Changes in Eastern Hardwood Sawtimber Growth and Harvest

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Abstract

This article examines increases in eastern hardwood sawtimber volume by species group and species, the utilization of sawtimber by species groups and important eastern species, the utilization of sawtimber by species group by subregion, and discusses issues that could impede future growth of the hardwood timber resource. Eastern hardwood sawtimber volume has nearly tripled between 1953 and 2011 with yellow-poplar, soft maple, ash, and cottonwood/aspen having the greatest increase. Ironically, the cottonwood/aspen group appears to be currently overutilized with relatively low net growth-to-harvest ratios, but this finding appears to be the result of a high volume of aspen stems being less than sawtimber size. In general, lower-value species, including other red oaks and sweetgum, are relatively overutilized and have growth-to-harvest ratios less than 2.0. By contrast, higher-value species, including select red oaks, select white oaks, and hard maple, are utilized at the level at which they are found in the timber inventory, and all have growth-to-harvest ratios greater than 2.0. These results may be reflective of the declining production of appearance-based hardwood products relative to less valuable industrial products in the last 5 years. While the growth in hardwood sawtimber on timberland has been substantial, there are several factors that could affect future growth, including nonnative disease and insect mortality, adversely high deer populations, and land conversion.

Eastern hardwood sawtimber volume[1] nearly tripled between 1953 and 2011 (Fig. 1) as smaller trees reached sawtimber size, larger trees continued to increase in volume, and agricultural land reverted back to forests. But has this increase in volume affected all hardwood species and species groups, and by how much is current growth exceeding harvest? The answers to these questions are important because future sawtimber inventories will be needed to support the forecasted increases in sawtimber consumption in primary hardwood product and fuelwood production (US Department of Agriculture Forest Service [USDA FS] 2012). This article examines increases in eastern hardwood sawtimber volume by species group and species, sawtimber utilization by species groups and select species in the eastern United States, and the utilization of species group by subregion. We also discuss factors that could impede future growth of the hardwood timber resource.

The US Forest Service Inventory and Analysis (FIA) program has defined species groups; these are presented in Table 1 (USDA FS 2001). Species groups can be composed of a single species, such as yellow-poplar (*Liriodendron tulipifera*), or multiple species (Table 1). For instance, the other red oaks species group includes black oak (*Quercus velutina*), water oak (*Q. nigra*), southern red oaks (*Q. falcata*), and numerous other red oak species (*Quercus* spp.) that tend to have relatively poorer form. By contrast, the select red oaks species group includes northern red oak (*Q. rubra*), cherrybark oak (*Q. pagoda*), and Shumard oak (*Q. shumardii*), which have a greater proportion of volume in higher tree grades (USDA FS 2013a). It is useful to examine species groups when species within the group have similar uses, but it is also useful to examine individual species when species groups are too broad. For example, black cherry (*Prunus serotina*) is included in a group called other soft hardwoods, and important aspen species are lumped together in a group termed cottonwoods/aspens (*Populus* spp.).

[1] Sawtimber consists of live trees containing at least one 12-foot log or two noncontiguous 8-foot logs and meeting regional specifications for freedom from defects. Hardwood sawtimber trees must be at least 11 inches diameter at breast height (DBH; US Department of Agriculture Forest Service [USDA FS] 2001).

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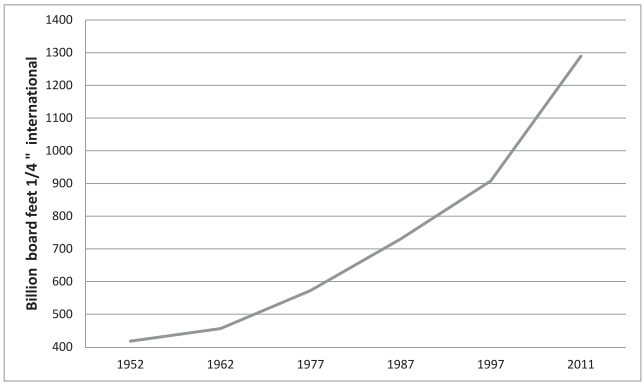

Figure 1.—Volume of eastern hardwood sawtimber on timberland from 1953 to 2011 (US Department of Agriculture Forest Service 2001, 2013a).

