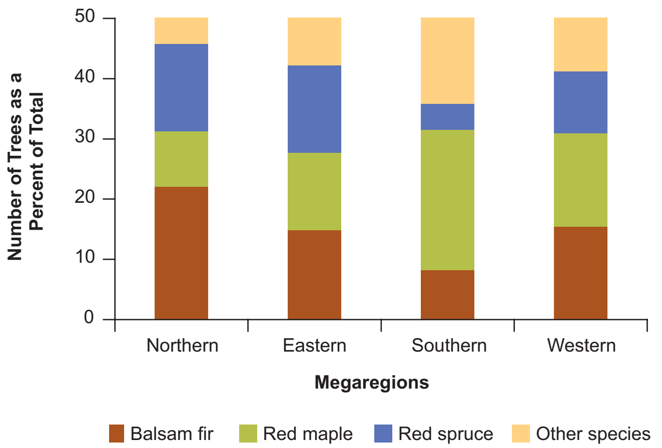


Figure 22.—Percent of growing-stock trees by species within each megaregion, Maine, 2008.

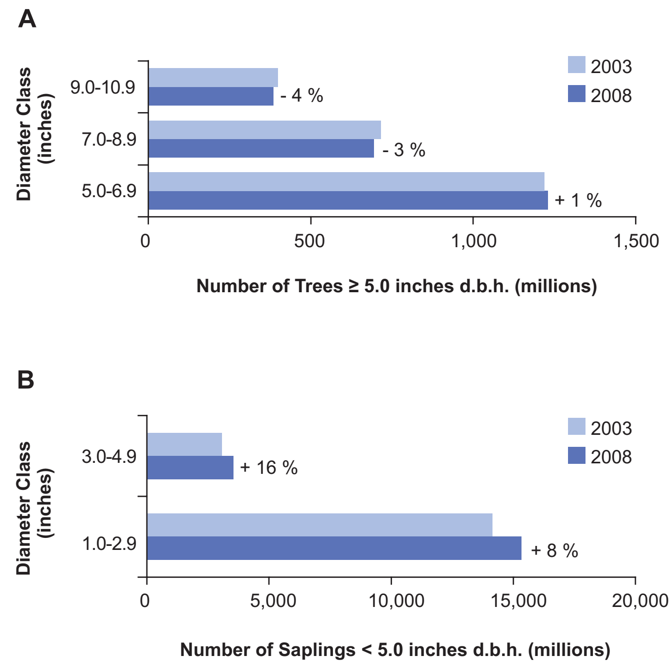


Figure 23.—Number of pole-size trees (A) and saplings (B) for all species (millions of trees), Maine, 2003 and 2008. Percent values represent change between 2003 to 2008.

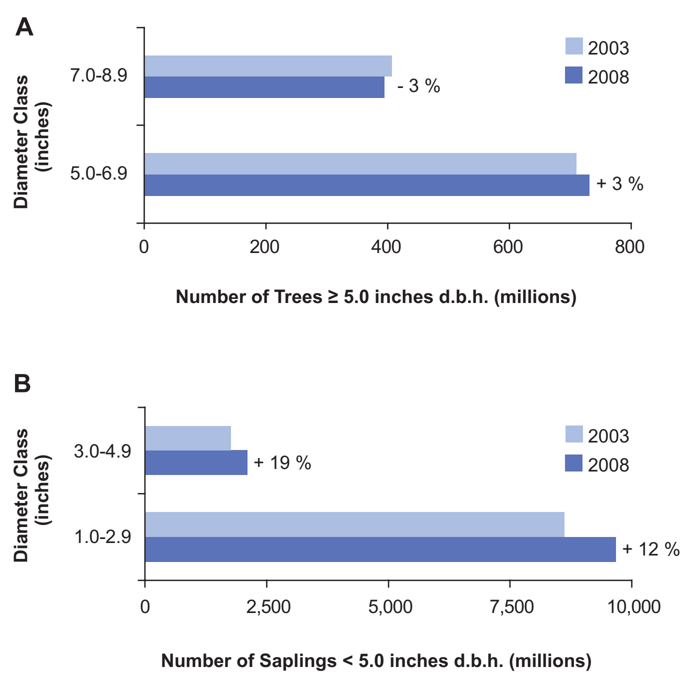


Figure 24.—Number of pole-size trees (A) and saplings (B) for softwood species (millions of trees), Maine, 2003 and 2008. Percent values represent change between 2003 to 2008.

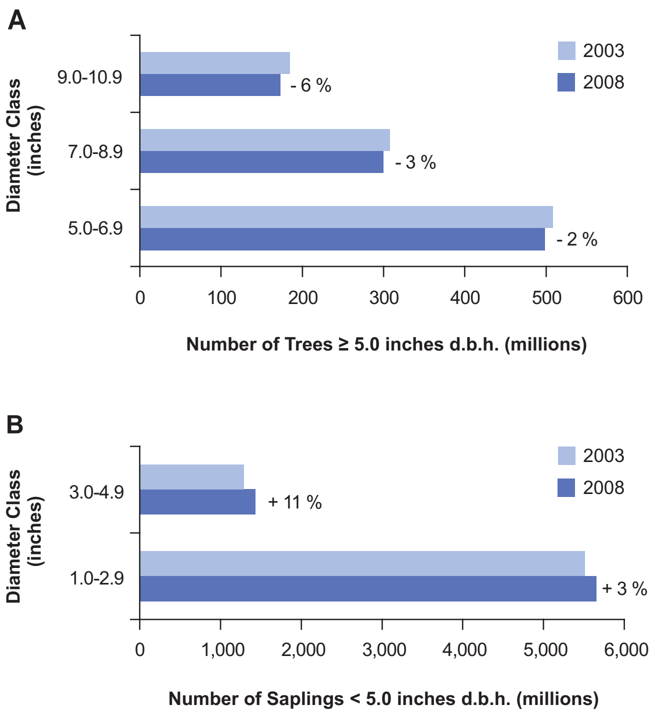


Figure 25.—Number of pole-size trees (A) and saplings (B) for hardwood species (millions of trees), Maine, 2003 and 2008. Percent values represent change between 2003 to 2008.

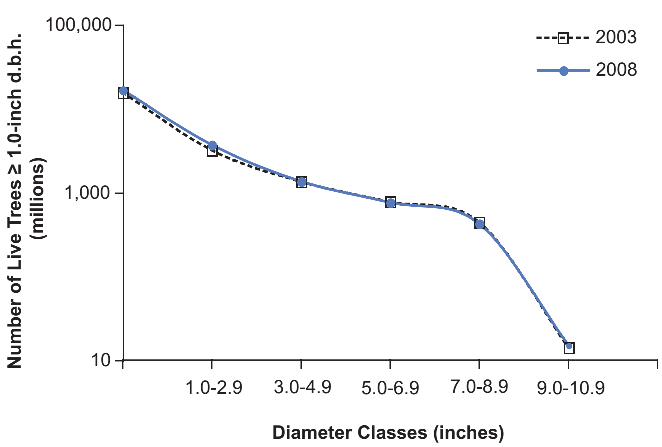


Figure 26.—Number of growing-stock pole trees and saplings by 2.0-inch diameter classes (millions of trees), Maine, 2003 and 2008.

Volume of All Live Trees on Forest Land

Background

Net volume of growing-stock trees 5.0 inches d.b.h. or greater on forest land produces the baseline for determining the amount of wood, and most of the biomass and carbon which exist within the forests of Maine. To assess changes in individual species volume along biogeographical gradients and at a precise scale, the data are displayed as species per acre by county from south to north, then coastal to inland.

What we found

Red maple, red spruce, eastern white pine, northern white-cedar, and balsam fir represent 52 percent of the estimated live volume in the State. In 2008, red maple gross volume exceeded red spruce; and northern white-cedar volume was higher than balsam fir volume (Fig. 27). Overall live-tree volume has not increased significantly on forest land since 2003. Softwood volumes have remained statistically flat since 2003, but by contrast, total hardwood growing-stock volumes have decreased since 2003, driven by the reductions in sugar maple, American beech, and paper birch (*Betula papyrifera*) (Fig. 27).

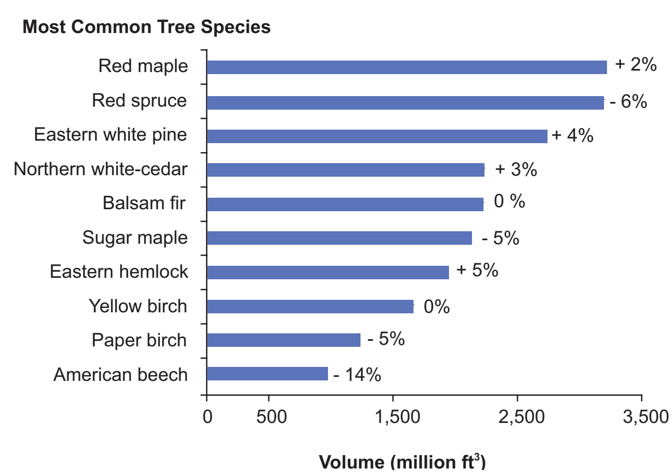


Figure 27.—Ten most common species for live tree volume (million cubic feet) on forest land Maine, 2008. Percent values represent change between 2003 to 2008.

Growing-stock volumes for all species remained statistically unchanged in three of the four megaregions, and decreased in the large northern megaregion. Hardwood growing-stock represents 46 percent of the total statewide growing-stock volume. Total growing-stock volume for the hardwoods decreased in the northern and western megaregions since 2003, while it remained unchanged in the southern and eastern megaregions. In addition to losses in hardwood volumes (-6.4 percent), spruce/fir growing-stock also decreased (-2.1 percent) within the Northern megaregion; both declines are attributed to ongoing harvest levels. Hardwood volumes significantly decreased in the medium 5 to 10.9-inch d.b.h. classes within the eastern and western megaregions, and within the 9 to 10.9-inch and 13 to 18.9-inch diameter classes for the Northern megaregion. Red spruce, sugar maple, and balsam fir growing-stock volumes are highest in the northern and western portions of the State (Fig. 28, Fig. 29, Fig. 30), while red maple and eastern white pine growing-stock volumes are higher in the southern, southwestern, and the central portions of the State (Fig. 31, Fig. 32). American beech volumes are concentrated in the southern portions of Oxford, Franklin, Somerset, and Piscataquis Counties (Fig. 33).

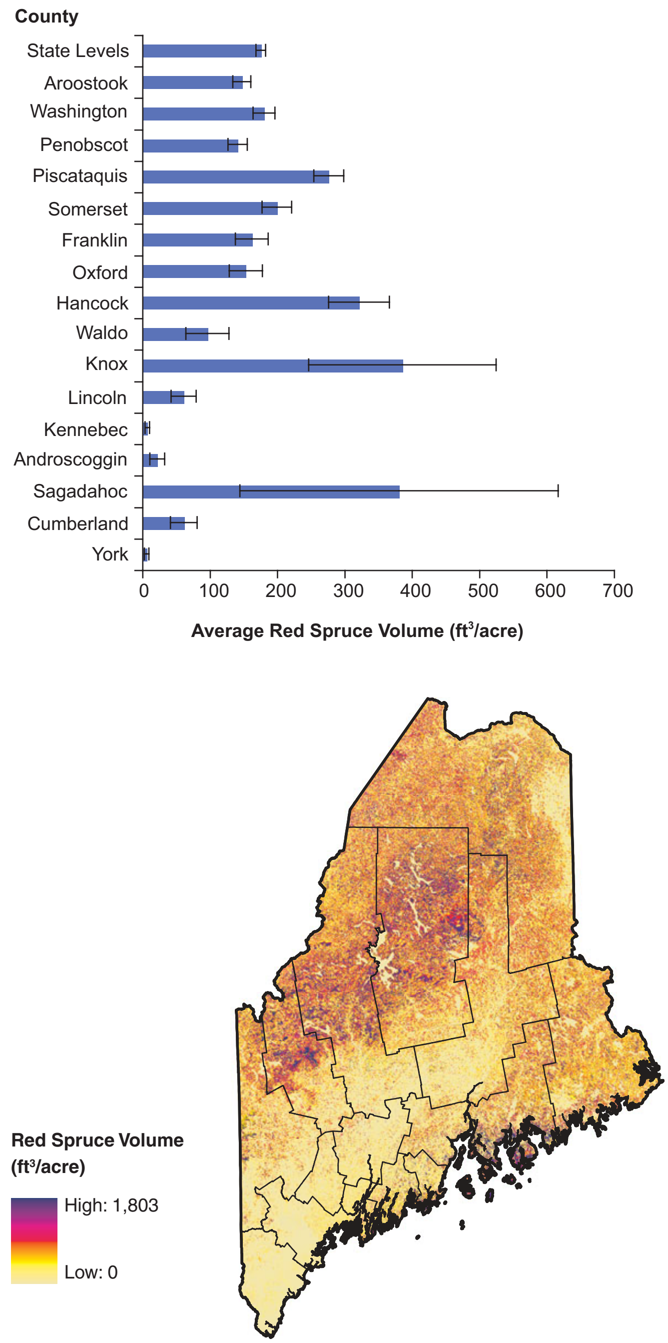


Figure 28.—Concentrations (as depicted on map) and average red spruce volume (ft³/acre), by county in Maine, 2008 (error bars represent 68-percent confidence interval around estimate).

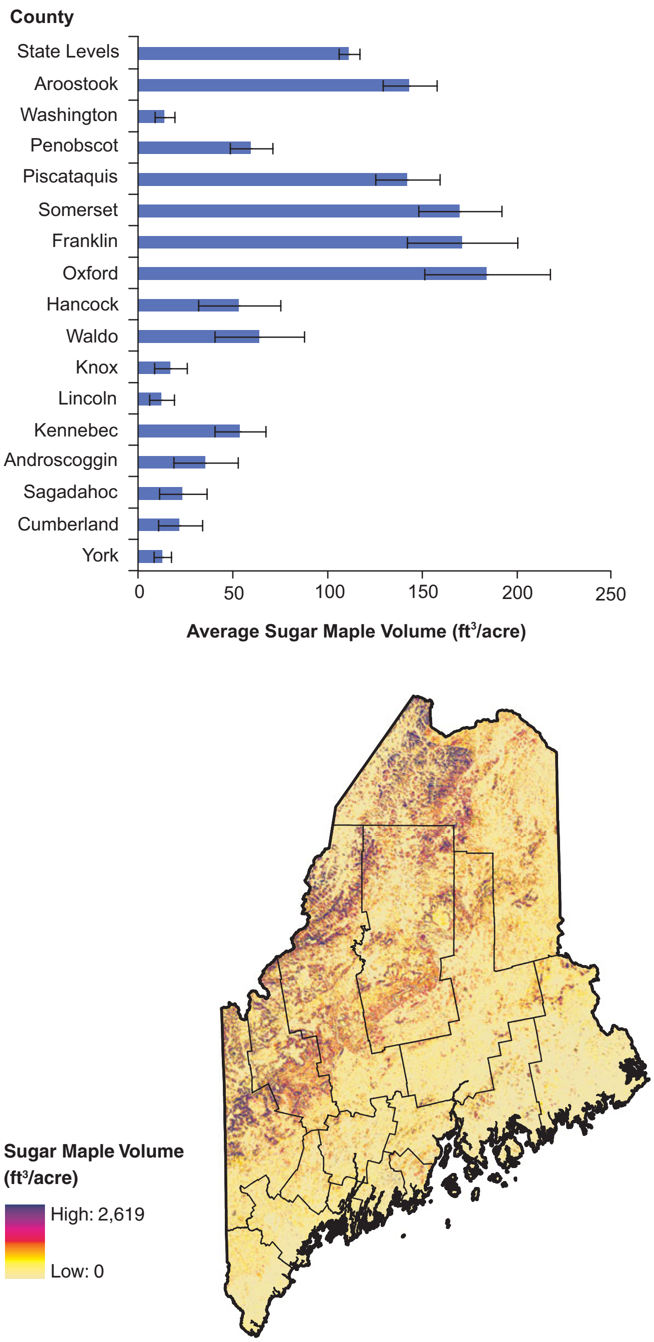


Figure 29.—Concentrations (as depicted on map) and average sugar maple volume (ft³/acre), by county in Maine, 2008 (error bars represent 68-percent confidence interval around estimate).

