INDICATOR 2

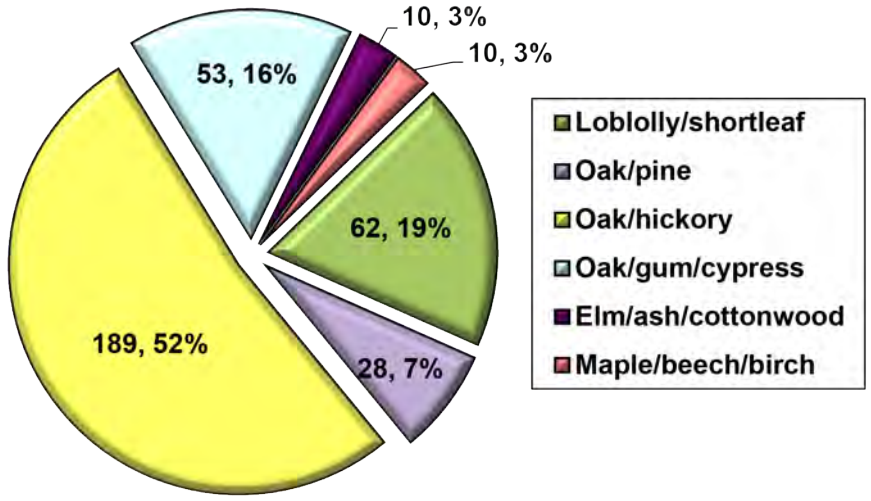
Forest type, size class, age class, and successional stage

This indicator provides a view of the overall forest resource in the state. Periodic forest inventories are used to develop reports that describe the basic biological characteristics of our forests and trees contained therein. Ideally, the state's forest resource will contain a mixture of native forest types and, within each type, there exists a mosaic of tree size and age classes.

Forest types in Delaware

Forests are often classified by type—that is, the common dominant tree species or combination of tree species found in those forests. Forest types found in Delaware are based on periodic inventories conducted by the U.S. Forest Service through its Forest Inventory and Analysis (FIA) program. Just over half of the forested area in Delaware currently consists of an oak/hickory species complex (Figure 6). Pine and pine/oak types make up about one fourth of the total area. Minor hardwood components such as gum, maple, and beech, inhabit the remaining forested acreage.

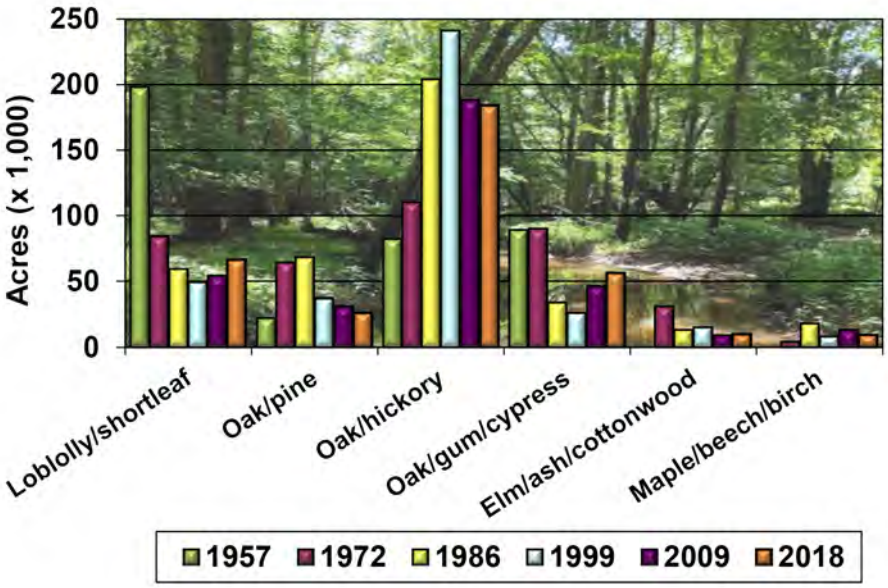
Figure 6. Acres (x 1,000) by forest type in Delaware, 2018.