This study is based primarily on hardwood sawtimber volume, annual net growth (growth), and annual removal through harvest on timberland (harvest). Timberland is forestland either producing or capable of producing crops of industrial wood and is not withdrawn from timber utilization by statue (Pugh et al. 2011). Net growth is average annual growth minus mortality. Sawtimber volume, growth, and harvest are calculated on a 5- to 7-year survey period via yearly panels.

Changes in the Hardwood Sawtimber Inventory by Species Group

FIA conducted the first comprehensive assessment of US timber resources in 1953. At that time, eastern hardwood sawtimber volume was slightly above 400 billion board feet (USDA FS 1958). While this volume appears to be large, it was likely significantly less than sawtimber volume in the years prior to 1850. After the Civil War, the US economy grew, and timberland was harvested to produce lumber, crossties, fuel wood, and charcoal (Luppold and Miller 2005). Much of the harvested land would transition to agricultural uses, such as food crop, to feed an expanding population or hay to feed horses, a major form of within-continental transportation. The advent of the Great Depression, the transition from horses to automobiles, and higher-yielding agricultural practices resulted in marginal agricultural land reverting back to forests from the 1930s to the 1950s. These changes set the stage for a relatively rapid accumulation of sawtimber volume that continues today.

Since 1953, hardwood sawtimber volume on timberland has been steadily increasing (Fig. 1) and reached over 1.3 trillion board feet in 2011. In the 1950s, 1960s, and 1970s, much of this increase was the result of smaller-diameter pole timber growing to sawtimber-size trees (ingrowth). Much of the increase in recent years is sawtimber-size trees adding volume (accretion). These changes are apparent when examining changes in hardwood growing stock (trees over 5 in. DBH that are not culls) by diameter class (Fig. 2). In 1953, nearly 50 percent of the hardwood growing stock was in trees that were in the less than 11-inch-diameter threshold for sawtimber-size trees with the greatest volume being in the 9- to 10.9-inch-diameter class. Between 1953 and 1977, the greatest increases in growing stock volumes remained in trees in the less than the 11-inch-diameter class, with the greatest volume of trees remaining in the 9- to 10.9-inch-diameter class. By 2011, the volume in pole timber–size trees had declined to 1953 levels, but the volume in large-diameter trees over 17 inches had more than doubled from 1977 levels. The volume would have been even greater if acreage had not been transferred from the timberland category into reserve status, such as wilderness areas. In 2011, more than 4 percent of the hardwood sawtimber volume on forestland in the eastern United States was in reserve (USDA FS 2013a).

The 1953 assessment provided a benchmark for sawtimber volume information, but within-species-group data was limited to six groups. In 1963, a second forest assessment was conducted, and sawtimber volume information was provided for 16 species groups (Table 2). Between 1963 and 2011, all species groups had increases in sawtimber volume, with yellow-poplar, red maple (*Acer rubrum*), and cottonwood/aspen exhibiting the largest increases. While these three species groups contain relatively fast-growing species, there are other factors that have caused these large increases.

Table 1.—Major species groups and the major species in these groups.