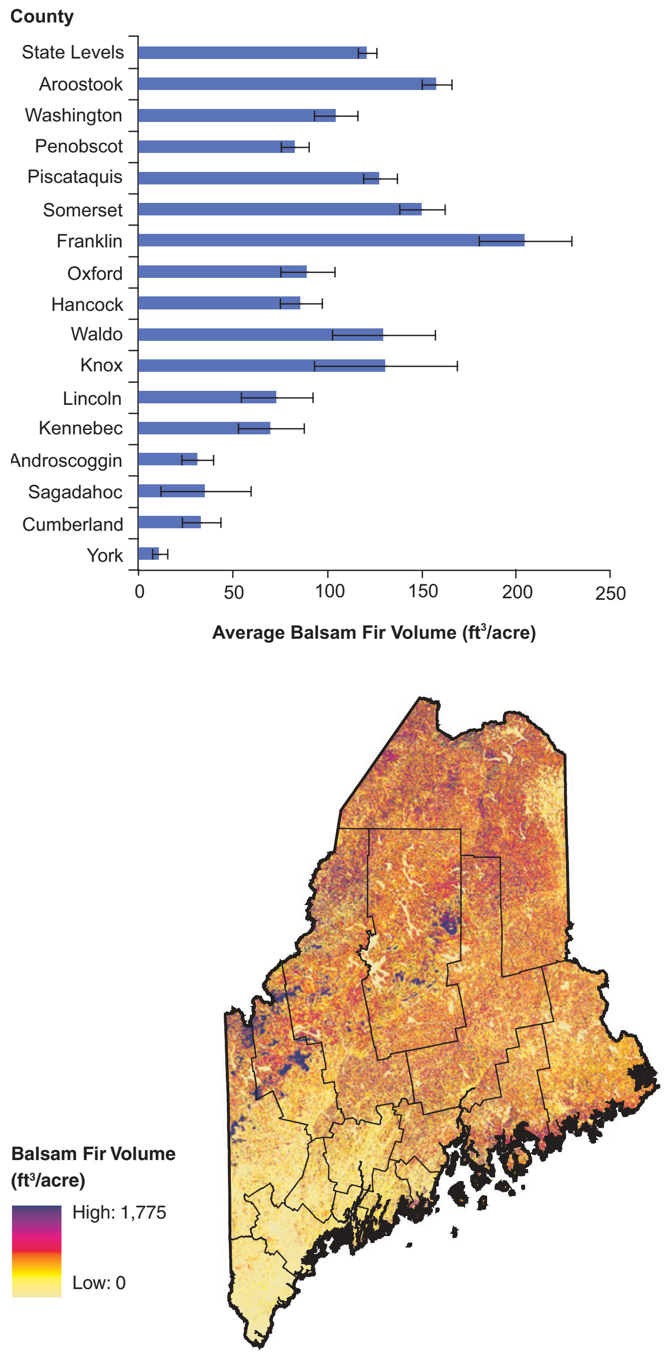


Figure 30.—Concentrations (as depicted on map) and average balsam fir volume (ft³/acre), by county in Maine, 2008 (error bars represent 68-percent confidence interval around estimate).

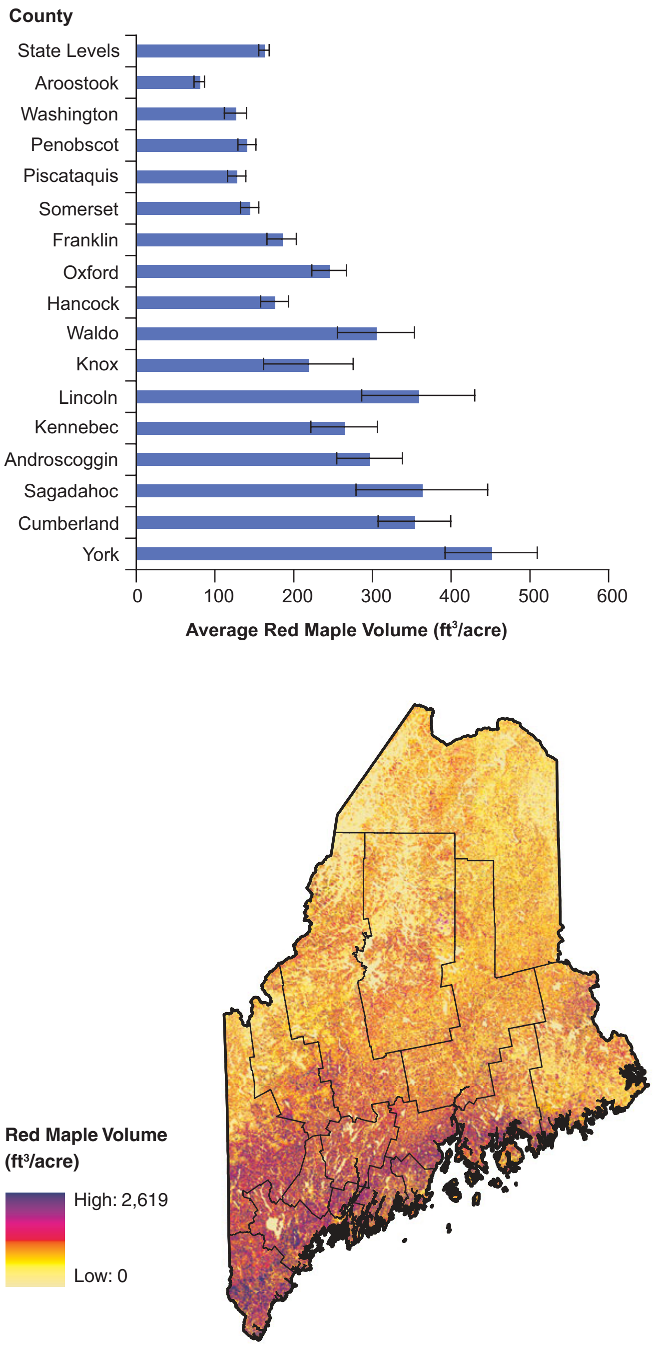


Figure 31.—Concentrations (as depicted on map) and average red maple volume (ft³/acre), by county in Maine, 2008 (error bars represent 68-percent confidence interval around estimate).

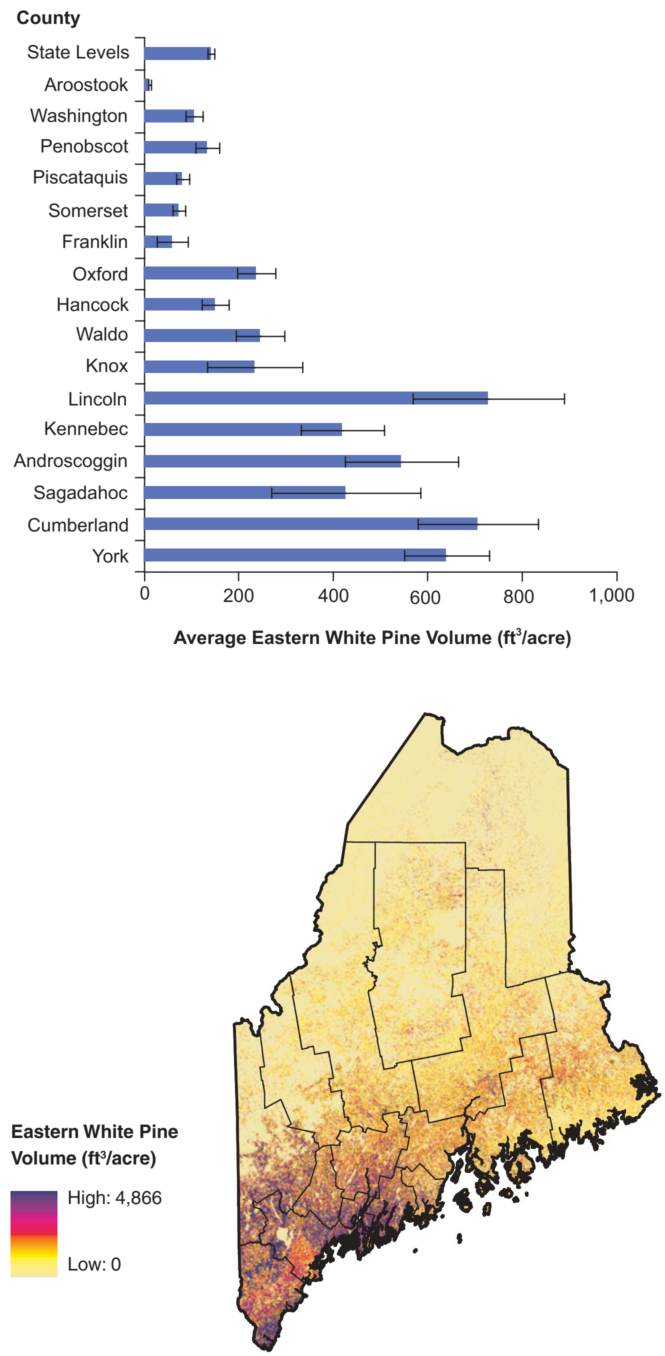


Figure 32.—Concentrations (as depicted on map) and average eastern white pine volume (ft³/acre), by county in Maine, 2008 (error bars represent 68-percent confidence interval around estimate).

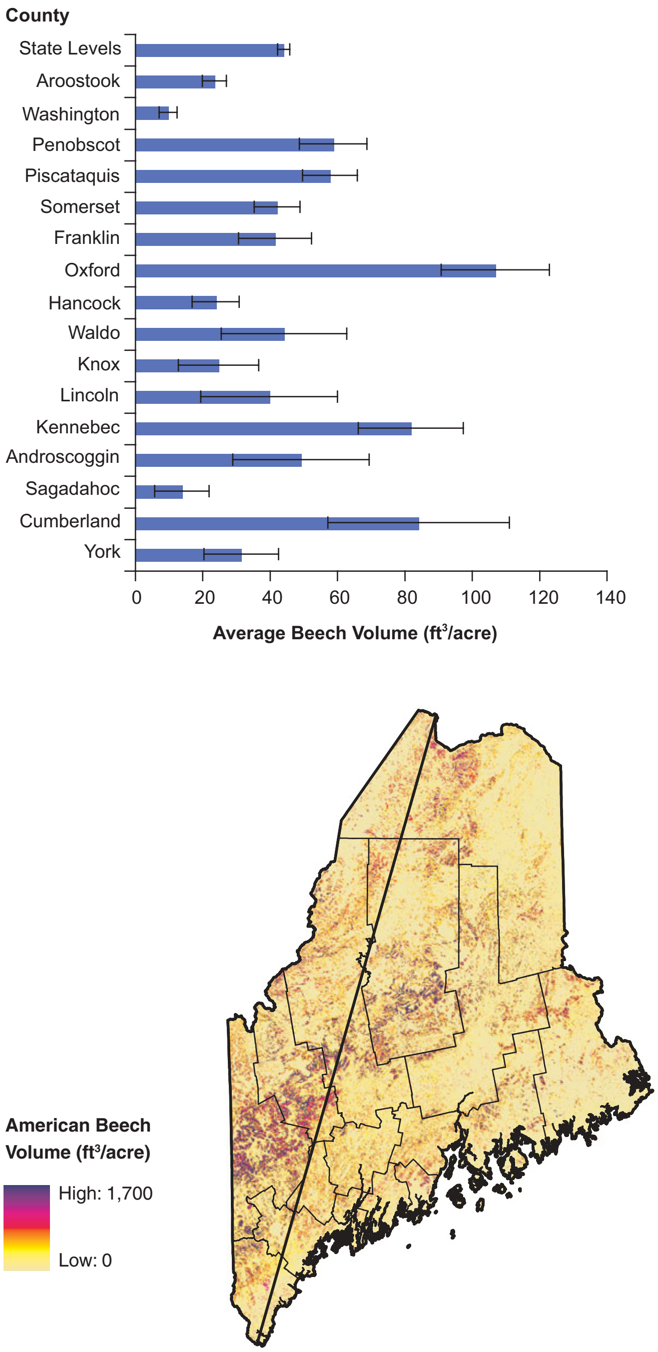


Figure 33.—Concentrations (as depicted on map) and average American beech volume (ft^3/acre), by county in Maine, 2008 (error bars represent 68-percent confidence interval around estimate).

What this means

The results show no significant gains in the statewide growing-stock volumes since 2003. Any increases in softwood volume were offset by decreases in growing-stock volume for hardwoods. Similar to "the number of trees" data, the volumes for balsam fir and red maple illustrate the wide distribution and strong competitive interaction of these two tree species with other species, on a statewide basis. Their statewide volumes are significant given their smaller average diameters compared to the other commercial tree species (Table 7).

Table 7.—Average d.b.h. of growing-stock trees (≥ 5.0-inch d.b.h.) by species. "Top Ten" refers to 10 most common species or genus.

"Top Ten" 2008	Species	mean d.b.h.
1	Eastern white pine	10.3
2	Sugar maple	9.5
3	Eastern hemlock	9.4
4	Yellow birch	9.0
5	No. white-cedar	8.9
6	Aspen	8.5
7	Red spruce	8.3
8	Red maple	8.2
9	Paper birch	7.7
10	Balsam fir	7.0

Seedlings and Saplings

Background

Numbers and species composition of seedlings and saplings on forest land gives is an indicator of future conditions of the forest resources of Maine.

Seedlings

What we found

The numbers of seedlings measured on FIA micro-plots increased by 66.4 percent, or more than 42 billion seedlings, since 2003. The spruce/fir forest-type group had a 76.2 percent (16 billion seedlings) gain. Balsam fir seedlings represented 25.7 percent (4.2 billion seedlings) of this gain. The maple/beech/birch forest-type group had a 68.7 percent gain or 19 billion seedlings.

