



United States Department of Agriculture

New Jersey Forests 2013



Forest Service

Northern
Research Station

Resource Bulletin
NRS-109

Publication Date
January 2017

Abstract

The second full annual inventory of New Jersey's forests reports more than 2.0 million acres of forest land and 77 tree species. Forest land is dominated by oak/hickory forest types in the north and pitch pine forest types in the south. The volume of growing stock on timberland has been rising since 1956 and currently totals 3.3 billion cubic feet. Average annual net growth of growing stock from 2008 to 2013 was about 65.7 million cubic feet per year. This report includes additional information on forest attributes, land-use change, carbon, timber products, and forest health. The following information is available online at <https://doi.org/10.2737/NRS-RB-109>: 1) detailed information on forest inventory statistics, methods, and quality assurance of data collection, 2) a glossary of terms, 3) tables that summarize quality assurance, 4) a core set of tabular estimates for a variety of forest resources, and 5) a Microsoft® Access database that represents an archive of data used in this report, with tools that allow users to produce customized estimates.

Acknowledgments

The authors would like to thank the many individuals who contributed to both the inventory and the analysis of New Jersey's forest resources. Primary field crew and quality assurance staff over the 2009-2013 inventory cycle were Thomas Albright, Joseph Kernan, William Moir, Stephen Potter, Richard Starr, Jr., Michael Whitehill, and Thomas Willard. Data management personnel were Charles Barnett, James Blehm, Mark Hatfield, Bob Ilgenfritz, Dan Kaisershot, Richard McCullough, Kevin Nimerfro, Barbara O'Connell, Jay Solomakos, and Paul Sowers. Thanks also to Courtney Compton, Bernard Isaacson, Richard Widmann, and Michael Zsoldos for reviewing the manuscript and providing insightful, constructive comments.

Cover: Fall color in southern New Jersey. Photo by New Jersey State Forestry Services, used with permission.

Manuscript received for publication February 2016.

Published by:
U.S. FOREST SERVICE
11 CAMPUS BLVD SUITE 200
NEWTOWN SQUARE PA 19073-3294

For additional copies:
U.S. Forest Service
Publications Distribution
359 Main Road
Delaware, OH 43015-8640

January 2017

Visit our homepage at: <http://www.nrs.fs.fed.us>



Printed on recycled paper

New Jersey Forests 2013

Susan J. Crocker, Charles J. Barnett, Brett J. Butler, Mark A. Hatfield, Cassandra M. Kurtz, Tonya W. Lister, Dacia M. Meneguzzo, Patrick D. Miles, Randall S. Morin, Mark D. Nelson, Ronald J. Piva, Rachel Riemann, James E. Smith, Christopher W. Woodall, William Zipse

Contact Author:

Susan J. Crocker

scrocker@fs.fed.us

651-649-5136

About the Authors

Susan J. Crocker, Dacia M. Meneguzzo, Patrick D. Miles, Mark D. Nelson, and Christopher W. Woodall are research foresters with the Forest Inventory and Analysis (FIA) program, Northern Research Station, St. Paul, MN.

Charles J. Barnett is a biological scientist with the FIA program, Northern Research Station, Newtown Square, PA.

Brett J. Butler is a research forester with the FIA program, Northern Research Station, Amherst, MA.

Mark A. Hatfield is a forester with the FIA program, Northern Research Station, Durham, NH.

Cassandra M. Kurtz is a natural resources specialist with the FIA program, Northern Research Station, St. Paul, MN.

Tonya W. Lister and Randall S. Morin are research foresters with the FIA program, Northern Research Station, Newtown Square, PA.

Ronald J. Piva is a forester with the FIA program, Northern Research Station, St. Paul, MN.

Rachel Riemann is a research forester/geographer with the FIA program, Northern Research Station, Troy, NY.

James E. Smith is a research plant physiologist with the FIA program, Northern Research Station, Durham, NH.

William Zipse is a regional forester with the New Jersey State Forestry Services, New Jersey Department of Environmental Protection, Trenton, NJ.

Foreword

It is with great satisfaction that we present to you New Jersey's statewide forest inventory report. This report is a cooperative effort led by the Forest Inventory and Analysis program of the Forest Service, U.S. Department of Agriculture, and the New Jersey State Forestry Services, New Jersey Department of Environmental Protection summarizing conditions and trends in New Jersey's forest resources.

Maintaining open space is a value supported by the majority of New Jersey residents. Despite New Jersey's dense population and small size, the State is 40 percent forested. As New Jersey's population has risen, the amount of forest land in the State has remained fairly constant since the 1970s. The reversion of farmland to forest plays a role in maintaining forest land. In addition, the State's dedication to conservation efforts has expanded public land holdings and promoted the stewardship of private lands.

The continued conservation of forested land in our State is not without its challenges, however. New Jersey's forests are aging and increasing in volume, and regeneration of younger trees has been in decline, leaving our forests vulnerable to rapid, widespread changes due to succession. These changes could have impacts on water quality, wildlife habitat, recreation opportunities, and overall quality of life in the State. Threats from insects and diseases, parcelization, invasive species, wildfire, urban sprawl, and associated land conversion present additional challenges.

Moving forward, New Jersey land managers must be flexible and adapt to changing land use and conditions. With nearly half of our State's forested lands in private ownership, government and private entities will have to meet these challenges together. It is our hope that New Jersey Forests, 2013 will provide valuable information to land managers. We invite the readers of this report to reach out to other interested stakeholders in order to engage in thought-provoking discussion about our forest resources.

A handwritten signature in black ink, appearing to read "John Sacco", with a stylized flourish at the end.

John Sacco
State Forester
New Jersey State Forestry Services
Department of Environmental Protection

Contents

Highlights 1

Background 3

Forest Features 11

Forest Health Indicators 35

Forest Economics 67

Future Forests 75

Data Sources and Techniques 80

Literature Cited 81

Appendix 1 87

Appendix 2 89

Statistics, Methods, and Quality Assurance
Online at <https://doi.org/10.2737/NRS-RB-109>

Summary Tables for Statistics, Methods, and Quality Assurance
Online at <https://doi.org/10.2737/NRS-RB-109>

Additional Resources
Online at <https://doi.org/10.2737/NRS-RB-109>



Highlights

On the Plus Side

- Despite a growing population, statewide estimates of forest area have remained relatively consistent since 1971 and currently account for 40 percent of total land area.
- New Jersey forests are highly diverse and support a wealth of tree species.
- Maturing forests have contributed to a rise in carbon stocks across the State.
- More than 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.
- Forest growth continues to increase and exceeds volume losses from harvest, land-use change, and mortality.
- The quality and quantity of sawtimber resources on timberland have been steadily increasing across New Jersey.
- Wildlife habitat provided by standing dead trees (snags) is relatively high; most of these snags are Atlantic white-cedar.
- The small amount of forest loss that occurred over the last 5 years was offset by gains in forest land.

Areas of Concern

- Mortality is on the rise, particularly within large diameter stands and among hemlock, ash, and cottonwood and aspen species groups.
- Rising housing density within the wildland-urban interface contributes to fragmentation of contiguous forest parcels, which is likely to lead to permanent loss of wildlife habitat.
- Largely attributable to hemlock woolly adelgid, mortality of hemlock has reached its highest rate since 1987.
- Invasive plant species, including multiflora rose, Japanese honeysuckle, and Japanese barberry, are widely distributed across New Jersey.

- Emerald ash borer, an exotic tree-killing bark beetle, has been detected in New Jersey and threatens the statewide ash resource. Ash mortality was relatively stable from 1987 to 1999, but has since doubled.
- The abundance of high density pine stands in southern New Jersey increases potential damage from southern pine beetle.

Issues to Watch

- Nearly half of forest land in New Jersey is privately owned; it is important to understand landowner needs and desires in order to help protect forests for future generations.
- Though growing-stock volume continues to rise, most forest stands are maturing and will eventually undergo density- and age-related issues.
- Increasing demands for bioenergy and carbon will make monitoring forest biomass more critical. As the bulk of New Jersey biomass is found in tree boles, forest management is closely tied to carbon storage dynamics and future wood availability.
- Under a variety of potential economic and climate scenarios, New Jersey forest land is projected to decrease in area over the next 50 years. Nevertheless, knowledge of potential future trends will help land managers to manage for desired conditions.

Background



Aerial view of wetlands near Cape May Villas. Photo by Anthony Bley, U.S. Army Corps of Engineers.

An Overview of Forest Inventory

What is a tree?

The U.S. Forest Service's Forest Inventory and Analysis (FIA) program defines a tree as any perennial woody plant species with central stems and distinct crowns that can attain a height of 15 feet at maturity. A complete list of the tree species measured in this inventory can be found in Appendix 1. An electronic record of every tree measured in this inventory, as well as a glossary of additional terms, is available online at <https://doi.org/10.2737/NRS-RB-109>.

What is a forest?

The FIA program defines forest land as land that has at least 10 percent canopy cover of live tree species of any size or has had at least 10 percent canopy cover of live species in the past, based on the presence of stumps, snags, or other evidence, and not currently developed for nonforest use(s) that prevent normal tree regeneration and succession. The area with trees must be at least 1 acre in size; and roadside, streamside, and shelterbelt strips of trees must be at least 120 feet wide to qualify as forest land. Trees in narrow windbreaks, urban boulevards, orchards, and other “nonforest” situations are very valuable too, but they are not described in this report.

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

From an FIA perspective, there are three types of forest land: timberland, reserved forest land, and other forest land. In New Jersey, about 87 percent of forest land is timberland, 13 percent is reserved forest land, and less than 1 percent is other forest land.

- Reserved forest land is land withdrawn from timber utilization through legislation or administrative regulation.
- Timberland is unreserved forest land that meets the minimum productivity requirement of 20 cubic feet per acre per year at its peak.
- Other forest land is commonly found on low-lying sites with poor soils where the forest is incapable of producing 20 cubic feet per acre per year at its peak.

In New Jersey's periodic inventories (1999 and prior), only trees occurring on timberland plots were measured. Therefore, volume of trees on forest land cannot be reported for those inventories. Since the implementation of the annual inventory system, which in New Jersey began with the 2004-2008 inventory, FIA has been able to report volume on all forest land. With the first remeasurement of annual plots completed, comparison

of growth, mortality, and removals on forest land is now possible. Because periodic inventories reported only on timberland, trend reporting in this publication is primarily focused on timberland.

Where are New Jersey’s forests and how many trees are in New Jersey?

Where trees grow, how they grow, and the types of forests they form are influenced by an array of ecological characteristics, such as terrain, soil type, geology, climate, and hydrology, which vary across the landscape. These characteristics 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). The unique features of each region influence where forests are found and their composition and structure. Exposed bedrock and thin, rocky soils characterize the Ridge and Valley section, where oak/hickory and oak/pine forest types are prominent on the landscape (Collins and Anderson 1994). Mesic soils, which characterize the broad ridges of the Highlands and rolling hills of the Piedmont, then give way to white oak/red oak/hickory and maple/beech/birch forests. Soils of the Inner Coastal Plain have higher clay content and are thus more fertile than the dry, sandy, acidic soils of the Outer Coastal Plain. Therefore, white oak, chestnut oak, scarlet oak, and American holly are dominant species within the Inner Coastal Plain; pitch pine, red maple, and scrub oaks thrive in the Outer Coastal Plain (Collins and Anderson 1994).

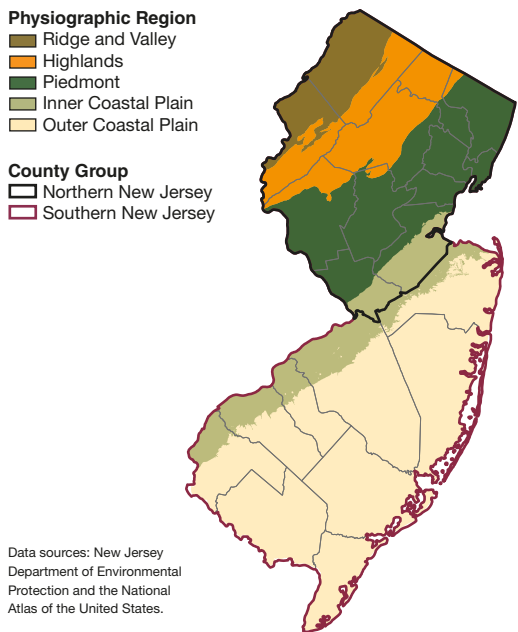


Figure 1.—Physiographic regions and county groups, New Jersey.

Forest land area is concentrated in the southeastern and northwestern portions of the State (Fig. 2). Forest types in these two regions vary greatly. Northern New Jersey is dominated by forest types within the oak/hickory forest-type group and southern New Jersey is largely made up of the pitch pine forest type. New Jersey forest land contains about 917.4 million trees that are at least 1 inch in diameter at breast height (d.b.h., 4.5 feet above the ground). We do not know the exact number of trees because the estimate is based on a sample of the total population. Trees were measured on 364 forested plots. Full details of sample design and estimation procedures are available in Bechtold and Patterson (2005) and a summary explanation is included in the Statistics, Methods, and Quality Assurance section available at <https://doi.org/10.2737/NRS-RB-109>.

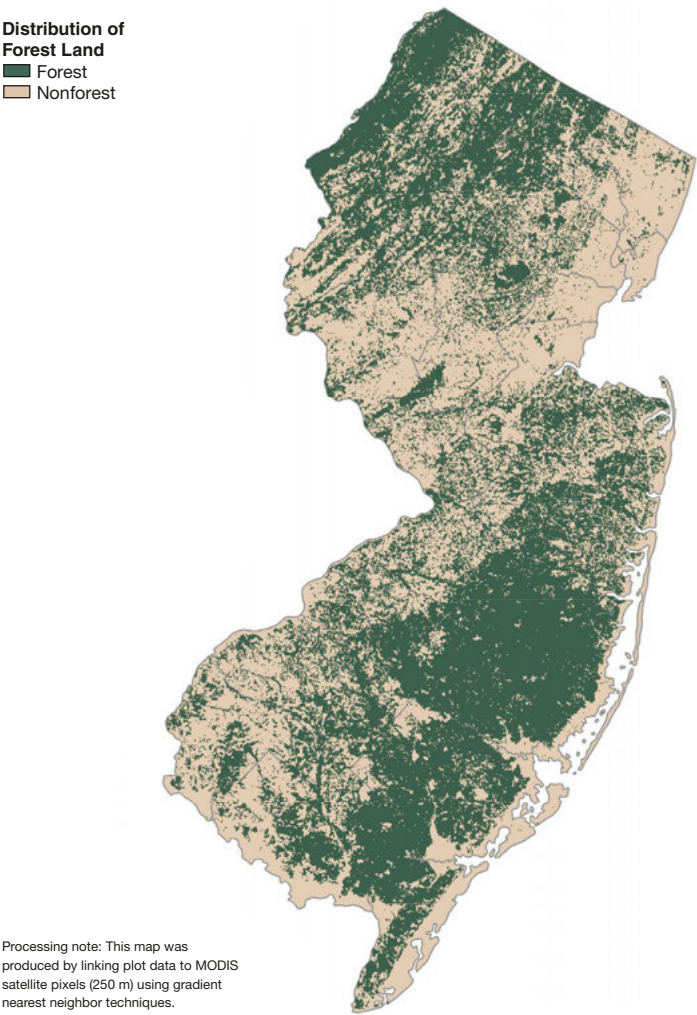


Figure 2.—Distribution of forest land, New Jersey, 2009.

How do we estimate a tree's volume?

Statistical models are used to predict volumes within a species group or for a specific species. Individual tree volumes are based upon species, diameter, and merchantable height from trees within the region. Tree volumes are reported in cubic feet or board feet based on the International ¼-inch log scale rule.

How much does a tree weigh?

Specific gravity values for each tree species or group of species were developed at the U.S. Forest Service's Forest Products Laboratory (Miles and Smith 2009) and were applied to FIA tree volume estimates to determine merchantable tree biomass (weight of tree bole). Total aboveground live-tree biomass is calculated by adding the biomass for stumps, limbs, and tops (Woodall et al. 2011). Live biomass for foliage is currently not reported. FIA inventories report biomass weights as oven-dry short tons. Oven-dry weight of a tree is the green weight minus the moisture content. Generally, 1 ton of oven-dry biomass is equal to 1.9 tons of green biomass.

How do we estimate all the forest carbon pools?

FIA does not directly measure the carbon in standing trees; it estimates forest carbon pools by assuming that half the biomass in standing live/dead trees consists of carbon. Additional carbon pools (e.g., soil, understory vegetation, belowground biomass) are modeled based on stand/site characteristics (e.g., stand age and forest type).

How do we compare data from different inventories?

Data from new inventories are often compared with data from earlier inventories to determine trends in forest resources. A pitfall occurs when the comparison involves data collected under different schemes or processed using different algorithms. Recently, significant changes were made to the methods for estimating tree-level volume and biomass (dry weight) for northeastern states, and the calculation of change components (net growth, removals, and mortality) was modified for national consistency. These changes focus on improving the ability to report consistent estimates across time and space—a primary objective for FIA. Regression models were developed for tree height and percent cull to reduce random variability across datasets.

Volume and biomass were originally estimated using separate sets of equations; recently the component ratio method (CRM) has been implemented (Heath et al. 2009). With the CRM, determining the biomass of individual trees and forests has

become an extension of FIA volume estimates, allowing biomass estimates for tree growth, mortality, and removals to be obtained not only for live trees, but also for belowground coarse roots, standing dead wood, and down woody debris.

Another new method, termed the “midpoint method,” has introduced some differences in methodology for determining growth, removals, and mortality for a specified sample of trees (Westfall et al. 2009). The new approach involves calculating tree size attributes at the midpoint of the inventory cycle (2.5 years for a 5-year cycle) to obtain a better estimate for ingrowth, mortality, and removals. Although the overall net change component is equivalent under the previous and new evaluations, estimates for individual components will be different. For ingrowth, the midpoint method can produce a smaller estimate because the volumes are calculated at the 5.0-inch threshold instead of the actual diameter at the time of measurement. The actual diameter could be larger than the 5.0-inch threshold. The estimate for accretion is higher because growth from ingrowth, mortality, and removal trees is included. As such, the removals and mortality estimates will be higher than before (Bechtold and Patterson 2005).

Reserved status—improved implementation

FIA defines reserved forest land as forest land withdrawn by law(s) prohibiting the management of land for the production of wood products (not merely controlling or prohibiting wood-harvesting methods). All private forest lands, regardless of conservation easements that may restrict harvesting, are considered not reserved. Such lands are declared timberland if they meet minimum productivity requirements and “other forest” if they do not. Timberland does not include reserved forest land.

In an effort to increase consistency among states and across inventory years, a refined set of procedures for determining reserved status have been implemented with version 6.0 of the FIA field manual, which took effect with the 2013 inventory year (which began in October 2012). Furthermore, all previously collected annual inventory data (2004 to present) have been updated using the new standardized interpretation.

Starting with this report, timberland estimates generated for earlier annual inventories will differ from previously published estimates. The 2012 inventory was the last inventory in which all data were available under the previous and improved implementations. Small changes are associated with timberland acreage, number of trees, volume, and biomass. The changes associated with the remaining timberland estimates are minor given the inherent variability in the associated estimates. The improved implementation of the reserved status definition increases the spatial and temporal precision of timberland estimates allowing for higher quality trend analyses and potentially better forest management decisions.