Major species group	Associated species in groups
Select white oaks	White oak (*Quercus alba*), swamp white oak (*Q. bicolor*), swamp chestnut white oak (*Q. michauxii*), bur oak (*Q. macrocarpa*), and chinkapin oak (*Q. muehlenbergi*)
Select red oaks	Northern red oak (*Quercus rubra*), cherrybark oak (*Q. falcate*), and Shumard oak (*Q. shumardii*)
Other white oaks	Chestnut oak (*Quercus prinus*), overcup oak (*Q. lyrata*), and post oak (*Q. stellate*)
Other red oaks	Black oak (*Quercus velutina*), water oak, (*Q. nigra*), pin oak (*Q. palustris*), willow oak (*Q. phellos*), laurel oak (*Q. laurifolia*), northern pin oak (*Q. ellipsoidalis*), scarlet oak (*Q. coccinea*), southern red oak (*Q. falcata*), bear oak (*Q. ilicifolia*), shingle oak (*Q*. imbricaria), and blackjack oak (*Q*. marilandica)
Hickory	Pignut hickory (*Carya glabra*), bitternut hickory (*C. cordiformis*), pecan (*C. illinoensis*), water hickory (*C. aquatica*), mockernut hickory (*C. tomentosa*), shagbark hickory (*C. ovata*), black hickory (*C. texana*), and shellbark hickory (*C. laciniosa*)
Hard maple	Sugar maple (*Acer saccharum*) and black maple (*A. nigrum*)
Soft maple	Red maple (*Acer rubrum*) and silver maple (*A. saccharinum*)
Sweetgum	Sweetgum (*Liquidambar styraciflua*)
Tupelo/blackgum	Water tupelo (*Nyssa aquatica*), Ogeechee tupelo (*N. ogeche*), swamp tupelo (*N. biflora*), blackgum (*N. sylvatica*)
Yellow-poplar	Yellow-poplar (*Liriodendron tulipifera*)
Ash	White ash (*Fraxinus americana*), green ash (*F. pennsylvanica*), and black ash (*F. nigra*)
Cottonwood/aspen	Quaking aspen (*Populus tremuloides*), eastern cottonwood (*P. deltoides*), bigtooth aspen (*P. grandidentata*), plains cottonwood (*P. deltoides*), and balsam poplar (*P. balsamifera*)

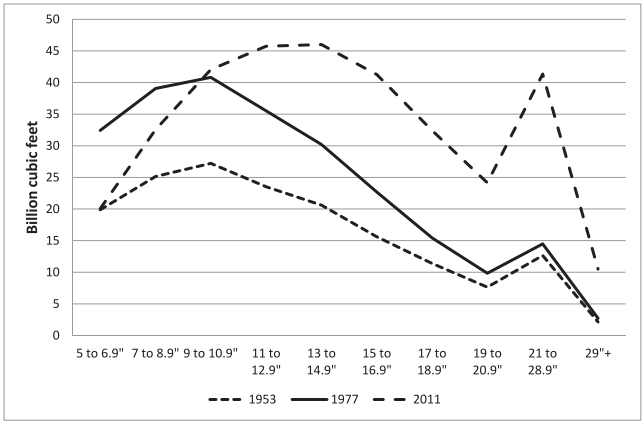

Figure 2.—Distribution of hardwood growing stock by diameter class in 1953, 1977, and 2011 in the eastern hardwood region (US Department of Agriculture Forest Service 2009, 2013a).

Yellow-poplar is very competitive in the central Appalachian region and is often a pioneer on abandoned old fields or clear-cut land (Burns and Honkala 1990). The most predominant soft maple is red maple, a species that is very competitive on Appalachian and northern sites after a diameter-limit harvest or other partial harvesting practices (Schuler 2004). The two most common species in the cottonwood/aspen species group are quaking aspen (*Populus tremuloides*) and eastern cottonwood (*P. deltoides*). Quaking aspen is very competitive on bare soils in the northeastern and north-central regions of the United States but is short lived without disturbance and is considered an early successional species (Burns and Honkala 1990). Eastern cottonwood is found in wet areas and grows very quickly.

