USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Northern Research Station | Resource Bulletin NRS-138 | January 2026

New Jersey Forests 2018: Summary Report

Citation

Crocker, Susan J.; Schanning, Sjana L.; Woodall, Christopher W.; Butler, Brett J.; Caputo, Jesse; Goff, Thomas C.; Kurtz, Cassandra M.; Lister, Tonya W.; Morin, Randall S.; Nelson, Mark D.; Riemann, Rachel I.; Piva, Ronald J.; Walters, Brian F.; Zipse, William. 2026. **New Jersey forests 2018: summary report.** Resour. Bull. NRS-138. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 24 p. [plus interactive report]. https://doi.org/10.2737/NRS-RB-138.

Abstract

This summary report provides an overview of the current conditions, changing trends, issues, and threats to statewide forest resources based on findings from the 2018 inventory of New Jersey's forests. New Jersey's forests report an estimated 1.9 million acres of forest land and 89 tree species. Forest land is dominated by maples in the north and pitch pine in the south. The volume of growing stock on timberland currently totals 3.3 billion cubic feet. Average annual mortality of sound volume of live trees on forest land has remained relatively stable since 2013 and currently totals 54.7 million cubic feet per year. This report includes additional information on forest attributes, land-use change, carbon, timber products, and forest health. A detailed interactive report and supplemental information, including (1) tables summarizing quality assurance, (2) a core set of tabular estimates for a variety of forest resources, and (3) user and database guides for P2 and P2+ protocols can be accessed at https://doi.org/10.2737/NRS-RB-138.

Acknowledgments

The authors would like to thank the many individuals who contributed to both the inventory and analysis of New Jersey's forest resources. Primary field staff included Thomas Albright, Joseph Kernan, William Moir, Stephen Potter, Richard Starr, Jr., Michael Whitehill, and Thomas Willard. Data management personnel included Charles Barnett, Brian Gaspar, Mark Hatfield, Kevin Nimerfro, Todd Roffe, and Paul Sowers. Additional thanks to Charlie Paulson and Bernard Isaacson for reviewing the manuscript and providing insightful, constructive comments.

Cover photo: Pequest River Valley from Jenny Jump Mountain, Jenny Jump State Forest, New Jersey. Licensed photo by Nicholas Tonelli/Flickr.

Manuscript received for publication 2 April 2024.

Published by:
USDA Forest Service
One Gifford Pinchot Drive
Madison, WI 53726
January 2026

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Contents

Highlights

On the Plus Side

- Statewide estimates of forest area have remained relatively consistent since 1971 and currently account for 40 percent of total land area.
- At the northern and southern end of many species' ranges, New Jersey's forests are highly diverse and support a wealth of tree species.
- Small gains in forest land were offset by small losses of forest land resulting in no net change in land use.
- Given the connection between residents and urban areas, the establishment of an urban inventory will provide much needed information on the quality and extent of New Jersey's urban forest resources.
- Maturing forests have contributed to a rise in carbon stocks across the State.
- Nearly half of New Jersey's forested resources are held in public ownership, which ensures that the land will remain in forest for years to come.

Issues to Watch

- While statewide mortality is generally stable, there is high mortality among ash species and hemlock, a likely impact of emerald ash borer and hemlock woolly adelgid activity.
- New Jersey's forest land is maturing, thus maintaining a diverse range of size and age classes will be an important part of future forest sustainability.
- Rising housing density within the wildland-urban interface (WUI) and the increasing extent of WUI forest land contribute to forest fragmentation, resulting in loss of wildlife habitat, increased risk of human-mediated wildfire, and subsequently greater risk to human lives and property.
- Highly dense pine stands in southern New Jersey increase the risk of wildfire and tree mortality caused by southern pine beetle.
- Despite an abundance of understory seedlings, there is a lack of younger aged forests, which in combination with a preponderance of maturing stands indicates that there is a higher likelihood of density and age-related issues in the future.
- As nearly half of New Jersey's forest land is privately owned, it is critical to understand the needs of forest owners and the policies and programs that can help them conserve forests for future generations.

An Overview of Forest Inventory

What is FIA?

The U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) program was established by the U.S. Congress to "make and keep current a comprehensive inventory and analysis of the present and prospective conditions of and requirements of the forest and range lands of the United States" (Forest and Rangeland Renewable Resources Planning Act of 1974). The program has collected forest information for over 80 years. A wide breadth of forest metrics are collected and analyzed for use by the general public, resource managers, policy makers, and researchers to better understand forest resources and the demands placed on them to make informed decisions on the fate of the forests of the United States.

What is This Report?

This report summarizes the findings of the 2018 inventory of New Jersey forest resources conducted by FIA. Prior to 1999, inventories were conducted periodically, or approximately once every 10 to 20 years. Previous periodic inventories were completed in 1956 (Webster and Stoltenberg 1958), 1971 (Ferguson and Mayer 1974), and 1987 and 1999 (Griffith and Widmann 2001). In New Jersey, an annual inventory system was implemented in 2004, wherein a percentage of plots are measured each year, and an entire inventory cycle is completed after 5 years and continually using a 5-year moving average. Previous annual inventories were completed in 2008 (Crocker et al. 2011) and 2013 (Crocker et al. 2017). In 2014, New Jersey moved from a 5-year cycle, completing 20 percent of plots annually to a 7-year cycle, completing 14.3 percent of plots annually. Beginning in 2015, the cycle length was accelerated back to 5 years and statewide sampling intensity was doubled. For this report, plots measured from 2013 to 2018 are collectively referred to as the 2018 inventory.

For the 2018 inventory of New Jersey, current estimates of forest area, composition, volume, and other statistics are based on 1,375 plots. Estimates of change (e.g., forest area change, growth, mortality, and removals) are based on 725 plots that were measured between 2008 and 2013. For detailed information on forest inventory methods, data, and quality control estimates, see "Statistics and Quality Assurance for the Northern Research Station Forest Inventory and Analysis Program" (Gormanson et al. 2018).

Additional analyses are provided in the New Jersey Forests, 2018: Interactive Report StoryMap collection. Supplemental information, including (1) tables summarizing quality assurance, (2) a core set of tabular estimates for a variety of forest resources, and (3) user and database guides for P2 and P2+ protocols can be accessed at https://doi.org/10.2737/NRS-RB-138.

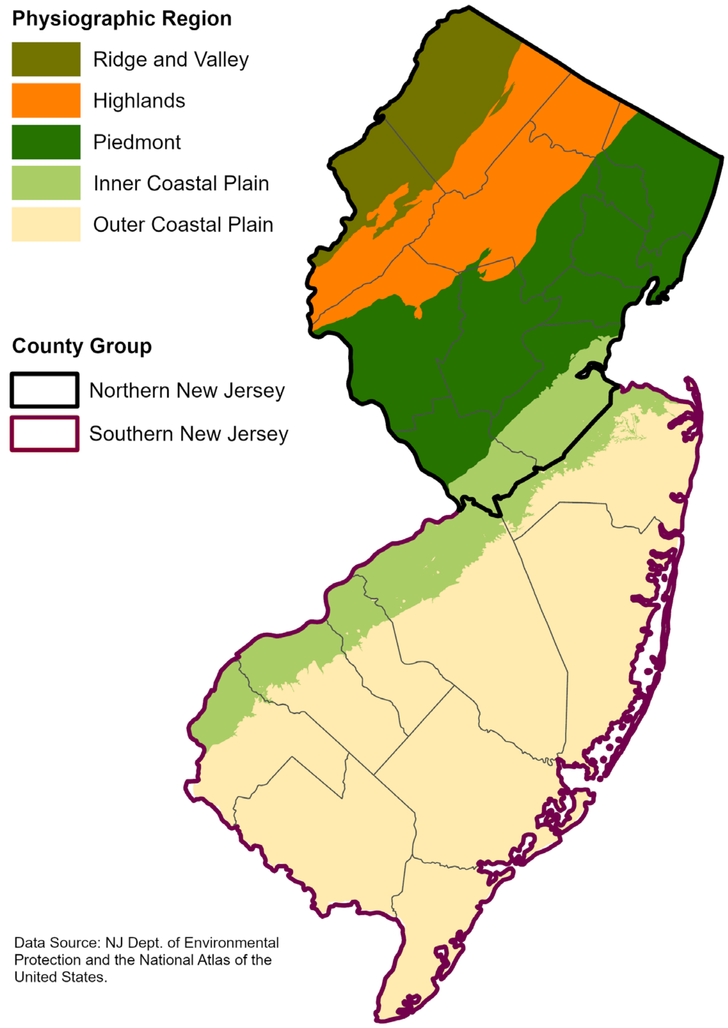

Figure 1.—Physiographic regions and county groups, New Jersey.