A word of caution on suitability and availability

FIA does not attempt to identify which lands are suitable or available for timber harvesting. Land classified by FIA as “timberland” is not necessarily suitable or available for timber production. Suitability and availability are subject to changing laws, economic and market constraints, physical conditions, adjacency to human populations, and ownership objectives. Forest inventory data alone are inadequate for determining the area of forest land available for timber production. Additional factors, like those provided above, need to be considered when estimating the timber base, and these factors may change with time.

How do we produce maps?

A geographic information system (GIS) and various geospatial datasets were used to produce the maps in this report. Maps were constructed using (1) categorical coloring of New Jersey counties according to forest attributes (such as forest land area), (2) a variation of the k-nearest-neighbor (KNN) technique to apply information from forest inventory plots to remotely sensed MODIS imagery (250-m pixel size) based on the spectral characterization of pixels and additional geospatial information (see Wilson et al. 2012 for more information on this technique), or (3) colored dots to represent plot attributes at approximate plot location.

Unless otherwise indicated, forest resource data are from FIA; base map layers, such as state and county boundaries, were obtained from the National Atlas of the United States™ (U.S. Geological Survey 2011). Depicted FIA plot locations are approximate. Additional FIA data are available at <http://fia.fs.fed.us/tools-data/>. Sources of other geospatial datasets are cited within individual figures. All New Jersey maps are portrayed in the State Plane Coordinate System, North American Datum of 1983.

Forest Features



Hemlock Pond, Delaware Water Gap National Recreation Area. Photo by Noel Schneeberger, U.S. Forest Service.

Forest Area

Background

Forest ecosystems play an important role in providing wildlife habitat, wood products, and clean air and water; therefore, information on the current status and trends is essential for assessing the quality and quantity of these resources. As fluctuations in estimates of forest land area may indicate changing land use or forest health conditions, monitoring these changes provides information necessary for management and decisionmaking.

What we found

Forest land area in New Jersey is an estimated 2.0 million acres, or 40 percent of the State’s land base (Fig. 3). Although forest land area has remained stable over the past 5 years, it has significantly decreased from the 2.2 million acres (46 percent of total land area) estimated in 1956. Forest land is found throughout most of the State, though it is predominantly found in northwestern and southeastern New Jersey (Fig. 4). Since 1987, gains and losses in forest land have varied by county. Sussex, Passaic, Burlington, and Atlantic Counties have remained the most heavily forested counties—each with more than 50 percent forest land—over the past two and a half decades (Fig. 4). Forests continue to grow and age. Sawtimber stands predominate, making up 68 percent of forest area (Fig. 5). Poletimber stands compose nearly 26 percent of forest land. Five percent of forest land contains seedling-sapling stands and 1 percent is nonstocked. Across the State, the age of forest stands continues to increase: 68 percent of forest land is more than 60 years old (Fig. 6).

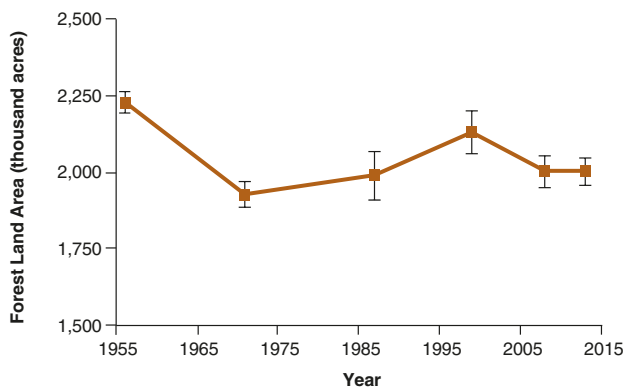
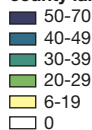


Figure 3.—Area of forest land by inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

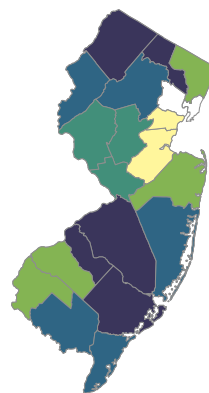
**Area of Forest Land
(percentage of
county land area)**



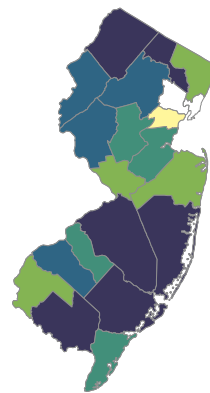
County List

- | | |
|--------------|---------------|
| 1 Sussex | 12 Mercer |
| 2 Passaic | 13 Monmouth |
| 3 Bergen | 14 Burlington |
| 4 Warren | 15 Ocean |
| 5 Morris | 16 Camden |
| 6 Essex | 17 Gloucester |
| 7 Hudson | 18 Salem |
| 8 Union | 19 Atlantic |
| 9 Hunterdon | 20 Cumberland |
| 10 Somerset | 21 Cape May |
| 11 Middlesex | |

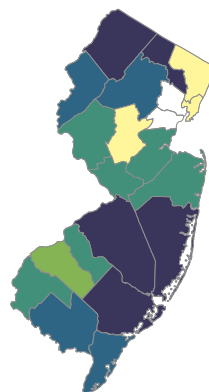
1987



1999



2008



2013

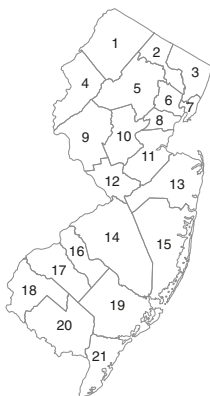
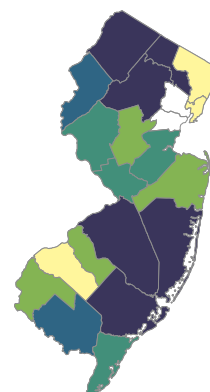


Figure 4.—Area of forest land as a percentage of county land area by inventory year, New Jersey.

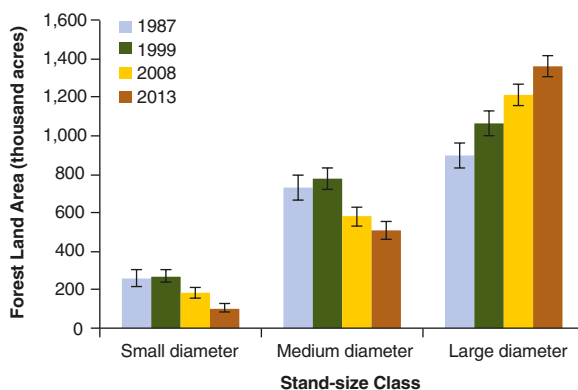


Figure 5.—Area of forest land by stand-size class and inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

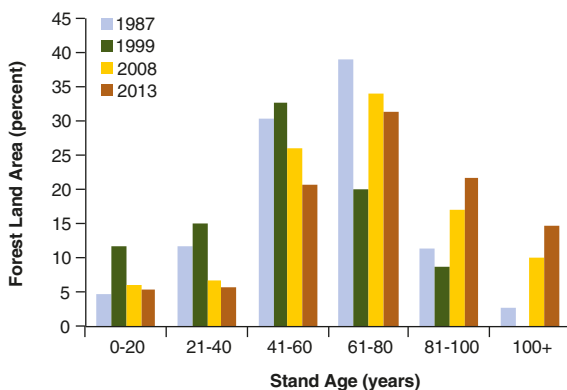


Figure 6.—Proportion of forest land by stand-age class and inventory year, New Jersey.

What this means

Although one of the Nation’s smallest and most densely populated states, New Jersey has a high concentration of forest land that is widely distributed across the State. Reversion of farmland to forest and successful preservation efforts have helped to maintain a consistent forest land base since the 1970s concurrent with human population growth. As these forests continue to mature, maintaining a diverse range of size and age classes will become increasingly important in terms of overall forest health and sustainability.

Forest Biomass

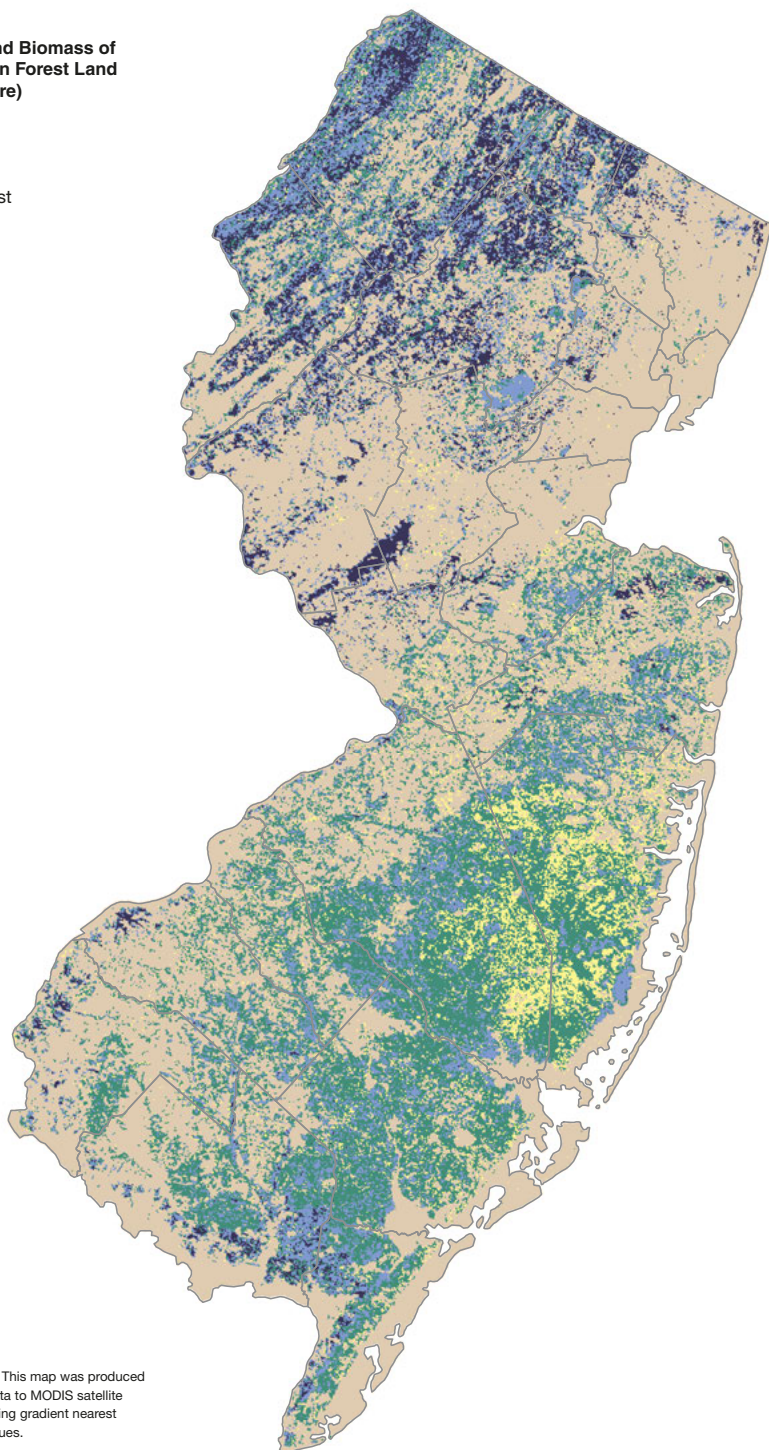
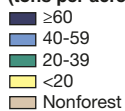
Background

Measurements of total biomass and its allocation among tree components, including saplings, tree boles, and tree limbs, help to further our understanding of the distribution of forest resources and their availability for different uses (e.g., carbon sequestration, wildlife habitat, or biofuels).

What we found

New Jersey forest land supports an estimated 117 million dry tons of aboveground live-tree biomass, held almost equally by public and private owners (49 and 51 percent, respectively). However, the distribution of biomass across the landscape is uneven, with the highest concentrations in the northern half of the State, primarily in the Highlands region (Fig. 7). Two-thirds of statewide biomass is contained in the boles of growing-stock trees; 19 percent is in growing-stock stumps, tops, and limbs; 6 percent is in saplings; and 8 percent is in nongrowing-stock trees (Fig. 8).

**Aboveground Biomass of
Live Trees on Forest Land
(tons per acre)**



Processing note: This map was produced by linking plot data to MODIS satellite pixels (250 m) using gradient nearest neighbor techniques.

Figure 7.—Distribution of aboveground live-tree biomass on forest land, New Jersey, 2009.

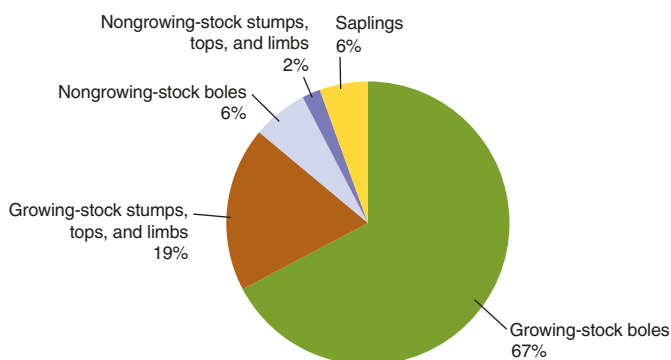


Figure 8.—Forest biomass on forest land by tree component, New Jersey, 2013.

What this means

Public and private forest landowners play an important role in sustaining forest biomass, which is a valuable resource with environmental and economic importance. In light of potential opportunities to expand woody biomass for energy production and carbon sequestration, it is important to continue to monitor the status and trends of this resource. Additionally, because most forest biomass is found in the boles of growing-stock trees, the management of forests is closely tied to the dynamics of carbon storage and future wood availability. Given the increasing demand to manage biomass components for bioenergy and carbon, monitoring forest biomass will become more critical.

Species Composition

Background

Forest composition is constantly evolving. 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.

What we found

New Jersey forest land contains 917.4 million trees (1-inch d.b.h. or greater) representing 77 different tree species (common and scientific names of trees are found in Appendix 1).

Pitch pine and red maple remain the most abundant species by both number and volume; combined, they represent 30 percent of total trees by number and 26 percent of total volume (Figs. 9 and 10). Oaks are also prolific throughout New Jersey. Fifteen species of oaks were recorded on forest land; these species account for 16 percent of all species by number and 28 percent of total live-tree volume. Species composition varies across the State (Fig. 11A, B). Red maple has decreased in number of trees per acre since 2008, but it is still the most numerous species per acre in northern New Jersey (Fig. 11A). Declines in red maple and sugar maple abundance have accompanied an increase in the prevalence of eastern redcedar. In southern New Jersey, pitch pine, red maple, Atlantic white-cedar, and white oak are the most numerous species (Fig. 11B). Pitch pine showed the greatest reduction in trees per acre since 2008. Pines, which make up 29 percent of southern New Jersey’s species composition, decreased from 183 trees per acre in 2008 to 158 trees per acre in 2013.

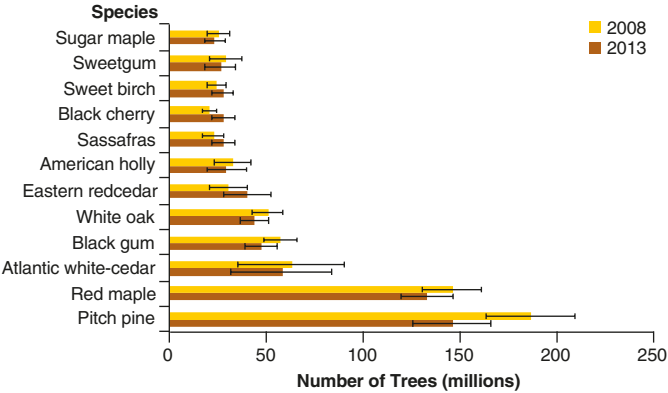


Figure 9.—Number of live trees on forest land for the 12 most numerous species in 2013, New Jersey. Error bars represent a 68 percent confidence interval.

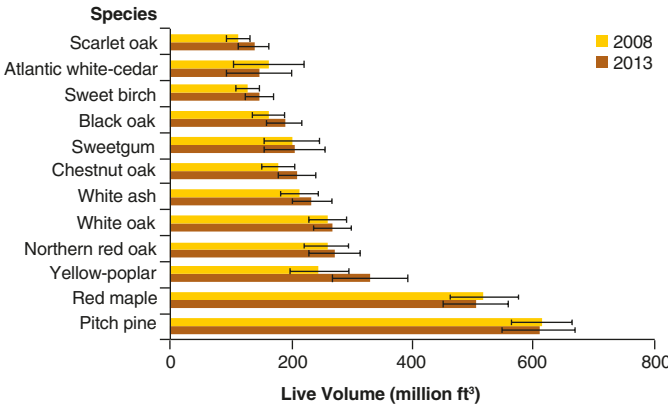


Figure 10.—Volume of live trees on forest land for the 12 most voluminous species in 2013, New Jersey. Error bars represent a 68 percent confidence interval.

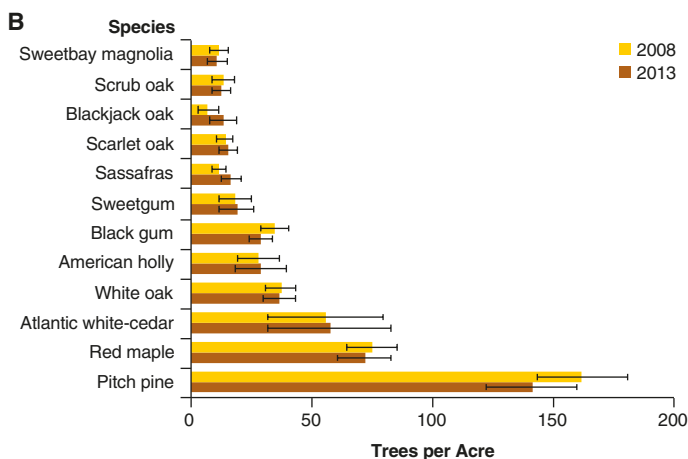
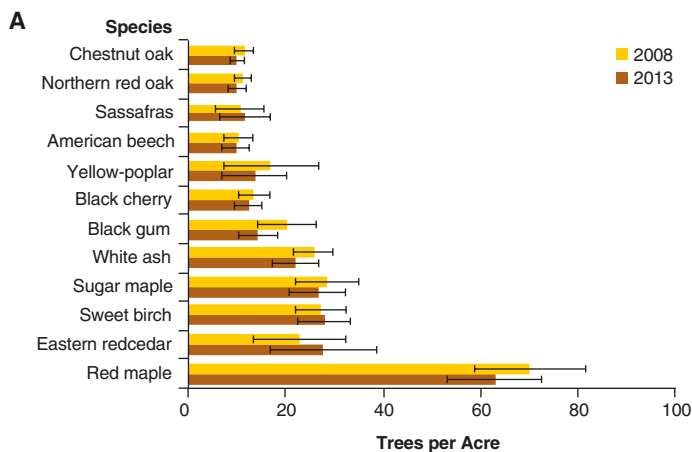


Figure 11. — Trees per acre for the 12 species with the highest densities on forest land in (A) northern New Jersey and (B) southern New Jersey. Error bars represent a 68 percent confidence interval.

What this means

Thanks to a rich geologic past, the landscape of New Jersey varies over a wide ecological gradient that extends from the mesic soils of the northwest to the sandy, acidic soils of the southeast. The range of conditions is reflected in the diverse composition of species across the State. In southern New Jersey, there has been little change in species dominance, which is likely a reflection of harsher growing conditions, to which relatively few species are adapted. The decrease in pine density may be due to increased mortality from southern pine beetle activity.