Yellow birch (*Betula alleghaniensis*), tupelo/blackgum (*Nyssa* spp.), and beech (*Fagus grandifolia*) had relatively small increases in sawtimber inventory between 1963 and 2011. Nearly 30 percent of the yellow birch sawtimber volume has been placed in reserve, but it is unknown exactly when this happened (USDA FS 2013a). This figure is nearly 50 percent higher than hard maple and beech, the next two species with large volumes in reserve. Major species in the tupelo/blackgum groups are swamp tupelo (*N. sylvatica* var. *biflora*), water tupelo (*N. aquatica*), and black tupelo (*N. sylvatica*), which is also known as blackgum. Swamp and water tupelo grow on bottomlands (Burns and Honkala 1990) that often is converted into cropland. Blackgum grows on upland sites and coastal plains but is often a form of understory interference for many years before reaching sawtimber size. Beech sawtimber volume has been affected by beech bark disease (Burns and Honkala 1990), and 8 percent of volume is in reserve.

Growth versus Harvest by Species Group and Species

There are several ways to analyze hardwood sawtimber harvest levels. A broad measure is the proportion of total harvest that can be attributable to an individual species or species group. A relative measure is the proportion of harvest level for a species or species group divided by the proportion of the species or species group in the forest inventory (relative utilization coefficient [RUC]; Luppold et al. 2001). Finally, net growth volume divided by harvest volume results in the growth-to-harvest removal (GR) ratio. The GR ratio is often used as a measure of forest resource sustainability (James et al. 2012). Each of these indicators represents a different perspective of the relationship between the market and the hardwood resource.

Tables 3 and 4 present the proportion of the inventory, proportion of harvest, RUC, and GR ratio for major hardwood species groups and species. The most predominant species groups in the eastern sawtimber resource are other red oaks, yellow-poplar, select white oaks, select red oaks, and soft maple. Collectively, these species groups account for more than 50 percent of the eastern sawtimber volume. Species groups that account for most harvest activity include other red oaks, yellow-poplar, select white oaks, select red oaks, and sweetgum. Together, these species groups account for 56 percent of sawtimber harvest volume.

The RUC is indicative of how heavily a species is being harvested relative to inventory levels (Luppold et al. 2001).

Table 2.—Changes in sawtimber volume on timberland for major hardwood species groups between 1963 and 2011.[a]

Species group	Sawtimber volume 1963 (million board ft)	Proportion volume 1963 (%)	Sawtimber volume 2011 (million board ft)	Proportional volume 2011 (%)	Change between 1963 and 2011 (%)
Select white oaks	42,847	10.0	133,167	10.3	210.8
Select red oaks	35,020	8.1	116,531	9.0	232.8
Other white oaks	29,990	7.0	78,490	6.1	161.7
Other red oaks	55,397	12.9	178,593	13.8	222.4
Hickory	28,488	6.6	71,885	5.6	152.3
Yellow birch	11,594	2.7	13,065	1.0	12.7
Hard maple	25,764	6.0	77,737	6.0	201.7
Soft maple	19,216	4.5	108,392	8.4	464.1
Beech	19,311	4.5	27,889	2.2	44.4
Sweetgum	25,879	6.0	61,903	4.8	139.2
Tupelo/blackgum	25,830	6.0	33,609	2.6	30.1
Ash	14,606	3.4	58,724	4.6	302.1
Cottonwood/aspen	11,345	2.6	47,887	3.7	322.1
Basswood	7,812	1.8	21,643	1.7	177.0
Yellow-poplar	21,202	4.9	138,708	10.8	554.2
Black walnut	2,956	0.7	10,991	0.8	271.8

[a] Sources: US Department of Agriculture Forest Service (1965, 2013a). Percentages do not add to 100 because the other hard hardwood and other soft hardwood categories were not included.