Saplings

What we found

There was a significant gain of 18 percent in the number of small trees (2.0- and 4.0-inch d.b.h. classes) statewide since 2003. This represents more than 1.4 billion saplings or an average gain of 80 trees per acre (Fig. 34). There was also a significant statewide gain of 24 percent in the number of softwood saplings over 2003 numbers, especially in the spruce-balsam-fir forest type. This represents an average gain of 50 softwood saplings per acre across the state. The northern counties had larger gains than the southern counties (Fig. 35). Balsam fir saplings alone represented more than 56 percent of the gain. Hardwood saplings increased 10 percent in the maple/beech/birch forest-type group. The number of red maple saplings also increased overall (6 percent), particularly in the Northern (12 percent) and Eastern (+9 percent) megaregions, with an offsetting decrease in the Southern (-8 percent) megaregion. Sugar maple sapling numbers increased 5 percent in the Northern megaregion since 2003, almost enough to totally offset the sapling losses for this species in the other three megaregions.

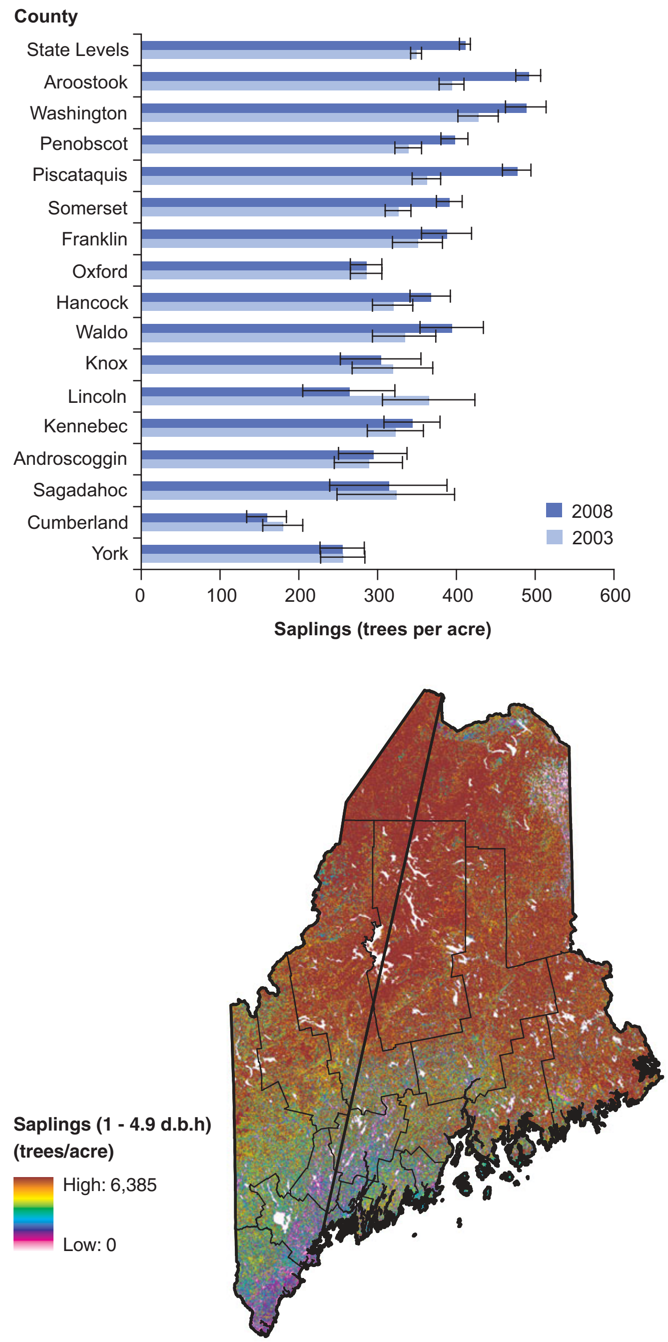


Figure 34.—Concentrations (as depicted on map) and average number of saplings (1.0 to 4.9 inches d.b.h.) per acre, by county in Maine, 2008 (error bars represent 68-percent confidence interval around estimate).

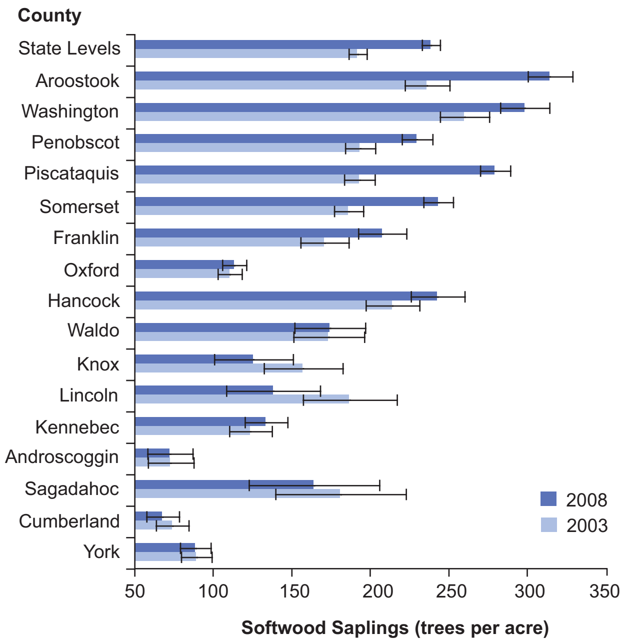


Figure 35.—Average number of softwood saplings (1.0 to 4.9 inches d.b.h.) per acre, by county, Maine, 2003 and 2008 (error bars represent 68-percent confidence interval around estimate).

What this means

Most of the gains in seedlings and saplings are found in the northern counties where a softwood composition dominates. Given the statewide gains in both seedlings and sapling numbers, there should be sufficient regeneration to insure future merchantable sizes and quality. This may not be the case for every species. Overall hardwood stocking is consistently lower than softwood stocking. Management can improve both the growth and yield of this important stocking (Homyack et al. 2004).

Sustainability: Components of Change

Rocky coast of Maine, Petite Manan National Wildlife Refuge. www.forestryimages.com.

Growth and Removal

Background

Net tree growth-to-removal ratios give an indication of resource sustainability by comparing estimates of harvest and other removals to net growth. If an area has a ratio greater than 1.0 then the resource is increasing. On the other hand, if the ratio is less than 1.0, then the resource is decreasing. To assess the actual condition of Maine's forest resource, one must first examine separate softwood and hardwood components. Major tree species can also be individually assessed. Alternatively, one can analyze the growth-to-harvest ratios of the individual softwood and hardwood dominated forest communities. The following data are growth-to-removal ratios of growing stock on timberlands. Only timberland estimates were used in periodic inventories conducted prior to 1999. These ratios include all types of removals, including those that are harvest related and removals due to land-use changes.

What we found

The overall growth-to-removal (G:R) ratio is 1.02. The Northern megaregion has a G:R of 0.79.The Eastern region currently is 1.09, and the Southern and Western regions are 2.33 and 0.97, respectively (Fig. 36). Separating softwood and hardwood groups provides a clearer picture of the ratios.

The statewide softwood G:R is 1.11. The Northern megaregion has a softwood growth-to-removal ratio of 0.92. The Eastern is at 1.27, and the Southern and Western regions are 1.89 and 1.02, respectively (Fig. 37). The statewide hardwood G:R is 0.94. The Northern region's ratio is 0.63. The Eastern region currently is 0.83, and the Southern and Western regions are 2.86 and 0.93, respectively (Fig. 38).

Examining individual species provides additional insights to those at risk. Red spruce has a statewide growth-to-removal ratio of 0.67, and a Northern megaregion G:R of 0.54. Balsam fir has a statewide G:R of 1.11, and a Northern megaregion ratio of 1.36.

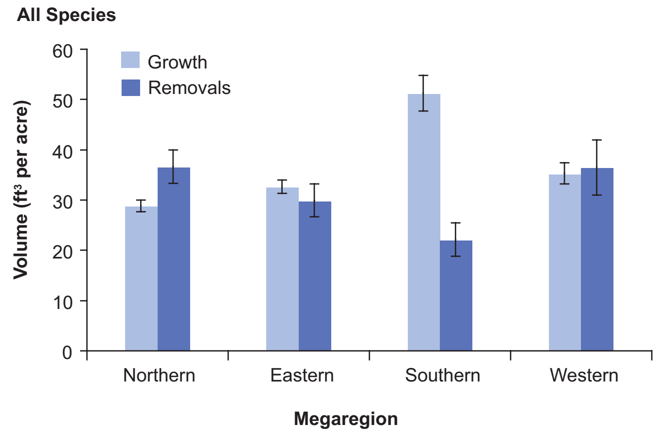


Figure 36.—Growth and removal volume (ft^3/acre) for all species by megaregion, Maine, 2008 (error bars represent 68-percent confidence interval around estimate).

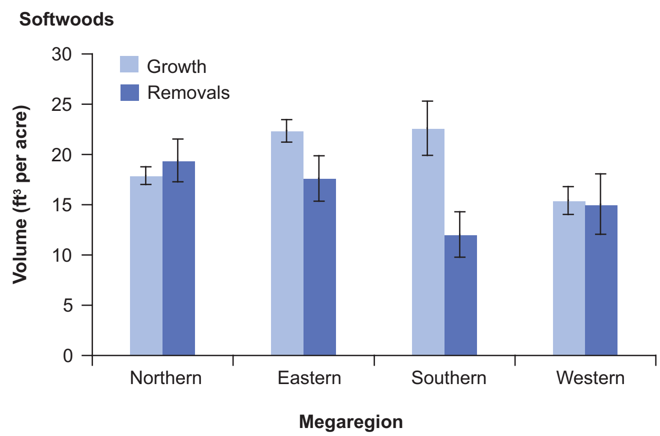


Figure 37.—Growth and removal volume (ft^3/acre) for softwoods by megaregion, Maine, 2008 (error bars represent 68-percent confidence interval around estimate).

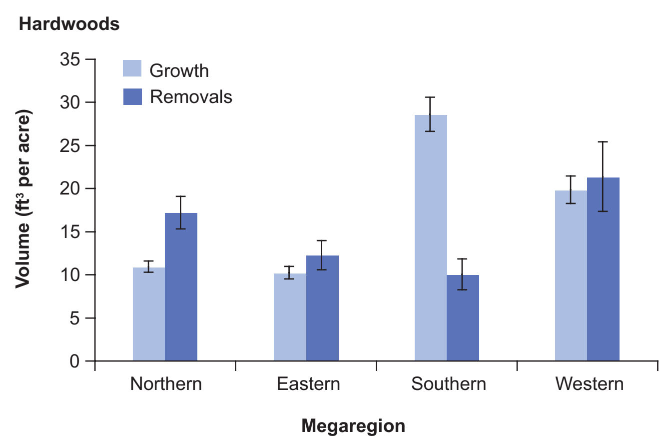


Figure 38.—Growth and removal volume (ft^3/acre) for hardwoods by megaregion, Maine, 2008 (error bars represent 68-percent confidence interval around estimate).

Sugar maple has a statewide G:R of 0.65, and a Northern megaregion ratio of 0.53. Red maple has a statewide G:R of 1.26, and a Northern megaregion ratio of 0.77.

Comparing past inventory data to the current estimates on a per-acre basis shows that removals for softwoods have decreased and hardwood removals have increased since 1995 (Fig. 39, Fig. 40). The growth-to-removal ratios for 1995, which represent the period from 1982 to 1995, include both reduced net growth and increased salvage operations related to the spruce budworm epidemic. In 1992 there was a major shift and substitution of hardwoods for softwoods in the pulp and paper industry. All species' G:R peaked in 1982, followed by a softwood low G:R in the 1995 inventory, and a hardwood low in the 2006 inventory (Fig. 41).

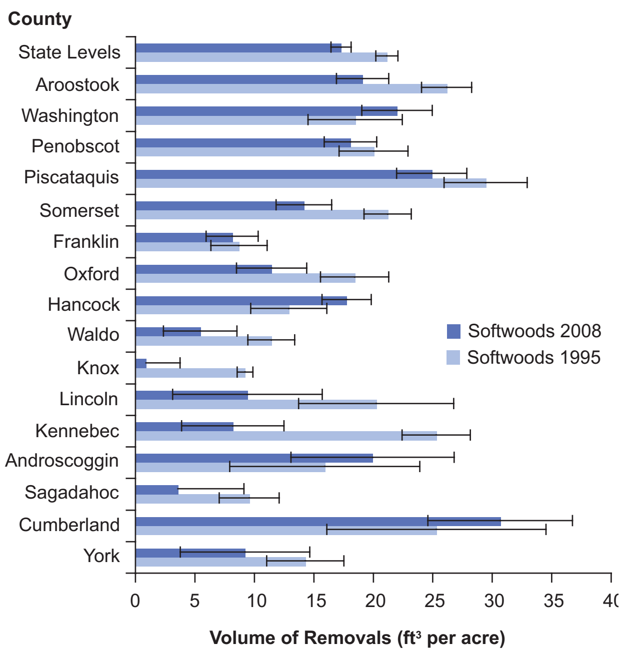


Figure 39.—Softwood growing-stock removal volume (ft³/acre) by county, Maine, 1995 and 2008 (error bars represent 68-percent confidence interval around estimate).

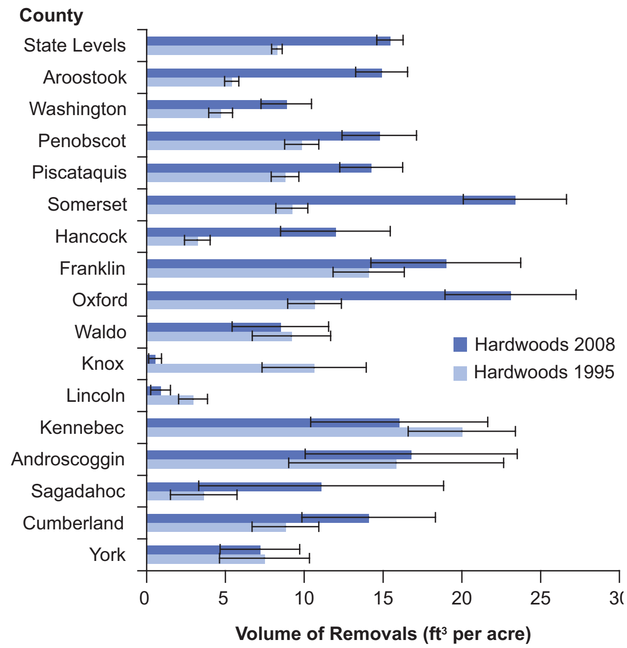


Figure 40.—Hardwood growing-stock removal volume (ft³/acre) by county, Maine, 1995 and 2008 (error bars represent 68-percent confidence interval around estimate).