Source: U.S. Forest Service Forest Inventory and Analysis

Although the total area of forestland has remained relatively stable over the last 60 years, significant changes have occurred within Delaware's forests (Figure 7). Notably, loblolly pine (*Pinus taeda*) acreage steadily decreased from nearly 200,000 acres in 1957 to less than 50,000 in 1999 (a 75% decline). However, in the last 20 years, pine acreage has increased to 67,000 acres. A dramatic decline occurred between 1957 and 1972 when large areas of woodland were cleared for agricultural use and before Delaware's *Seed Tree Law* was enacted. This steep decline is significant because loblolly pine is one of Delaware's most valuable commercial timber species and historically has contributed significantly to Delaware's economy.

Figure 7. Forest types of Delaware, 1957–2018.

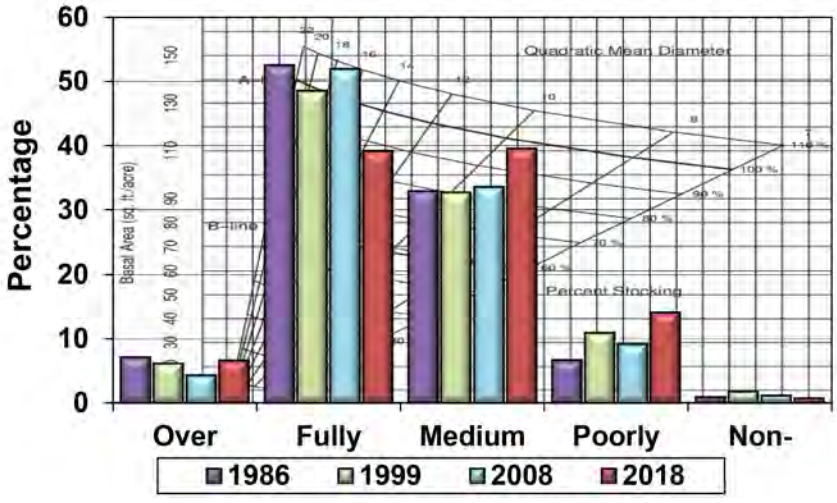


Source: U.S. Forest Service Forest Inventory and Analysis

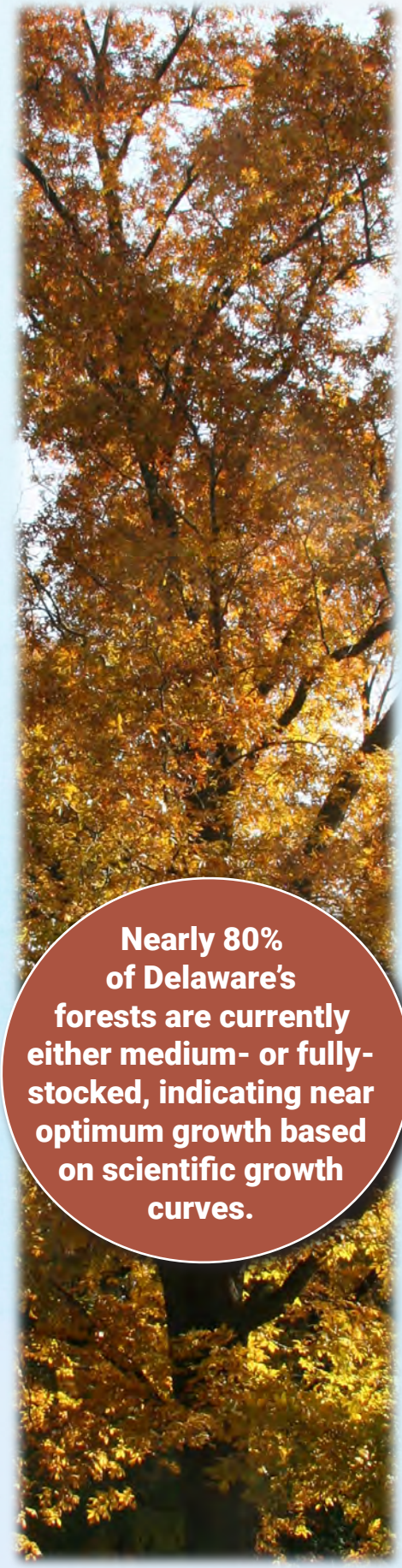
The passage of Delaware's *Seed Tree Law* in 1989 was prompted by the precipitous loss of loblolly pine forests. The law requires forest landowners to ensure sufficient regeneration after a harvest. Loblolly pine and yellow-poplar (*Liriodendron tulipifera*) are covered under this law that only applies to forests greater than 10 acres. This law only applies to parcels that will remain in forestland and it does not apply to land-use changes such as development.