Regional Analysis

The distribution, composition, and structure of New Jersey's forests are influenced by a variety of ecological characteristics, such as climate, soil type, geology, and hydrology, which help define the five physiographic regions of New Jersey: Ridge and Valley, Highlands, Piedmont, Inner Coastal Plain, and Outer Coastal Plain (Collins and Anderson 1994) (Fig. 1). To help quantify regional trends in forest resources, some analyses in this report were conducted by grouping counties along a physiographic gradient.

Forest Features

Forest Area

New Jersey's forests provide a number of benefits and ecosystem services, which include wildlife habitat, forest products, clean air and water, recreation opportunities, and carbon sequestration. Estimates describing the current status and changing trends in forest area are essential when assessing the quality and quantity of these resources. Changes in land use or forest health conditions may impact the extent of forest land; thus, monitoring these changes provides information necessary for management and decision making.

The area of New Jersey's forest land totals an estimated 1.9 million acres, which equates to 40 percent of the State's land base (Fig. 2). While forest land has remained relatively stable for the past 60 years, it has significantly decreased from the 2.2 million acres (46 percent of total land area) found in 1956. Forest land is distributed across the State. While there have been variations in county-level gains and losses since 1987, forest land is predominantly concentrated in northwestern and southeastern New Jersey.

Although one of the Nation's smallest and most densely populated states, New Jersey has a high concentration of forest land. Reversion of farmland to forest and successful conservation efforts have helped to maintain a consistent forest land base since the 1970s concurrent with human population growth.

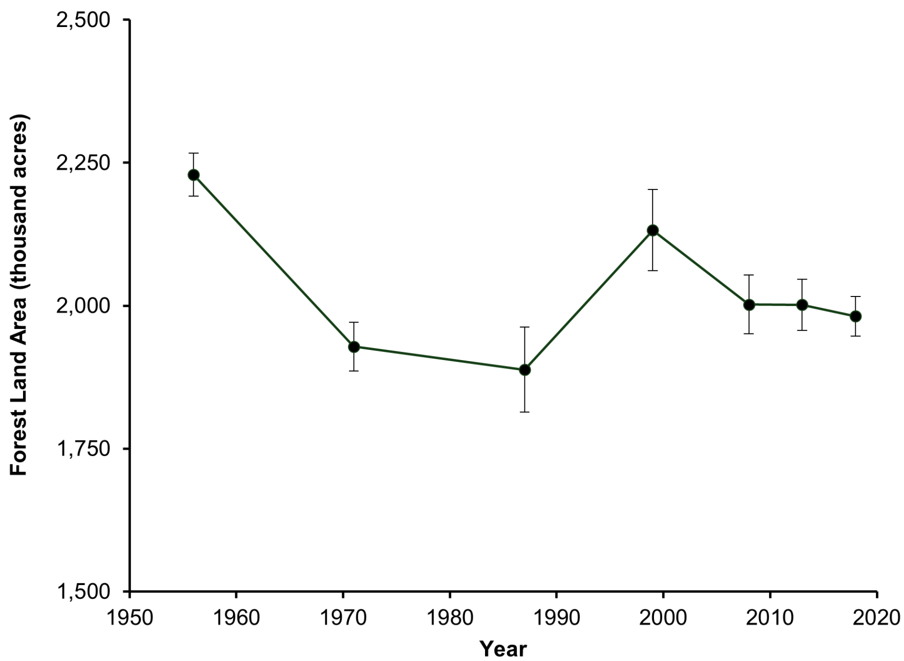

Figure 2.—Area of forest land by inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

Land-use Change

FIA characterizes land into forest and several nonforest land use categories. Tracking change in land use is necessary to understand factors affecting forest loss (diversion) and forest gain (or reversion). To accomplish this, land use is compared on plots measured at two separate occasions; in this report, plots were measured between 2009 and 2013 and remeasured between 2013 and 2018. Understanding land-use change dynamics is essential for monitoring the sustainability of New Jersey's forest resources and helps land managers make informed policy decisions.

In addition to New Jersey's 1.9 million acres of forest land, terrestrial nonforest land uses cover 3.0 million acres. In 2018, 39 percent of New Jersey remained forest, 60 percent remained nonforest, and approximately 1 percent of land area underwent a change in land use, which was nearly balanced between forest diversions (21,000 acres) and reversions (34,000 acres) (Fig. 3). While forest losses were limited to plots in northern New Jersey, forest gains were more distributed across the State. Developed (largely due to cultural land uses, which include business, residential, other intense human activity) and agricultural land uses were the largest drivers of gains and losses in forest land.

Gross gains and gross losses were largely offset, resulting in no substantial net change in forest land. Even without substantial net change, many factors are driving gross changes that affect forest land-use dynamics in New Jersey.

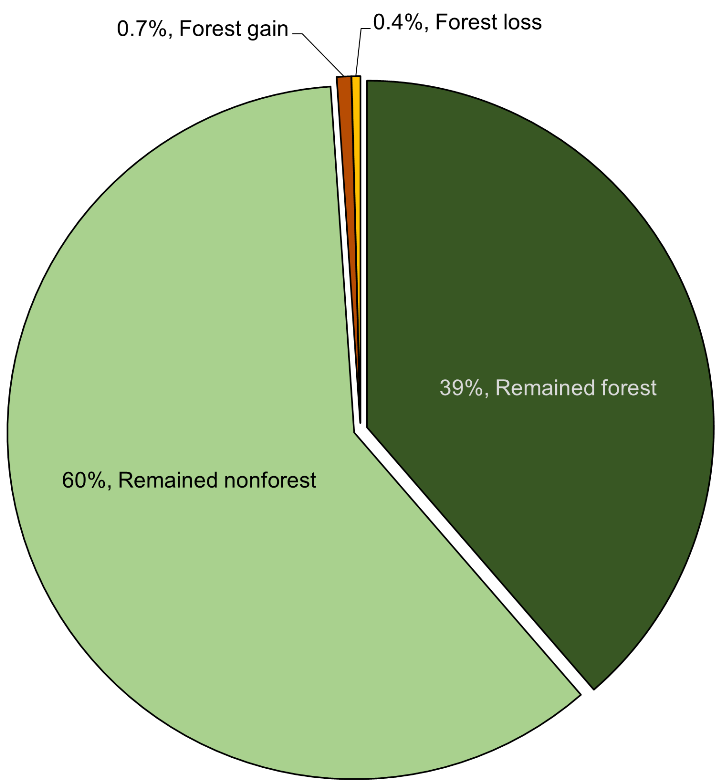

Figure 3.—Proportion of plots that remained unchanged or showed a loss or gain in forest land, New Jersey, 2013 to 2018.