Table 3.—Proportion of the inventory, proportion of harvest, and relative utilization coefficients for major hardwood species groups and black cherry and quaking aspen in the eastern hardwood region.[a]

Species group (and species)	Proportion of inventory (%)	Proportion of harvest (%)	Relative utilization coefficient (ratio)
Other red oaks	13.8	18.6	1.3
Yellow-poplar	10.8	12.7	1.2
Select white oaks	10.3	9.7	0.9
Select red oaks	9.0	7.6	0.8
Sweetgum	4.8	7.2	1.5
Hard maple	6.0	6.7	1.1
Soft maple	8.4	5.9	0.7
Cottonwood/aspen	3.7	5.6	1.5
Hickory	5.6	4.4	0.8
Other white oaks	6.1	4.4	0.7
Ash	4.6	3.6	0.8
Black cherry	2.6	2.9	1.1
Quaking aspen	1.4	3.4	2.4

[a] Source: US Department of Agriculture Forest Service (2013a).

Underutilized species have a RUC less than 0.80, fully utilized species have a RUC of 0.80 to 1.2, and overutilized species have a RUC greater than 1.2 (Luppold et al. 2001). When the RUC exceeds 2.0, the species or species group is considered highly overutilized. The most utilized species groups are cottonwood/aspen, sweetgum (*Liquidambar styraciflua*), and other red oaks; the most underutilized species groups are soft maple, ash, and other white oaks (Table 3). Yellow-poplar, select red and white oaks, hard maples, and hickories are being harvested at roughly the levels at which these groups are represented in the inventory. Black cherry also is a fully utilized species for the period studied (Table 3).

The species groups with the highest GR ratio are soft maple, ashes, hickory, other white oaks, and select red oaks (Table 4). The most predominant soft maple is red maple. The other white oaks have a high GR ratio because of relatively low demand for these species, especially for chestnut oak (*Q. prinus*; USDA FS 2013a). The predominant select white oaks is white oak (*Q. alba*). Northern red oak is the most important select red oak. Although regeneration problems have been observed and documented for northern red oak over the past 60 years (Dey et al. 2007), established trees continue to grow, and harvest levels have decreased in recent years (USDA FS 2013a).

The species groups with the lowest GR ratio are cottonwood/aspen, sweetgum, and other red oaks. The aspen component of the cottonwood/aspen group was heavily harvested in the Great Lakes states to produce oriented strandboard and pulp. Quaking aspen was the only highly overutilized species listed in Table 3. Because many strandboard mills have closed in recent years, the aspen harvest level has declined, but this decline has not yet become apparent in the moving average of harvest volume estimates. Aspens are short-lived species and need disturbance to regenerate, and if not harvested, their sites will transition to other species. There is an assertion that the sawtimber volume of aspen species will increase as smaller trees grow into larger size classes. Other red oaks can be cut for grade lumber production but also are sawn into crossties, pallet cants, and board-road, which are markets that have maintained or approached pre-Recession levels (Johnson 2013).

Regional Differences in Growth and Removal

It is useful to examine growth and harvest trends on a regional basis because of differences in forest composition and the level of harvest. After examining differences in forest composition, we divided the eastern hardwood region into six subregions (Table 5). The major species in the northern subregion are hard and soft maple, but relatively large volumes of select red oaks and cottonwood/aspen also are harvested (Table 6). Hard maple is harvested at a rate higher than its proportion of inventory in the northern region, resulting in a RUC greater than 1.2, but the GR ratio is still 2.0 (Table 7). Soft maple and select red oaks are underutilized and have GR ratios above 3.0, indicating robust growth. The most utilized species group in this subregion is cottonwood/aspen with a RUC of 1.8 and GR ratio of 1.4.

The Great Plains subregion is lightly forested, and the major species group is cottonwood/aspen. This species group represents 37 percent of the sawtimber inventory but 68 percent of the harvest, resulting in a RUC of 1.8 (the highest in Table 7) and GR ratio of 0.8. These statistics do not necessarily indicate a declining resource because more

Table 4.—Net growth, harvest removal, and the growth harvest ratio for major hardwood species groups and black cherry and quaking aspen in the eastern region.[a]