Forest Density

Background

The density of a forest indicates the current phase of stand development and has implications for diameter growth, tree mortality, and yield. Density is typically measured in terms of number of trees or basal area per unit area. Stocking, a relative measure of density, represents the degree of tree occupancy required to fully utilize the growth potential of the land.

What we found

The density of trees in New Jersey’s forests has gradually decreased since 1987 (Fig. 12). In contrast, the average volume of live trees per acre of timberland continues to increase; currently, total live-tree volume is an estimated 2,088 cubic feet per acre (Fig. 13). The level of stocking has remained fairly constant since 1999. Currently, overstocked stands, which contain too many trees to support adequate tree growth and development, represent only 3 percent of timberland, or 60,000 acres (Fig. 14). Most stands are fully stocked (44 percent or 765,000 acres) or moderately stocked (40 percent or 700,000 acres). Poorly stocked stands, which do not contain enough trees to fully utilize a site, represent 11 percent of timberland, or 181,000 acres (Fig. 14).

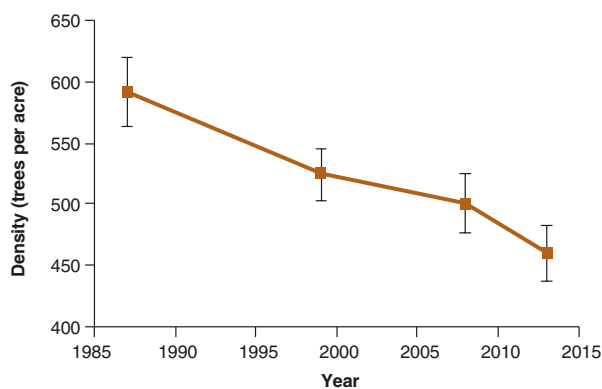


Figure 12.—Density of live trees on timberland by inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

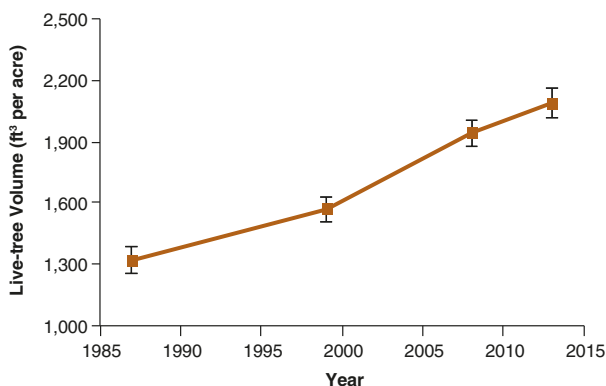


Figure 13.—Live-tree volume per acre on timberland by inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

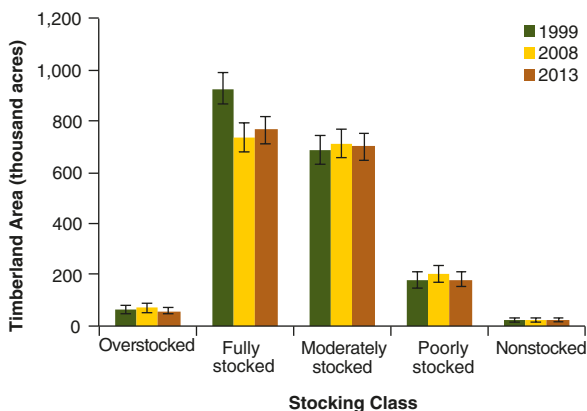


Figure 14.—Area of timberland by stocking class and inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

What this means

Decreasing numbers of trees and increasing volume are indicative of a maturing forest resource. In the absence of natural or human disturbance, this trend can be expected to continue until stands reach a state of senescence. Current stocking levels indicate adequate growing conditions, but also show a preponderance of fully stocked stands. As trees grow and put on additional volume, these stands are expected to face an increased amount of stand stagnation issues, such as density-induced mortality.

Carbon Stocks

Background

Among terrestrial ecosystems, forests contain the largest reserves of sequestered carbon. Forests sequester carbon from the atmosphere and thus help mitigate greenhouse gas emissions. The continuing increase in carbon stocks in New Jersey forests contributes to the offset of total U.S. greenhouse gas emissions that result from forest fires and the burning of fossil fuels. Carbon accumulates in growing trees via the photosynthetically driven production of structural and energy-containing organic (carbon) compounds that primarily accumulate in trees as wood. Over time, this stored carbon also accumulates in dead trees, woody debris, litter, and forest soils. For most forests, the understory grasses, forbs, and nonvascular plants as well as animals represent minor pools of carbon stocks. Procedures for the estimation of carbon are detailed in U.S. Environmental Protection Agency (2015).

What we found

Total forest ecosystem carbon stocks in New Jersey are estimated to be 152 million tons, a 3 percent increase since 2008. Live trees and soil organic carbon are the largest pools and account for 87 percent of forest carbon stocks (Fig. 15). Statewide, 68 percent of total carbon stocks are in two forest-type groups: oak/hickory and loblolly/shortleaf pine. Average aboveground carbon per acre increased with increasing stand age (Fig. 16). Fifty-eight percent of total aboveground carbon stocks are represented by the two age classes spanning stand ages of 61 to 100 years; in contrast, the two youngest age classes together account for 6 percent of forest carbon stocks. The largest single pool is soil organic carbon within the elm/ash/cottonwood forest-type group, which totals 49.8 short tons of carbon per acre (Fig. 17).

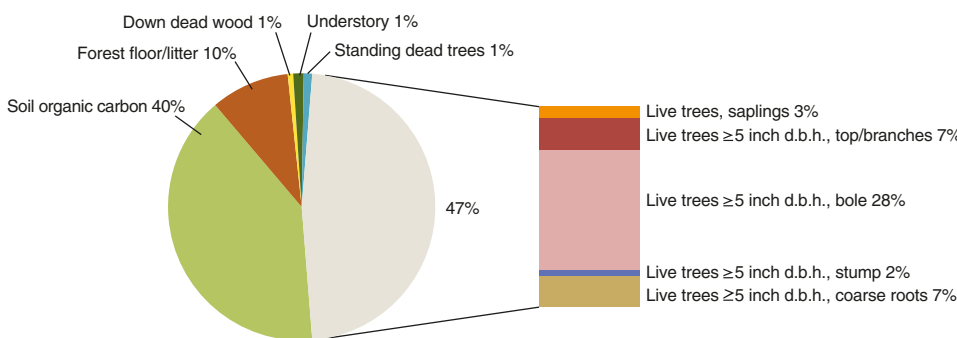


Figure 15. — Estimated carbon stocks on forest land by forest ecosystem component, New Jersey, 2013.

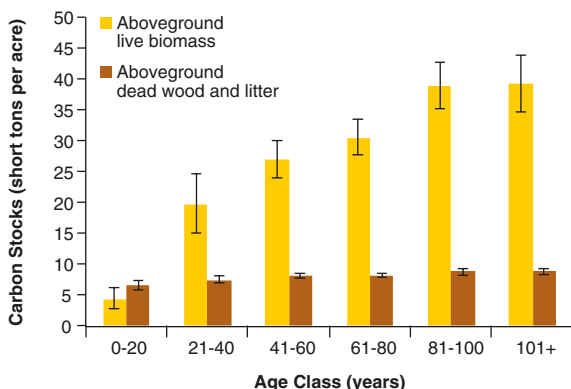


Figure 16.—Average carbon stocks per acre for aboveground live biomass on forest land by stand-age class, New Jersey, 2013. Error bars represent a 68 percent confidence interval.

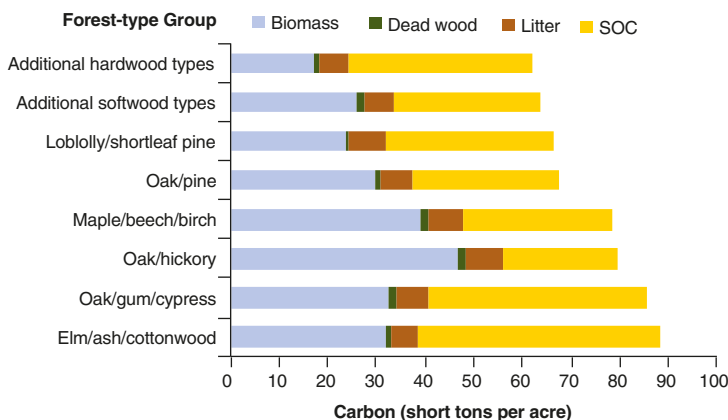


Figure 17.—Average carbon stocks per acre on forest land by forest-type group and carbon pool, New Jersey, 2013. SOC indicates soil organic carbon.

What this means

New Jersey's forest carbon stocks continue to rise, as maturing stands accumulate carbon, particularly in aboveground components. Given the age-class structure and species composition, this trend is likely to persist. Managing forest carbon to help offset U.S. greenhouse gas emissions has become increasingly important. Therefore, an understanding of trends in carbon storage will be an essential tool for forest managers.

Forest Ownership

Background

How land is managed is primarily the owner’s decision. Therefore, landowners largely determine the availability and quality of forest resources, including recreational opportunities, timber, and wildlife habitat. By understanding their priorities, the forest conservation community can better help forest landowners meet their needs, and in so doing, help conserve New Jersey’s forests for future generations. The National Woodland Owner Survey (NWOS; www.fia.fs.fed.us/nwos), conducted by the FIA program, studies private forest landowners’ attitudes, management objectives, and concerns. It focuses on the diverse and dynamic group of owners that is the least understood—families, individuals, and other unincorporated groups, collectively referred to as “family forest owners.” The NWOS data reported here are based on the responses from 115 family forest ownerships from New Jersey that participated between 2011 and 2013 (Butler et al. 2016).

What we found

More than half (52 percent or 1.0 million acres) of New Jersey forest land is publicly owned (Fig. 18). State agencies maintain the greatest percentage (60 percent) of public forest land, followed by local government (28 percent) and Federal agencies (12 percent), such as the U.S. Fish and Wildlife Service. Of the nearly 967,000 privately owned acres, most is held by family forest owners (584,000 acres). Corporations and other private owners, including conservation organizations and unincorporated clubs and partnerships, own an estimated 274,000 acres and 113,000 acres, respectively.

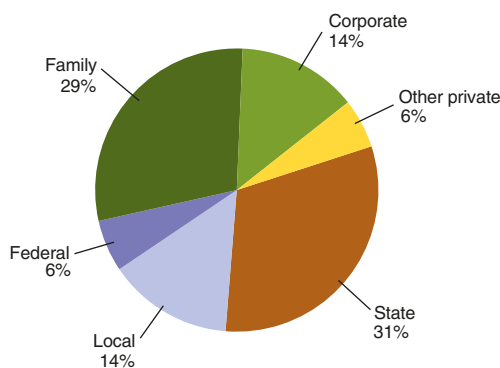


Figure 18.—Distribution of forest land by ownership category, New Jersey, 2013.

The majority of family forest land (60 percent or 348,000 acres) is held by owners with at least 10 acres of forest land (Fig. 19). Eighty-three percent of family forest owners have between 10 and 49 acres of forest land. However, 50 percent of land owned by family forest owners is in holdings of 50 acres or more. The primary reasons for owning forest land are related to aesthetics, privacy, and nature. The most common activities on family forest land are cutting trees for personal use, such as firewood, and personal recreation, such as hunting and hiking (Fig. 20). Participation in a preferential property tax program, such as the State’s Farmland Assessment program, is fairly common with an estimated 48 percent of the ownership having partaken. Additionally, 38 percent of owners have received forest management advice and 31 percent have a forest management plan (Fig. 21). The average age of family forest owners in New Jersey is 60 years and 44 percent of family forest land is held by people who are 65 years of age or older.

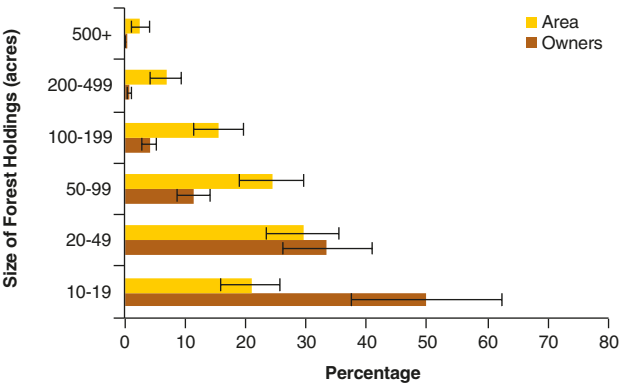


Figure 19.—Area of forest land and number of family forest owners by size of forest landholdings, New Jersey, 2013. Error bars represent a 68 percent confidence interval.

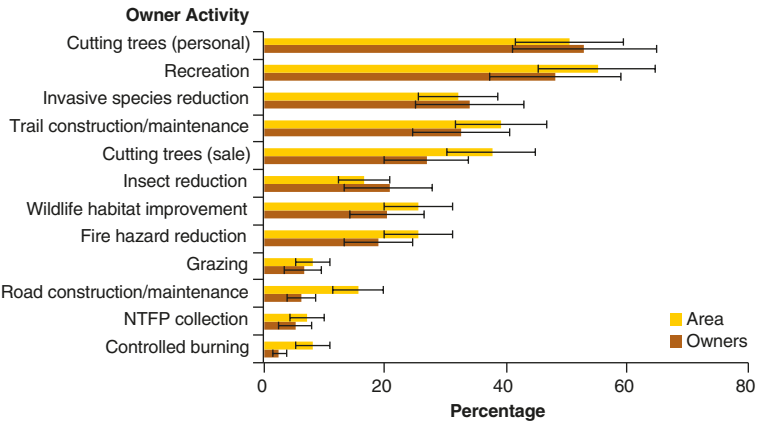


Figure 20.—Area of forest land and number of family forest owners by primary activity within the past 5 years, New Jersey, 2013. Categories are not exclusive. NTFP indicates nontimber forest products. Error bars represent a 68 percent confidence interval.

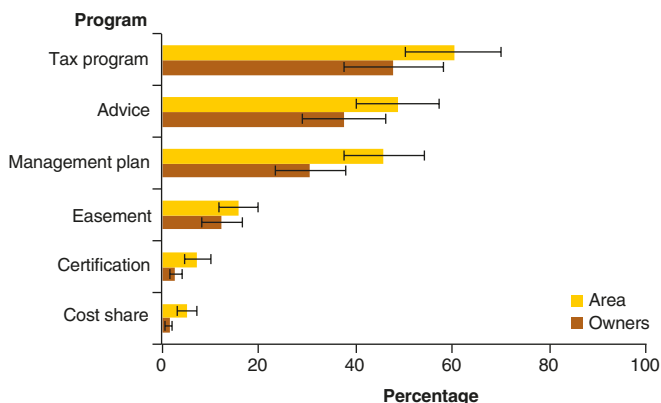


Figure 21.—Area of forest land and number of family forest owners by participation in forest management programs, New Jersey, 2013. Categories are not exclusive. Error bars represent a 68 percent confidence interval.

What this means

The future of the forests lies primarily in the hands of those who own and manage the land. It is therefore critical to understand forest owners and the policies and programs that can help them conserve forests for current and future generations. Family forest owners are the least understood ownership group and the fate of their land is arguably the most uncertain; more than half of family forest owners do not have a management plan and most have not participated in traditional forest management planning or assistance programs, other than preferential property tax programs. Opportunities to help these owners increase their engagement and stewardship of their lands can be found in programs such as Tools for Engaging Landowners Effectively (<http://www.engaginglandowners.org>). As a substantial share of New Jersey's private forest land is owned by individuals aged 65 years and older, much of private forest land in New Jersey is at an increased likelihood of a change in ownership. Programs such as Your Land, Your Legacy (<http://masswoods.net/monthly-update/your-land-your-legacy-deciding-future-your-land>) and Ties to the Land (<http://tiestothe land.org>) are being implemented to help owners meet their bequest goals. However, it is uncertain who future forest owners will be and what they will do with their land. As forest ownership in New Jersey is almost equally in public and private ownership, land stewards will benefit from collaborative efforts to conserve forest land for future generations.

Land-Use Change

Background

A period of rapid population growth in the northeastern United States during the 1990s raised a great deal of concern about the effects of increased urban pressures on forest resources. Some areas in this region experienced significant loss and fragmentation of forest land due to land-use change as the population and urban development increased. Current census data suggest that the southern and western regions of the United States are now experiencing relatively more population growth and urban development than the Northeast. Population growth in New Jersey slowed from 8.6 percent between 1990 and 2000 to 4.5 percent between 2000 and 2010; this shift in urban pressure may have an effect on land-use change in the region.

To better understand New Jersey's forest land dynamics, it is important to explore land-use change occurring throughout the State. FIA characterizes the area of the State using several use categories, which can be generalized to the following classes: forest, agriculture (including pasture and cropland), developed land, rights-of-way, water, and other nonforest land. By comparing land use on current inventory plots with land use recorded at the same location during the previous inventory, we can characterize forest land-use change. Understanding land-use change dynamics helps land managers make informed policy decisions. Because analysis of land-use change is based solely on plots measured in 2008 and remeasured in 2013, estimates may not be directly comparable to estimates that include all available plots.

What we found

The majority (60 percent) of land in New Jersey is nonforest, and most nonforest land is in developed uses. Little change in land use occurred between 2008 and 2013. Most of the State remained forested (38 percent) or stayed nonforest (60 percent); only 2 percent of land had a forest loss or forest gain (Fig. 22). Between 2008 and 2013, forest land decreased by 53,000 acres; however, this was offset by a gain of 57,000 acres, resulting in no appreciable net change in forest land area (Fig. 23).

Analysis of forest loss and gain by land use indicates that areas that are the source of new forest land have a similar land-use distribution to the nonforest areas that were formerly forest. Gains in forest land come from developed land (48 percent) and rights-of-way (15 percent) converting to forest (Fig. 24). Agricultural land uses account for 24 percent of forest gains. The majority (56 percent) of gross forest loss is from forest land converting to developed land, specifically commercial and residential development. Sixteen percent of forest loss was classified as agricultural land uses (Fig. 24). Unlike the 2008 inventory, where forest loss was generally occurring in the more populated areas of the State, there is no strong spatial pattern in the distribution of forest change plots in New Jersey in 2013 (Crocker et al. 2011) (Fig. 25).

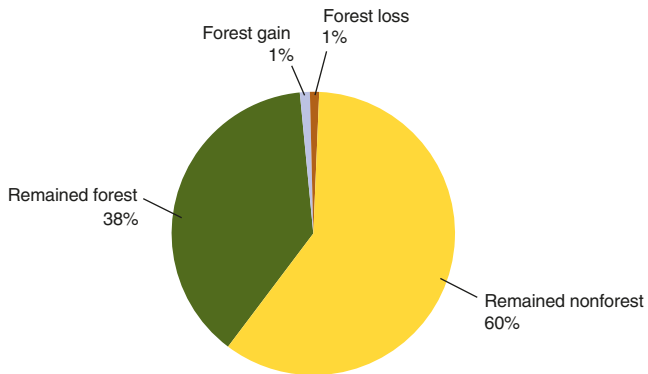


Figure 22.—Proportion of plots that remained forest, remained nonforest, or showed a loss or gain in forest land, New Jersey, 2008 to 2013.