Forest Structure

Stand size and stand age are indicators of forest structural and successional stage. FIA classifies forest land into three stand-size classes. Stands where at least 50 percent of total stocking in seedlings and saplings (trees less than 5.0 inches diameter at breast height [d.b.h.]) are in the small diameter class. The medium diameter stand-size class is assigned to stands where at least half of total stocking is comprised of trees at least 5.0 inches d.b.h. but less than the diameter standards for a softwood or hardwood sawtimber tree. Stands with a majority of stocking in softwoods at least 9.0 inches d.b.h. and hardwood species at least 11.0 inches d.b.h. fall into the large diameter stand-size class. Stand age is estimated based on the average total age of live trees in the predominant stand-size class that are not overtopped.

Since 1972, the proportion of large diameter timberland has increased, while the small diameter stand-size class decreased. Currently, 72 percent of timberland in New Jersey is in the large diameter stand-size class compared to 25 percent during the 1956 and 1972 inventories. Comprising nearly a quarter of timberland area, the pitch pine forest type has been a large driver of the increase in large diameter stands. Since 1987, the area of large diameter pitch pine stands nearly doubled from 148,000 acres to 289,000 acres, as small and medium sized stands matured. In 1987, 32 percent of pitch pine stands were classified as large diameter stands, 41 percent as medium diameter, and 27 percent as small diameter stands. In 2018, large diameter stands make up 69 percent of timberland, followed by 26 percent in medium diameter stands, and 5 percent are small stands.

In northern New Jersey, six of the major forest-type groups have greater than 50 percent of timberland area in the large diameter stand-size class (Fig. 4a). In contrast, small diameter stands make up the bulk (58 percent) of the other eastern softwoods group, where eastern redcedar is predominant. Stands in southern New Jersey are somewhat more evenly distributed by stand size, with a greater percentage of medium and small diameter classes (Fig. 4b). Similar to stand-size class, the average stand age across New Jersey timberland also increased. Since 2008, the area of stands over 60 years old increased by 41 percent, while the area of stands 20 to 60 years old declined and the area of younger stands remained relatively stable.

As the total area of timberland has risen, maturing stands have resulted in a decrease in the area of small and medium diameter stands and an increase in the area of large diameter stands, a trend that is particularly apparent in northern New Jersey. The availability of forest stands containing a mixture of age and size classes helps provide habitat diversity for an array of forest-associated wildlife species with early and late successional habitat requirements, which can vary from the need for canopy gaps to vertical vegetation structure.

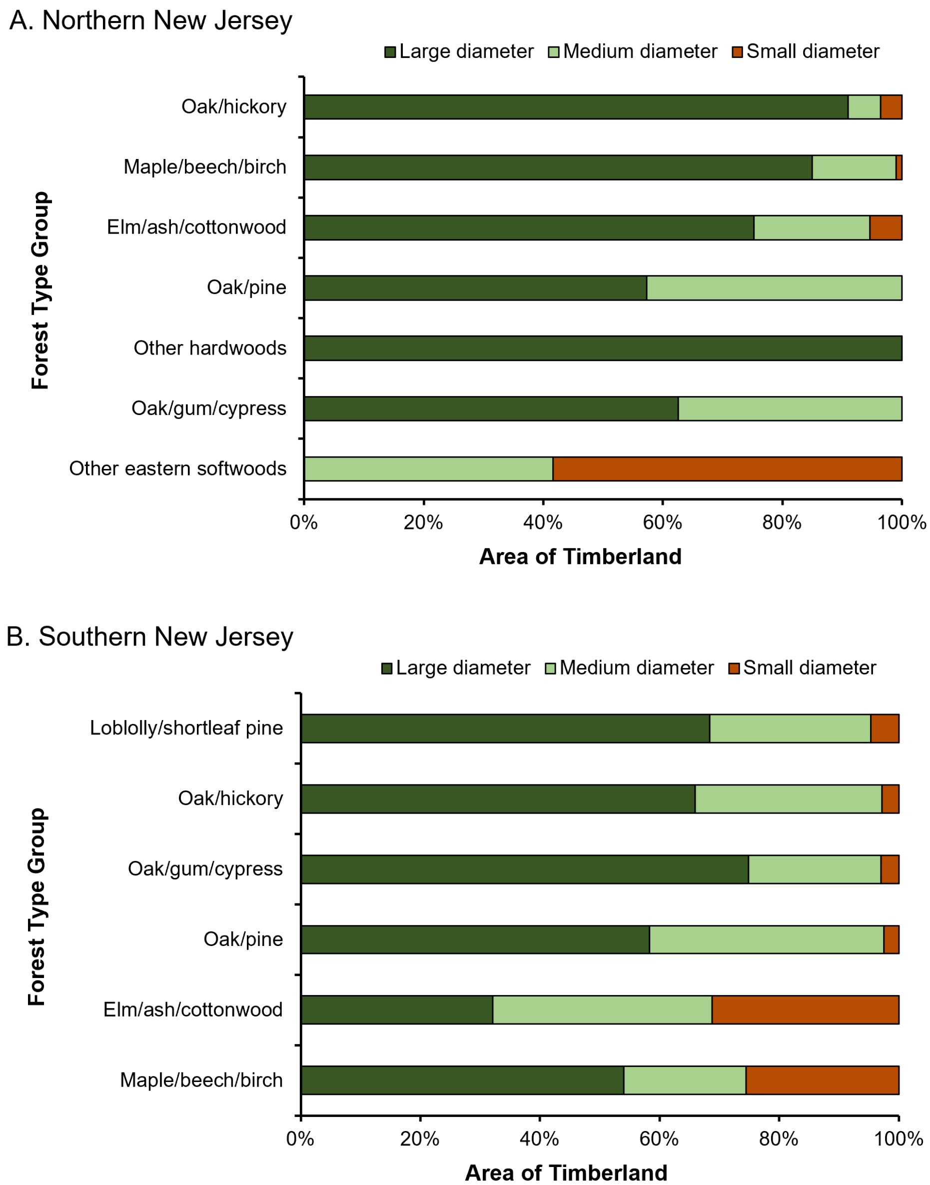

Figure 4.—Area of timberland by stand-size class and major forest type group in 2018, northern New Jersey (A) and southern New Jersey (B).

Forest Resource Attributes

Species Composition

Influenced by the presence or absence of disturbances such as timber management, recreation, wildfire, prescribed burning, extreme weather, and invasive species, the current state of species composition is a reflection of historical and environmental trends within a forest. As a result, the composition of species in a forest is an indicator of forest health, growth, succession, and the need for stand improvement, i.e., management. Knowledge of the distribution of species within a stand allows for the measurement and prediction of change.

Since 2008, the number of trees on New Jersey's forest land has significantly decreased from 989.9 million trees (greater than 1-inch d.b.h.) to 851.6 million trees in 2018 representing 89 different tree species. Pitch pine and red maple remain the most numerous species throughout the State, approximately 19 percent and 14 percent of total trees by number, respectively. Additionally, oak species are predominant throughout New Jersey. Fifteen species of oaks were recorded on forest land; combined, these species account for 17 percent of total trees by number. Species composition is variable in a north-south gradient across the State (Fig. 5). While the number of red maple trees has significantly decreased since 2008, it is still the most numerous species in northern New Jersey, followed by sweet birch, eastern redcedar, and sugar maple (Fig. 5a). In southern New Jersey, pitch pine is the most abundant species, followed by red maple, blackgum, white oak, and Atlantic white-cedar (Fig. 5b).

New Jersey's forests are home to a diverse array of tree species, the composition of which varies over a wide ecological gradient that is reflective of changes in soils conditions that range from mesic soils in the northwest to sandy, acidic soils in the southeast (Collins and Anderson 1994). As a result, hardwoods, including maples, ashes, birches, and beech are predominant in northern New Jersey, while pines, Atlantic white-cedar, and scrub oaks dominate in southern New Jersey. Overall, southern New Jersey has seen little change in species dominance in the past 10 years, which is likely a reflection of harsher growing conditions to which relatively few species are adapted. However, historic loss of Atlantic white-cedar swamps as a result of harvesting have made this species the subject of widespread restoration efforts across southern New Jersey.