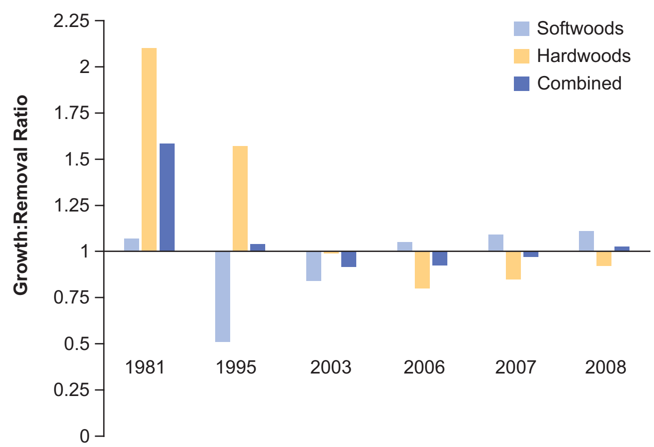


Figure 41.—Historical trends in growth-to-removal ratios, Maine.

What this means

Total growing-stock removals (including all land-use changes) have a substantial impact on Maine's ability to maintain a sustainable annual harvest. These results indicate the wood supply is increasing within the softwood base, but is quite limited within the hardwood supplies. Specifically, the wood volume for balsam fir and red maple is increasing while recent statewide harvest levels for red spruce and sugar maple are jeopardizing these species' sustainability. Both softwoods and hardwoods are recovering from their low G:R ratios, but these numbers are augmented by balsam fir and red maple.

Biomass

Background

Biomass and carbon estimates have become increasingly important as demand for bioenergy has increased and carbon sequestration has emerged as a vital component of climate-change analyses. As such, a method for harmonizing volume, biomass, and carbon estimates was needed. Prior to implementation of the Component Ratio Method (CRM), volume and biomass were estimated using separate sets of equations. In 2007, the CRM method was adopted by FIA and is comprised of the following steps (Heath et al. 2009): 1) conversion of sound-wood volume in the merchantable bole to biomass using species-level specific gravities (dry mass per unit of green volume); 2) calculation of bark biomass using a set of percentage bark and bark specific gravities; 3) calculation of the biomass contained in the tops and limbs as a proportion (ratio) of merchantable bole biomass based on component proportions using equations from Jenkins et al. (2003); 4) calculation of the biomass in the aboveground portion of the stump using equations from Raile (1982); and 5) summarizing of biomass components to obtain total aboveground biomass.

With the implementation of the CRM, determining the biomass of individual trees and forests has become an extension of FIA volume estimates and allows calculations of biomass estimates for growth, mortality, and removals on forest lands, and not just for live trees.

Other biomass estimates for standing dead, down woody debris, shrubs and forbs, and the belowground stump with coarse roots can also be calculated.

What we found

Estimated total aboveground live-tree biomass on Maine's forest land is 664 million dry tons. Another 137 million dry tons are estimated in the belowground live-tree portion. In Maine, approximately 50 percent of a living tree's biomass is found in its main bole. The belowground portion of the stump and coarse roots store approximately 17 percent of the living biomass. The tops and limbs contain another 12 percent. The aboveground portion of the stump contains only 3 percent of the total. Saplings amount to approximately 14 percent of the living aboveground biomass. A tree's foliage, though not a part of CRM estimates, is included here for completeness and accounts for 4 percent (Fig. 42).

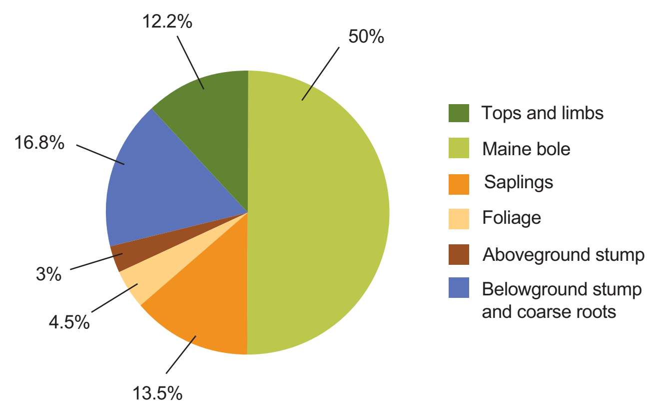


Figure 42.—Components of live-tree biomass by percent of total, Maine, 2008.

The Northern megaregion contains 45 percent of the forested aboveground biomass of the State. The Eastern megaregion contains 22 percent of the total. The Southern megaregion has 17 percent of the forested biomass whereas the Western megaregion represents 16 percent. The Southern megaregion has the largest amount on a per-acre basis at 51 dry tons per acre. The Western megaregion is estimated at 46 dry tons per acre, with the Northern megaregion at 34.5 dry tons per acre, and the Eastern megaregion having 32.6 dry tons per acre (Fig. 43). The component contributions of live-tree biomass vary by tree species and size. Biomass of spruces, white pine, hemlock, northern white-cedar, yellow birch, and sugar maple is primarily in saw log-size trees. By contrast, most of the tree biomass in balsam fir, red maple, aspen, paper birch, the ashes, and beech are contained in pole-size and sapling-size trees. Since 2003, there has been an estimated increase of 2 percent, or 10 million dry tons, of biomass.

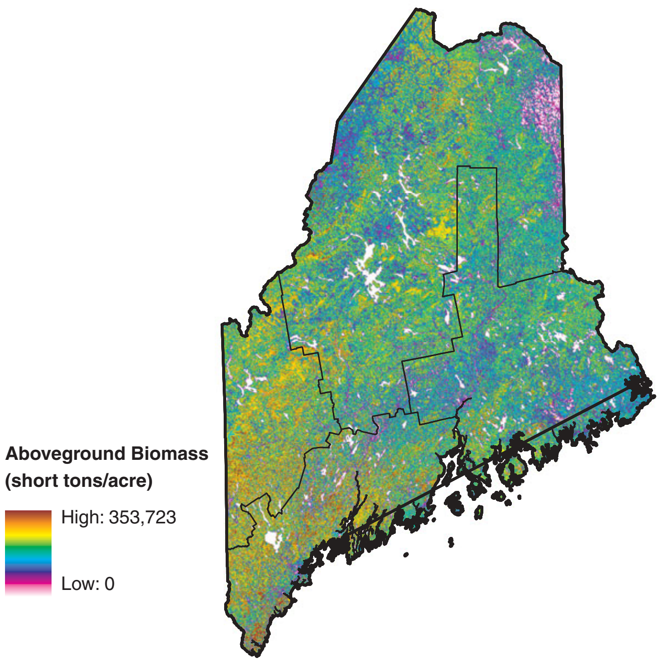


Figure 43.—Concentrations (as depicted on map) of forest biomass (short tons per acre) Maine, 2008.

What this means

The largest amounts of biomass are found in the southern portions of the State and around Baxter State Park, possibly the result of a greater concentration of large-diameter trees and standing dead being located in these areas.

Carbon

Background

Since climate change became a topic of public concern, forest carbon sequestration has been promoted to help mitigate the problem. Carbon is stored in forest soils, as well as the portion stored in the biomass components. Soil and forest litter are important long-term stores of carbon that accumulate from the decomposition of woody biomass, foliage, and decaying leaf litter. Tree roots along with decaying material from the forest floor add organic carbon to the mineral soil. Measurements of current carbon stocks help managers understand the importance of different forest types and landscapes in the carbon cycle.

What we found

Maine's forests sequester 1.48 billion metric tons of carbon within the aboveground, belowground, and soil pools. The greatest portion (> 48 percent) of the stored carbon is found below ground in the soil organic matter. Live tree pools in above- and belowground biomass account for another 30 percent of the total. Another 22 percent is contained in standing dead trees, down woody material, understory plants, and the forest floor litter (Fig. 44). Tree size and species are important for determining the amount, retention time, and accumulation rates of carbon stored. If three conifers averaging 18 inches d.b.h. are sampled, each will be found to contain approximately 1 ton of carbon. Three hardwoods averaging 14 inches d.b.h. collectively contain about the same amount of carbon. Trees are important for carbon storage because of their size. A eastern white pine tree with a 26-28 inch d.b.h., stores 1.95 tons of carbon. A sugar maple of the same diameter stores approximately 3.24 tons of carbon.

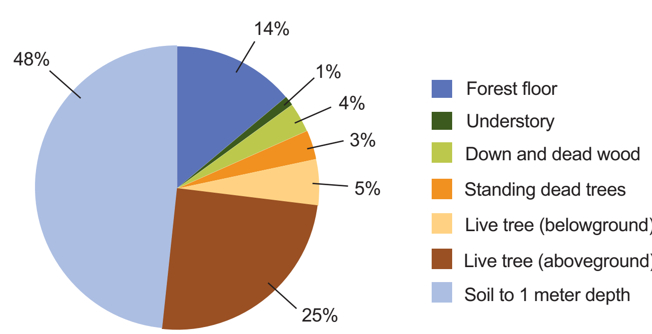


Figure 44.—Distribution of organic carbon on forest land, Maine, 2008.

Forest Health Indicators

Osprey in Maine forest. Photo by Alfred Viola, www.forestryimages.com.

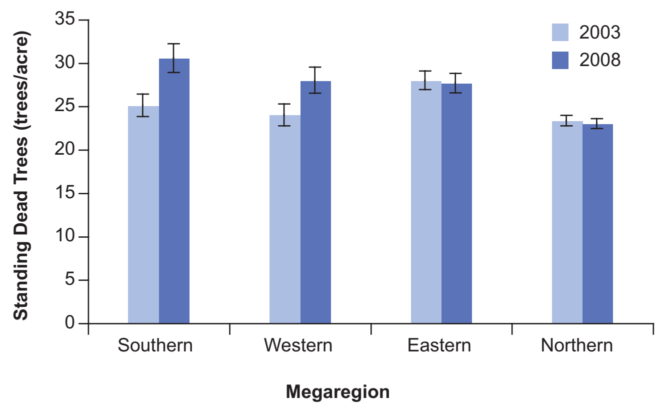
Standing Dead Trees

Background

There is a trend to treat standing dead trees as a separate entity from down woody material. This situation is due in part to the distinct methods used by FIA to estimate their volumes. But in actuality, standing dead trees are simply an earlier stage that will eventually become down woody material. Numbers of standing dead trees can indicate future levels of downed woody debris. Standing dead wood is one of several forest health indicators used to assess the current and potential condition of Maine's forests (Steinman 2000, Woodall et al. 2010).

What we found

A comparison between 2003 and 2008 inventories shows an increase in the number of standing dead trees per acre in the southern FIA units of Casco Bay, Capitol and Western, and a decrease in the number of standing dead trees per acre in the northern FIA units (counties) of Aroostook, Penobscot, and Washington. The result is no significant change in the number of standing dead trees per acre statewide (Fig. 45). The number of standing dead trees for softwood species follow the same pattern as for all species and are driven by the number of standing dead for balsam fir (Fig. 46, Fig. 47). The descriptions for each of the five decay classes used for standing dead trees are distinct from the descriptions used for coarse woody debris. The results show more of an equal distribution of decay classes amongst the standing dead trees compared to the decay class distribution results for coarse woody debris (Fig. 48, Fig. 50B).



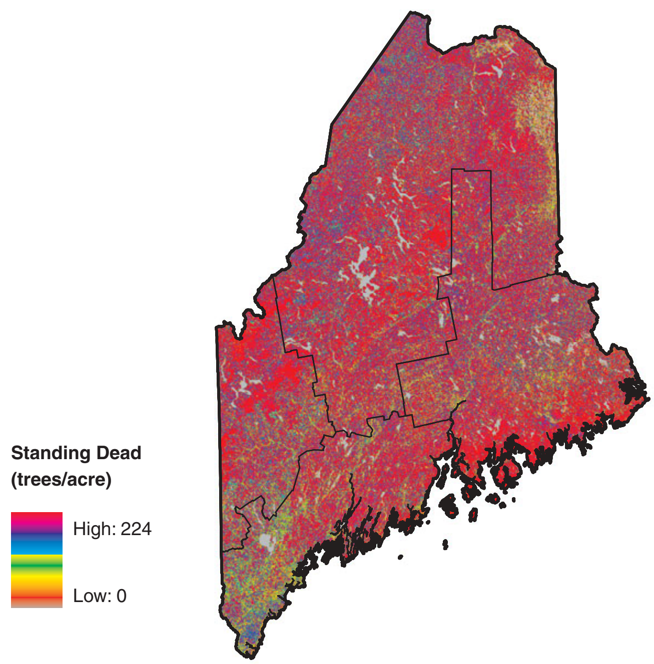


Figure 45.—Concentrations (as depicted on map) and the changes in the number of standing dead trees (trees per acre) on timberland by megaregion, Maine, 2003 and 2008 (error bars represent 68-percent confidence interval around estimate).

What this means

Increases in the numbers of standing dead trees in the Southern and Western megaregions coupled with a slight decrease in standing dead tree numbers in the northern FIA units of Aroostook, Penobscot, and Washington Counties could indicate a regional difference in stand development or stand age, especially considering balsam fir is a major component of statewide numbers.

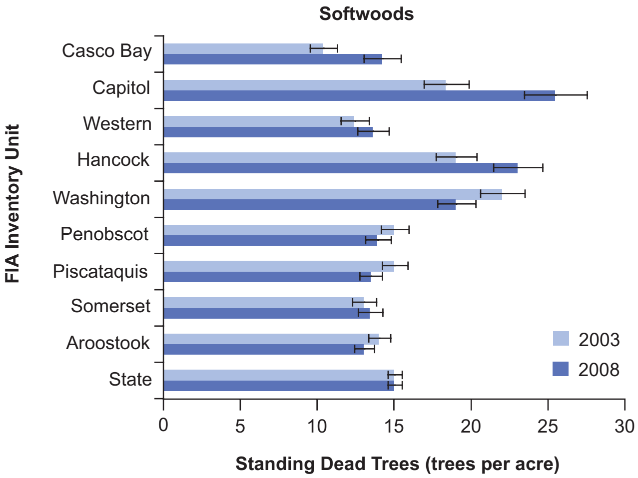


Figure 46.—Number of standing dead (trees per acre) on timberland by FIA inventory unit, Maine, 2003 and 2008 (error bars represent 68-percent confidence interval around estimate).

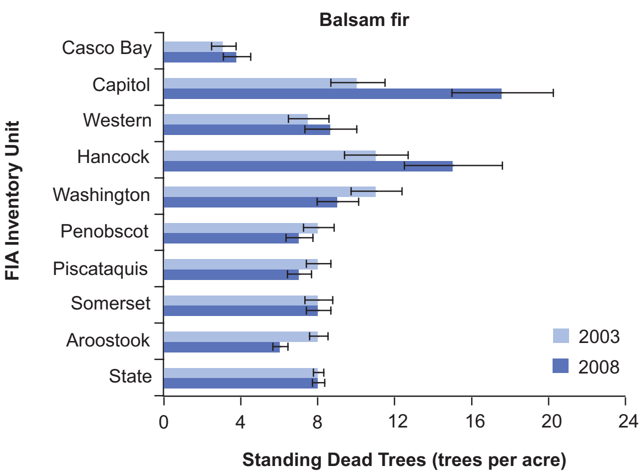


Figure 47.—Number of standing dead trees (trees per acre) on timberland by FIA inventory unit, Maine, 2003 and 2008 (error bars represent 68-percent confidence interval around estimate).