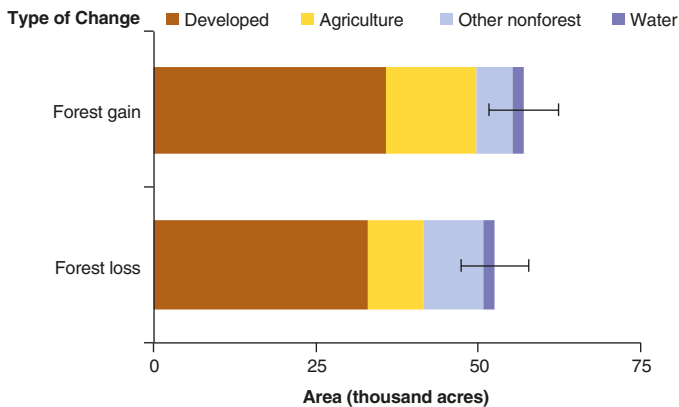


Figure 23.—Area of forest loss and forest gain by land-use category, New Jersey, 2008 to 2013. Developed class includes rights-of-way. Error bars represent a 68 percent confidence interval.

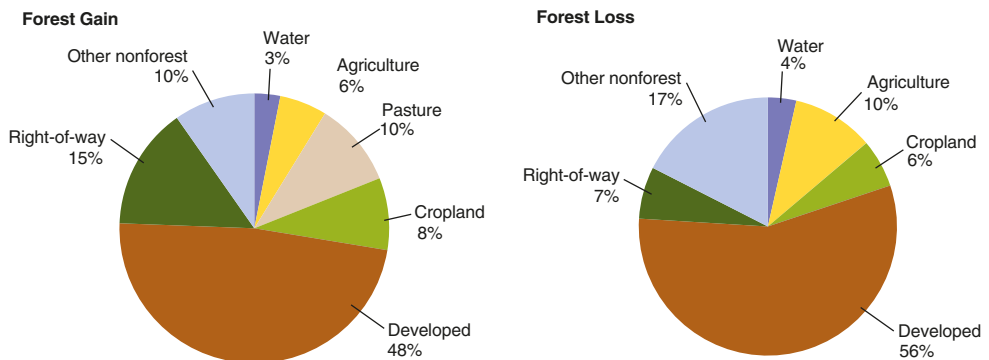


Figure 24.—Forest gain by previous land use and forest loss by current land use, New Jersey, 2008 to 2013.

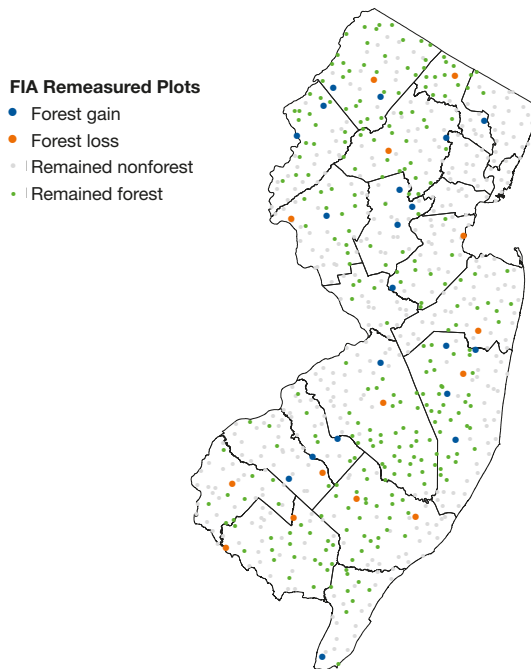


Figure 25.—Distribution of remeasurement plots showing forest gains and losses, New Jersey, 2008 to 2013. Plot locations are approximate.

What this means

Since the late 1980s, forests in the northeastern United States have been under pressure from urban expansion and increased population growth. A great deal of concern has been expressed regarding the effect of this growth on the forest resource; in particular, people worried that conversion to urban uses could cause significant forest loss. To a large extent, those pressures and concerns have lessened for many states in the region. Population growth in New Jersey is below the national average and the area of forest land appears to have stabilized, perhaps aided by the large acreage of publicly owned forest land. The small amount of forest loss that has occurred over the last 5 years has been offset by gains in forest land.

Some gains and losses in forest land may be from marginal tracts of forest land moving into and out of the forest land base. Movement between forest and nonforest classifications may be a result of land meeting or not meeting FIA's definition of forest land due to small changes in understory disturbance, forest extent, or forest cover. These fluctuations likely contribute to the losses from and gains in developed land and rights-of-way. In contrast with the net loss of 4 percent of forest land in the 2008 inventory, gains in forest land equaled forest losses in the 2013 inventory (Crocker et al. 2011). The difference in net change between the two inventories can be attributed to a decrease in the amount of gross forest losses coupled with a small increase in gross forest gains.

Forest Growth

Background

A forest stand’s capacity for growth, that is, for trees to increase in volume, is an indication of the overall condition of the stand and more specifically of tree vigor, forest health, and successional stage. Forest growth is measured as average annual net growth, where net growth is equivalent to gross growth minus mortality. Average annual net growth represents an average for the annual change in volume between previous and current inventories for the individual tally trees before accounting for the impact of removals.

What we found

Despite a sharp rise and fall in net growth between 1999 and 2013, the overall rate of growing-stock growth on timberland has steadily increased since 1971; net growth of growing stock currently averages 65.7 million cubic feet per year (Fig. 26). Seventy percent of net growth resulted from growth in hardwoods. However, pitch pine had the highest growth, followed by yellow-poplar, red maple, and northern red oak (Fig. 27). In contrast, growth of white oak has significantly decreased since 2008. The bulk of growth (78 percent) has occurred in the large diameter stand-size class. Growth-to-volume ratios decreased for most species groups in 2013, particularly within the other red oaks and select white oaks groups (Fig. 28).

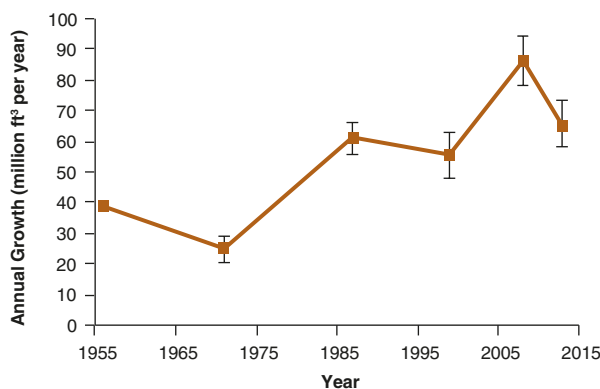


Figure 26.—Average annual net growth of growing stock on timberland by inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

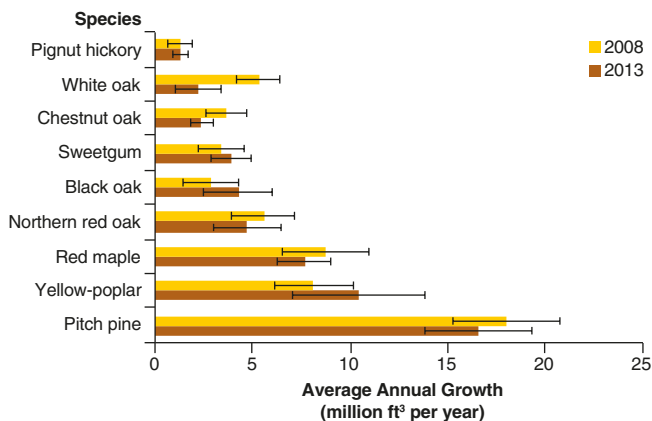


Figure 27.—Average annual net growth of growing stock on timberland for the nine species with the highest growth in 2013, New Jersey. Error bars represent a 68 percent confidence interval.

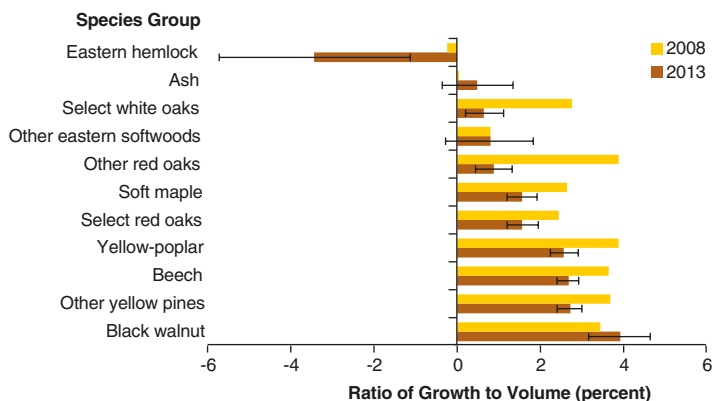


Figure 28.—Average annual net growth expressed as a percentage of total growing-stock volume on timberland for 11 selected species groups, New Jersey. Error bars represent a 68 percent confidence interval.

What this means

Even though the overall rate of growth on New Jersey's forests is generally increasing, the preponderance of growth is occurring within large diameter stands, which indicates that mature trees are continuing to add volume. Several economically desirable tree species, such as northern red oak and white oak, are showing reductions in annual growth each year, as well as low growth relative to their total volumes. For species like ash and eastern hemlock, low growth rates relative to volume are likely due to activity from emerald ash borer and hemlock woolly adelgid (see Emerald Ash Borer on page 46 and Hemlock Woolly Adelgid on page 52). Given the declining growth rates, trends should continue to be monitored in the future.

Tree Mortality

Background

Forest health, vigor, and the rate of accretion and depletion are all influenced by tree mortality. Mortality can be caused by insects, disease, adverse weather, succession, competition, fire, old age, or human or animal activity, alone or in combination. Tree volume lost as a result of land clearing or harvesting is not included in mortality estimates. Growing-stock mortality estimates represent the average cubic-foot volume of sound wood in growing-stock trees that died each year as an average for the years between inventories.

What we found

Following an early decline, the rate of mortality has increased since 1987 (Fig. 29). Average annual mortality of growing stock on timberland is currently an estimated 38.2 million cubic feet per year, or 1.2 percent of total growing-stock volume. Seventy-nine percent of mortality occurred within large diameter stands. The other red oaks species group, which includes black oak and pin oak, had the highest mortality, followed by ash and other yellow pines (Fig. 30). Mortality-to-volume ratios generally increased between 2008 and 2013 (Fig. 31), such that only 35 percent of trees had mortality-to-volume ratios less than 1 percent. Eastern hemlock had the highest mortality-to-volume ratio at 4.6 percent. Cottonwood and aspen, eastern white and red pine, other eastern soft hardwoods, and other red oaks had mortality ratios greater than 2 percent (Fig. 31).

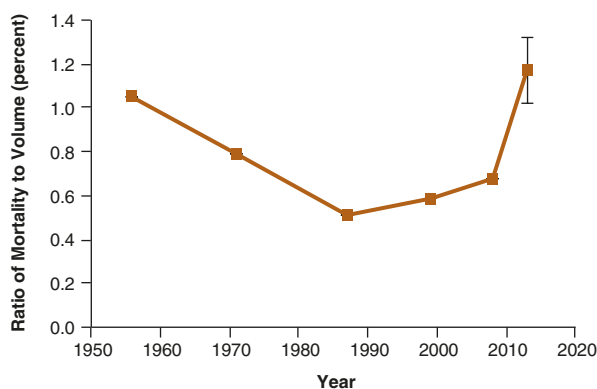


Figure 29.—Average annual mortality of growing stock as a percentage of total growing-stock volume on timberland by inventory year, New Jersey. Error bar represents a 68 percent confidence interval.

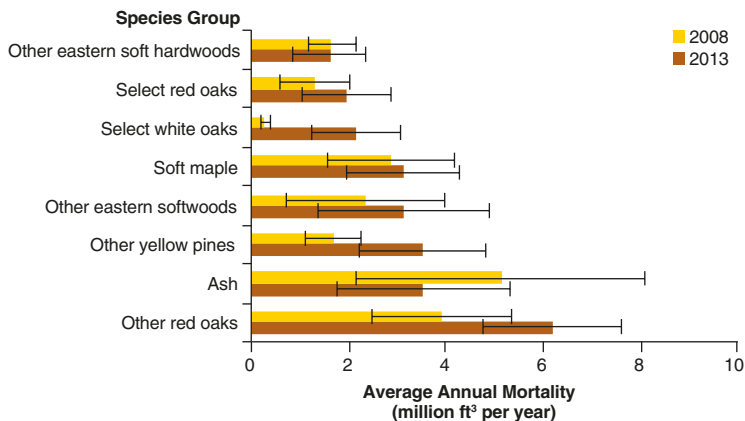


Figure 30.—Average annual mortality of growing stock on timberland for the eight species groups with the highest mortality in 2013, New Jersey. Error bars represent a 68 percent confidence interval.

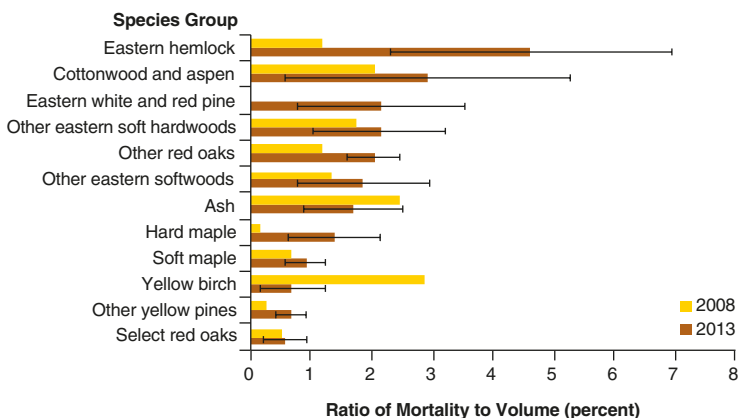


Figure 31.—Average annual mortality of growing stock as a percentage of total growing-stock volume on timberland for 12 selected species groups by inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

What this means

Mortality is a natural process in forest stands as they develop and change over time. Over the past few decades, the rate of tree mortality across New Jersey has risen. High mortality rates within the eastern hemlock and cottonwood and aspen species groups indicate a yearly loss greater than 3 percent of statewide volume. The increasing rate of mortality of hemlock likely reflects hemlock woolly adelgid activity. As tree mortality is a crucial component of overall forest health, continued monitoring will help to identify future areas of concern.

Tree Removals

Background

One way to analyze forest sustainability is to assess change in tree volume as a result of removals. Removals include harvested trees and trees lost due to a change in land use, in other words, living trees previously on land classified as forest land now on land classified as nonforest land. Changes in the quantity of growing stock removed help to identify trends in land-use change and forest management. 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.

What we found

Annual growing-stock removals rates relative to volume have fallen since 2008 and now roughly approach 1987 estimates (Fig. 32). Growing stock is currently removed from timberland at an average of 17.9 million cubic feet per year; of this, 37 percent of removals occurred as a result of a change in land use. As a percentage of total growing-stock volume, the statewide removals rate is 0.3 percent (Fig. 32). Total removals were highest in the sweetgum, other red oaks, and select red oaks species groups (Fig. 33). Removals-to-volume ratios decreased for many species groups, most notably for black walnut (Fig. 34).

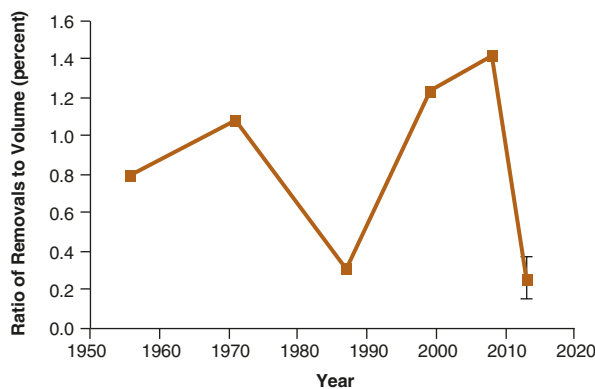


Figure 32.—Average annual removals of growing stock as a percentage of total growing-stock volume on timberland by inventory year, New Jersey. Error bar represents a 68 percent confidence interval.

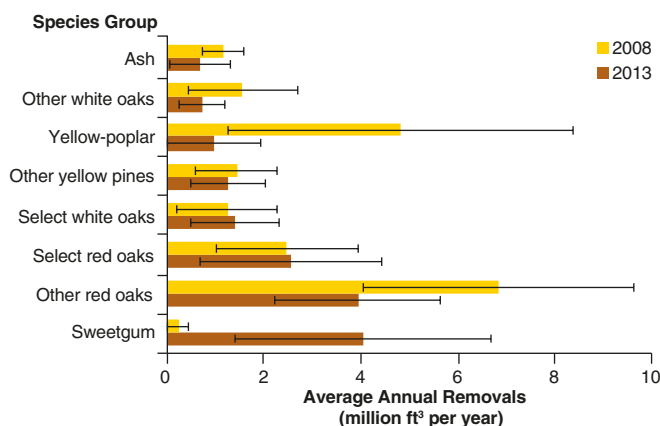


Figure 33.—Average annual removals of growing stock on timberland for the eight species groups with the highest removals in 2013, New Jersey. Error bars represent a 68 percent confidence interval.

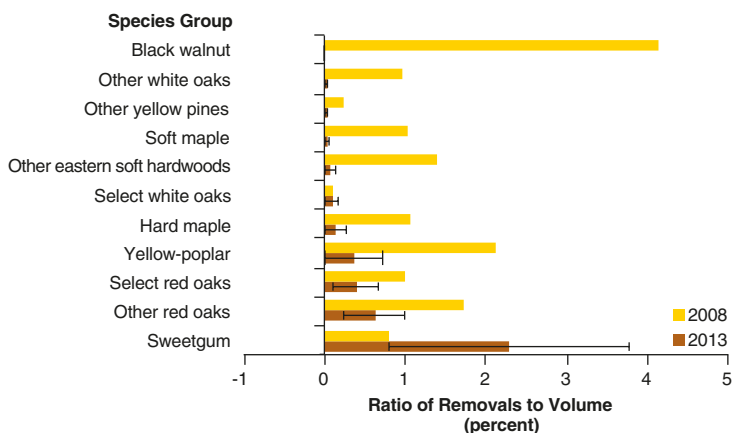


Figure 34.—Average annual removals of growing stock as a percentage of total growing-stock volume on timberland for 11 selected species groups by inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

What this means

Removals rates are indicative of both harvest and land-use change. The rate of removals (0.3 percent) is far less than mortality (1.2 percent). On the other hand, the rate of growth averages 1.5 percent, exceeding both removals and mortality. From a statewide perspective, removals appear to be in balance with forest growth and mortality, such that total volumes continue to increase. However, this may not be the case at smaller scales (e.g., county) or for specific species. In these cases, removals rates should be monitored and evaluated on a case-by-case basis.

Forest Health Indicators



Shortleaf and pitch pine stand, Silas Little Experimental Forest. Photo by Rich Widmann, U.S. Forest Service.

Down Woody Materials

Background

Down woody materials, in the form of fallen trees and shed branches, fulfill a critical ecological niche in the forests of New Jersey. These materials provide valuable wildlife habitat, structural diversity, and a store of carbon/biomass. They also contribute to forest fire hazards via surface woody fuels. Down woody materials include fine woody debris (diameter less than 3 inches), coarse woody debris (diameter of 3 inches or greater), and residue piles.

What we found

The total carbon stored in down woody materials on New Jersey forest land exceeded 2.3 million tons (Fig. 35). Downed woody debris carbon was irregularly distributed by stand age class with moderately aged stands having the highest total carbon (1.1 million tons). The downed dead wood biomass across the State was dominated by fine woody debris at about 2.7 million tons, representing nearly 60 percent of statewide totals (Fig. 36). The total volume of coarse woody debris was highest in the private ownership category at 132.1 million cubic feet (Fig. 37). State and local forests had the second largest totals of coarse woody debris volume (72.4 million cubic feet). As there is a relatively sparse sample intensity of downed dead wood plots across New Jersey, no dead wood piles were sampled and sampling uncertainty is high.