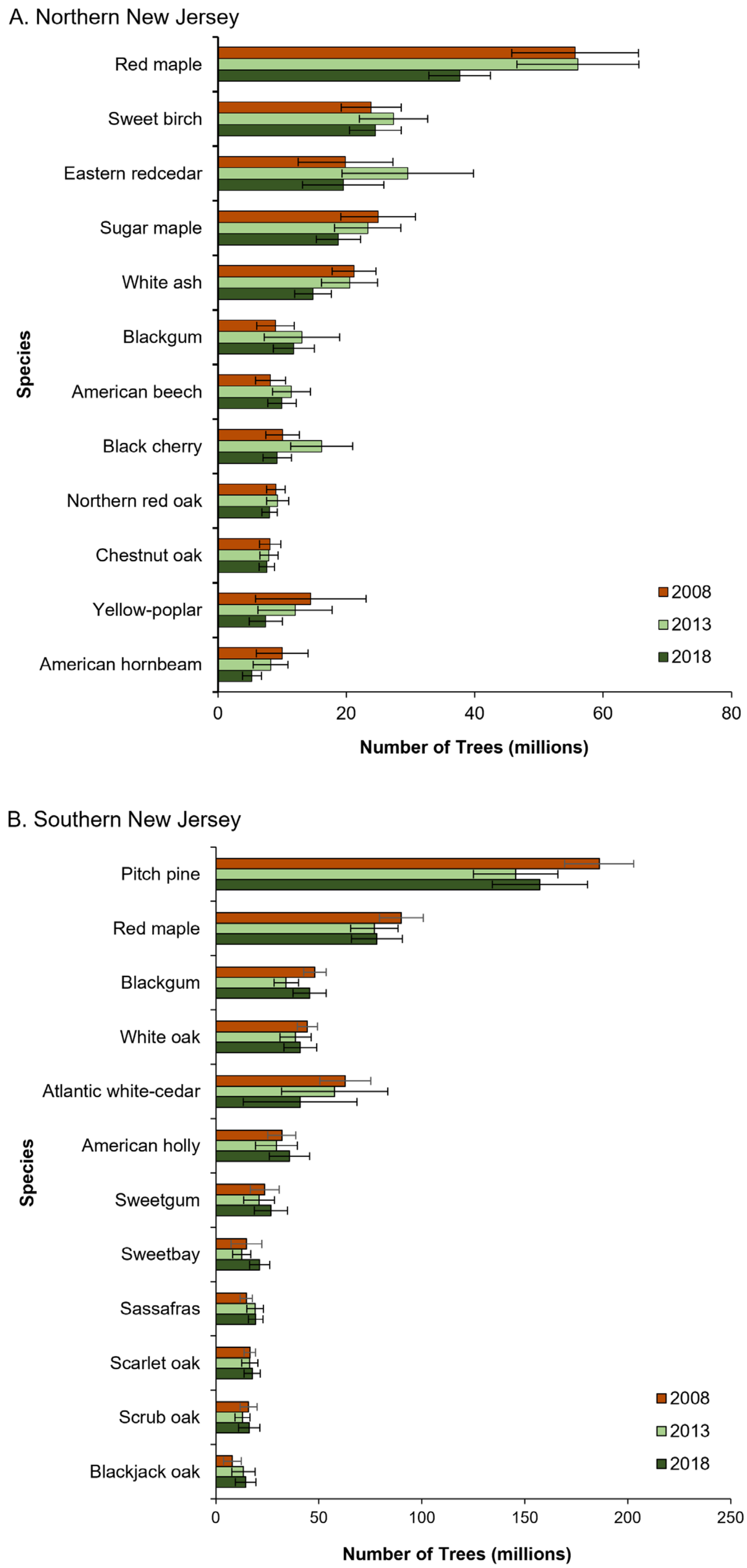

Figure 5.—Number of live trees on forest land for the 12 most numerous species in 2018, northern New Jersey (A) and southern New Jersey (B). Error bars represent a 68 percent confidence interval.

Growth, Mortality, and Removals

Growth rates are an indicator of the overall condition of a stand as well as forest health, successional stage, and tree vigor. Average annual net growth estimates (gross growth minus mortality) are based on the change in volume of growing stock on timberland between inventories. Negative net growth occurs when mortality exceeds gross growth and is indicative of a serious forest health issue and results in a reduction of total inventory volume.

Tree mortality is a natural part of stand development in healthy forest ecosystems. Many factors contribute to mortality, including competition, succession, insects, disease pathogens, fire, human activity, and severe weather events. Average annual growing-stock mortality estimates represent the average cubic-foot volume of sound wood that dies each year between inventories.

Tree volume lost as a result of changes in land use or harvesting is not included in mortality estimates, but instead represents tree removals. Because removals are usually recorded on a limited number of plots, the estimates for removals show greater variance than those for growth, mortality, or area. Like forest growth, the rate at which trees are removed represents the annual average of removals that occurred between previous and current inventories.

Average annual net growth of sound volume of live trees currently totals 117.6 million cubic feet, or 1.4 percent of total volume (Fig. 6). The bulk of growth occurred in the large diameter stand-size class (74 percent). As a percentage of total volume, the black walnut species groups had the highest net growth-to-volume ratio, followed by cottonwood and aspen, yellow-poplar, other yellow pines, and eastern white and red pines. In contrast, the ash and eastern hemlock species groups had negative net growth-to-volume ratios, -1.2 percent and -2.3 percent, respectively.

Average annual mortality of sound volume of live trees on forest land has remained relatively stable since 2013 and currently totals 54.7 million cubic feet (Fig. 6). Sawtimber-sized trees accounted for 52 percent of mortality. The other red oaks species group, which includes scarlet oak and black oak, had the highest mortality, followed by the other yellow pines, ash (mainly due to white ash), and soft maple (mainly due to red maple). As a percentage of total volume, the statewide mortality rate was 1.3 percent. For the majority of species groups, there was no significant change in mortality-to-volume ratios between 2013 and 2018. However, the mortality-to-volume ratio for ash has doubled since 2013, totaling 3.2 percent.

In contrast to mortality, comparatively little volume is lost due to removals due to harvest or land-use change (Fig. 6). Sound live volume is currently removed from forest land at an average of 9.3 million cubic feet per year; of this, 18 percent of removals occurred as a result of a change in land use. Statewide, the total removals-to-volume rate is 0.2 percent. Though not a significant change, harvest removals have decreased by 47 percent since 2013.

While not statistically significant, minor reductions in gross growth and harvest removals, along with a slight increase in mortality have yielded a decrease in net growth and net change over the past 5 years. The preponderance of growth is occurring within large diameter stands, which is an indication that mature trees are continuing to add volume. For species like ash and eastern hemlock, negative growth relative to volume is likely due to insect activity, i.e. emerald ash borer (*Agrilus planipennis*) and hemlock woolly adelgid (*Adelges tsugae*).

While mortality is a natural process in stand development and contributes to functional ecosystems, dramatic increases in mortality can be indicative of forest health issues. Statewide, mortality rates have been relatively stable. Much of overall mortality is among sawtimber trees and is likely due to natural succession. However, high mortality rates within the ash species group indicate a yearly loss greater than 3 percent of statewide volume. The increasing rate of ash mortality is likely reflective of emerald ash borer activity. As tree mortality is a crucial component of overall forest health, continued monitoring will help to identify future concerns. Statewide, the rate of removals on New Jersey's forest land (0.2 percent) is low and continues to remain far below that of mortality (1.3 percent) and net growth (1.4 percent).