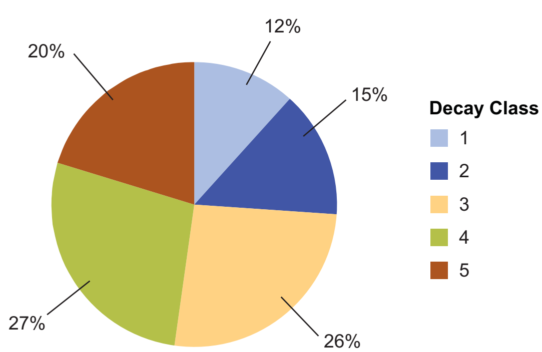


Figure 48.—Proportions of standing dead trees by decay class on timberland, Maine, 2008.

Down Woody Material

Background

Down woody material (DWM), in the form of fallen trees and branches, fulfill a critical ecological niche in Maine's forests. DWM provide valuable wildlife habitat in the form of coarse woody debris and contribute toward forest fire hazards via surface woody fuels. DWM is also a sink for carbon storage.

What we found

The fuel loadings of DWM (time-lag fuel classes) are not exceedingly high in Maine (Fig. 49). When compared to New Hampshire and Vermont, Maine's fuel loadings of all time-lag fuel classes are not substantially different (for time-lag definitions see Woodall and Monleon 2008). Of all down woody components, coarse woody debris (i.e., 1,000+-hr fuels) comprised the largest amounts.

The size-class distribution of coarse woody debris appears to be heavily skewed (82 percent) toward pieces less than 8 inches in diameter based on plot sampling transects (Fig. 50A).

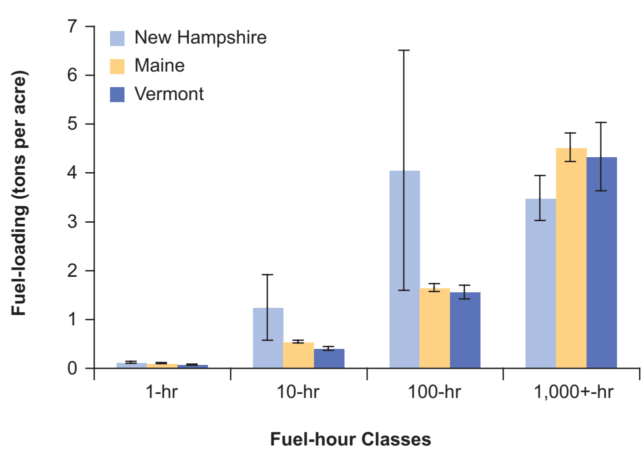


Figure 49.—Means and standard errors of fuel loadings (tons per acre, time-lag fuel classes) on forest land, Maine and nearby states, 2008 (error bars represent 68-percent confidence interval around estimate).

With regard to decay-class distribution, the moderate stages (decay classes 2, 3, and 4) are equally present and collectively account for 94 percent of DWM statewide (Fig. 50B). Coarse woody debris in decay classes 3 and 4 are typified by moderate to heavily decayed logs that are sometimes structurally sound but missing most or all of their bark, and with extensive sapwood decay. There is no strong trend in coarse woody debris volume per acre among classes of live-tree density (basal area per acre; Fig. 51). Statewide levels for the gross accumulation of coarse woody debris varied from 177 ft^3 to 228 ft^3 per acre per year, depending on the stocking levels for hardwood or softwood species within the stand. Most of Maine's forests have more than 500 ft^3 per acre of coarse woody debris (Fig. 51).

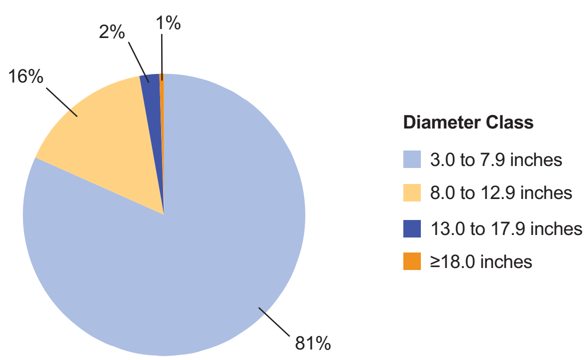


Figure 50A.—Proportions of coarse woody debris by diameter class (inches) on forest land, Maine, 2008.

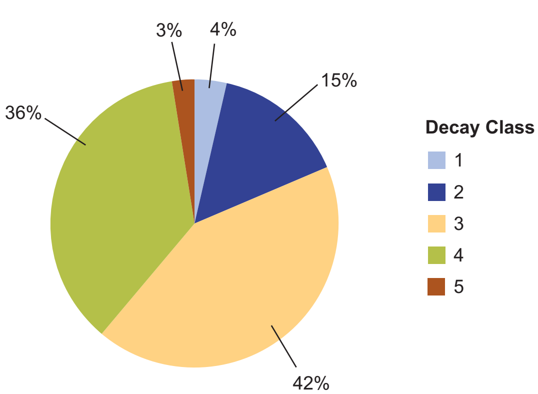


Figure 50B.—Proportions of coarse woody debris by decay class on forest land, Maine, 2008.

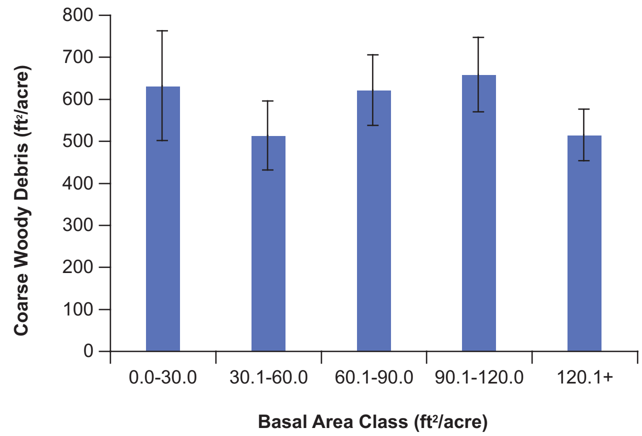


Figure 51.—Means and standard errors of coarse woody debris volumes (ft^3/acre) on forest land by basal area (ft^2/acre) class, Maine, 2008 (error bars represent 68-percent confidence interval around estimate).

What this means

Only in times of extreme drought would these low amounts (< 800 ft^3 per acre) of fuels pose a fire hazard in Maine's forests. Coarse woody debris volumes were still relatively low and were represented by small, moderately decayed pieces. The scarcity of large diameter wood material within coarse woody loads may indicate a lack of high quality wildlife habitat.

Forest Soils

Background

The soils that support forests are influenced by a number of factors, including: climate, vegetation and animals, landscape position, elevation, and time. The cool climate and the moisture holding capacity of Maine's wet forest soils help to prevent large losses of carbon. Carbon stored in the litter and humus of the forest floor is strongly influenced by several factors: forest-type group of trees present, latitude, and longitude. In addition, interactions between these factors and the weather also affect carbon storage (Simmons et al. 1996).

Human activity can affect climate-soil interactions as well as soil productivity, thus affecting forest productivity (O'Neil et al. 2005). For example, industrial emissions of sulfur and nitrogen oxides lead to "acid rain". The deposition of acids deprives the soil of important nutrients, notably calcium (Ca) and magnesium (Mg). The loss of Ca and Mg results in a shifting balance of soil elements toward aluminum (Al), which in high concentration, is toxic to plants (Horsley et al. 2008). As a result, the Ca:Al ratio is an important measure of the impact of acid deposition on forest soils and is strongly correlated to tree crown conditions. When the soil Ca:Al ratios are below 1.0 and tree crown transparencies are greater than 30 percent, forest stand health diminishes while the soil accumulates more aluminum (> 250 mg Al per kg soil) (Schaberg et al. 2006). The accumulation of this metal will be indicated by a drop in soil pH.

What we found

Figure 52 shows expected values of forest floor carbon by forest-type group separated as conifer or angiosperm (Fig. 52). By contrast, carbon in the mineral soil under Maine's forests is not strongly correlated to forest-type group; this is true for the surface soil (0-10 cm), the shallow subsoil (10-20 cm), and the sum of the two. In fact, the best predictor of mineral soil carbon based on spatial modeling is the combination of latitude and longitude (Fig. 53). This is contrary to expectations; additional investigations are under way. Soil pH was found to be a good predictor of the Ca:Al ratio (Fig. 54).

What this means

The cool climate and the moisture holding capacity of Maine's wet forest soils helps to prevent large losses of carbon provided the forest canopy is not removed from large areas within the landscape. Tree species occupy different niches in the landscape. This provides a competitive advantage for colonization, growth, and reproduction. Atmospheric deposition of sulfur and nitrogen compounds changes the soil substrate through additions and/or removals of nutrients and pollutants. Any major changes in the soil pH can significantly

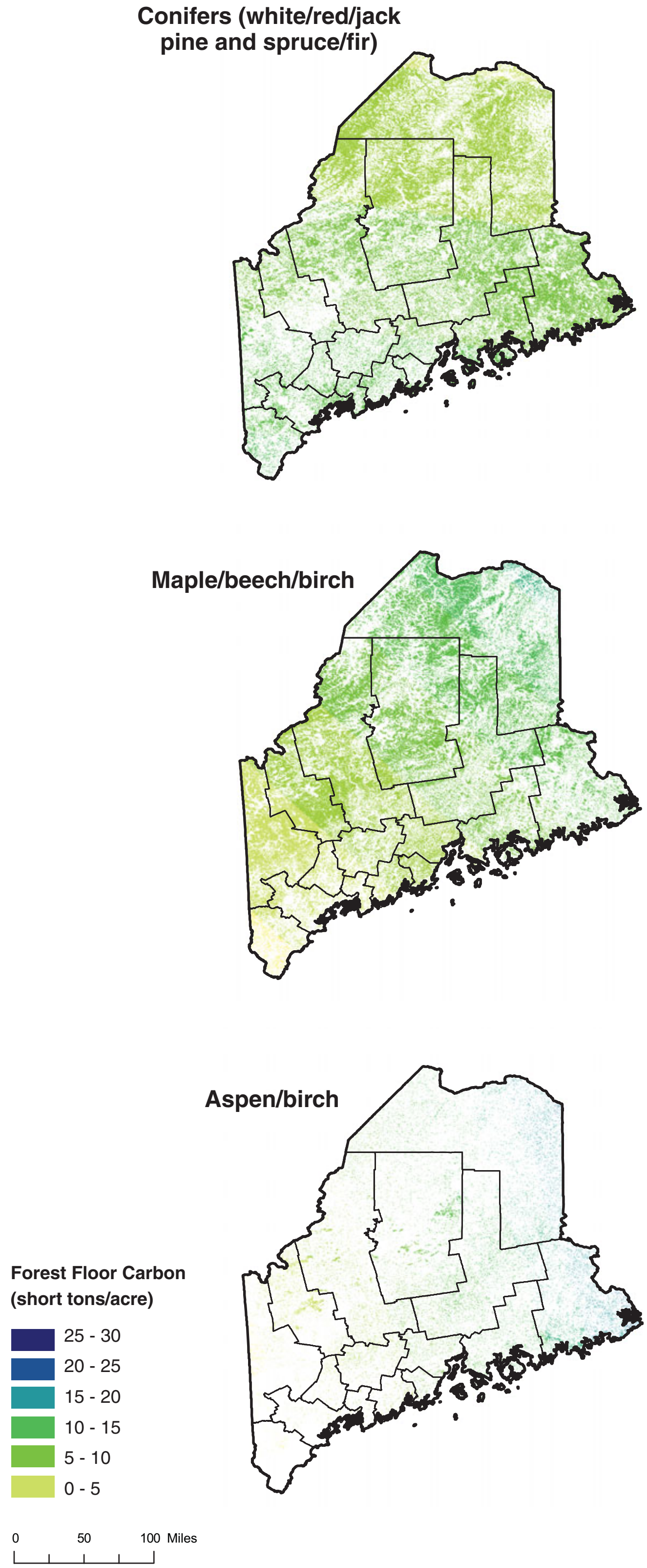


Figure 52.—The spatial distribution of mean values of forest-floor carbon (litter and humus) predicted by forest-type group, latitude, and longitude. A forest-type group stratification is used to emphasize differences in spatial location of carbon.

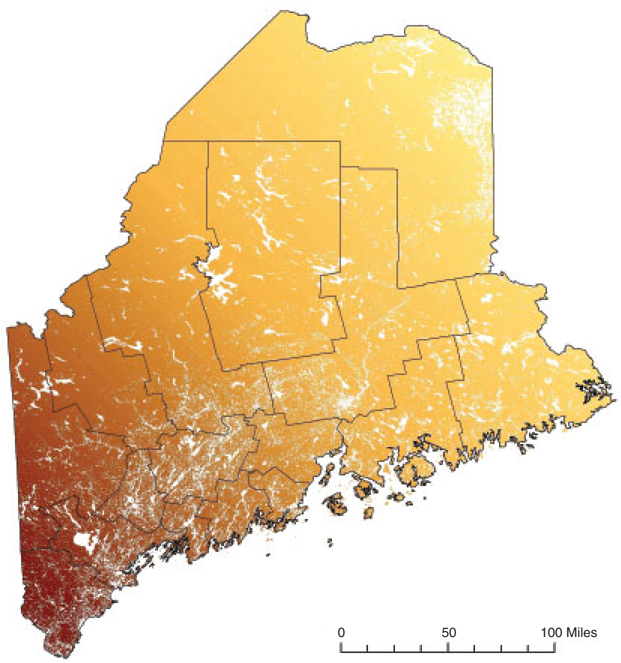


Figure 53.—Soil mineral carbon (short tons per acre) from a southwestern-to-northeastern gradient, Maine.

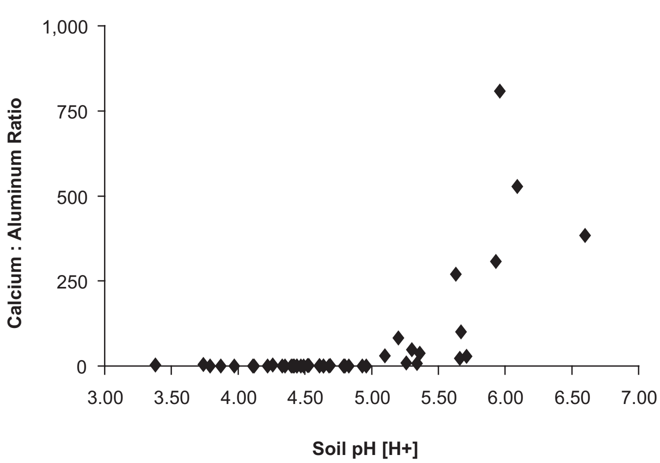


Figure 54.—Calcium-to-aluminum (Ca:Al) ratios and soil pH. Calcium is more available in soils with a pH greater than 5.0. High Ca:Al ratios lead to healthier tree crowns.

reduce the availability of soil nutrients. These soil changes influence the ability of trees to thrive and reproduce in their current locations and affect the ability of other trees to colonize new landscapes. It is important to document and understand natural and anthropogenic processes affecting the soil since they profoundly influence the current forest and success of future forests.