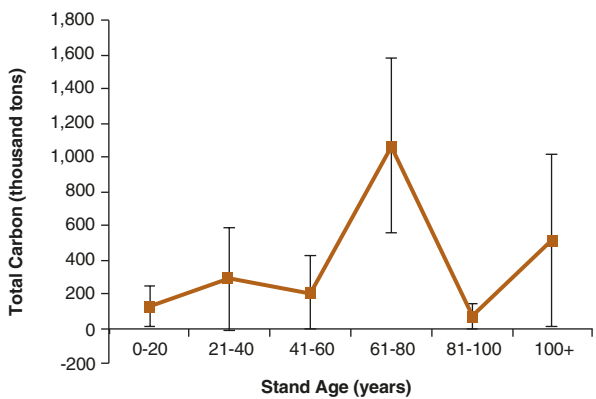


Figure 35.— Total carbon in down woody materials by stand-age class on forest land in New Jersey, 2006 to 2010. Error bars represent a 68 percent confidence interval.

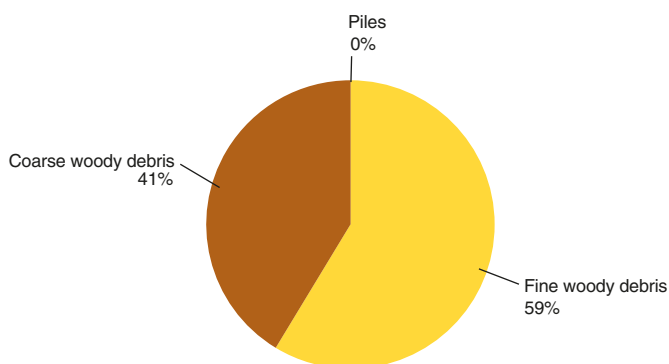


Figure 36.—Proportion of down woody biomass on forest land by dead wood component, New Jersey, 2006 to 2010.

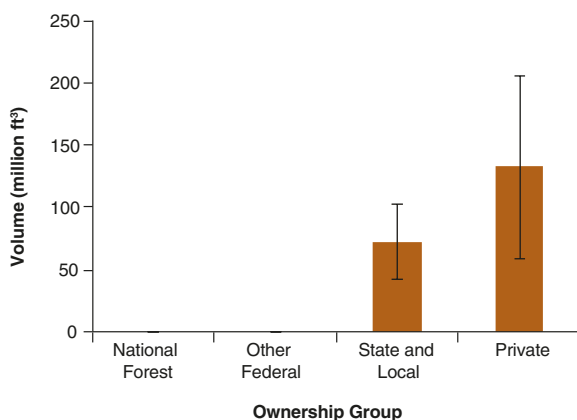


Figure 37.—Total volume of coarse woody debris on forest land by ownership group, New Jersey, 2006 to 2010. Error bars represent a 68 percent confidence interval.

What this means

The fuel loadings of down woody materials can be considered a forest health hazard in times of drought or in isolated stands with excessive tree mortality. Although carbon stocks of down woody materials are small compared to those of soils and standing live biomass statewide, they are a critical component of the carbon cycle, serving as a transitional stage between live biomass and other detrital pools such as litter. Beyond transition of dead wood carbon to other pools, these carbon stocks may be reduced due to increased rates of decay if future temperature and precipitation patterns change (Russell et al. 2014a, 2014b). This is an important consideration because of the lack of coarse woody debris in New Jersey. The loss of dead wood

carbon stocks could mean the reduction of other pools in the future. Unlike in southeastern states, where industrial management of forests is more common, dead wood piles were not sampled in this first down woody materials inventory of New Jersey's forests (Woodall et al. 2013). Considering that the vast majority of coarse woody debris volume was estimated to be in private ownership, management of New Jersey's private forests may affect the future of down woody material contributions to statewide forest carbon stocks and wildlife habitat (i.e., stand structure). As estimated fuel loadings were not extremely high across the State, the fire risk associated with down woody materials may be outweighed by the numerous ecosystem services that they provide.

Tree Damage and Crown Health

Background

Tree damage is assessed for all trees with a d.b.h. of 5.0 inches or greater. Up to two of the following types of damage can be recorded: insect damage, cankers, decay, fire, animal damage, weather, and logging damage. If more than two types of damage are observed, decisions about which two are recorded are based on the relative abundance of the damaging agents (U.S. Forest Service 2010a).

Tree crown condition is influenced by various biotic (e.g., insects, diseases, invasive plants, and animals) and abiotic stressors (e.g., drought, flooding, cold temperatures, nutrient deficiencies, soil moisture and aeration, and pollutants). Crown dieback is defined as recent mortality of branches with fine twigs and reflects the severity of recent stresses on a tree. A crown was labeled as "poor" if crown dieback was greater than 20. This threshold is based on findings by Steinman (2000) that associated crown ratings with tree mortality. Additionally, crown dieback has been shown to be the best crown variable to use for predicting tree survival (Morin et al. 2015).

What we found

Damage was recorded on about 14 percent of the trees in New Jersey, but there was considerable variation between species. The most frequent damage on all species was decay (11 percent), which ranged from 5 percent on Atlantic white-cedar and pitch pine to more than 15 percent on white ash and red maple. The occurrence of all other injury types was very low (Table 1).

Table 1.—Percentage of trees with damage by damage type and species, New Jersey, 2013

Damage type	Atlantic										
	All	white-cedar	Black oak	Chestnut oak	Northern red oak	Pitch pine	Red maple	Sweet-gum	White ash	White oak	Yellow-poplar
None	86	92	87	91	87	93	77	90	80	88	88
Animal	0	0	1	1	1	0	0	0	0	1	0
Cankers	1	0	1	0	0	0	0	0	0	0	0
Decay	11	5	12	7	10	5	21	8	18	10	9
Insect damage	1	0	0	0	0	0	0	0	0	1	0
Logging	0	0	0	0	1	0	0	1	0	1	1
Other	1	2	1	2	0	2	1	2	1	1	1
Weather	0	0	0	0	0	0	1	0	2	0	1

The incidence of poor crown condition is low across New Jersey with no discernable spatial pattern (Fig. 38). Black oak has the highest percentage of basal area with poor crowns (13 percent); all other species have less than 5 percent (Table 2). For northern red oak, the proportion of basal area with poor crowns decreased substantially since 2008. Mean crown dieback ranges from less than 1 percent for pitch pine up to 5 percent for black oak (Table 3). The proportion of the trees that died increased with increasing crown dieback (Fig. 39). Half of trees with crown dieback greater than 20 percent in 2008 were dead by the 2013 inventory.

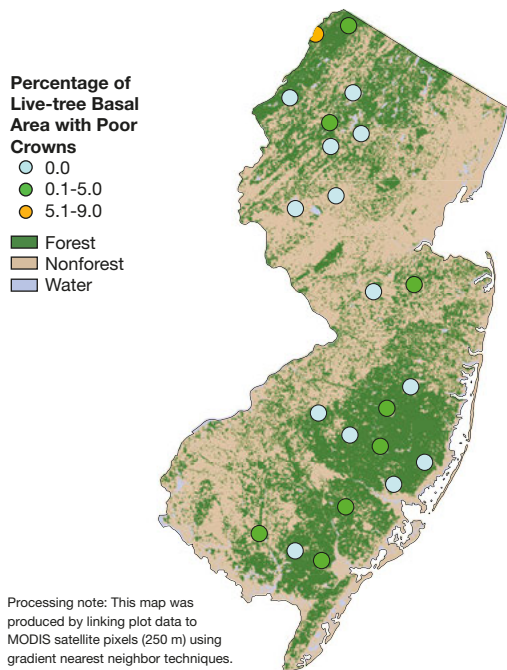


Figure 38.—Distribution of plots by percentage of live-tree basal area with poor crowns, New Jersey, 2013. Depicted plot locations are approximate.

Table 2.—Percentage of live-tree basal area with poor crowns for eight selected species by inventory year, New Jersey

Species	Percentage of Live-tree Basal Area with Poor Crowns	
	2008	2013
Black oak	7.3	12.7
Atlantic white-cedar	0.0	4.9
White ash	0.0	4.0
White oak	4.5	2.8
Red maple	0.0	0.7
Pitch pine	0.3	0.4
Sweetgum	0.0	0.0
Northern red oak	9.1	0.0

Table 3.—Mean crown dieback and other statistics for live trees (5-inch d.b.h. or greater) on forest land by species, New Jersey, 2013

Species	Trees	Mean	SE	Minimum	Median	Maximum
	<i>number</i>	<i>percent</i>				
Black oak	25	4.8	2.3	0	0	55
Red maple	60	4.2	1.7	0	0	99
White ash	9	3.9	2.7	0	0	25
White oak	54	2.4	0.6	0	0	20
Atlantic white-cedar	43	1.9	0.9	0	0	30
Northern red oak	14	1.4	0.6	0	0	5
Sweetgum	18	1.4	0.8	0	0	10
Pitch pine	186	0.6	0.3	0	0	40

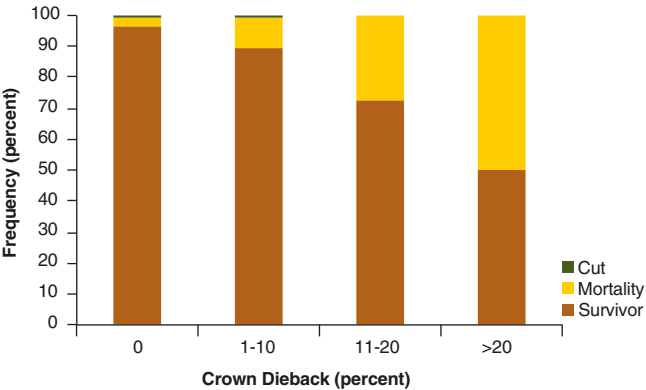


Figure 39.—Distribution of crown dieback by tree survivorship for remeasured trees, New Jersey, 2008 to 2013.

What this means

Overall, New Jersey's trees are generally in good health. As in most eastern forests, decay is the most commonly observed damage across the State. This is not unusual given that the majority of New Jersey's forests are large diameter stands composed of mature trees. Additionally, red maple is a relatively short-lived species that is likely to develop decay as it ages. The health of tree crowns in maple and ash species should be monitored closely for future impacts expected from Asian longhorned beetle and emerald ash borer.

Fragmentation and Urbanization of Forest Land

Background

Forest fragmentation is the process by which contiguous tracts of forest land are broken down into smaller, more isolated forest patches that are surrounded by nonforest land uses, such as urban development or agriculture (Wilcox and Murphy 1985). This results in a reduction of continuous or core forest land and an increase in edge habitat. Fragmentation often has negative effects, including the loss of wildlife habitat and biodiversity, and the increased prevalence of invasive species (Honnay et al. 2005). To compare changing forest condition and the degree of fragmentation across the landscape, an adaptation of the spatial integrity index (SII) developed by Kapos et al. (2000) was used to create a single fragmentation metric that integrates measures of patch size, local forest density, and patch connectivity¹. SII classes range from core forest to unconnected forest fragments, and are applied at a 30 m scale. Forest parcels that did not meet the definition of core forest or unconnected forest fragment were scaled into low, medium, and high integrity classes.

Urbanization is a major cause of fragmentation, particularly when housing development occurs in or near forest land (Radeloff et al. 2005). The zone where undeveloped wildland vegetation intermingles with human development (with at least one house per 40 acres) is called the wildland-urban interface (WUI). Not only does housing development that takes place in the WUI contribute to the effects of fragmentation, but homes and structures built within the WUI face significant risk from wildfire (Radeloff et al. 2005).

¹ Riemann, R. 2014. Adaptation of a spatial integrity index to 30 m and 250 m scales, and its application across the northeastern United States. Unpublished paper on file at U.S. Forest Service, Northern Research Station, Forest Inventory and Analysis Program, Troy, NY.

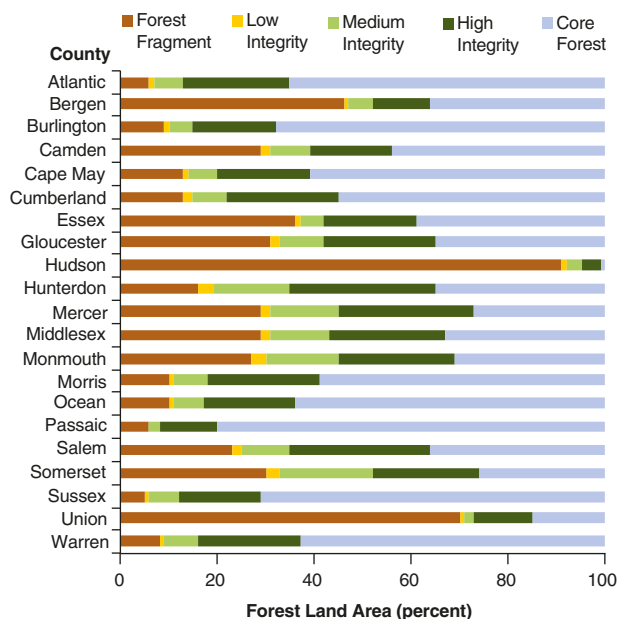


Figure 40.—Forest land by spatial integrity class and county, New Jersey, 2006.

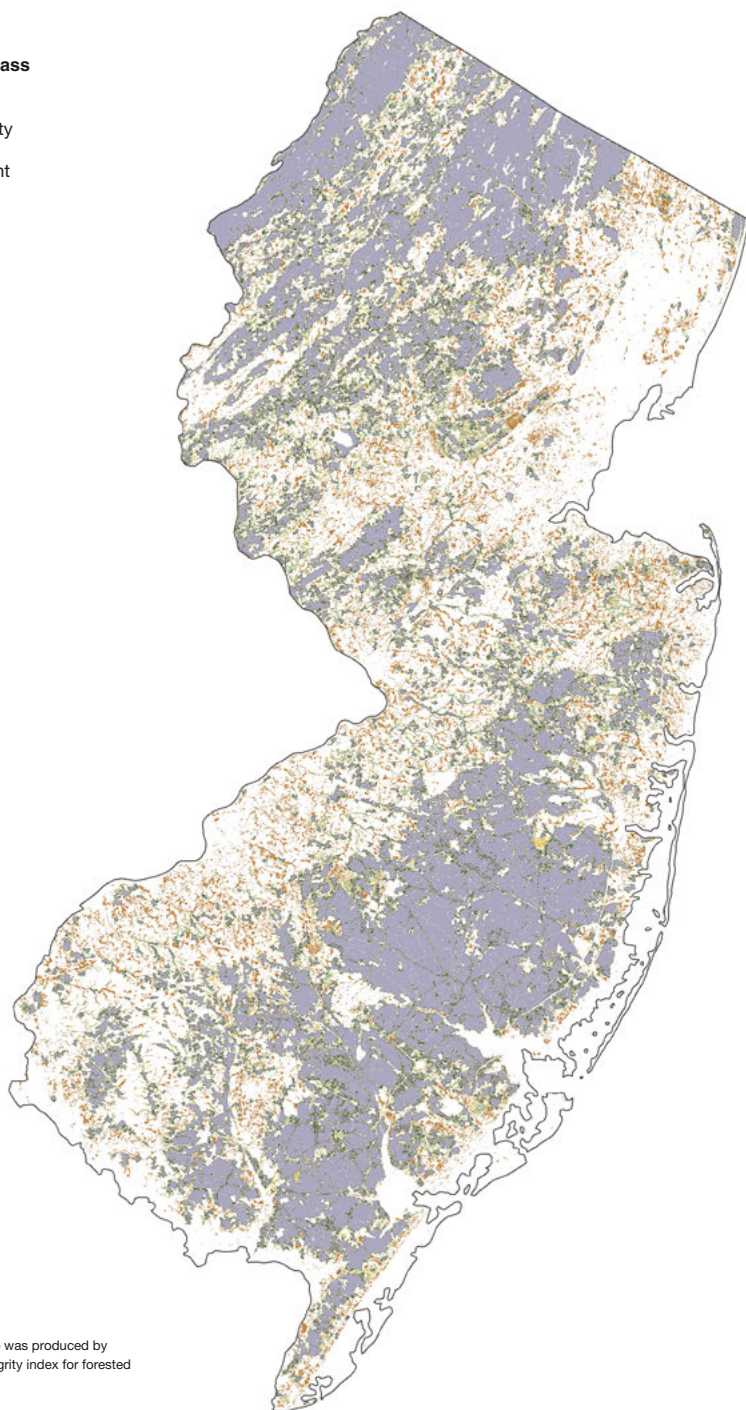
What we found

New Jersey is largely made up of core forest parcels, which compose 55 percent of forest land (Figs. 40 and 41). Core forest parcels are most abundant in Passaic and Sussex Counties (Fig. 40). Twenty-one percent of forest parcels have high spatial integrity; 14 percent are in unconnected fragments and 9 percent have medium or low integrity. Forest connectivity is highest in northwestern and southeastern New Jersey, and lowest within the New York City/Philadelphia/Delaware corridor, which stretches from the northeastern portion of the State to the southwestern portion (Fig. 41). Average patch size by county ranged from 8 to 153 acres (Fig. 42). Larger patches tend to be found in the northwestern part of the State, and the smallest patches are found near developed areas. Conversion of forest land to developed land was highest in Hudson (8 percent), Bergen (3 percent), and Essex Counties (3 percent); in each of these counties, average patch size decreased by 1 acre since 2006.

The area of forested WUI is steadily growing, increasing from 42 percent in 1990 to 46 percent in 2010 (Table 4). WUI areas are primarily clustered along forested margins, and within core forest parcels throughout the State, particularly in the Pine Barrens of southern New Jersey and in the Highlands of northern New Jersey (Fig. 43). WUI data and SII data should be combined for a more detailed depiction of fragmentation. In so doing, the proportion of core forest land decreases from 55 percent to 37 percent statewide.

Spatial Integrity Class

- Core Forest
- High Integrity
- Medium Integrity
- Low Integrity
- Forest Fragment
- Nonforest



Processing note: This map was produced by calculating the spatial integrity index for forested NLCD 2006 pixels (30 m).

Figure 41.—Distribution of forest land by spatial integrity class, New Jersey, 2006.