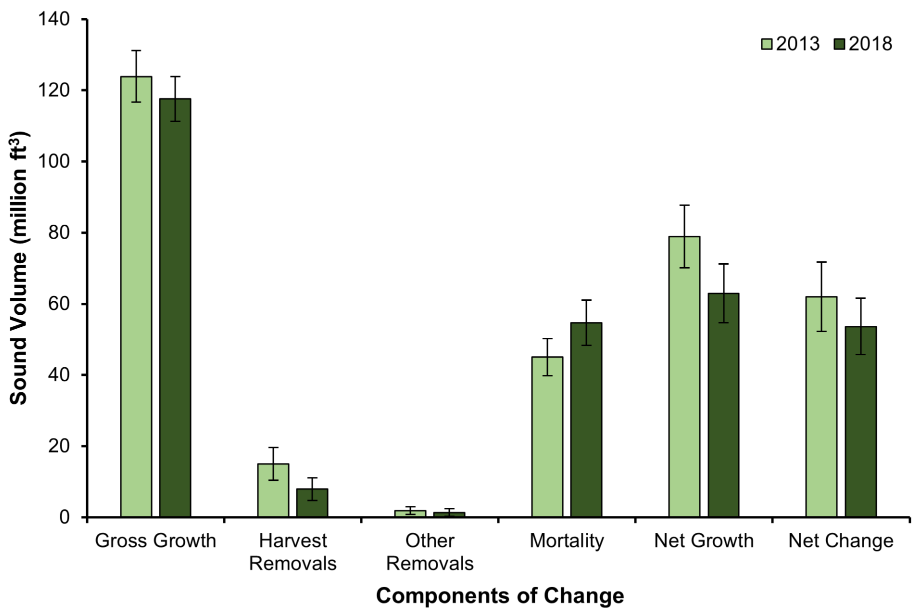

Figure 6.—Components of change for sound bole volume of live trees (at least 5 inches d.b.h.) on forest land by inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

Forests and People

Forest Ownership

To a large extent, the quantity and quality of forest resources are determined by landowners, including recreational opportunities, timber supply, and wildlife habitat. By understanding the priorities of forest landowners, the forest conservation community can better help owners meet their needs, and in so doing, help conserve the State's forests for future generations. The U.S. Forest Service, National Woodland Owner Survey studies private forest owners' attitudes, management objectives, and concerns with a focus on the families, individuals, and other unincorporated groups collectively referred to as "family forest ownerships." Results reported here are from studies completed in 2006 (Butler 2008), 2013 (Butler et al. 2016), and 2018 (Butler et al. 2020).

Forty-eight percent of New Jersey's forest land is privately owned (Fig. 7). A majority of these private acres, an estimated 531,000 acres, are family forests. Corporate ownerships total an estimated 275,000 acres, while other private owners, including conservation organizations and unincorporated clubs and partnerships, own an additional 137,000 acres. Federal, State, and local governments are responsible for the other 52 percent of the forest land. State agencies, in particular forestry, parks, and wildlife agencies, are responsible for most (617,000) of these acres. Some of the largest changes in area of forest land by ownership group have been a decrease in the area of family forest land and an increase in the area of forest land managed by local governments.

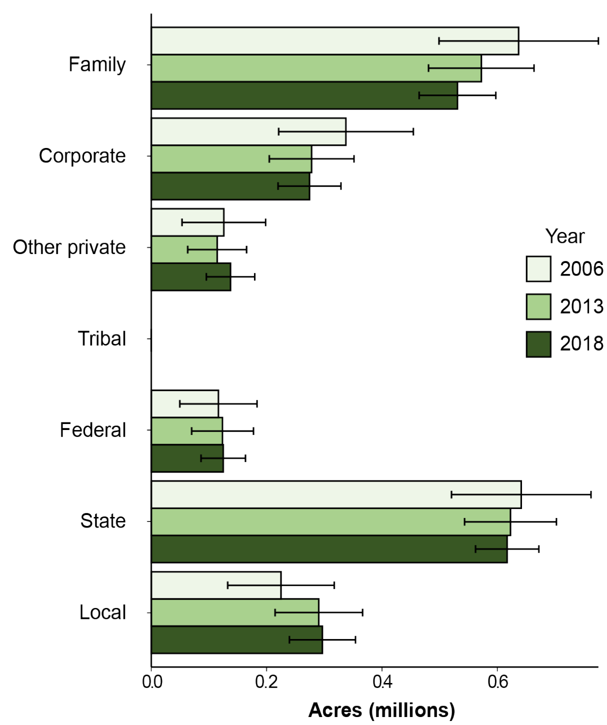

Figure 7.—Area of forest land by ownership group, New Jersey. Error bars are 95 percent confidence intervals.

One out of every four acres of forest land in New Jersey is owned by family forest owners. As of 2018, there are an estimated 11,000 family forest ownerships with 10 or more acres of forest land in the State. An estimated 88 percent of these family forest ownerships own less than 50 acres of forest land, but 40 percent of the family forest land is in holdings of 50 acres or more. The average size of family forest holdings is 29 acres in 2018, which is not substantially different than the averages in 2013 and 2006. The primary reasons for owning family forests are related to amenity values, such as aesthetics, nature protection, and privacy. The most common activity on family forest land in the previous five years is personal recreation; 58 percent of the family forest ownerships that control 66 percent of the family forest land participated in activities such as hiking or hunting on their land.

The fate of the forests lies primarily in the hands of those who own and control the land. It is therefore critical to understand forest landowners and what policies and programs can help them conserve the forests for current and future generations. Among ownership groups, family forest owners are the least understood and the fate of their land is arguably the most uncertain. While they own their land primarily for amenity reasons, many family forest owners are actively doing things with their land.

Forest Urbanization and Fragmentation

The wildland-urban interface (WUI), where human development intermingles with undeveloped wildland vegetation, is the fastest-growing land use type in the conterminous United States (Mockrin et al. 2019, Radeloff et al. 2018). This interface is associated with a variety of consequential human-environment conflicts, including increased risk of wildfire; loss and fragmentation of native species; introduction and spread of nonnative species (Gavier-Pizarro et al. 2010); habitat loss or reduced connectivity (Bregman et al. 2014); and increases in non-native insect and disease activity (Guo et al. 2018).

Here, changes in housing density and forest land (2013 data) were analyzed using the following categories: WUI (forest in census blocks with housing densities above WUI thresholds since 1990 or prior), new WUI (forest in census blocks that reached WUI housing density levels in the 1990s, reached WUI housing density levels in the 2000s, or that underwent change in WUI housing density levels in both decades), non-WUI (forest in non-WUI census blocks in 1990 that remained non-WUI through 2010), and reversion to non-WUI (forest in census blocks with WUI housing densities in 1990 that reverted to non-WUI in 2010) (Fig. 8).

The amount of non-WUI forest continued to shrink, decreasing from 1.2 million acres in 1990 (58 percent of forest land) to 1.1 million acres in 2010 (54 percent). Between 1990 and 2010, forest urbanization occurred in all counties except Essex and Union counties. While seven counties experienced increases in WUI greater than 5 percent, Hudson and Gloucester experienced the greatest increases. By 2020, 800 thousand acres of forest land will have been in WUI conditions for at least 30 years, with an additional 83 thousand acres of forest land crossing the WUI threshold between 1990 and 2010. Federal and state ownerships had the greatest proportion of forest land that remained non-WUI forest; 95 percent and 94 percent, respectively. While state ownerships represented 54 percent of the forest land remaining non-WUI, private ownerships had the lowest proportion of forest land that remained non-WUI (24 percent).