Species group (and species)	Net growth (billion board ft, ¼-in. international scale)	Harvest removal (billion board ft, ¼-in. international scale)	Growth to harvest removal (ratio)
Other red oaks	4,837.3	2,857.9	1.7
Yellow-poplar	5,152.2	1,958.5	2.6
Select white oaks	3,626.3	1,484.2	2.4
Select red oaks	3,404.4	1,161.7	2.9
Sweetgum	1,780.3	1,098.8	1.6
Hard maple	2,338.0	1,026.2	2.3
Soft maple	3,603.1	904.5	4.0
Cottonwood/aspen	1,217.2	866.7	1.4
Hickory	1,893.2	680.1	2.8
Other white oaks	2,026.9	675.9	3.0
Ash	1,630.8	560.5	2.9
Black cherry	1,062.6	445.8	2.4
Quaking aspen	532.4	516.0	1.0

[a] Source: US Department of Agriculture Forest Service (2013a).

Table 5.—Eastern hardwood subregions.

Subregion	States	Major species group
Northern	CT, ME, MA, MI, NH, NY, PA, RI, VT, WI	Hard maple, soft maple, cottonwood/aspen, selected red oaks
Plains	KS, MN, NE, ND, SD	Cottonwood/aspen
West-central	IL, IA, MO	Other red oaks, select white oaks
East-central	IN, KY, OH, TN, WV	Yellow-poplar, other red oaks, select white oak
Mid-Atlantic	DE, MD, NJ, NC, VA	Yellow-poplar, other red oaks, select white oaks, sweetgum
Southern	AL, AR, FL, GA, LA, MS, OK, SC, TX	Other red oaks, sweetgum, select white oaks

Table 6.—Net growth, harvest removal, and the growth-to-harvest ratio for major hardwood species groups by region.[a]

Subregion	Species group	Net growth (billion board ft, ¼-in. international scale)	Harvest removal (billion board ft, ¼-in. international scale)	Growth-to-harvest removal (ratio)
Northern	Hard maple	1,612.4	811.5	2.0
	Soft maple	2,158.2	605.5	3.6
	Cottonwood/aspen	715.9	507.0	1.4
	Select red oaks	1,659.1	481.8	3.4
Plains	Cottonwood/aspen	229.2	304.1	0.8
West-central	Other red oaks	438.9	256.9	1.7
	Select white oaks	452.1	168.3	2.7
East-central	Yellow-poplar	1,858.8	846.4	2.2
	Other red oaks	778.9	623.0	1.3
	Select white oaks	1,023.4	506.9	2.0
Mid-Atlantic	Yellow-poplar	2,028.9	687.0	3.0
	Other red oak	630.7	253.8	2.5
	Select white oaks	691.7	220.0	3.1
	Sweetgum	376.2	204.4	1.8
Southern	Other red oaks	2,480.6	1,565.1	1.6
	Sweetgum	1,207.9	838.4	1.4
	Select white oaks	993.6	418.3	2.4

[a] Source: US Department of Agriculture Forest Service (2013a).

than 80 percent of the aspen stems in this region are less than sawtimber size (USDA FS 2013a).

The west-central subregion contains high volumes of other red and select white oaks with other red oaks having the greatest rate of harvest (Table 7). Nearly 60 percent of the other red oaks sawtimber in this region is tree Grade 4 or lower (USDA FS 2013a), which is less suitable for the production of grade lumber because of the relatively low yield of Grade 1 Common and Better lumber (Hanks 1976) but can be used to produce industrial products such as pallet lumber, cross-ties, and mine props. A large proportion of sawmills in this region specialized in the production of sawn industrial products (Tuttle et al. 2007, Illinois Forestry Development Council 2013). The lumber consumption by

Table 7.—Proportion of inventory, proportion of harvest, and relative utilization coefficient for major hardwood species groups by region.[a]