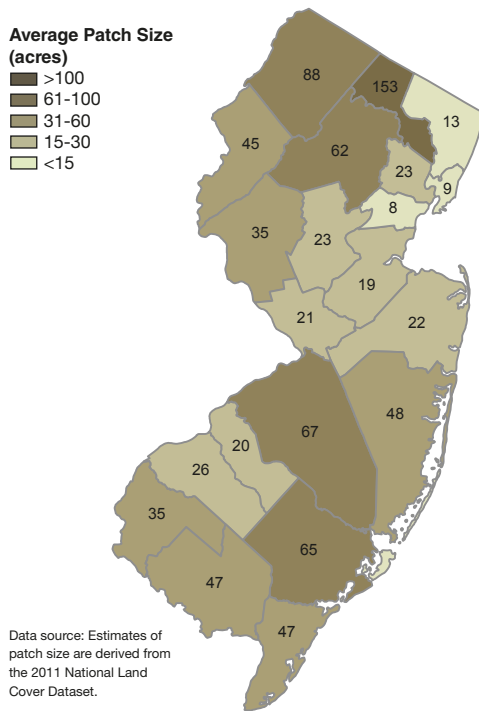


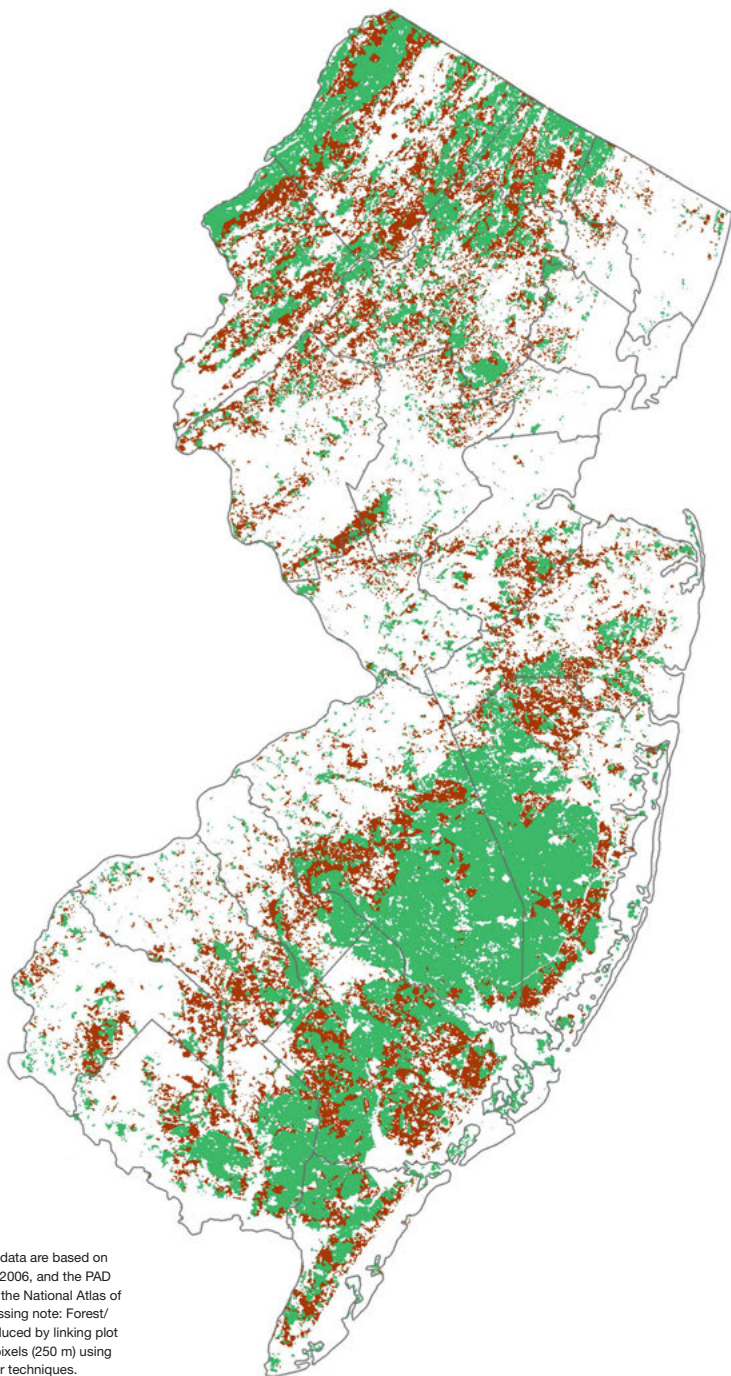
Figure 42.—Average forest patch size (derived from NLCD 2011) by county, New Jersey.

Table 4.—Percentage of forest land within the wildland-urban interface by county and year, New Jersey

County	1990	2000	2010
Atlantic	48	51	53
Bergen	29	34	39
Burlington	16	16	19
Camden	45	46	42
Cape May	41	42	46
Cumberland	30	33	32
Essex	31	28	29
Gloucester	54	53	56
Hudson	0	0	0
Hunterdon	60	60	66
Mercer	46	47	55
Middlesex	44	42	43
Monmouth	42	45	47
Morris	59	60	60
Ocean	22	24	23
Passaic	33	34	43
Salem	59	59	65
Somerset	58	62	62
Sussex	43	43	46
Union	48	49	47
Warren	53	54	56
Total	42	45	46

**Distribution of
Forest Land**

- Non-WUI
- WUI
- Nonforest



Data sources: WUI 2010 data are based on the 2010 Census, NLCD 2006, and the PAD v1.1; FIA 2009 data; and the National Atlas of the United States. Processing note: Forest/nonforest data were produced by linking plot data to MODIS satellite pixels (250 m) using gradient nearest neighbor techniques.

Figure 43.—Distribution of forest land by wildland-urban interface status, New Jersey, 2010.

What this means

Fragmentation and urbanization continue to influence the function and health of New Jersey's forests. Even though there is a large percentage of core forest land, the arrangement of these parcels is not evenly distributed across the landscape. Larger tracts of continuous forest land are concentrated in the northwest and southeast. The remaining forest patches are small, isolated, and scattered within areas of heavy residential and urban development. Rising housing density within the WUI has further fragmented core forest land. Development within the WUI increases encounters with wildlife and heightens the risks associated with fire suppression. The latter of these risks is greatest within the fire-adapted landscape of the Pine Barrens, which burn on a regular basis, thus increasing the need to protect human populations and structures from wildfire damage. Continued development will further fragment existing forest land and result in long-term or permanent loss of forest habitat, elevated risk of invasion by nonnative species, reductions in native species diversity, and loss of forest connectivity necessary for wildlife.

Forest Insects

Emerald Ash Borer

Background

A wood-boring beetle native to Asia, emerald ash borer (*Agrilus planipennis*; EAB) is a pest of all North American ash (*Fraxinus* spp.). Additionally, this insect has recently been found to attack white fringetree (*Chionanthus virginicus*), an understory shrub native to New Jersey but not tallied by FIA (Cipollini 2015, Herms and McCullough 2014, Natural Resources Conservation Service 2015). Although EAB shows some preference for stressed trees, all trees 1 inch in diameter or greater are susceptible regardless of vigor (Herms and McCullough 2014). Since its discovery in southeastern Michigan in 2002, EAB has been identified in 25 states as of October 2015. EAB was not found in New Jersey during the 2013 inventory period; however, it was confirmed in Somerset County in May 2014.

What we found

There are an estimated 23.6 million ash trees (1-inch d.b.h. or greater), about 3 percent of total species composition, on New Jersey forest land. White ash is the most numerous

ash species in the State, making up 92 percent of total ash abundance; green ash and black ash make up 5 percent and 3 percent, respectively. Ash is distributed across much of the State, but most of it is concentrated in northern New Jersey (Fig. 44). Ash accounts for 251.2 million cubic feet of live-tree volume on forest land.

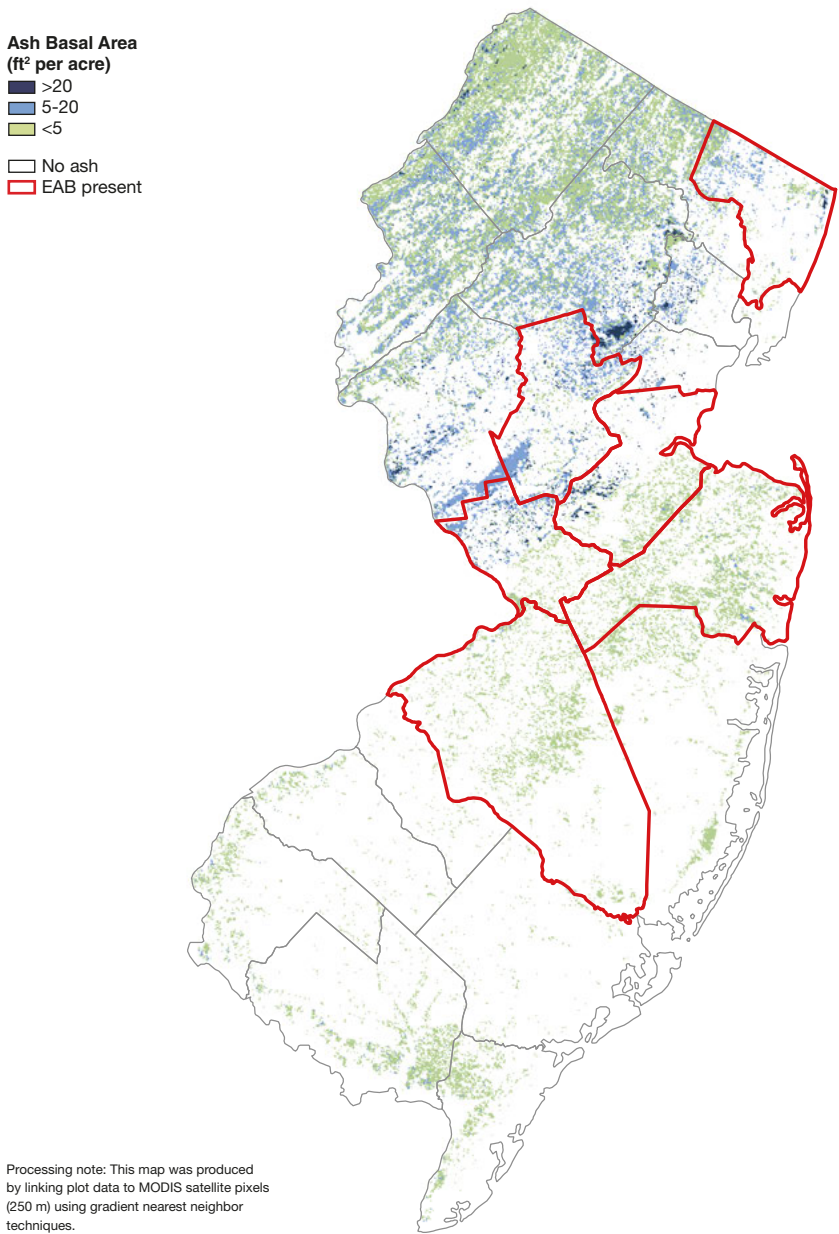


Figure 44.—Ash density on forest land, New Jersey, 2009. EAB-positive counties as of October 1, 2015.

Due to a small sample size, mortality estimates for ash have large sampling errors. Still, ash mortality has significantly increased, rising from 535,000 million cubic feet in 1987 to 3.5 million cubic feet in 2013 (Fig. 45). Though not statistically significant, the trend line suggests an increase between 1999 and 2013. With the exception of Salem County, ash mortality primarily occurred in northern New Jersey (Fig. 46). Somerset County, where EAB was first detected, had the highest mortality of ash (66 percent).

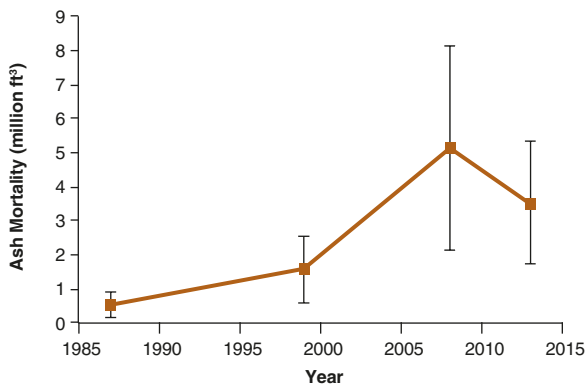


Figure 45.—Mortality of ash growing stock on timberland by inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

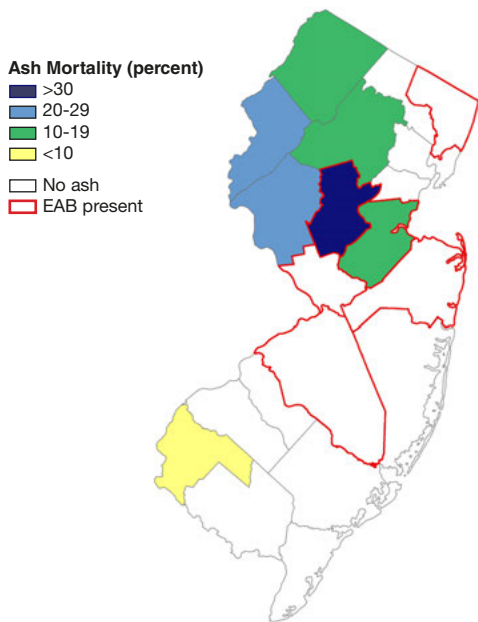


Figure 46.—Ash mortality expressed as a percentage of total tree mortality on forest land by county, New Jersey, 2013. EAB-positive counties as of October 1, 2015.

What this means

As EAB has caused extensive ash mortality throughout the eastern United States, it represents a significant threat to the ash resource in New Jersey. Ash mortality is high in several northern New Jersey counties, but EAB has not been identified in all of them. Counties with high ash mortality that are not currently known to be infested serve as good candidates for increased EAB survey efforts. Mortality of ash is expected to increase as EAB spreads. 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

Background

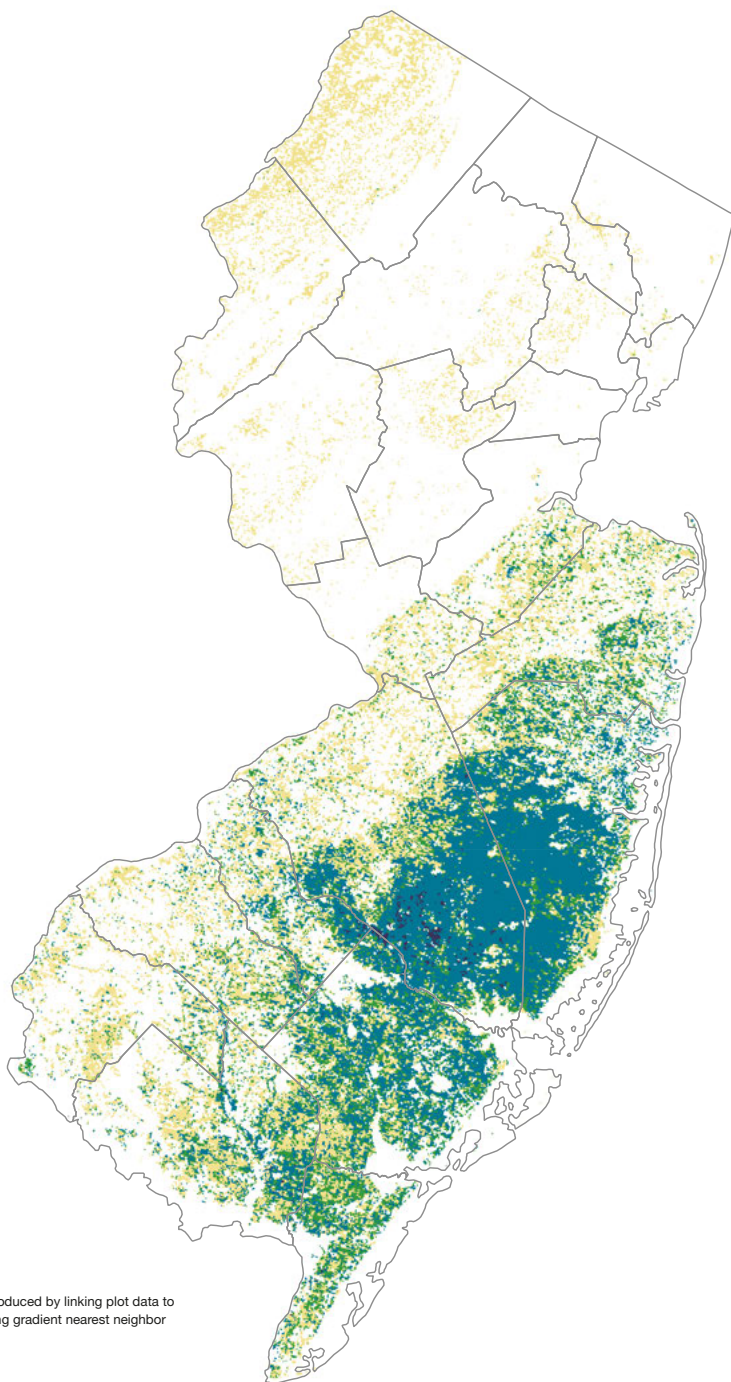
Outbreaks of southern pine beetle (*Dendroctonus frontalis*; SPB) have been documented in the United States as early as the 1750s (Thatcher et al. 1980). SPB has since proven to be one of the most destructive pests of pine in the southern United States (Clarke and Nowak 2009). Pitch, shortleaf, loblolly, pond, and Virginia pines are the preferred hosts; during outbreaks, however, 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.

What we found

Of the susceptible host species, pitch pine is the most numerous, with an estimated 145.8 million trees (1-inch d.b.h. or greater). Virginia pine (68 percent), shortleaf pine (29 percent), pond pine (2 percent), and loblolly pine (less than 1 percent) account for an additional 13.2 million trees. Pitch pine is found on the ridgetops of northwestern New Jersey, but preferred hosts are primarily distributed throughout southern New Jersey, largely within the Pine Barrens (Fig. 47). Species preferred by SPB occur on 22 percent of forest land, or 430,000 acres (Fig. 48). Of these stands, 65 percent are high density stands, where the basal area of host trees is greater than 80 square feet per acre. Mortality of preferred hosts has risen since 2008, reaching 4.3 million cubic feet of volume loss in 2013 (Fig. 49).

**Basal Area of SPB
Preferred Hosts
(ft² per acre)**

- >80
- 30-79
- 15-29
- <15
- No hosts



Processing note: This map was produced by linking plot data to MODIS satellite pixels (250 m) using gradient nearest neighbor techniques.

Figure 47.—Density of host trees preferred by southern pine beetle on forest land, New Jersey, 2009.

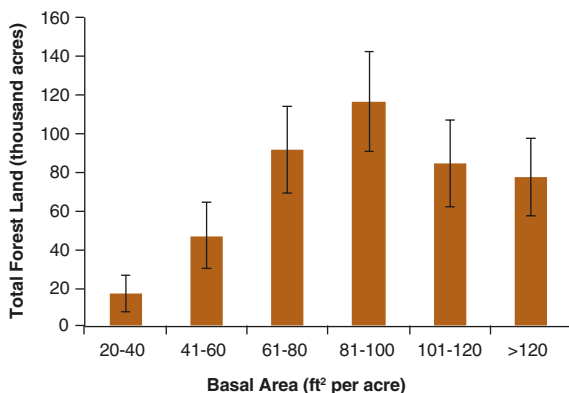


Figure 48.—Area of forest land by basal area for pitch, loblolly, shortleaf, pond, and Virginia pine forest types, New Jersey, 2013. Error bars represent a 68 percent confidence interval.

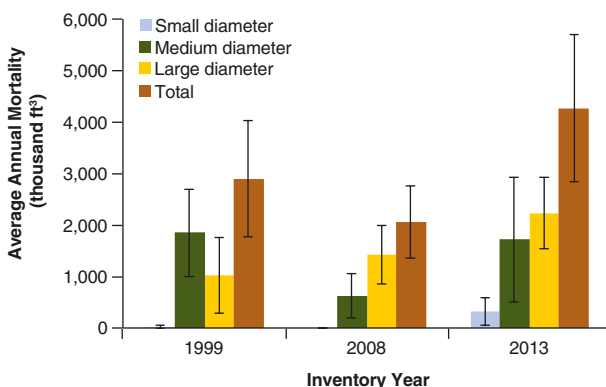


Figure 49.—Average annual mortality of growing stock on timberland for preferred hosts of southern pine beetle, by stand-size class and inventory year, southern New Jersey. Error bars represent a 68 percent confidence interval.

What this means

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 increase the risk of SPB outbreak. As susceptible stands cover 22 percent of New Jersey forest land, SPB has the potential to affect a vast area—especially in the southern portion of the State—and cause extensive pine mortality.