Nonnative Invasive Plants

Background

Understory vegetation plays many important roles in forests. Understory vegetation helps to control runoff, regulate soil temperature, and provide habitat and forage for animals. The plant community plays a vital role in determining the fauna that are able to inhabit a site as some species have specific requirements. Forest understory vegetation data provide information on species diversity, nonnative invasive plant species, and stand structure (Schulz et al. 2009). FIA assessed plant communities in Maine for 2007 and 2008 on accessible forested Phase 2 Invasive plots (approximately 20 percent of the field plots) and Phase 3 plots (approximately 6.25 percent of field plots). See Statistics and Quality Assurance section for more detailed plot descriptors.

What we found

In 2007-2008 FIA examined 155 forested Phase 2 invasive and 85 Phase 3 plots. In surveys of Phase 2 invasive plots, 13 nonnative invasive species were found and are believed to substantially reduce the number of tree seedlings (Fig. 55). Morrow's honeysuckle (*Lonicera morrowii*) was the most commonly observed nonnative invasive species on Phase 2 plots (6 plots; Fig. 55), followed by glossy buckhorn (*Frangula alnus*) and reed canarygrass (*Phlaris arundinacea*) (5 plots each). Two of the three most common nonnative invasive species found

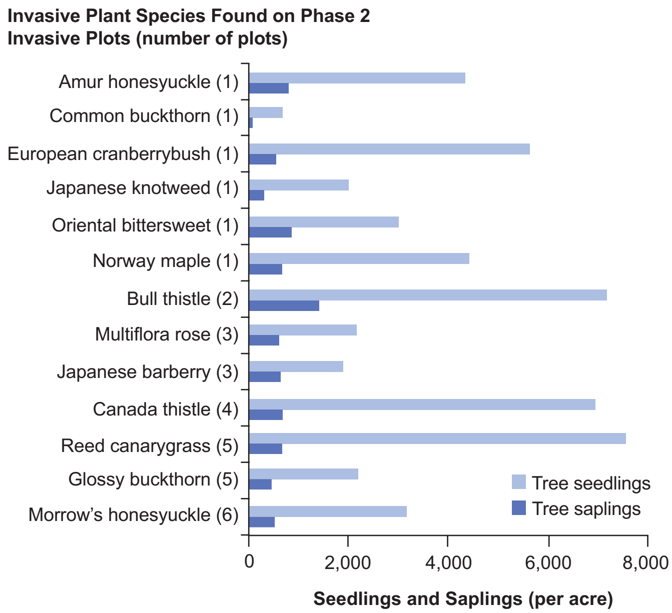


Figure 55.—Tree seedlings and saplings per acre compared to number of nonnative invasive species found on Phase 2 plots, Maine 2007-2008. Number of plots on which nonnative invasive species are found is shown in parenthesis.

were of woody growth form (trees and shrubs). Since 24 of 43 "targeted" species are woody plants (Table 8), there is a higher likelihood that the "targeted" species will be observed on Phase 2 nonnative invasive plots.

On the Phase 3 plots, 546 species were found with the greatest quantity in the forb/herb growth habit category based on classification by NRCS PLANTS database (Table 9; USDA Natural Resources Conservation Service 2011). Ninety-five plants were classified as graminoids (grass or grass-like plants). Analyzing broad growth habit categories, there were 74 tree-shrub-subshrubs, 79 shrub-subshrub-vine-forbs, and 13 vine-forb-subshrub-shrubs. For the Phase 3 plots, 408 (75 percent) of the 546 plant species, were native to the United States and 47 species (9 percent) were nonnative, a relatively small proportion (Table 10).

On Phase 3 plots, the most commonly observed species were balsam fir and Canada mayflower (*Maianthemum canadense*) found on 78 of 85 plots (Table 11), followed by red maple which was observed on 76 plots. Of the 30 most commonly observed species, 11 were trees. There was no significant relationship found between

Table 8.—Invasive plant species target list for FIA Phase 2-Phase 3 plots, 2007 to present.

Tree Species
Acer platanoides (Norway maple)
Ailanthus altissima (tree of heaven)
Albizia julibrissin (silktree)
Elaeagnus angustifolia (Russian olive)
Melaleuca quinquenervia (punktree)
Melia azedarach (Chinaberry)
Paulownia tomentosa (princesstree)
Robinia pseudoacacia (black locust)
Tamarix ramosissima (saltcedar)
Triadica sebifera (tallow tree)
Ulmus pumila (Siberian elm)
Shrub Species
Berberis thunbergii (Japanese barberry)
Berberis vulgaris (common barberry)
Elaeagnus umbellata (autumn olive)
Frangula alnus (glossy buckthorn)
Ligustrum vulgare (European privet)
Lonicera x.*bella* (showy fly honeysuckle)
Lonicera maackii (Amur honeysuckle)
Lonicera morrowii (Morrow's honeysuckle)
Lonicera tatarica (Tatarian bush honeysuckle)
Rhamnus cathartica (common buckthorn)
Rosa multiflora (multiflora rose)
Spiraea japonica (Japanese meadowsweet)
Viburnum opulus (European cranberrybush)
Vine Species
Celastrus orbiculatus (Asian bittersweet)
Hedera helix (English ivy)
Lonicera japonica (Japanese honeysuckle)
Herbaceous Species
Alliaria petiolata (garlic mustard)
Centaurea biebersteinii (spotted knapweed)
Cirsium arvense (Canada thistle)
Cirsium vulgare (bull thistle)
Cynanchum louiseae (black swallow-wort)
Cynanchum rossicum (European swallow-wort)
Euphorbia esula (leafy spurge)
Hesperis matronalis (dames rocket)
Lysimachia nummularia (creeping jenny)
Lythrum salicaria (purple loosestrife)
Polygonum cuspidatum (Japanese knotweed)
Polygonum x. *bohemicum* (P. cuspida/P. sach.hybrid)
Polygonum sachalinense (giant knotweed)
Grass Species
Microstegium vimineum (Japanese stiltgrass)
Phalaris arundinacea (reed canarygrass)
Phragmites australis (common reed)

the presence of these 30 species and the number of tree seedling or sapling counts (Table 11). The list of the most common 30 species did not contain any of the 43 nonnative invasive plants on a FIA target listing (Table 11; USDA Forest Service 2007), and common dandelion (*Taraxacum officinale*) was the most commonly observed nonnative plant species on Phase 3 plots (14 of 85 plots, Table 12), followed by claspleaf twistedstalk (*Streptopus amplexifolius*) (13 of 85 plots; Table 12).

Table 9.—Number of species observed on Maine Phase 3 plots, by growth habit (USDA Natural Resources Conservation Service 2011), 2007-2008.

Growth habit	Number of Species or Undifferentiated Genuses
forb/herb	201
graminoid	95
shrub	43
shrub, subshrub, vine	1
subshrub, forb/herb	4
subshrub, shrub	24
subshrub, shrub, forb/herb	7
tree	33
tree, shrub	38
tree, shrub, subshrub	3
vine	2
vine, forb/herb	6
vine, subshrub	1
vine, subshrub, forb/herb	3
vine, subshrub, shrub	1
unclassified	84
Total	546

Table 10.—Number of species observed on Maine Phase 3 plots, by origin (USDA Natural Resources Conservation Service 2011), 2007-2008.

Origin	Number of Species
Cultivated or not in the U.S.	1
Introduced to the U.S.	47
Native and introduced to the U.S.	6
Native to the U.S.	408
Probably introduced to the U.S.	1
Unclassified	83
Total	546

Table 11.—Thirty most common plant species or undifferentiated genera or categories found on Maine Phase 3 plots and the total number of plots on which each species is observed (in parentheses). In addition, the mean number of tree saplings and seedlings counts per acre on those plots, 2007-2008.

Species Name (number of plots species observed)	Tree Saplings per acre	Tree Seedlings per acre
Balsam fir (78)	1,651	6,574
Canada mayflower (78)	1,517	6,254
Red maple (76)	1,548	6,292
Starflower (71)	1,616	6,528
Red spruce (65)	1,801	6,934
Wild sarsaparilla (63)	1,357	6,600
Sedge (62)	1,515	5,652
Bunchberry dogwood (61)	1,836	6,507
Paper birch (58)	1,790	6,880
American red raspberry (54)	1,273	6,782
Threeleaf goldthread (51)	1,655	6,614
Dwarf red blackberry (51)	1,500	6,413
Bluebead (49)	1,478	6,877
Whorled wood aster (47)	1,445	6,564
Striped maple (45)	1,388	7,503
Serviceberry (45)	1,617	5,189
Eastern white pine (44)	1,612	6,049
Painted trillium (44)	1,576	7,212
American beech (43)	1,153	7,802
Arborvitae (42)	2,047	7,545
Intermediate woodfern (40)	1,120	5,228
American fly honeysuckle (39)	1,478	6,606
Yellow birch (38)	1,323	7,103
Quaking aspen (37)	1,472	5,668
Rare clubmoss (36)	1,688	5,351
Western brackenfern (36)	1,486	5,291
Long beechfern (36)	1,419	8,275
Mountain woodsorrel (36)	1,867	7,300
Catberry (35)	2,093	5,242
Withe-rod (35)	1,506	5,323

Table 12.—Twenty most common nonnative invasive plant species observed on Maine Phase 3 plots and the total number of plots for each species (in parentheses). In addition, the mean number of tree saplings and seedlings counts per acre on those plots, 2007-2008. Some plots have multiple nonnative plant species and thus may be double-counted in the table.

Species Name (number of plots species observed)	Tree Saplings per acre	Tree Seedlings per acre
Common dandelion (14)	1,121	6,100
Claspleaf twistedstalk (13)	2,018	9,389
Broadleaf helleborine (8)	836	6,144
Timothy (8)	801	5,724
Oxeye daisy (7)	678	8,084
Golden clover (5)	1,022	4,926
Brittlestem hempnettle (4)	927	6,581
Mouseear hawkweed (4)	1,609	6,479
Meadow hawkweed (4)	1,018	4,016
Ornamental jewelweed (4)	2,113	3,146
Bird vetch (4)	1,264	5,886
Common yarrow (4)	600	7,874
Climbing nightshade (4)	706	3491
Canada thistle (3)	723	8,506
Glossy buckthorn (3)	367	1,827
Tall buttercup (3)	350	3,049
Common sheep sorrel (3)	250	3,149
White clover (3)	268	3,356
Morrow's honeysuckle (3)	615	3,532
Orange hawkweed (3)	1,577	5,661

Most of the nonnative invasive plant species observed on Phase 3 plots fell into the forb/herb category, only two of these species were of woody growth form. These data, from only 2 years (2007-2008) of observations, show nonnative invasive plants have spread widely across the State (Fig. 56). Although the small sample size limits extensive analysis, Fig. 57 suggests that there might be a relationship between the percent of the plot covered by nonnative invasive plants and the average number of tree seedlings and saplings inventoried.

Only 13 nonnative invasive plants were detected on 34 of 240 forested plots in Maine. Reed canarygrass and glossy buckthorn were most common in more developed areas with higher populations. Areas where no invasive plants were found coincided with more

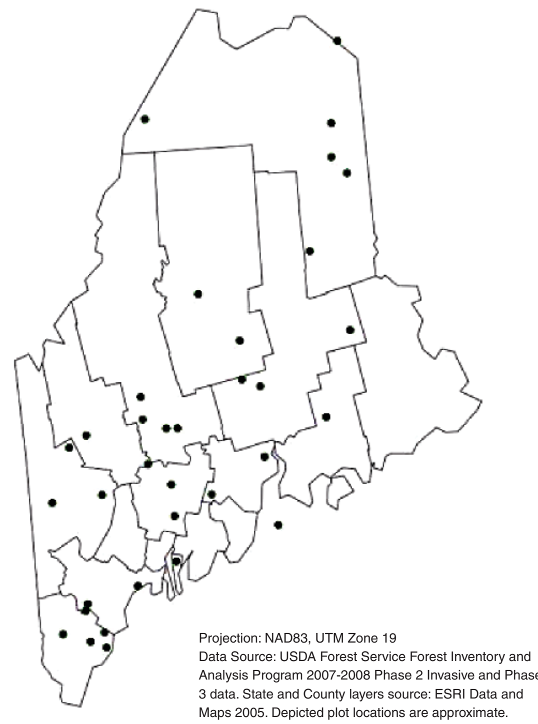


Figure 56.—Distribution of invasive plant species in Maine observed on 2007-2008 Phase 2 invasive plots, approximate locations depicted.

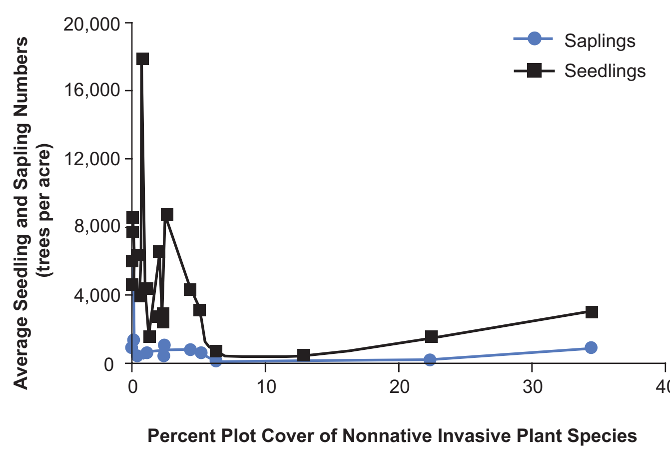


Figure 57.—Average number of seedlings and saplings per acre compared to percent nonnative invasive plant cover for Phase 2 invasive and Phase 3 plots, Maine, 2007-2008.

rural settings. Future monitoring of these plots will aid in understanding the distribution and spread of the nonnative invasive plant species FIA is recording as well as help resource managers and concerned individuals in predicting areas of greater invasion risk (Moser et al. 2009).

What this means

Maine's forests host a plethora of species covering five growth habits (forb/herb, graminoid, shrub, tree, and vine). In the limited (2007-2008) survey period, only 22 of the 155 plots (14 percent), had at least one nonnative invasive plant species. These species pose a concern as they are able to alter forested ecosystems by displacing native species and altering resource availability (water and nutrient levels).

The presence of nonnative invasive species may also result in reduced regeneration because most of the plots with tallied nonnative invasive plants had fewer saplings and seedlings per acre than plots with only native species (Fig. 55, Table 11). The impact of invasive plant species is both short term, by deleteriously influencing ground flora diversity, and long term by changing future forest composition, resulting in impacts on future carbon stocks and forest genetic pools. Additionally, nonnative invasive plants may reduce future timber yields by limiting regeneration. Remeasurement of the Phase 2 invasive and Phase 3 plots will provide valuable information by enabling research to incorporate site and regional characteristics that influence species presence. Understanding the effect of site and region characteristics will provide insight into factors influencing species presence and allow concerned individuals to predict the threat of invasion and future ecosystem response.