The decline of loblolly pine acreage is due, to a large extent, to trends in growth and removals (see Criterion 6, page 54). From 1959 to 1999, removals of softwood growing-stock consistently exceeded growth. During that same time period (and continuing today) hardwood growth far-exceeded removal of hardwood growing-stock. In many cases, natural regeneration by hardwoods (particularly oaks and hickories) after a loblolly pine clearcut harvest results in a hardwood stand replacing a former pine stand.

Figure 8. Stocking classes in Delaware forests, 1986–2018.



Source: U.S. Forest Service Forest Inventory and Analysis



Nearly 80% of Delaware's forests are currently either medium- or fully-stocked, indicating near optimum growth based on scientific growth curves.

Table 2. Growing-stock wood volume by tree species groups, 2009–2018.

	Wood Volume (1,000 cubic feet)		
Species Group	**2009**	**2016**	**2018**
Loblolly and shortleaf pine	98,294	117,253	146,359
Other yellow pines	24,841	15,772	16,577
Other eastern softwoods	1,592	582	3,626
All softwoods	***124,727***	***133,607***	***166,562***
Select white oaks	70,760	83,248	98,490
Other white oaks	1,246	1,944	2,876
Select red oaks	10,435	3,895	2,990
Other red oaks	114,656	141,089	142,730
Hickory	6,010	6,934	7,452
Soft maple	189,720	197,964	231,836
Beech	12,266	12,786	16,034
Sweetgum	114,517	113,236	123,207
Tupelo and blackgum	33,821	37,959	43,147
Ash	18,923	20,711	24,966
Cottonwood and Aspen	1,436	1,019	2,540
Yellow-poplar	94,652	137,733	161,811
Black walnut	5,355	6,188	9,838
Other eastern soft hardwoods	38,763	30,435	36,262
Other eastern hard hardwoods	23,321	19,815	23,397
Eastern non-commercial hardwoods	1,945	886	1,010
All hardwoods	***737,826***	***815,842***	***928,587***
Total	***862,553***	***949,449***	***1,095,149***

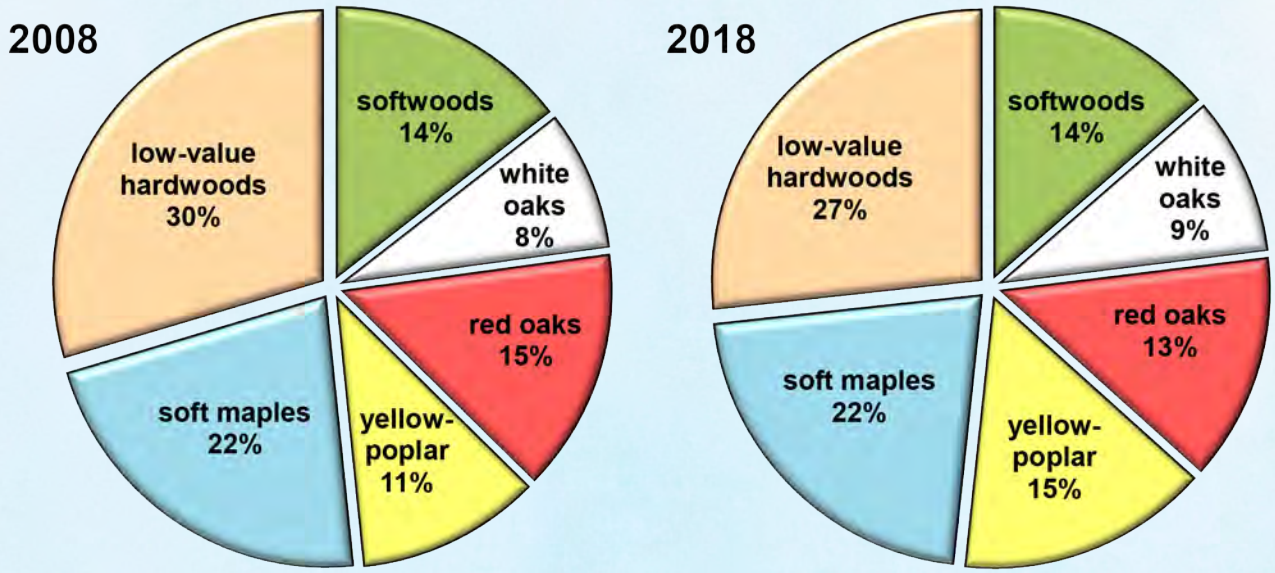
Source: U.S. Forest Service Forest Inventory and Analysis

Between 1959 and 1999, the oak-hickory forest type nearly tripled from 82,000 to 241,000 acres. In the last 20 years loblolly pine has reclaimed significant acreage at the expense of the oak-hickory forest type that is currently at 184,000 acres.