Subregion	Species group	Proportion of inventory (%)	Proportion of harvest (%)	Relative utilization coefficient (ratio)
Northern	Hard maple	15.6	19.6	1.3
	Soft maple	18.0	14.6	0.8
	Cottonwood/aspen	7.0	12.2	1.7
	Select red oaks	13.8	11.6	0.8
Plains	Cottonwood/aspen	36.9	67.9	1.8
West-central	Other red oaks	20.0	38.4	1.9
	Select white oaks	23.0	25.2	1.1
East-central	Yellow-poplar	16.8	22.6	1.3
	Other red oaks	10.7	16.7	1.6
	Select white oaks	12.4	15.0	1.2
Mid-Atlantic	Yellow-poplar	27.8	35.7	1.3
	Other red oak	11.9	13.2	1.1
	Select white oaks	11.7	11.4	1.0
	Sweetgum	6.6	10.6	1.6
Southern	Other red oaks	27.3	34.7	1.3
	Sweetgum	13.9	18.6	1.3
	Select white oaks	9.9	9.3	0.9

[a] Source: US Department of Agriculture Forest Service (2013a).

these industries has remained relatively high when compared with kitchen cabinet, furniture, millwork, and other appearance products (Johnson 2013).

Yellow-poplar, other red oaks, and select white oaks represent 40 percent of the inventory and 54 percent of the harvest in the east-central subregion. Other red oak and yellow-poplar are relatively overutilized, but other red oaks are the only species group with a GR ratio of less than 2.0 (Tables 6 and 7). Yellow-poplar and select white oak are important export species (US Department of Agriculture, Foreign Agricultural Service [USDA FAS] 2013). This area contains numerous flooring plants with the greatest capacity being in Tennessee, Kentucky, and West Virginia; the primary woods used in flooring are various red and white oak species.

The forest composition in the mid-Atlantic subregion is similar to that of the east-central subregion except that yellow-poplar represents nearly 28 percent of the sawtimber volume and sweet gum represents over 10 percent of the harvest. Sweetgum is the only relatively overutilized species in this region and the only major species group to have a GR ratio of less than 2.0 (Table 6). The relatively high GR ratios for yellow-poplar and other red oaks in this region may be related to the closure of many furniture plants in North Carolina, Virginia, and Maryland that occurred after 2000.

Other red oaks, sweetgum, and select white oaks make up 51 percent of the sawtimber volume in the southern subregion but 63 percent of the harvest (USDA FS 2013a). This subregion produces cross-ties and is the center of the fast-growing crane mats and board-road industries, but 70 percent of the industrial roundwood consumed in the southern region was for pulp production in 2009 (USDA FS 2013b).[2] An examination of 2011 estimates of hardwood harvest removals (which includes the 2009 panel) of growing stock found that 67 percent of these removals were trees that were at or above 11 inches DBH (sawtimber size). In the case of other red oaks, 75 percent of harvest removals were trees 11 inches and larger, while 56 percent of sweetgum removals were sawtimber-size trees. These numbers indicate that a sizable portion of other red oak sawtimber removals and a smaller portion of sweetgum sawtimber harvest removals in the southern region go to the pulp industry. As a result of combined pulp and hardwood lumber production, other red oaks and sweetgum are relatively overutilized and have GH ratios of less than 2.0 (Tables 6 and 7).

The analysis of eastern sawtimber inventory found that the less valuable timber species, which include cottonwood/aspen, other red oaks, yellow-poplar, and sweetgum, are relatively overutilized and, with the exception of yellow-poplar, have a GR ratio below 2.0. The only low-value species group that is not overutilized is other white oaks. By contrast, the higher-value species, including hard maple, select red oaks, and select white oaks groups, are harvested at roughly the same level as are found in the resource and also have GR ratios above 2.0. These results may be reflective of the declining production of appearance-based hardwood products relative to less valuable industrial products that have been occurring for most of the 21st century (Johnson 2013).

[2] These figures do not include Texas, which had not completed a timber product output study in 2009.