Urbanization and Fragmentation of Forest Land

Background

Human population growth, migration, and urbanization can transform the landscape by fragmenting some of the remaining large tracts of forest land into smaller and disconnected parcels. Remote sensing utilizing geographical information system (GIS) software is the primary tool for assessing the extent of landscape-level impacts of urbanization and fragmentation on forest land. Other methods to measure the impacts of urbanization and fragmentation include monitoring changes in pollination rates of native species, the spread of nonnative invasive species, or the inbreeding of mega-populations by exotics where specific keystone plant species are evaluated. The growth of population centers puts numerous pressures on neighboring forest lands by exposing them to high numbers of people and their associated pollutants. Urban forests, many of which have their origins in the wildland-urban interface, provide a forested experience to high-density population centers while providing a buffer to intercept pollutants (Stein et al. 2009).

What we found

Maine is approximately 33,215 mi^2 of land with 1.3 million residents, resulting in a density of 40 people per mi^2. Maine currently ranks 38th out of 50 states in terms of population density. The current national average is 86 people per mi^2. The low population density of Maine reflects the fact that the State is 90 percent forested. The U.S. Census Bureau projects a 10.7 percent (136,000 people) increase in the State's population between 2000-2030. This rate of increase declines to only 4.0 percent over the next two decades (Table 13). Maine ranks 32nd in projected percent change of the total state population. The U.S. national rate of change is projected to be 29.2 percent (Table 14). Maine has two urbanized areas with more than 50,000 people. The Portland metro area is made up of Portland, South Portland, Westbrook, Biddeford, Old Orchard Beach, Saco, and Scarborough. This urban area impacts the Southern megaregion. The other large urban area consists of the towns of Bangor, Brewer, Hampden, Old Town, Milford, Ellisforth, and Orono, which are located in the southern portion of the Eastern megaregion (Fig. 58) (Bernstein 2005).

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 neighboring New Hampshire, Vermont, and the national average. Lower population increases usually result in slower rates of forest fragmentation, provided local governments have up-to-date urban plans that give value to maintaining open lands. Land managers are concerned about impacts on water quality

Table 13.—Population projections: Projected change in total population for regions, divisions, and states, 2000 to 2030.

Region, Division, and State	Numerical Change 2000 to 2010	Numerical Change 2010 to 2020	Numerical Change 2020 to 2030	Numerical Change 2000 to 2030	Percent Change 2000 to 2010	Percent Change 2010 to 2020	Percent Change 2020 to 2030	Percent Change 2000 to 2030
United States	**27,513,675**	**26,868,965**	**27,779,889**	**82,162,529**	**9.8**	**8.7**	**8.3**	**29.2**
Northeast	**2,190,801**	**1,350,258**	**535,631**	**4,076,690**	**4.1**	**2.4**	**0.9**	**7.6**
New England	816,272	570,739	313,487	1,700,498	5.9	3.9	2.0	12.2
Maine	82,211	51,531	2,432	136,174	6.4	3.8	0.2	10.7
New Hampshire	149,774	139,191	121,720	410,685	12.1	10.0	8.0	33.2
Vermont	43,685	38,174	21,181	103,040	7.2	5.9	3.1	16.9
Massachusetts	300,344	206,105	156,463	662,912	4.7	3.1	2.3	10.4
Rhode Island	68,333	37,578	-1,289	104,622	6.5	3.4	-0.1	10.0
Connecticut	171,925	98,160	12,980	283,065	5.0	2.7	0.4	8.3

U.S. Census Bureau, Population Division, Interim State Population Projections, 2005.
Internet Release Date: April 21, 2005

Table 14.—Population projections: Ranking of U.S. Census (2000) and Projected 2030 state population and change, 2000 to 2030.

Census 2000 State	2000 Census Population	2030 Census Rank	2030 Projections State	2030 Projections Population	2030 Projections Rank	Change: 2000 to 2030 State	Change: 2000 to 2030 Number	Change: 2000 to 2030 Percent	Change: 2000 to 2030 rank in percent change
Massachusetts	6,349,097	13	Massachusetts	7,012,009	17	New Hampshire	410,685	33.2	15
Connecticut	3,405,565	29	Connecticut	3,688,630	30	Vermont	103,040	16.9	23
Maine	1,274,923	40	New Hampshire	1,646,471	40	Maine	136,174	10.7	32
New Hampshire	1,235,786	41	Maine	1,411,097	42	Massachusetts	662,912	10.4	33
Rhode Island	1,048,319	43	Rhode Island	1,152,941	43	Rhode Island	104,622	10.0	34
Vermont	608,827	49	Vermont	711,867	48	Connecticut	283,065	8.3	38

U.S. Census Bureau, Population Division, Interim State Population Projections, 2005.
Internet Release Date: April 21, 2005

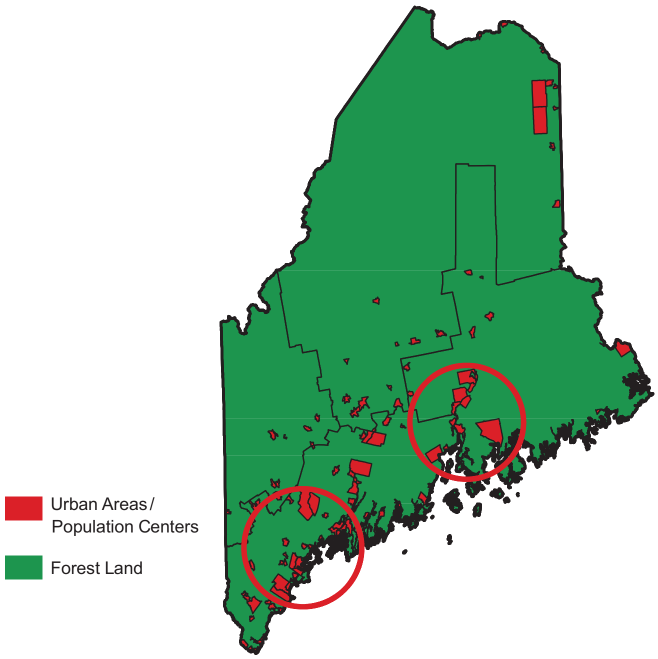


Figure 58.—Distribution of urban areas (red) and population centers (red circles), Maine, 2008.

within the Lower Kennebec and Saco watersheds from increased urbanization, particularly from outside the state (Stein et al. 2009).

Insects and Diseases

Background

Even though we may discuss insects and diseases separately, they commonly act together with other stressors on the forest resource base. Many insects are vectors for the spread of diseases by introducing the pathogen directly into the wood where wounds are found. Defoliators attack tree leaves leaving their tree crowns in poor condition. Tree crown condition indicates tree health and can be determined visually (Randolph et al. 2010). A crown is labeled as 'poor' if crown dieback is greater than 20 percent, crown density is less than 35 percent, or foliage transparency is greater than 35 percent. These thresholds are based on preliminary findings by Steinman (2000) that associate crown ratings with tree mortality.

What we found

Insects

Spruce budworm (*Choristoneura fumiferana*) infestations, a natural event in the spruce-fir forests of the Northeast, have been reoccurring approximately every 30 years (Boulanger and Arseneault 2004, Desponts et al. 2004). The budworm will eliminate most of the balsam fir and 25 percent of the spruce. Larva defoliates fir and spruce trees by mining into the needles or buds. Since the last major outbreak ended approximately in 1985, the next epidemic is predicted to occur around 2015 (McCarthy and Weetman 2007, Solomon and Braun 1992). When comparing our current data with earlier inventories using growing-stock tree density, balsam fir dropped dramatically from 1982-1995, reflecting the continued impacts of the spruce budworm mortality, mortality due to over-maturity, and associated salvage/harvest removals. This was especially the case within the Northern and Eastern megaregions where reductions were the greatest (Fig. 59). Balsam fir numbers have shown a partial recovery since 1995, especially within Aroostook, Piscataquis, Penobscot, and Washington counties. Red spruce had similar reductions over the same period when compared with balsam fir, but its subsequent recovery has not been realized over most of the state (Fig. 60). Average tree diameters for balsam fir have been decreasing since 1982, indicating larger trees were being replaced with greater numbers of smaller trees during this recovery timeframe (Fig. 61). Average tree diameters for red spruce have not declined since 1982, reflecting the replacement of larger trees by greater numbers of smaller trees has not occurred to the extent it has with balsam fir (Fig. 62). Currently, 78 percent of all conifer mortality (143 million ft^3) occurs within the spruce-balsam fir species group where the last spruce budworm epidemic had the highest impacts (Irland 1996).

Pathogens

Beech bark disease (*Nectria coccinea*) has impacted beech forests since the 1890 discovery of the beech scale (*Cryptococcus fagisuga*) in Nova Scotia. An infestation was

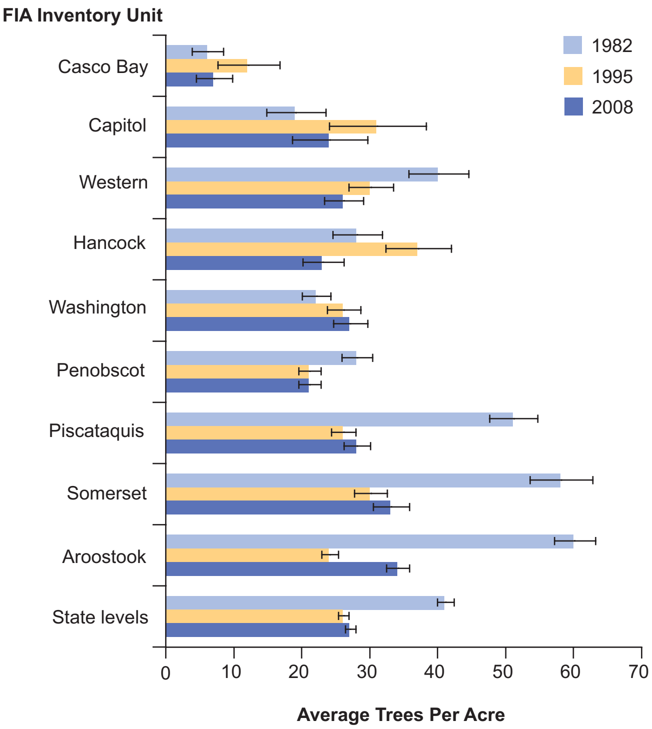


Figure 59.—Number of balsam fir trees (trees per acre) by FIA inventory unit, Maine, 1982, 1995, and 2008 (error bars represent 68-percent confidence interval around estimate).

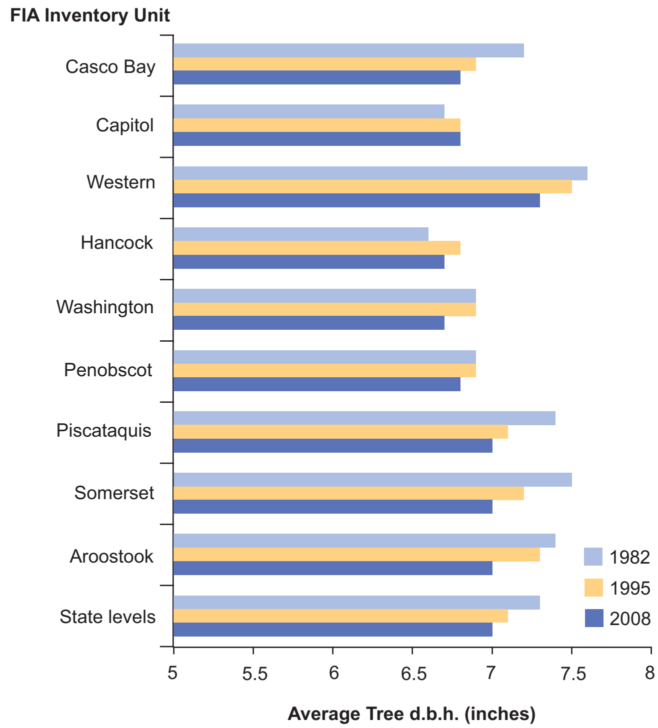


Figure 61.—Average d.b.h. (inches) for balsam fir by FIA inventory unit, Maine, 1982, 1995, and 2008.

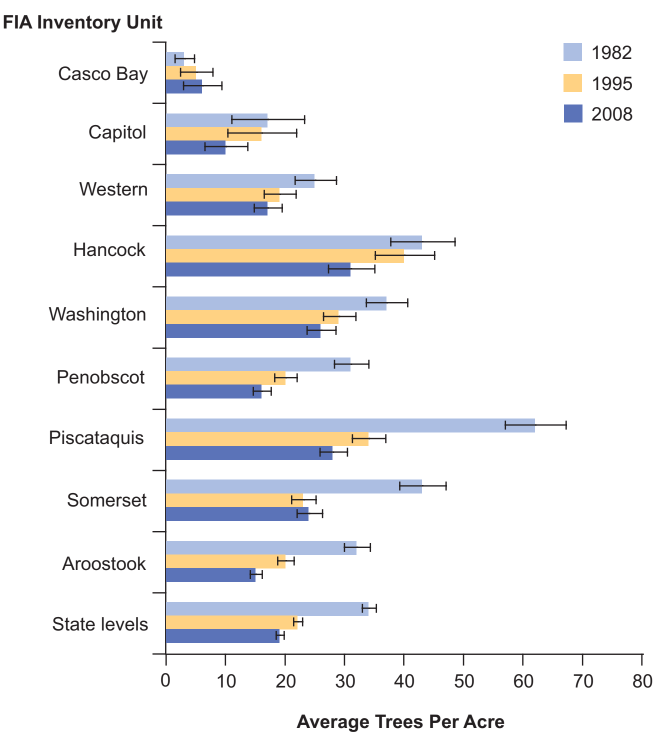


Figure 60.—Number of red spruce trees (trees per acre) by FIA inventory unit, Maine, 1982, 1995, and 2008 (error bars represent 68-percent confidence interval around estimate).