There were more than 240 million trees (≥1 inch in diameter) in 2018, an 8% drop since 1999, which reflects the corresponding loss of forest acreage. Tree stocking is a measure of the number and size of trees on an acre of forest. Since 1986 the percentage of forested acres fully-stocked decreased by 13% but the medium-stocked acreage increased by 7% (Figure 8). There was also a 7% increase in poorly-stocked acres. Nearly 80% of Delaware's forests are currently either medium- or fully-stocked, indicating near optimum growth based on scientific growth curves.

Total growing-stock volume of all species was 862 million cubic feet in 2009 (Table 2). But in the last ten years, there has been a significant increase (27%) in volume to the current level of 1,095 million cubic feet. Growing-stock, by definition, does not include non-merchantable species or trees that are unmarketable due to defects. Approximately 95% of total volume is marketable and considered growing-stock volume. Note the large volume increases for loblolly pine (+49%), white oak (*Quercus alba*) (+39%), and yellow-poplar (+71%), the most valuable commercial tree species growing in Delaware. Also note the rapid decline in northern red oak (*Quercus rubra*) (-71%), the most commercially valuable of all species in the red oak group.

Figure 9. Total volume by species in 2008 and 2018.



Source: U.S. Forest Service Forest Inventory and Analysis

The breakdown of growing-stock volume by major species group over the last ten years is shown in Figure 9. Hardwoods still account for 86% of the total volume. Low-value hardwoods and red oaks (primarily northern red oak) decreased slightly whereas the more valuable white oaks and yellow-poplar increased. Softwoods, primarily loblolly pine, stayed constant over this time period.

Nearly one-half of all growing-stock volume consists of red maple (*Acer rubrum*) and other low-value hardwoods. This abundance is due to a combination of factors including oak decline and mortality from widespread gypsy moth infestations in the 1980s and 1990s, damage from the 1994 ice storm (particularly pine forests), and improper timber harvests. Past poor timber harvests resulted in pine forests regenerating to low quality hardwood forests and the common practice of high-grading (removing only the best species and specimens) that results in an increase of poorly-stocked forests.

A primary reason why poor hardwood management is so common is the lack of markets for small-diameter and low-quality hardwood. Better and sustainable management of such stands and a greatly improved market for low-value hardwood in the future could help shift species composition back to favor oak, yellow-poplar, loblolly pine, and other valuable species. The development of new markets for low-value hardwood products would help improve the health and sustainability of many hardwood forests.

Conifers (softwoods) account for 14% of all live growing-stock tree volume in Delaware. Loblolly pine accounts for about 90% of the entire conifer volume. Virginia pine (*Pinus virginiana*), baldcypress (*Taxodium distichum*), and Atlantic white-cedar (*Chamaecyparis thyoides*) account for most of the remaining conifer volume. The amount of baldcypress and Atlantic white-cedar has declined due to past timber harvesting and the historical practices of draining wetlands and channelizing streams.

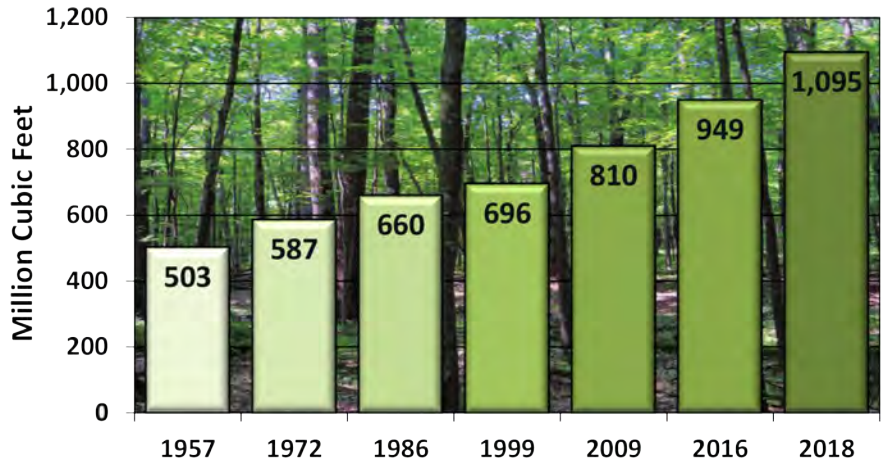
A primary reason why poor hardwood management is so common is the lack of markets for small-diameter and low-quality hardwood.