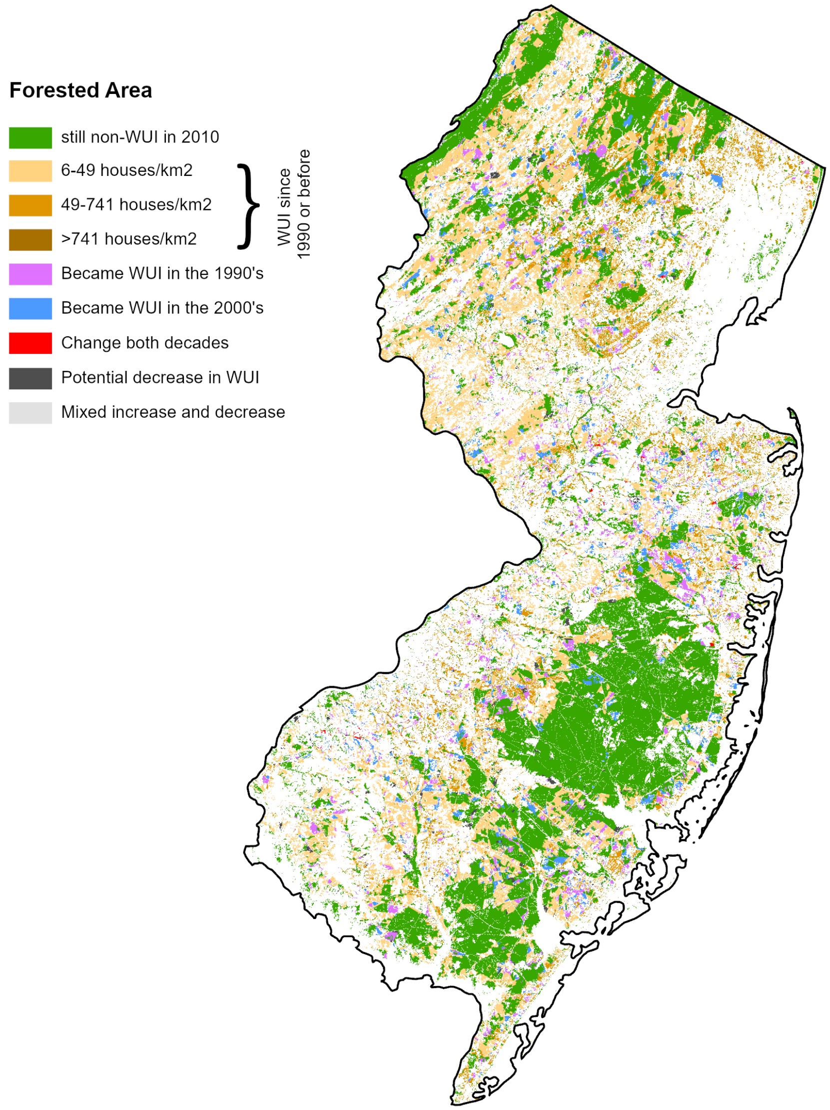

Figure 8.—Map of forest distribution classified by the National Land Cover Database (NLCD) by census block-level change in wildland-urban interface (WUI) status, New Jersey, 1990–2010. Sources: Wildland-Urban Interface 2010 (Radeloff et al. 2017), NLCD 2011 (Homer et al. 2015).

Urbanization is affecting an increasing amount of New Jersey forest land, including unfragmented forest in core or high spatial integrity situations. Increasing urbanization has the potential to change how forests function which affects inherent ecosystem services provided by forests such as clean air and water, flood protection, wildlife habitat, and forest products. Many of the above changes in forest ecosystems become apparent only after longer periods of time. As the area of New Jersey forest land in WUI conditions continues to increase, the risk of human-mediated wildfire intensifies (Radeloff et al. 2018). Given that a large portion of the increases in WUI forest land have occurred in portions of southern New Jersey, specifically within the fire-adapted Pinelands region, the risk of wildfire in these areas represents a growing concern, particularly given the potential risks to human lives and property damage.

Urban FIA

Historically, the focus of the FIA inventory had been to collect information on trees that were part of a forest at least an acre in size with a natural or unmaintained understory. Because many urban trees do not fall into this category, they were not captured in the traditional FIA inventory. To address this data gap and improve urban forest monitoring, FIA established a national urban forest inventory program in 2014 and began monitoring in urban areas, focusing on the most populous cities. The Urban FIA program uses established FIA monitoring methods, database and reporting tools, and statistical techniques, along with the i-Tree suite of tools that quantify ecosystem services.

According to 2010 U.S. Census estimates, New Jersey has 1.9 million acres of urban land, covering 40 percent of the State's land area; this represents the highest state total in the U.S. and is well above the national average of 3 percent (U.S. Census Bureau 2010). Urban area increased by 166,000 acres in New Jersey between 2000 and 2010 and is projected to increase 22.6 percent by the year 2060 (Nowak and Greenfield 2018b). In New Jersey, FIA's annualized urban inventory monitoring began in the summer of 2018. At full implementation, tree and site field data will be monitored on approximately 200 plots within the Trenton city sample and approximately 300 plots within additional urban areas across the State (Fig. 9).

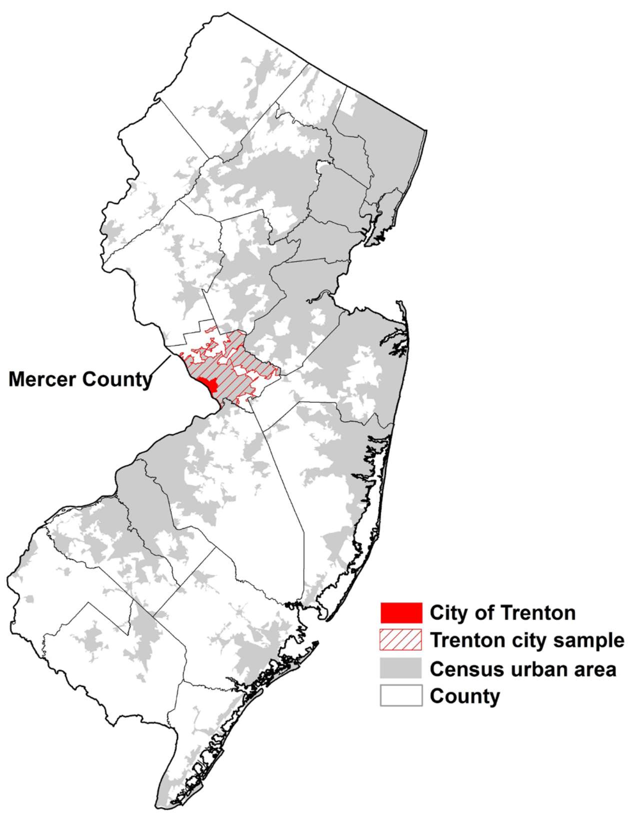

Figure 9.—Urban FIA monitoring is concentrated in the city of Trenton and surrounding U.S. Census urban areas of Mercer County (1 plot per 400 acres), with a lower intensity of sample plots (1 plot per 6,000 acres) distributed throughout the additional urban areas of New Jersey.

The Urban FIA inventory in New Jersey is still being established, so it will be a couple years before a complete cycle of data are published. However, other research has been conducted by Forest Service scientists that uses remote sensing data to derive estimates of urban forest attributes. Nowak and Greenfield (2018a) conducted a study to quantify urban tree cover and cover change in the United States using aerial photo-interpretation methods. According to their data, tree cover in New Jersey's urban areas was 46.1 percent in 2013, which dropped slightly from 46.7 percent in 2008. This average annual decrease in urban tree cover of 0.11 percent per year is below the national estimate.

Trees cover 46 percent of the urban land in New Jersey and represent a vital resource. With nearly 95 percent of the State's residents living in urban areas, urban forests are important to the health and well-being of the people of New Jersey, and the ecosystem services these forests provide have both ecological and economic value. For these reasons, along with constant forest changes due to such forces as development, storms, aging and mortality, insects and diseases, tree planting and natural regeneration, it is especially important to monitor the urban forest resource and quantify changes in its structure, composition, and health. With implementation of the Urban FIA program in New Jersey, data will soon be available to provide sample-based estimates of urban forest structure and associated ecosystem services, as well as provide a means to monitor resource changes through time.