Hemlock Woolly Adelgid

Background

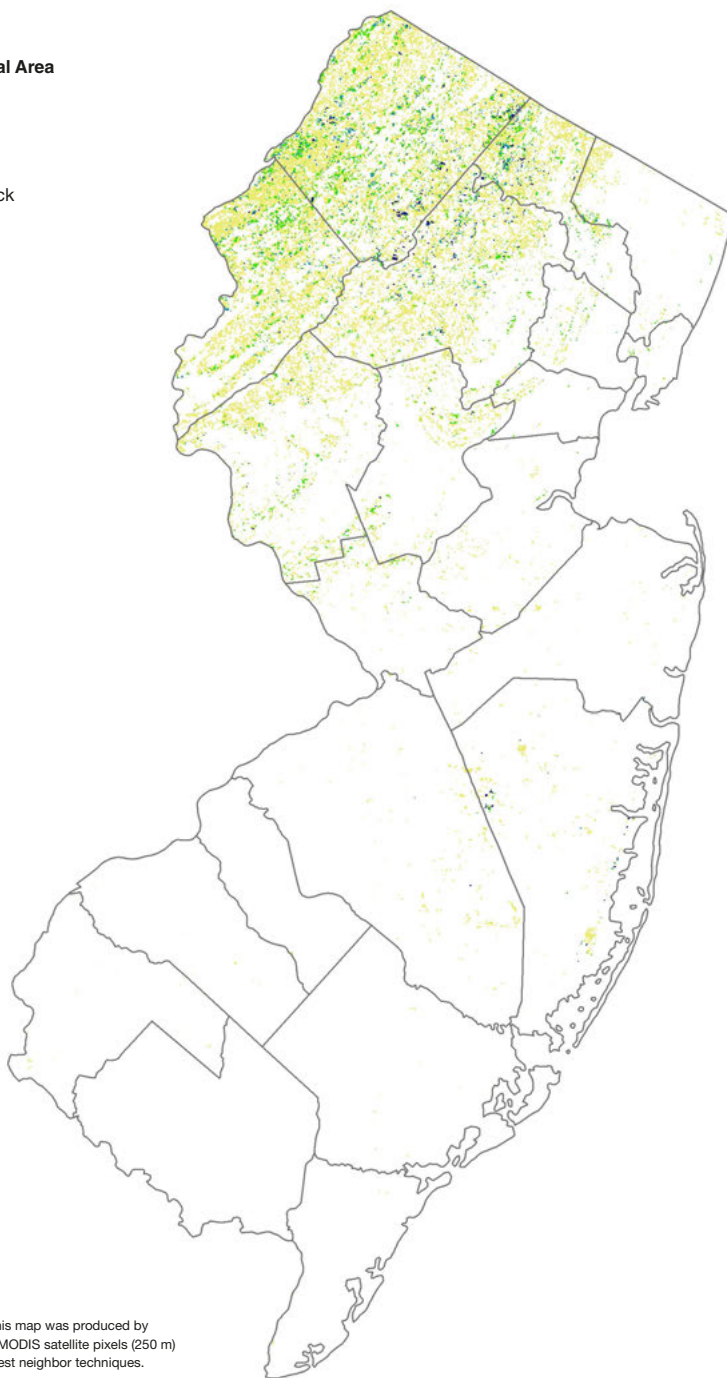
White “wool” on the branches of eastern hemlock is a tell-tale sign of a hemlock woolly adelgid (*Adelges tsugae*; HWA) infestation (U.S. Forest Service 2010b). A tiny, sap-feeding insect from Asia, HWA was first reported in Virginia in 1951. By 1978, the adelgid had spread to Burlington County, New Jersey (Smith-Fiola et al. 2004). In the northern range of hemlock, tree decline and mortality generally occur within 4 to 10 years of infestation (U.S. Forest Service 2010b). The rate of tree mortality increases if infested trees also experience drought, attack by secondary insects and diseases, or other stresses.

What we found

There are an estimated 3.6 million hemlock trees (1-inch d.b.h. or greater) on New Jersey forest land. Although hemlock is distributed across much of northern New Jersey, its distribution is limited to cool, moist slopes and streambanks (Fig. 50) (Harlow et al. 1996). Average annual mortality of hemlock has risen since 1987; mortality is currently an estimated 581,000 cubic feet of growing-stock volume on timberland (Fig. 51) and 1.2 million board feet of sawtimber volume on timberland. Hemlock mortality reached a peak rate of 4.63 percent in 2013 (Fig. 52).

**Hemlock Basal Area
(ft² per acre)**

- >20
- 11-20
- 5-10
- <5
- No hemlock



Processing note: This map was produced by linking plot data to MODIS satellite pixels (250 m) using gradient nearest neighbor techniques.

Figure 50. — Hemlock density on forest land, New Jersey, 2009.

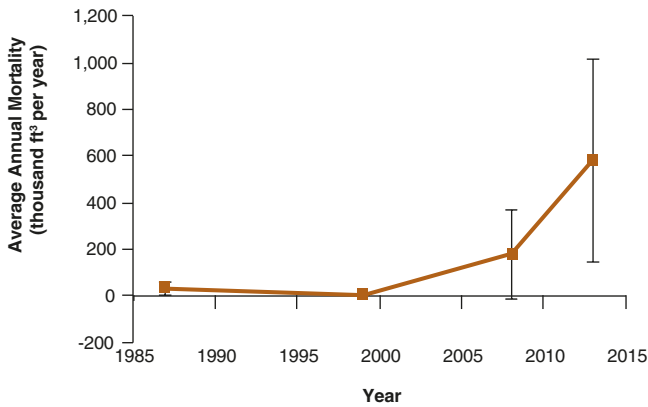


Figure 51.—Average annual mortality of hemlock growing stock on timberland by inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

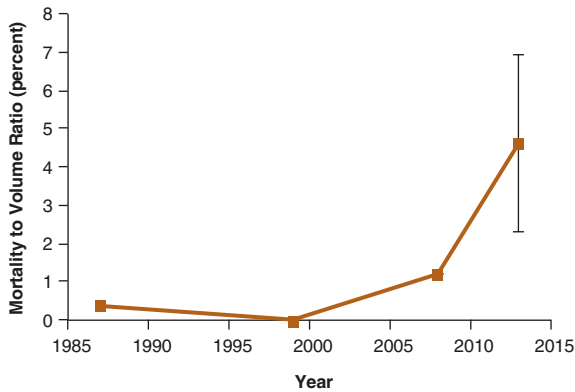


Figure 52.—Average annual mortality of hemlock growing stock per unit volume of growing stock on timberland by inventory year, New Jersey. Error bar represents a 68 percent confidence interval.

What this means

Hemlock represents a small, but unique and important, part of New Jersey's forests. Because it is found in cool, moist ravines, on low ridges, and along lakeshores (Harlow et al. 1996), hemlock mortality could affect soil stability and water temperature and quality. Hemlock occurs in both pure and mixed stands (Harlow et al. 1996). Therefore, hemlock mortality would impact a variety of species. Based on mortality trends, HWA has been especially damaging since 1999. Continued monitoring of the hemlock resource will help to quantify the effects of HWA in New Jersey.

Gypsy Moth

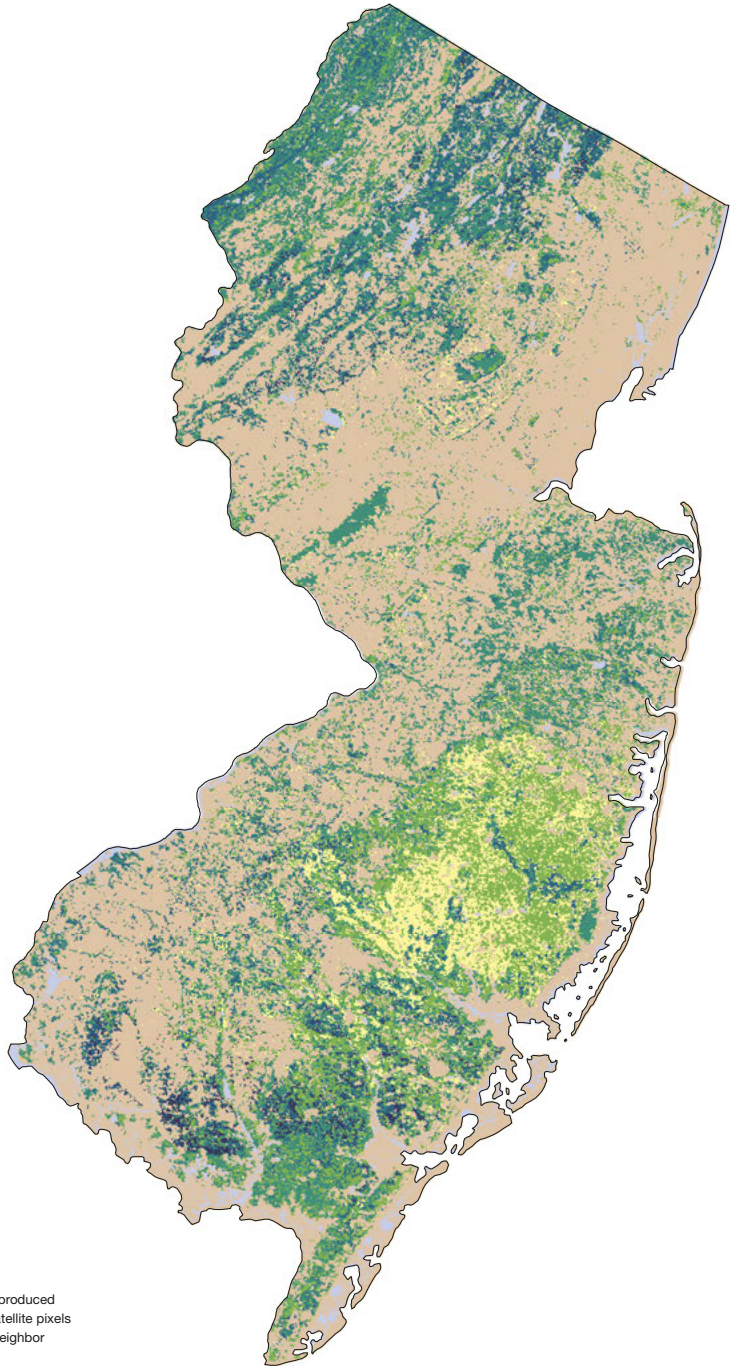
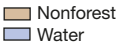
Background

European gypsy moth (*Lymantria dispar*) was first introduced to New Jersey in the early 1900s. Since then, periodic outbreaks have defoliated large areas of forest. The largest outbreaks occurred in the early 1980s, when more than 800,000 acres were defoliated. To quantify the impacts of gypsy moth defoliation, tree species were split into preferred and nonpreferred suitability classes based on field and laboratory tests by Liebhold et al. (1995). Species in suitability class 1 were considered preferred and all others were considered nonpreferred. In New Jersey, preferred species largely consisted of oaks but also included hardwoods such as birches, sweetgum, apple, and aspens (Liebhold et al. 1995).

What we found

About 38 percent of New Jersey's live-tree volume is preferred by gypsy moth. Oaks and sweetgum are the most abundant preferred species in the State. The density of host species preferred by gypsy moth is greatest in the Highlands of north-central New Jersey and in the southern third of the State (Fig. 53). The largest gypsy moth defoliation events were concentrated in the Pine Barrens of southern New Jersey and hardwood forests in the northern part of the State (Fig. 54). Between 1996 and 2010, nearly 500,000 acres of forest land were defoliated at least once. Most of the defoliation occurred in the oak/hickory forest-type group. The annual mortality rate of species preferred by gypsy moth increased fourfold in areas that were defoliated two or more times in the 10 years preceding remeasurement (Fig. 55).

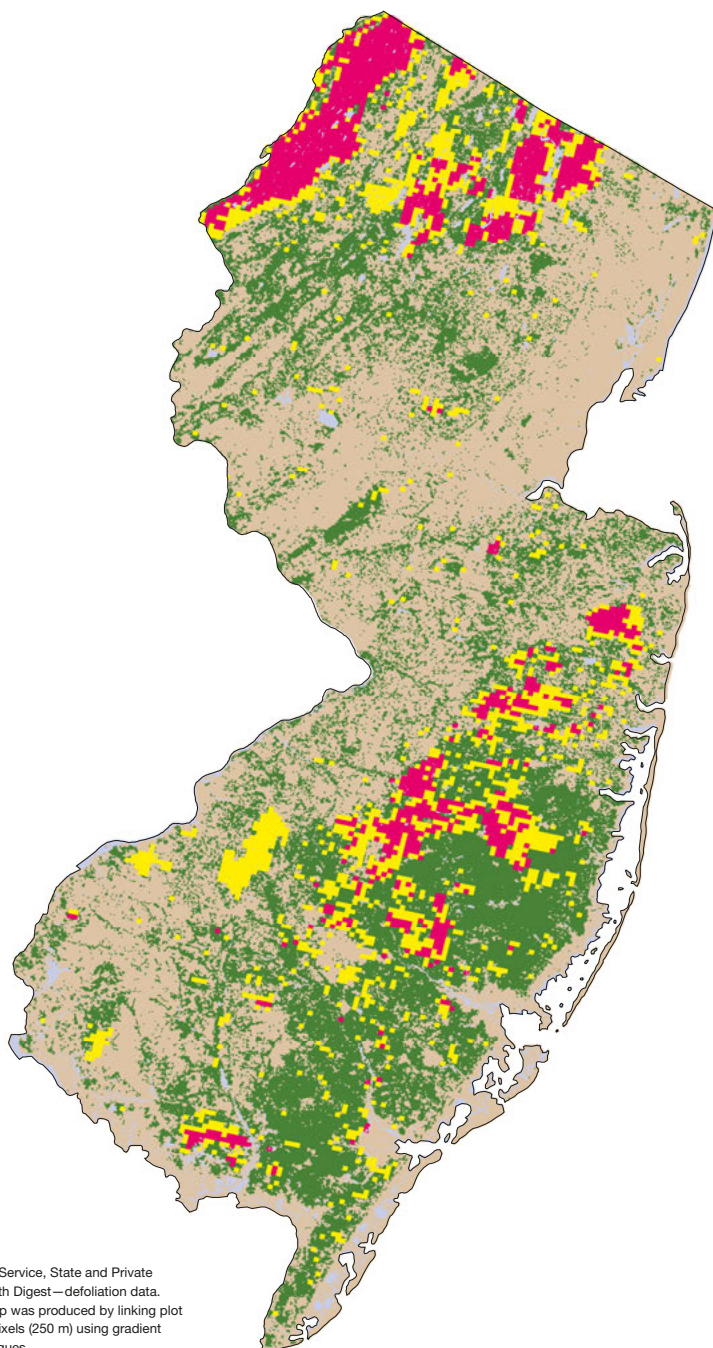
**Basal Area of Tree
Species Preferred
by Gypsy Moth
(percent)**



Processing note: This map was produced by linking plot data to MODIS satellite pixels (250 m) using gradient nearest neighbor techniques.

Figure 53.—Density of host trees preferred by gypsy moth on forest land, New Jersey, 2009.

**Years of Gypsy
Moth Defoliation**



Data source: U.S. Forest Service, State and Private Forestry, 2010 Gypsy Moth Digest—defoliation data.
 Processing note: This map was produced by linking plot data to MODIS satellite pixels (250 m) using gradient nearest neighbor techniques.

Figure 54.—Gypsy moth defoliation events by year, New Jersey, 1996 to 2010. Years of defoliation is based on the number of defoliations that occurred on a plot within the 10 years prior to measurement.

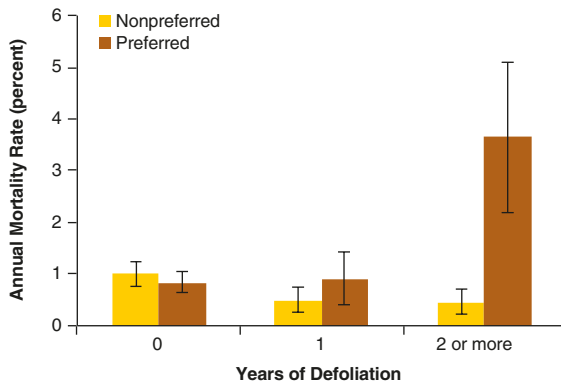


Figure 55.—Annual mortality rate by gypsy moth host preference, New Jersey, 2011. Years of defoliation is based on the number of defoliations that occurred on a plot within the 10 years prior to measurement. Error bars represent a 68 percent confidence interval.

What this means

Gypsy moth has been impacting New Jersey’s forests for more than a century, but records of defoliation have only been maintained since the 1960s. During that time defoliation has been cyclical, with peaks every 5 to 10 years. Although defoliation does have an impact on the health and survival of host tree species, the New Jersey Department of Agriculture has a comprehensive suppression program to reduce the impacts of gypsy moth which includes aerial spray treatments when gypsy moth population cycles peak. Quantifying the extent of forest area containing species preferred by gypsy moth can help land managers prepare for future outbreaks.

Invasive Plants

Background

Invasive plant species (IPS), native and nonnative species that can cause negative ecological effects, are becoming more prevalent in forest ecosystems. Their abundance in introduced environments can be attributed to high adaptability, the availability of disturbed habitats, or a lack of natural enemies, which allows them to outcompete and displace native species (Pimentel et al. 2000). IPS are a concern because they can form dense monocultures that alter natural plant communities and processes, threaten biodiversity, and contribute to a decrease in sustainability, productivity, and wildlife habitat quality. Inspection, management, and mitigation of IPS cost billions of dollars annually.

What we found

During the 2013 inventory, a subset of 65 P2 invasive plots in New Jersey were monitored for the presence of 39 IPS and one undifferentiated genus (nonnative bush honeysuckles) as part of the regional invasive plant monitoring protocol (Appendix 2). Nearly half (46 percent) of all plots contained invasive plants; on these plots, 16 species were observed (Table 5). Multiflora rose was found on 37 percent of plots and was the most commonly observed species, followed by Japanese honeysuckle and Japanese barberry. Invasive plants were found across the State, with the greatest abundance in northern New Jersey (Fig. 56). As many as 10 invasive plant species were found on plots (Fig. 57). Of plots with observed IPS, 47 percent had three or fewer species present.

Table 5.—Number of occurrences and percentage of invasive plant species on P2 invasive plots, New Jersey, 2013

Name	Occurrences	Percentage of plots
Multiflora rose	24	36.9
Japanese honeysuckle	18	27.7
Japanese barberry	16	24.6
Garlic mustard	14	21.5
Nonnative bush honeysuckles	13	20.0
Nepalese browntop	12	18.5
Oriental bittersweet	11	16.9
Autumn-olive	9	13.8
European privet	6	9.2
Norway maple	3	4.6
Black locust	3	4.6
Canada thistle	2	3.1
Common reed	2	3.1
Spotted knapweed	1	1.5
Dames rocket	1	1.5
Ailanthus	1	1.5

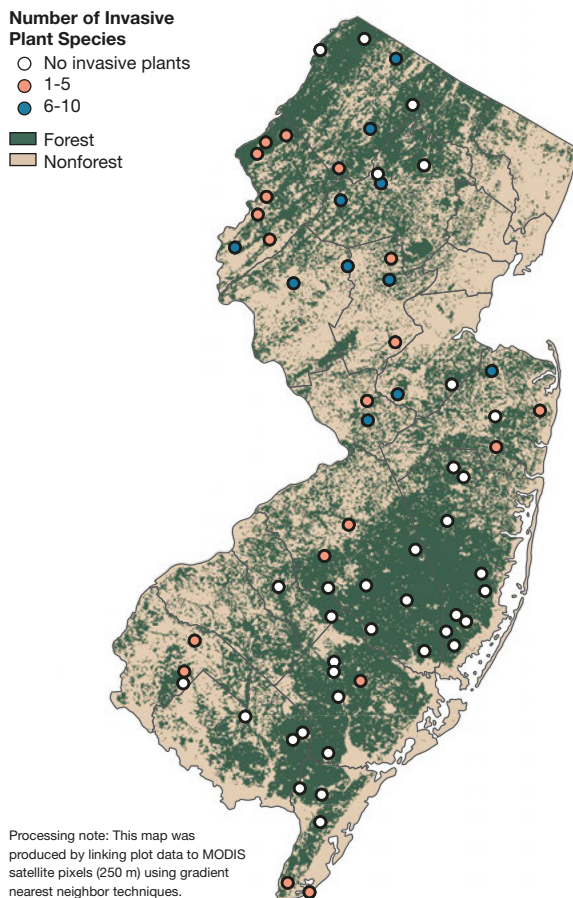


Figure 56.—Distribution and abundance of invasive plant species on forest land, New Jersey, 2013. Depicted plot locations are approximate.