Without a thriving timber industry in Delaware, the trend toward larger diameter trees will continue and eventually create an imbalance in forest age structure.

Forest age and size classes

Total growing-stock volume has more than doubled since 1957 (Figure 10). However, softwood and hardwood totals have not changed equally over this 60-year period as one might expect. Softwood volume had declined by half in 1999 and hardwood volume more than doubled (Table 3). Over the next two decades, softwood rebounded and regained half of that 50% volume loss since 1957. And hardwoods continued to increase in volume another 60%. These changes over the last 20 years indicate Delaware forests are moving in a positive direction in terms of health and viability.

Figure 10. Net volume of trees in Delaware for all diameter classes, 1957–2018.



Source: U.S. Forest Service Forest Inventory and Analysis

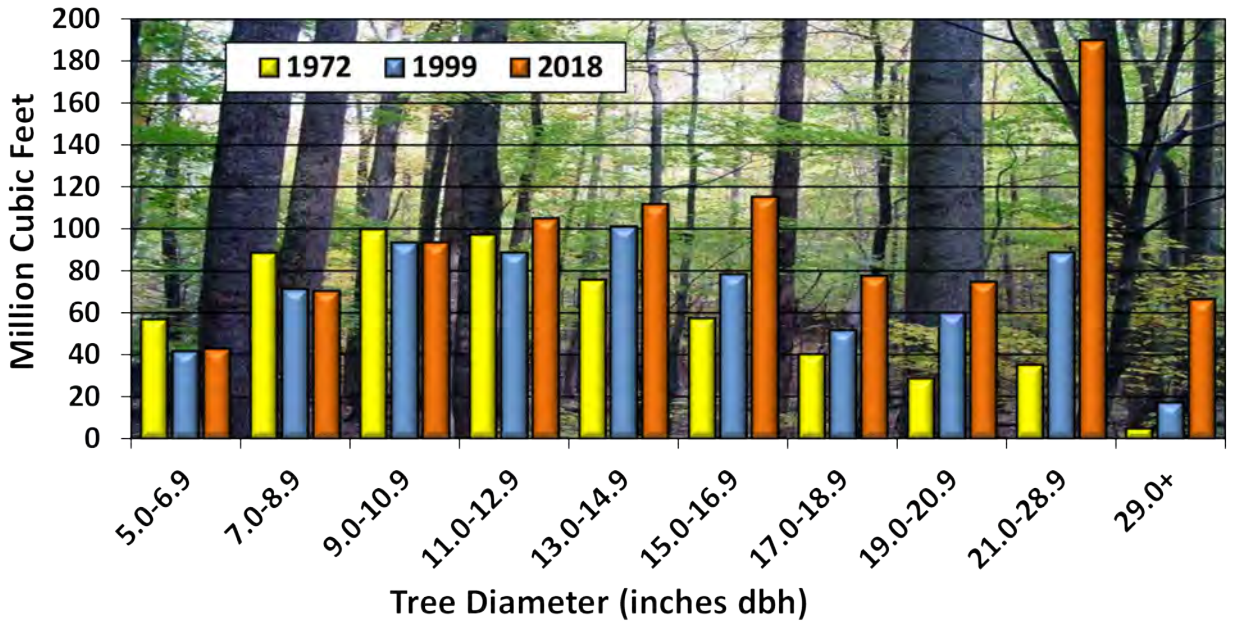
Table 3. Growing-stock volume, 1957–2018.