Forest Health Indicators

Forest Insect and Disease Activity

Insects and disease pathogens help shape the structure and composition of forest ecosystems. Monitoring their status provides a measure of forest health and is crucial in assessing the current state and changing trends in New Jersey's forests. Mortality caused by insect and disease activity can be hard to differentiate from other causes and natural senescence. The ratio of mortality-to-gross growth has been used as a national indicator of mortality; ratios above 0.6 are considered high and may be indicative of an acute forest health issue, if forests are not senescing (Ambrose 2019). Further, a high mortality-to-gross growth ratio, in combination with high average annual mortality as a percentage of live volume suggests an increased likelihood of a serious threat to forest health.

Over the 2018 inventory cycle, New Jersey's forests have been impacted by a variety of insects and diseases, including southern pine beetle (*Dendroctonus frontalis*); beech bark disease; bacterial leaf scorch (*Xylella fastidiosa*); spongy moth (*Lymantria dispar*); hemlock woolly adelgid (*Adelges tsugae*); and emerald ash borer (*Agrilus planipennis*). Some of the major species of concern are discussed below.

Emerald Ash Borer

Emerald ash borer (EAB), a wood-boring beetle native to Asia, was first detected in New Jersey in Somerset County in May 2014. As EAB is difficult to detect at low-levels, natural spread was enhanced by human-mediated transportation of infested materials; subsequently, spread of EAB has outpaced detection, with population establishment averaging 4 to 6 years prior to identification (McCullough 2019). All North American species of ash are hosts of EAB; however, host preference appears to vary by species, with consistently high observations of green and black ash mortality and variable white ash mortality (Herms and McCullough 2014, McCullough 2019). Although EAB shows some preference for stressed trees, all trees 1-inch diameter or greater are susceptible regardless of vigor.

Ash trees represent 2 percent of total species abundance on forest land. In 2018, there were an estimated 19.3 million ash trees (greater than or equal to 1-inch diameter), a significant decrease (18 percent) since 2013; this is largely due to a decrease in saplings. White ash is most prevalent (85 percent), followed by green ash (12 percent), and black ash (3 percent). Combined, ash species have a high mortality-to-gross growth ratio, which increased from 0.8 to 1.63 between 2013 and 2018. By species, the mortality-to-gross growth ratio is highest for white ash, increasing from 0.74 in 2013 to 1.53 in 2018. Average annual mortality as a percentage of total volume is 3.8 percent for white ash and 0.9 percent for black ash.

Ash, particularly white ash, represents a major component of New Jersey's forests, especially in the northern half of the State. A mortality-to-gross growth ratio above 1.0 is an indication that white ash volume is decreasing and not being replaced. The increase in mortality-to-gross growth ratio combined with the high mortality rate likely reflect impacts of EAB activity. The loss of ash in forested ecosystems will affect species composition and alter community dynamics. Continued monitoring of ash resources will help to identify the long-term impacts of EAB in forested settings.

Southern Pine Beetle

Southern pine beetle (SPB) is one of the most destructive pests of pine in the southeastern United States (Clarke and Nowak 2009). Pitch, shortleaf, loblolly, pond, and Virginia pines are the preferred hosts; however, during outbreaks, SPB may attack all pine species. Tree death results from girdling due to gallery construction by the beetle and blockage of water-conducting cells by the growth of blue stain fungi, spores of which are carried by SPB (Clarke and Nowak 2009). Periodically, populations of SPB reach outbreak proportions and cause extensive tree mortality. The current SPB outbreak in New Jersey has been ongoing since 2001.

Preferred host species account for 20 percent (171.7 million trees) of total tree abundance throughout the State. Of these species, pitch pine is the most numerous, with an estimated 158.1 million trees, followed by Virginia pine with 10.5 million trees and shortleaf pine with 2.5 million trees; combined, loblolly pine and pond pine total 545 thousand trees. While pitch pine is also found on the ridgetops of northwestern New Jersey, 99 percent of preferred hosts are distributed throughout southern New Jersey, largely within the Pinelands region. Species preferred by SPB occur on 24 percent of forest land, or 467,100 acres (Fig. 10). Since 1987, the area of SPB preferred high density stands, where the basal area of host trees is greater than 80 square feet per acre, has increased; currently, 73 percent of these stands are high density stands. While the mortality-to-gross growth ratio is generally low for the loblolly and shortleaf and other yellow pines species groups, average annual mortality as a percentage of total volume is 1.2 percent for pitch pine and 1.4 percent for Virginia pine.

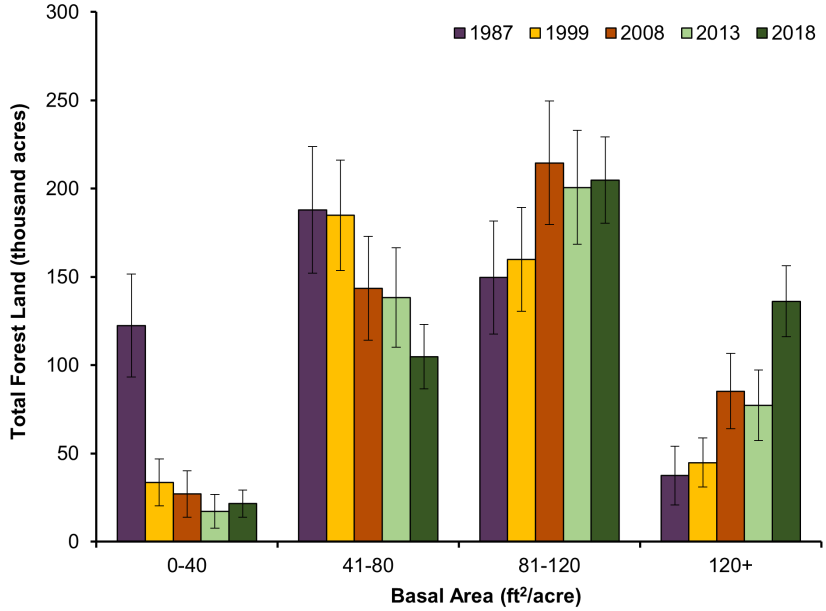

Figure 10.—Area of forest land by basal area for pitch, loblolly, shortleaf, pond, and Virginia pine forest types by inventory year, southern New Jersey. Error bars represent a 68 percent confidence interval.

Stand density is considered to be a critical factor in determining risk and expansion rate of southern pine beetle (Clarke and Nowak 2009). High density pine stands (greater than 80 square feet per acre) increase the risk of SPB outbreak. As susceptible stands cover 24 percent of New Jersey's forest land, SPB has the potential to affect a vast area, largely concentrated in southern New Jersey, and cause extensive pine mortality.

Hemlock Woolly Adelgid

First reported in Virginia in 1951, hemlock woolly adelgid (HWA) was identified in southern New Jersey in 1978 (Smith-Fiola et al. 2004). Subsequent spread has yielded HWA detections throughout the State. Eastern hemlock mortality generally occurs within 4 to 15 years of infestation by HWA (Havill et al. 2014). The rate of tree mortality increases if infested trees also experience drought, attack by secondary insects and diseases, or other stresses.

In 2018, there were 3.8 million hemlock trees (greater than 1-inch in diameter) on New Jersey's forest land. Saplings make up 42 percent of total hemlock abundance. Statewide, the rate of hemlock mortality to total volume increased from 2.8 percent in 2013 reaching 4.2 percent in 2018. The mortality-to-gross growth ratio has remained high, increasing from 1.35 to 2.29 between 2013 and 2018.

Eastern hemlock has played a significant role in the historical development of eastern forests in North America (Ellison et al. 2018). Identified as a foundation species, the widespread distribution and abundance of hemlock underpins the surrounding forest ecosystem, and its associated plants, animals, and processes (Ellison 2014, Ellison et al. 2018). Hemlock represents a small, but unique and important part of New Jersey's forests. Loss of hemlock will have implications for plant diversity; ecosystem dynamics; wildlife habitat; soil stability along streams; invertebrate habitat; water temperature and quality; and timber products availability.