Future Challenges

While the growth in hardwood sawtimber on timberland has been substantial, there are several factors that could affect future growth, including nonnative disease and insect mortality, adversely high deer populations, forestland conversion, fragmentation, and forestland ownership. Various nonnative fungi have changed the eastern forest over the past 150 years with chestnut blight virtually eliminating a once dominant species (Schlarbaum et al. 1998). American elm (*Ulmus americana*) has been divested by two strains of Dutch elm disease (*Ophiostoma ulmi* and *O. nova-ulmi*) that entered the country on a shipment of veneer logs from Europe. Gypsy moth was introduced to the eastern forest in 1869 and can cause occasional massive tree mortality with oak species being the most affected (Wallner 1998). Currently, the emerald ash borer (*Agrilus planipennis*) has killed large numbers of green ash trees in Michigan, Ohio, and Indiana and is now moving to many other states primarily through infected firewood (Pugh et al. 2011).

Ecological factors have also affected long-term sawtimber supplies. In the past 30 years, white-tailed deer (*Odocoileus virginianus*) populations have expanded, and this expansion is affecting forest regeneration and the species composition of future forests. In Pennsylvania, deer have caused regeneration problems for many desirable hardwood species and will continue to do so unless the population size is decreased (Kain et al. 2011).

From colonial times to the early 20th century, large portions of land were converted from forest to agricultural uses (Luppold and Miller 2005). This trend was reversed during the Great Depression as marginal farmland reverted back to forest. Since 1953, forested land has increased by about 10 percent; however, there are emerging issues that could cause a reduction in timberland. Continued high prices for agriculture commodities may cause forestland to be converted into farmland once again, but the most probable factor is land converting from forest to residential land (Alig et al. 2010). Fragmentation of remaining forestland is also projected by Alig et al. (2010), and this will reduce the average size of forest holdings.

Eighty-two percent of the timberland east of the Rocky Mountains is privately owned (USDA FS 2013a). Nationally, family forest owners account for 92 percent of the private forest owners and 62 percent of the private forestland (Butler 2008). Only 1 in 5 acres of family forestland is owned by someone who has a written forest management plan. Most family forest owners own their forestland for multiple reasons, including beauty/scenery, privacy, nature protection, and part of home/cabin. These factors, along with land conversion and fragmentation, indicate that the future growth of the sawtimber resource will not necessarily translate into future commercial sawtimber availability.

Conclusions

Eastern hardwood sawtimber volume nearly tripled between 1953 and 2011. All species groups had increases in sawtimber volume, with yellow-poplar, red maple, and cottonwood/aspen exhibiting the largest increases. In the 1950s, 1960s, and 1970s, much of this increase was the result of smaller-diameter pole timber growing to sawtimber-size trees (ingrowth). Much of the increase in recent years is sawtimber-size trees adding volume (accretion).

The market for higher-quality hardwood products has been poor for several years, but there has been improvement in the prices of better quality lumber during 2013 (Hardwood Market Report 2013). Market conditions prior to 2013 have reduced the harvest of select red and white oaks, hard and soft maple, and black cherry. Perhaps the most promising near-term markets for higher-grade and higher-quality hardwood products are China and Vietnam. Exports to these two nations have increased by 143 percent between 2009 and 2012, resulting in total exports reaching close to all-time highs in both dollar values and volume in 2012 (USDA FAS 2013).

By contrast, the market for lower-value species has remained relatively unaffected by the current economic malaise as indicated by the high relative utilization of other red oaks in all but the northern region and sweet gum in the southern and mid-Atlantic regions. In most regions, the high relative utilization of these species can be attributable to demand for industrial products, such as pallets and cross-ties. However, the high rate of utilization in the southern region is also the result of demand by pulp mills.

While the growth in hardwood sawtimber on timberland has been substantial, there are several factors that could affect future growth. Various nonnative fungi, including chestnut blight and Dutch elm disease, have changed the eastern forest over the past 150 years. Gypsy moth was introduced to the eastern forest in 1869, while the emerald ash borer has been recently introduced. Both insects have resulted in high mortality in specific regions. Land converting from forest to residential land and fragmentation of remaining forestland will reduce the average size of forest holdings.

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