	Wood Volume (million cubic feet)						
	1957	1972	1986	1999	2009	2016	2018
Softwoods	230	184	164	115	120	134	167
Hardwoods	273	403	496	581	690	816	929
Total	**503**	**587**	**660**	**696**	**810**	**949**	**1,095**

Sources: U.S. Forest Service Forest Inventory and Analysis and USFS Resource Bulletins NE-109 and NE-151

Along with this dramatic increase in growing-stock volume, there has been a corresponding shift in this volume from smaller diameter classes to the more commercially valuable larger diameter classes (≥13 inches in diameter). Figure 11 clearly shows that shift over the last 46 years. Note the dramatic increase in trees ≥21 inches in diameter. Many of these older trees are too large for conventional sawmills and have become unmerchantable. Without a thriving timber industry in Delaware, this trend toward larger diameter trees will continue and eventually create an imbalance in forest age structure.

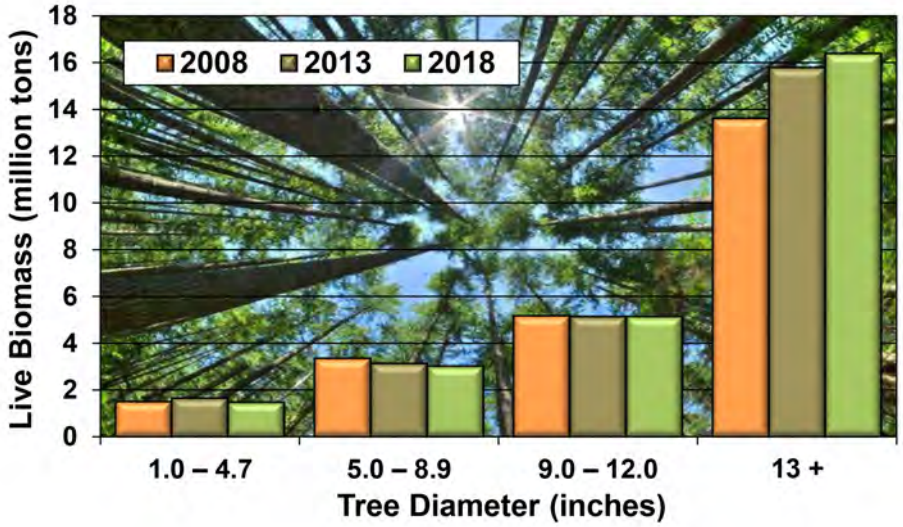
Figure 11. Net volume of trees in Delaware in 1972, 1999, and 2018, grouped by diameter class.



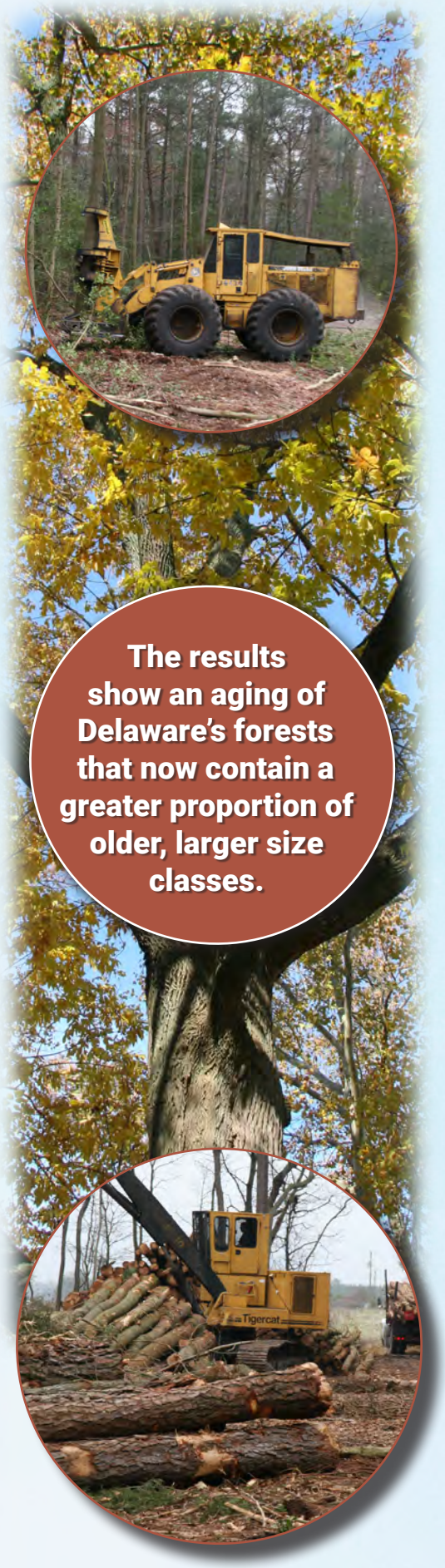
Source: U.S. Forest Service Forest Inventory and Analysis