Forest Economics

Tree Volume

Assessments of the volume of live trees provides information on trends, potential uses, and economic value. Volume estimates are reported for trees at least 5 inches in diameter. Sound volume is the total tree volume less deductions for rotten and unsound wood. Growing-stock volume is the amount of sound wood in live commercial tree species that are 5 inches d.b.h. or greater and free of defect. This measure has traditionally been used to ascertain wood volume available for commercial use. Estimates of the of growing stock are important considerations in economic planning and when evaluating forest sustainability. Trees not meeting merchantable requirements are called rough or rotten cull; while unsuitable for timber utilization, they provide critical wildlife habitat and carbon storage.

Sound volume on forest land significantly increased (9 percent) between 2008 and 2018 and currently totals 4.9 billion cubic feet, of which hardwoods make up 77 percent. Sound volume on forest land was evenly distributed between public and private ownership. Timberland accounted for 84 percent (4.1 billion cubic feet) of total sound volume. Growing-stock volume on timberland was 3.3 billion cubic feet in 2018. Pitch pine is the most voluminous species in the State, making up 19 percent of growing-stock volume on timberland, followed by red maple, yellow-poplar, and white oak (Fig. 11). Since 2008, the volume of sawtimber on timberland significantly increased by 16 percent, reaching an estimated 11.8 billion board feet in 2018. Pitch pine totaled 1.9 billion board feet (or 17 percent of total sawtimber volume) in 2018, a 27 percent increase from 2013. Sawtimber volume per acre on timberland was 6,969 board feet per acre in 2018, a 17 percent increase from 2008. Sixty-one percent of sawtimber volume is on private owned timberland, where sawtimber represents 7,698 board feet per acre. Conversely, sawtimber volume is 6,014 board feet per acre on public timberland.

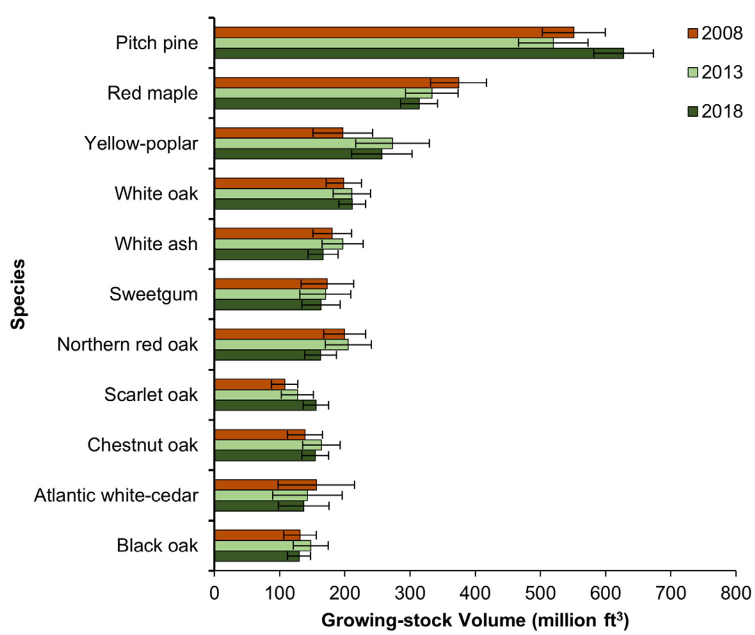

Figure 11.—Growing-stock volume on timberland for the 11 most voluminous species in 2018 by species and inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

Over the past 10 years, the quality of hardwood sawtimber has remained consistent, with a large portion of high grade sawtimber. Currently, 36 percent of hardwood sawtimber are in grade 1. The majority of hardwood sawtimber (69 percent) is on private forest land, which also has a higher proportion of grade 1 volume (38 percent) than public forest land (31 percent). Northern red oak and yellow-poplar had the greatest amount of grade 1 sawtimber, 64 percent and 61 percent, respectively.

The long trend of volume accumulation in New Jersey continues and is reflective of a maturing forest resource. Over the past 10 years, sound volume on forest land increased, while growing-stock volume on timberland remained consistent. Notable increases in softwood volume, specifically pitch pine, drove all volume metrics for the State. When recognizing the influence that softwoods had on changes to overall volume statistics, it is important to consider that much of that volume is located on public-owned lands.

New Jersey ranks second among states in the Northern Research Station FIA region for proportional hardwood sawtimber volume in high-quality tree grades, but that proportion appears to be in decline. While the proportional shifts in volume by tree grade may be minor, these things taken together make hardwood sawtimber volume and quality issues to monitor closely in the future. Since most of the hardwood volume in the State is on private property, continued engagement with landowners regarding responsible forest management is key to the future success of the State's hardwood forests.

Forest Carbon

Among terrestrial ecosystems, forests contain the largest reserves of sequestered carbon. The accumulation of carbon in forests helps to mitigate emissions of carbon dioxide to the atmosphere from sources such as wildfires or the burning of fossil fuels. Carbon accumulates in growing trees as wood; approximately 50 percent of tree biomass is carbon (based on dry weight). Over time, this stored carbon also accumulates in standing dead trees, down woody materials, litter, and forest soils.

Total forest ecosystem carbon stocks in New Jersey are an estimated 191 million tons, which has remained relatively unchanged since 2013. Carbon density is an estimated 96 tons per acre of forest land. Soil organic carbon and live trees are the largest components; combined, these account for 90 percent of forest carbon stocks (Fig. 12). Most of New Jersey's forest carbon stocks are in stands between 61 and 100 years old (56 percent of total forest carbon). Twenty-seven percent of total forest carbon is found in stands younger than 61 years and 17 percent in stands older than 100 years. As stands age, total carbon density generally increases, driven in large part by net carbon accumulation in live biomass. The live biomass pool rises from being only 8 percent of total density in the 0–20 years stand age class to a high of 43 percent of the total density in the over 100 years class.

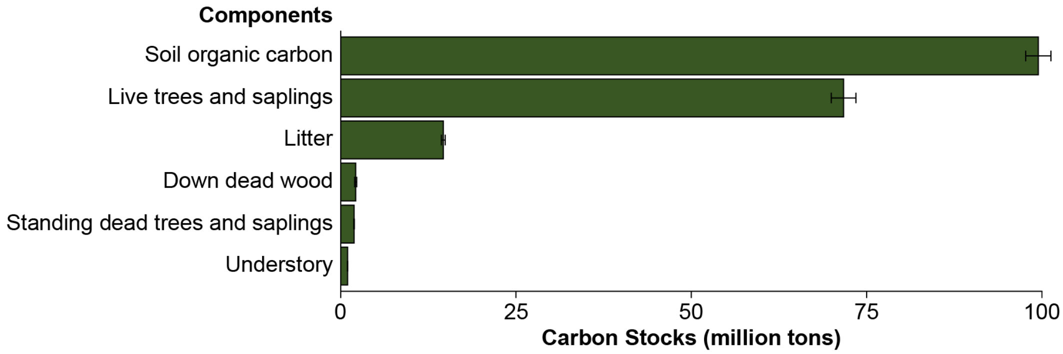

Figure 12.—Carbon stocks on forest land by component, New Jersey, 2018. Error bars represent a 68 percent confidence interval.

While forest ecosystem carbon stocks have remained relatively stable in New Jersey, density has risen slightly as a result of maturing stands accumulating carbon in the live biomass pool coinciding with a loss of forest land area. Soil organic carbon stocks represent the largest pool in New Jersey and are important to long-term carbon storage. The carbon stocks in live biomass also represent a substantial amount of the total carbon and there are opportunities to increase carbon stocks in the near term, as this pool is most affected by forest management. As mitigating U.S. greenhouse gas emissions becomes increasingly important, an understanding of trends in carbon sequestration in the face of land-use change will be an essential tool for forest managers.

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