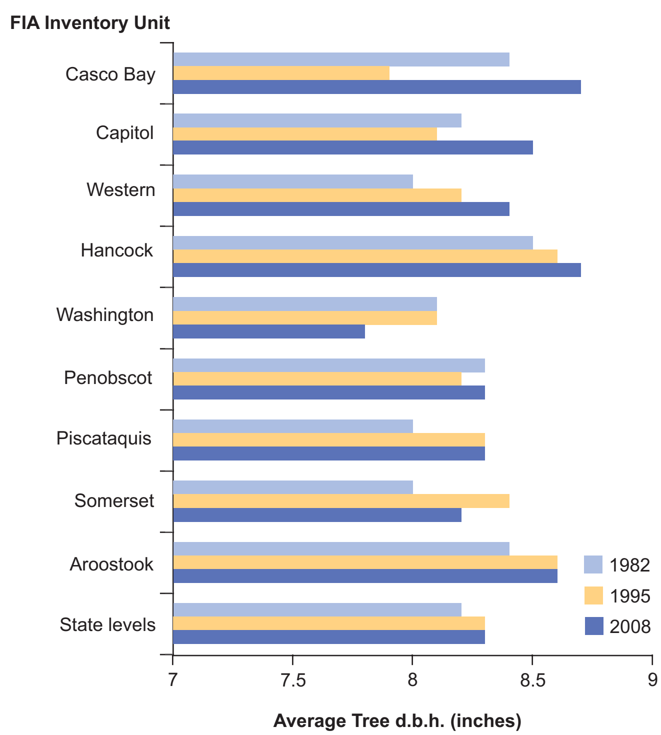


Figure 62.—Average d.b.h. (inches) for red spruce by FIA inventory unit, Maine, 1982, 1995, and 2008.

first discovered near Liberty, Maine, in 1931. The scale insect allows the introduction of the Nectria pathogen into the bark of beech trees and enhances the spread of the disease. The symbiotic relationship between the disease and scale insect creates a canker in the bole of the tree. Cold winters inhibit beech scale numbers thus reducing the number of beech bark-infected trees. Data shows almost 38,000 acres of maple-beech-birch were impacted by insects in 2008. Beech currently has the highest percentage of poor crowns (Table 15; Randolph et al. 2010).

Table 15.—Percent of live basal area with poor crowns for selected tree species, Maine, 2008.

Species	Percent of Basal Area With Poor Crowns
Balsam fir	7.0
Red maple	8.8
Red spruce	4.9
Northern white-cedar	10.3
Eastern white pine	5.9
Sugar maple	4.1
Eastern hemlock	3.4
Paper birch	10.5
Yellow birch	9.5
American beech	28.9

What this means

Insects and diseases will to continue to challenge us as we try to improve the productivity of our forests (Irland 1998).

The spruce budworm will continue to modify spruce-fir forests challenging forest managers to be more innovative with methods of management. Beech bark disease will continue to impact larger beech trees, seriously reducing net volume.

Late-successional Forests

Background

Forest diversity can also be assessed by considering late-successional attributes of existing forest conditions. Major attributes of late-successional forests are:

- Percentage (dominance) of stocking containing long-lived (100+ year old) shade-tolerant tree species such as red spruce, eastern hemlock, sugar maple, American beech, yellow birch, and the less tolerant but equally long-living eastern white pine
- Condition of their crowns
- Amounts and levels of decay for down woody material, amounts of standing dead trees
- Associated vegetative species

One simple indicator of late-successional forests has been the number of live and standing dead trees (trees per acre) having a d.b.h. of 15.0 inches or alternatively super-sized trees having a d.b.h. greater than 21.0 inches.

What we found

The total number of live and snag trees (≥15.0 inches d.b.h.) increased by almost 3.1 million trees while the total number of live and snag trees (≥21.0 inches d.b.h.) increased by more than 1.05 million on Maine's forest land. The numbers of large live and snag conifer trees (≥15.0 inches d.b.h.) increased by 4.6 million trees. Eastern hemlock represented the major portion of this gain at 1.6 million. There was no significant change in the number of red spruce trees in either large size class.

Even though live and snag hardwood growing-stock trees (≥15.0 inches d.b.h.) decreased by more than 1.5 million trees, sugar maple had an increase in live or snag trees in the same size class by almost 3.2 million trees. American beech had a 44 percent decrease in the number of live and snag trees (≥15.0 inches d.b.h.) There was no significant change in the number of live and snag yellow birch trees in the same size class since the last reporting period.

The number of live and snag trees (≥21.0 inches d.b.h.) increased on a per-acre basis in Cumberland, Sagadahoc, Androscoggin, Waldo, and Piscataquis Counties (Fig. 63).

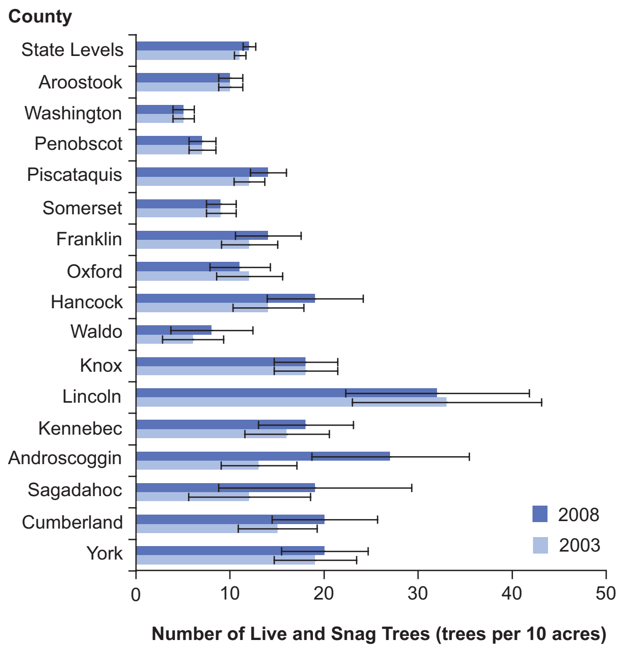


Figure 63.—Number of live and standing dead trees ≥ 21 inches d.b.h. (trees per 10 acres) by county, Maine, 2003 and 2008.

What this means

Most of the larger diameter trees are found in forests where stocking is made up of shade-tolerant hemlock, sugar maple, or the less tolerant eastern white pine. Most of the larger diameter conifers, such as eastern hemlocks or eastern white pines, were measured in stands with tree ages ranging from 60 to100 years old. The larger diameter hardwood trees are found in stands with a wider range of ages (41 to 100 years). American beech is an anomaly due to the continued impacts of beech bark disease on the older and larger diameter beech trees.

Forest Products

Stand of pine trees. Photo by Brian Lockhart, U.S. Forest Service, www.forestryimages.com.

Forest Products

Background

Forestry and forest products have remained important in Maine since the 17th century. Maine's forest products industry is the major employer of the State. It also adds significant revenue to the State economy. The major products from Maine's forests are saw logs, pulp wood, and biomass. Each year, the Maine Forest Service (MFS) collects wood processing numbers from processing facilities within the State (Maine Forest Service 2010). The following analysis is based on those reports from 1990 to present, as well as FIA inventory data.

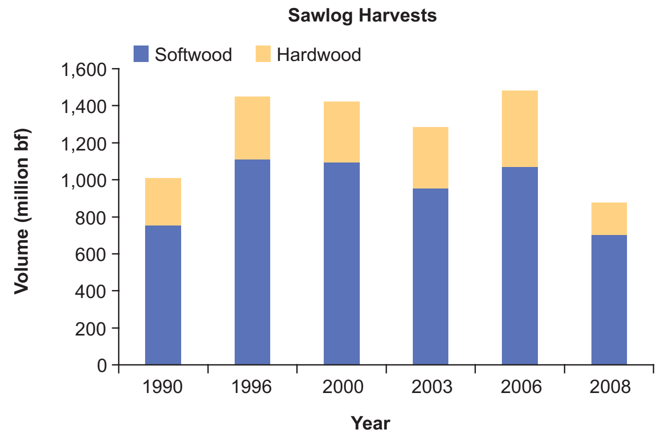


Figure 64.—Trends in saw log harvests by softwood and hardwood volumes (million board feet), Maine, 1990-2008.

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), indicating there was no significant change from the 2003 levels. The total softwood saw log volume on timberlands had a minor increase (2.5 percent) which was offset by a minor decrease (2.6 percent) in hardwood sawlog volume since 2003.

Saw log harvesting has been variable since 1990, according to the processing reports. Greater volumes of saw logs were produced from softwood removals than from hardwood trees. Saw log harvests have decreased from 2.9 million cords in 1996 to only 1.76 million cords in 2008 (Fig. 64). Pulp wood harvests have been reasonably steady from 3.2 million cords in 1990 to 2.9 million cords in 2008. Biomass chip harvests have increased from a low of 0.4 million cords in 2000 to 1.2 million cords in 2008 (Fig. 65). The number of primary processing mills has dropped from 438 in 1990 to only 155 mills in 2008 (Fig. 66). Hardwood tree volume makes up most of the pulpwood harvests since 1990 (Fig. 67).

Figure 65.—Saw log, pulpwood, and biomass chip harvest volumes since 1990.

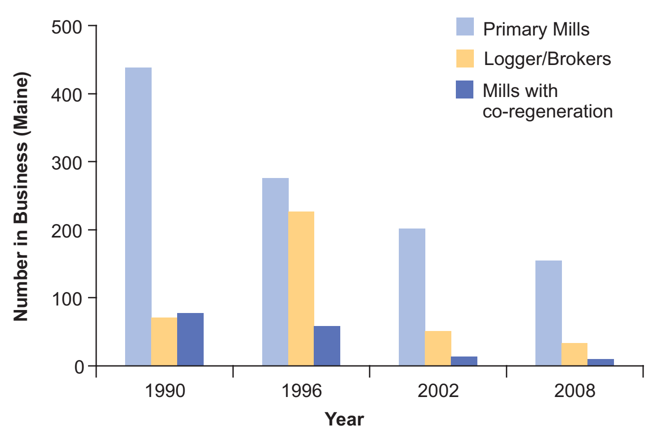


Figure 66.—Number of primary processing mills, loggers/timber brokers, and mills with co-regeneration facilities, Maine, 1990-2008.

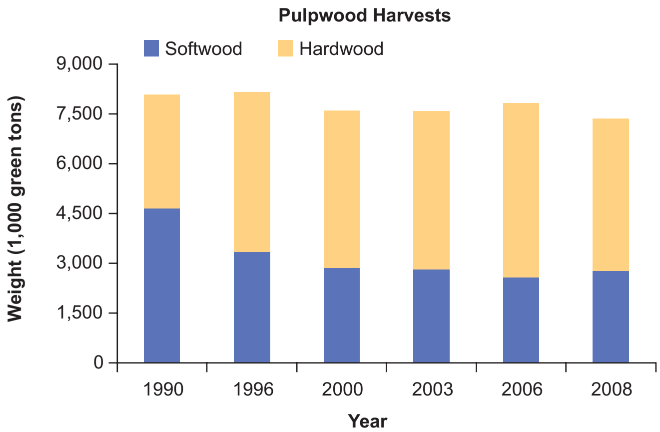


Figure 67.—Trends in pulpwood harvests by softwood and hardwood weight (1,000 green tons), Maine, 1990-2008.

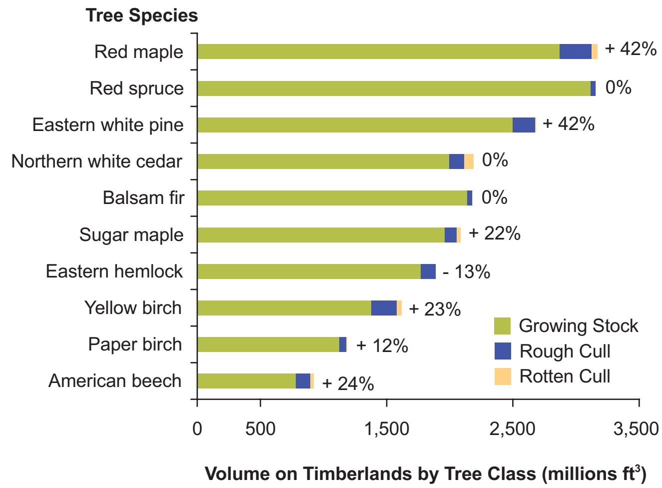


Figure 68.—Volume (million ft^3) of 10 most common tree species by tree class (tree quality). The percent values represent increase or decrease in volume of rough and rotten cull between 2003 and 2008.

Wood Quality

Background

Wood quality in standing trees has a direct impact on the amount and type of wood products can be produced from a forest. Drastic changes in the wood quality of standing trees can affect both current and future levels of wood supply. Each tree species has a distinct form and produces a different combination of wood products. The wood quality of trees can also change over time based upon the intensity of timber stand improvement practices applied to a forest.

What we found

Even though the greatest amount of gross timber was produced from red maple compared to other tree species, it also had one of the greatest percentage increases (42 percent) in the amount of rough and rotten cull since the 2003 reporting period. Red spruce produced the highest level of growing-stock class timber and lowest level of rough and rotten cull. Most conifers had no increases in the amount of rough or rotten cull volumes, with the exception of eastern white pine having an increase similar to red maple. Eastern hemlock had a 13 percent decrease in the amount of rough and rotten cull (Fig. 68).

Noncommercial Tree Species

Background

Additional future wood supplies for biomass markets may need to be generated from improved efficiencies in wood processing. These improved efficiencies might include further utilization of noncommercial tree and shrub species.

What we found

Most noncommercial tree species currently found on Maine's forested landscape are in the 3.0 to 7.0 inches d.b.h. classes. Six noncommercial species represent 67 percent of the biomass (13.4 million tons): striped maple (*Acer pensylvanicum*), gray birch (*Betula populifolia*), eastern hophornbeam (*Ostrya virginiana*), pin cherry (*Prunus pensylvanica*), mountain maple (*Acer spicatum*), and mountain ash (*Sorbus* spp.) (Table 16).

What this means

Even though many of these tree species do not have the size or form to produce growing stock volume, they do have sufficient biomass to provide some additional supplies to bioenergy markets.

Table 16.—Aboveground biomass (dry short tons) of noncommercial tree species by sapling diameter classes and total biomass per species.

	Biomass (dry short tons)		
Species	Saplings 1 to 2 inches d.b.h.	Saplings 3 to 4 inches d.b.h.	Total all diameter classes
Striped maple	2,655,699	1,769,578	4,659,161
Graybirch	1,383,739	1,564,935	3,806,257
Hophornbeam	345,013	577,370	2,243,107
Pin cherry	524,936	544,773	1,324,223
Mountain maple	814,512	74,166	892,170
Mountain ash	94,637	128,064	396,687
Hornbeam	50,070	28,481	78,550
Chokecherry	42,501	6,277	48,778
Subtotal	5,911,107	4,693,644	13,448,933

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The second annual inventory of Maine's forests was completed in 2008 after more than 3,160 forested plots were measured. Forest land occupies almost 17.7 million acres, which represents 82 percent of the total land area of Maine. The dominant forest-type groups are maple/beech/yellow birch, spruce/fir, white/red/jack pine, and aspen/white birch. Statewide volume equals 25.5 billion ft^3, resulting from nearly 590 million ft^3 of live-tree volume grown each year. The report also contains additional information on sustainability, biomass, carbon, forest health, land-use change, and timber products. The DVD includes detailed information on forest inventory methods, quality of estimates found, and tables forest statistics.

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

DVD Contents

Maine’s Forests 2008 (PDF)

Maine’s Forests 2008: Statistics and Quality Assurance (PDF)

Maine Inventory Database (CSV file)

Maine Inventory Database (Microsoft Access file)

FIA National Core Field Guide (PDF)

Database User Guide (PDF)

Maine's Forests 2008: Statistics and Quality Assurance

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