To further illustrate this shift, FIA measurements of live biomass are heavily skewed toward the 13+ inch diameter classes (Figure 12). Nearly two-thirds of all live-tree biomass is held in these larger diameter classes. Since 2008, 2.77 million tons of biomass have been added to Delaware forests. Biomass is defined as the quantity of wood fiber, for trees 1.0-inch dbh and larger, expressed in terms of oven-dry weight. This includes above-ground portions of the tree—bole/stem (trunk), bark, and branches.

Figure 12. Live-tree biomass (trees at least 1 inch dbh) on forestland by diameter class, 2008–2018.

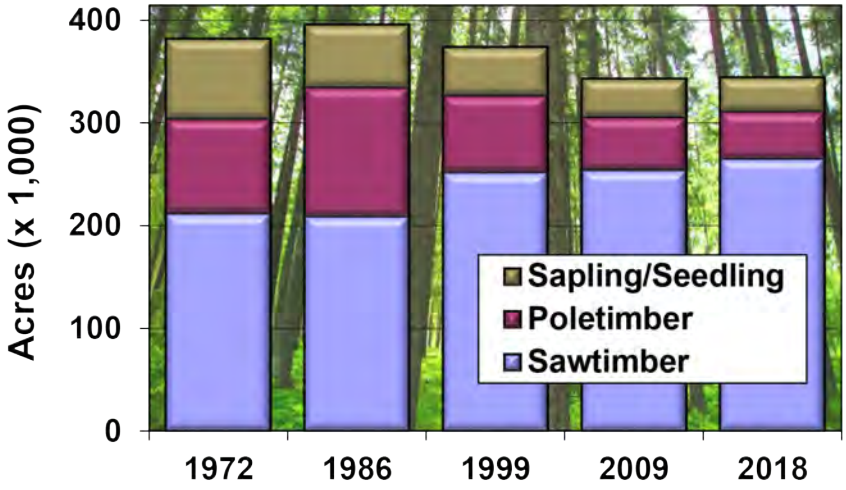


Source: U.S. Forest Service Forest Inventory and Analysis



The results show an aging of Delaware's forests that now contain a greater proportion of older, larger size classes.

Figure 13. Stand size classes, 1972–2018.



Source: U.S. Forest Service Forest Inventory and Analysis

Another way to view trends in tree size is to analyze the inventory data by size classes (Figure 13). Sawtimber accounts for the majority (77%) of the forested acreage in Delaware in 2018. In 1972 sawtimber only accounted for 55% of Delaware's forests. Poletimber and sapling/seedling acreage has decreased significantly, from 45% in 1972 to just 25% in 2018. As average diameter has increased, more stands moved into the sawtimber size class. The results show an aging of Delaware's forests that now contain a greater proportion of older, larger size classes. These changes are likely due to changing dynamics of forestland ownership, a dwindling of forest industry forestland holdings, more owners with smaller tracts of forestland who do not harvest timber, an increased acreage of publicly-owned forests, and a decreased demand from a shrinking forest industry.

U.S. Forest Service FIA Tree-Size Classes

A classification of trees based on diameter measurement.

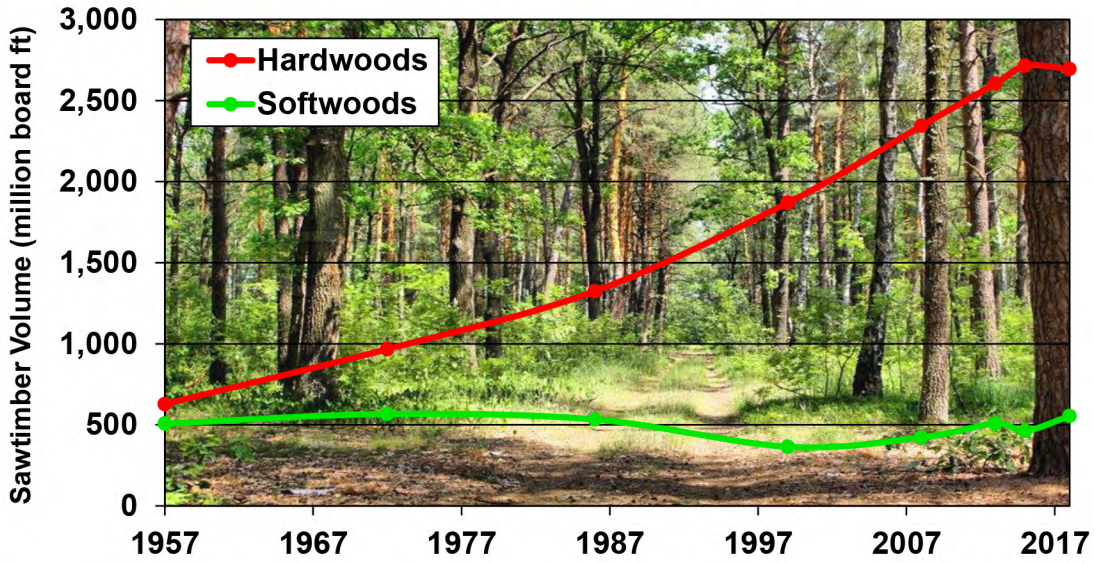
Seedling – An established tree smaller than 1.0-inch dbh (diameter at breast height [4.5 ft above the ground]) for timber species or 1.0-inch drc (diameter at root collar) for woodland trees.

Sapling – A timber species 1.0- to 4.9-inches dbh; also, a single-stemmed woodland tree 1.0- to 4.9-inches drc, or a multistemmed woodland tree with a cumulative drc of 1.0- to 4.9-inches.

Poletimber-size tree or medium tree – A timber species at least 5.0-inches dbh, but smaller than 9.0-inches dbh for a softwood, and smaller than 11.0-inches dbh for a hardwood. A woodland tree 5.0- to 8.9-inches drc (single stem measurement or computed multistem measurement) is also included in this category.

Sawtimber-size tree or large tree – A timber species that is at least 9.0-inches dbh for a softwood, and at least 11.0-inches dbh for a hardwood. A woodland tree 9.0-inches drc and larger (single stem measurement or computed multistem measurement) is also included in this category.

Figure 14. Sawtimber volume in board feet (1/4-inch rule), 1957–2018.



Source: U.S. Forest Service Forest Inventory and Analysis

Figure 14 shows the trends in sawtimber volume over the last six decades for both hardwoods and softwoods (mostly loblolly pine). Although overall pine volume has declined by nearly 30% since 1957, the amount of sawtimber volume has actually increased slightly after a dip in the 1990s and early 2000s. Conversely, hardwood sawtimber has seen a steady and dramatic increase in that same time period but appears to be leveling. The increases in sawtimber acreage can be directly attributed to increases in hardwood volume.

Ideally, Delaware forests should contain a balanced mixture of species and ages. Older timber may be appealing to those who envision this age class as a typical healthy forest, but having an imbalance of age classes, especially tipping toward older growth, is of great concern to a forest manager. Younger forests are needed to replace older forests that are lost to harvesting, natural mortality, or catastrophic events (hurricanes, ice storms, etc.). These forests are also filled with seedlings and saplings providing vital habitat to a variety of wildlife species. A mosaic of stand sizes, ages (including older-growth), and species composition will ensure future sustainability of the many natural benefits that come from forests.

In 1957, loblolly pine forests dominated with just over 50% of the total forest acreage. Now, loblolly pine accounts for less than 20% of that acreage.

Conclusions

Delaware's forestland base has remained relatively constant over the past century, but significant changes have occurred in forest composition. The oak-hickory forest type now covers more acreage than all the other types combined. In 1957, loblolly pine forests dominated with just over 50% of the total forest acreage—now loblolly pine accounts for less than 20% of that acreage. And today, half of all growing-stock volume consists of red maple and other low-value hardwood timber species, which are minor components of all forest types. This is a dramatic change since 1957 when half of all growing-stock was loblolly pine and other softwoods. Additionally, Delaware forests are aging and increasing in size to a significant degree. Three-quarters of Delaware's forests are now classified as sawtimber and less than 10% are seedlings and saplings. These trends are a great concern. It is imperative to maintain a balance of forest types and tree sizes and ages within each forest type, otherwise there will be a corresponding imbalance in other critical ecosystem functions forests perform, particularly wildlife habitat.