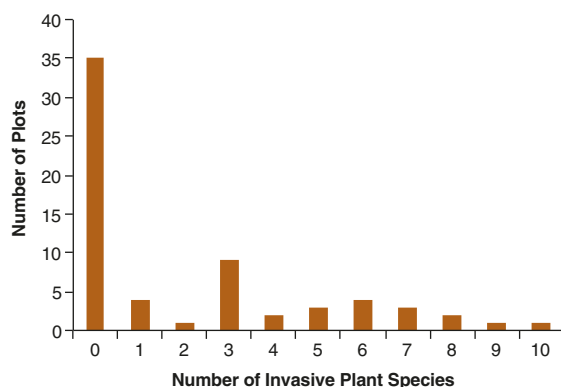


Figure 57.—Number of invasive plant species per P2 invasive plot, New Jersey, 2013.

What this means

The presence of IPS within New Jersey's forests is troublesome, and it is important that these species are monitored over time to ensure that managers and the public are aware of their occurrence and spread. Additional investigation of the inventory data may help to reveal influential site and regional trends as well as how the forest changes in response to changes in the plant community.

Forest Age and Size

Background

Forests provide habitat for many species of birds, mammals, amphibians, and reptiles. Forest composition and structure affect the suitability of habitat for each species. Some species depend upon early successional forests or the ecotone (edge) between different forest stages. Yet other species require old-growth forests or interior forests. Many species require multiple structural stages of forests to meet different phases of their life history needs. Abundance and trends in these structural and successional stages serve as indicators of population carrying capacity for wildlife species (Hunter et al. 2001).

What we found

The small diameter stand-size class accounts for less than 4 percent of New Jersey timberland, a steady decrease from 14 percent in 1987 (Fig. 58). Similarly, the medium diameter size class decreased from 38 percent to 28 percent of timberland between 1987 and 2013. The large diameter class has increased since 1987 and now constitutes two-thirds of timberland (Fig. 58). Since 2008, the abundance of timberland has changed very little in the young age class (0-20 years), has increased substantially in the oldest age classes (81-100 years and 100+ years), and has decreased moderately in forests of intermediate age classes (21-80 years) (Fig. 59). It is difficult to interpret the amount of change since 1987 or 1999 because a large area of timberland was classified as "mixed" age class in older inventories. The large diameter stand-size class contains forests from all six 20-year age classes (although the 0- to 20-year class is rare) and consists predominantly of forests that are 61 to 100 years old (Fig. 60). The medium diameter stand-size class includes five age classes and consists predominantly of forests 41 to 80 years of age. More than half of the small diameter class is in the 0- to 20-year stand age class, and most young forest is in the small diameter stand-size class (Fig. 60).

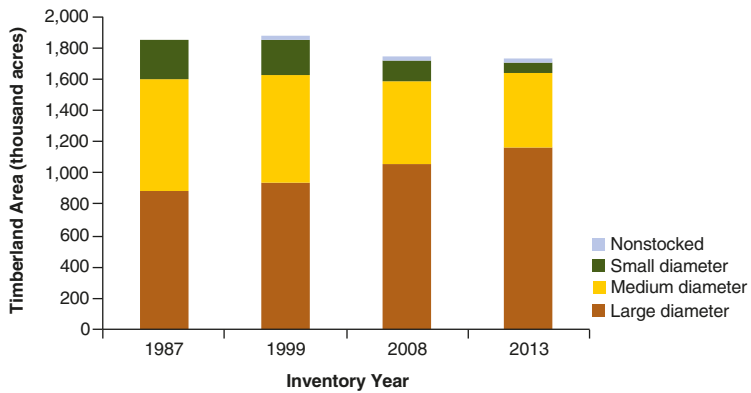


Figure 58.—Area of timberland by stand-size class and inventory year, New Jersey.

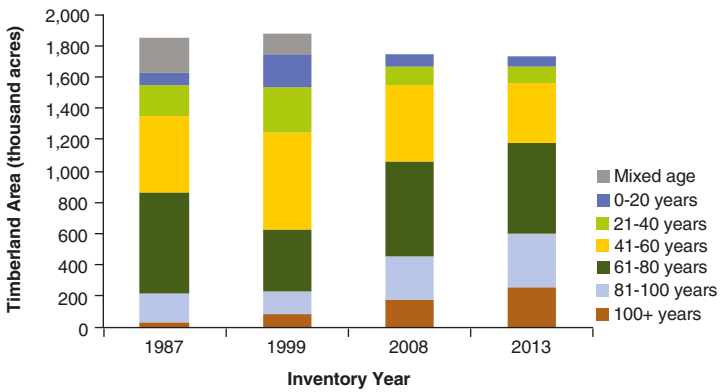


Figure 59.—Area of timberland by stand age and inventory year, New Jersey.

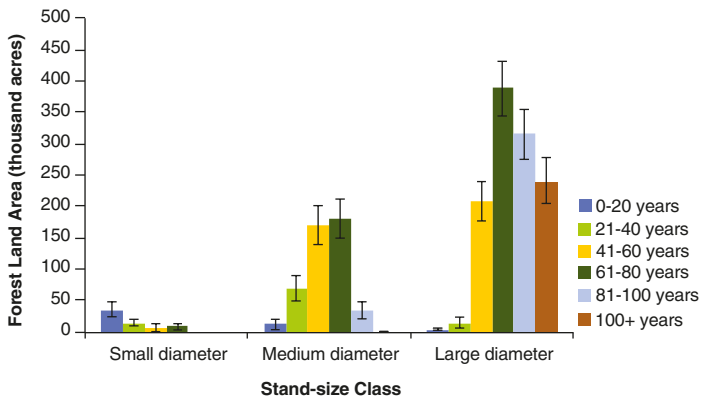


Figure 60.—Area of forest land by age class and stand-size class, New Jersey, 2013. Error bars represent a 68 percent confidence interval.

Both the small and medium diameter stand-size classes have had gradual declines in area during recent decades. In contrast, timberland in the large diameter class has increased over this period. Similarly, the area of forests of 81 to 100 years and 100+ years has increased since the previous inventory; meanwhile young and intermediate ages have declined in area. Historical comparisons are more problematic due to a change in age-class definitions.

What this means

Stand-size class and stand-age class are indicators of forest structural/successional stage. The smallest stand-size class and youngest age class (0-20 years) are consistent with one another, but stands become progressively more heterogeneous as they become larger and older. Such mixtures of different aged or sized trees provide a vertical diversity of vegetation structure that can enhance habitat conditions for some species. Managing forest conditions in both younger and older age classes (and smaller and larger structural stages) to maintain both early and late successional habitats for a diversity of forest-associated species may conserve habitat and viable populations of many forest-associated wildlife species.

Standing Dead Trees

Background

Specific habitat features like nesting cavities and standing dead trees (5-inch d.b.h. or greater) provide critical habitat components for many forest-associated wildlife species. Standing dead trees that are large enough to meet habitat requirements for wildlife are referred to as “snags.” When considered for the purpose of wildlife habitat, snags are generally defined as being 10 inches d.b.h. or greater with a minimum height of 6 feet (Helms 1998). Standing dead trees serve as important indicators not only of wildlife habitat, but also for past mortality events and carbon storage. Further, they serve as sources of down woody materials, which also provide habitat features for wildlife. The number and density of standing dead trees, together with decay classes, species, and sizes, define an important wildlife habitat feature across New Jersey’s forests.

What we found

FIA collects data on standing dead trees of numerous species and sizes in varying stages of decay. Currently, 29.5 million standing dead trees are present on New Jersey

forest land. This equates to an overall density of 14.8 standing dead trees per acre of forest land, with slightly higher densities on public (17.0 standing dead trees per acre) than on private (12.4 standing dead trees per acre) ownership classes. Eight species groups each contributed more than 1 million standing dead trees, with the four largest groups each contributing more than 3 million standing dead trees (Fig. 61). The other eastern softwoods species group had 6.8 million standing dead trees, 6.1 million of which are in a single species: Atlantic white-cedar. Five species groups exceeded 10 standing dead trees per 100 live trees (5-inch d.b.h. or greater) of the same species group; the other eastern softwoods species group had the highest density at 28 standing dead trees per 100 live trees (Fig. 62). The majority (69 percent) of standing dead trees are less than 9 inches d.b.h. and thus do not meet the definition of a snag (Fig. 63). Decay of standing dead trees is limited, with 83 percent of all standing dead trees having little to moderate decay (Fig. 63). Other eastern softwoods species group contained both the largest total number of standing dead trees and the largest number of standing dead trees per 100 live trees of the same species group. On average, 14.8 standing dead trees are present for every acre of New Jersey forest land; 9.0 standing dead trees are present for every 100 live trees.

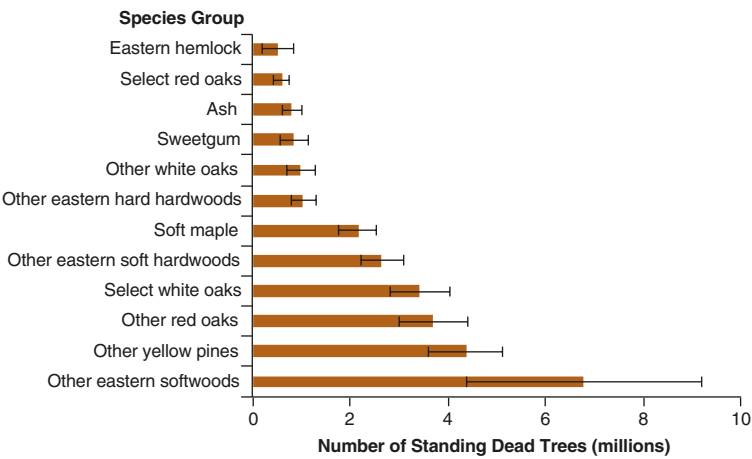


Figure 61.—Number of standing dead trees on forest land for 12 selected species groups, New Jersey, 2013. Error bars represent a 68 percent confidence interval.

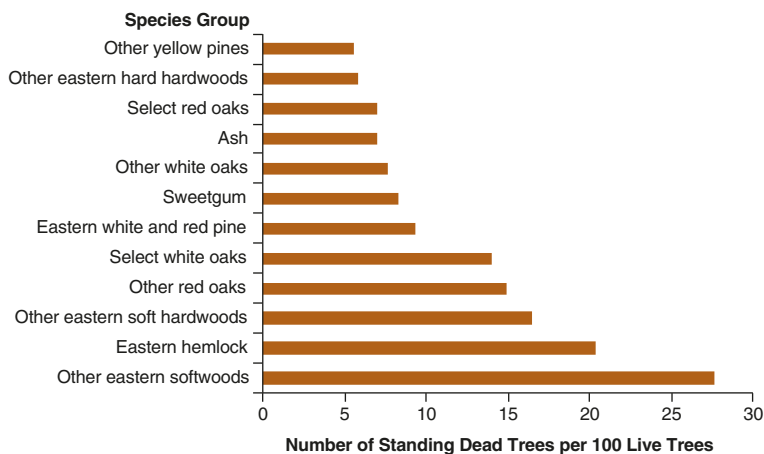


Figure 62.—Number of standing dead trees per 100 live trees on forest land for 12 selected species groups, New Jersey, 2013.

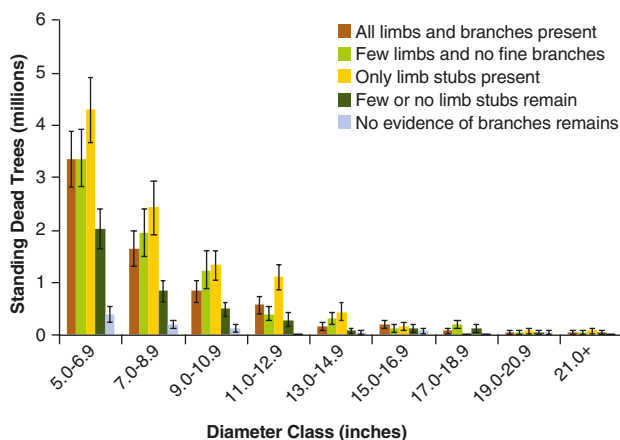


Figure 63.—Number of standing dead trees on forest land by diameter and decay class, New Jersey, 2013. Error bars represent a 68 percent confidence interval.

What this means

Snags and smaller standing dead trees result from a variety of potential causes, including diseases, insects, weather damage, fire, flooding, drought, and competition. Dead trees may contain significantly more cavities per tree than live trees (Fan et al. 2003). These cavities provide habitat features for foraging, nesting, roosting, hunting, and excavation for wildlife—from primary colonizers such as insects, bacteria, and fungi to birds, mammals, and reptiles. Most cavity nesting birds are insectivores, which help to control insect populations (Scott et al. 1977). Providing a variety of

forest structural stages and retaining specific features like snags on both private and public lands in New Jersey are ways that forest managers maintain the abundance and quality of habitat for forest-associated wildlife species.

Forest Economics



Pakim Pond, Brendan T. Byrne State Forest. Photo by Susan Crocker, U.S. Forest Service.

Growing-stock Volume

Background

Growing-stock volume is the amount of sound wood in live, commercial tree species that are 5 inches in 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 volume of growing stock are important considerations in economic planning and when evaluating forest sustainability.

What we found

Growing-stock volume on timberland has risen steadily since 1956 and currently totals an estimated 3.3 billion cubic feet (Fig. 64). Other yellow pines, which consist mainly of pitch pine, are the largest source of growing-stock volume, followed by other red oaks and soft maple (Fig. 65). Pitch pine, which accounts for 14 percent of growing-stock volume, is the most voluminous species on New Jersey timberland. Since 1987, there have been notable increases in volume in the other yellow pines, yellow-poplar, and select red oaks species groups. Growing-stock volume continues to increase in the middle diameter classes as trees grow (Fig. 66). Correspondingly, median tree diameter grows larger with successive inventories.

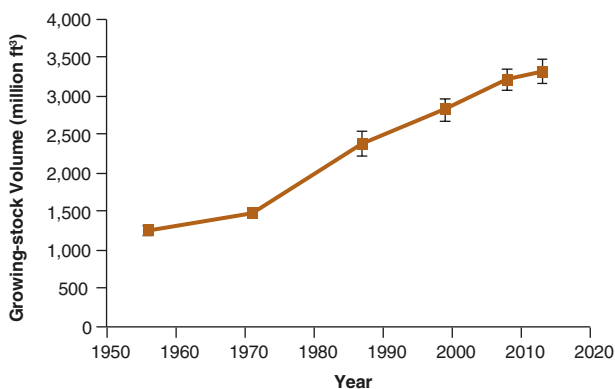


Figure 64.—Growing-stock volume on timberland by inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

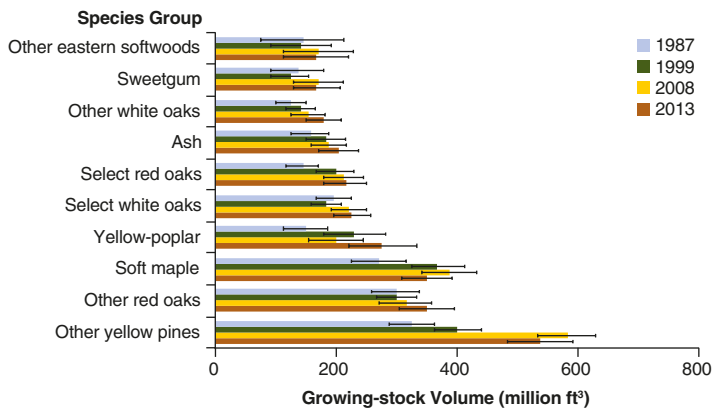


Figure 65.—Growing-stock volume on timberland for the 10 most voluminous species in 2013 by inventory year and species group, New Jersey. Error bars represent a 68 percent confidence interval.

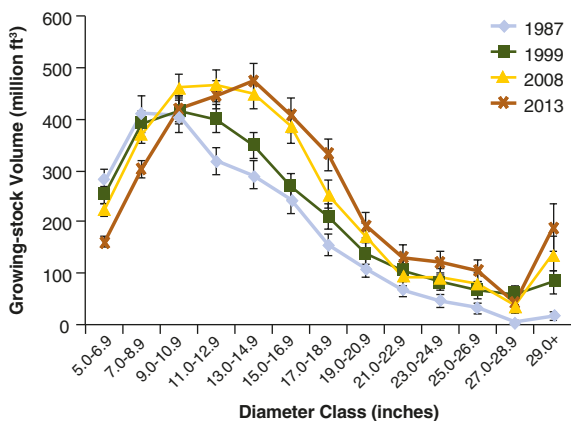


Figure 66.—Growing-stock volume on timberland by diameter class and inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

What this means

Even though growing-stock volume continues to rise, the rate of increase may be slowing. Although pitch pine and other red oaks still maintain significant growing-stock volumes, they show reductions or smaller increases than other species such as the soft maples (e.g., red maple). Statewide, the increase in growing-stock volume can be attributed to tree growth, moderate mortality of high-volume species, and an aging forest. New Jersey's growing-stock volume is increasing; as stands mature, sustainability issues (e.g., regeneration) should continue to be monitored.

Sawtimber Volume and Quality

Background

Sawtimber trees are live trees of commercial species that contain either one 12-foot or two noncontiguous 8-foot logs that are free of defect. Hardwoods must be 11 inches d.b.h. or greater and softwoods must be 9 inches d.b.h. or greater to qualify as sawtimber. Sawtimber volume is defined as the net volume of the saw log portion of live sawtimber, measured in board feet, from a 1-foot stump to minimum top diameter (9 inches for hardwoods and 7 inches for softwoods). Estimates of sawtimber volume are used to determine the monetary value of wood volume and the quantity of merchantable wood available.

What we found

The volume of sawtimber on New Jersey timberland has quadrupled since 1956, reaching an estimated 11.8 billion board feet in 2013 (Fig. 67). Most species groups had large gains in sawtimber volume since 2008 (Fig. 68). Eastern white and red pine and yellow-poplar had the greatest increases in the amount of sawtimber volume (45 percent and 38 percent, respectively). Sawtimber quality is determined using a grading system that incorporates factors including diameter, log length, and the cull portion of the saw log. Tree grade is based on a scale of 1 to 4, with grade 1 representing the highest quality and grade 4 the lowest. Over the past decade, the quality of New Jersey sawtimber has remained consistent, with a large portion of higher grade sawtimber (Fig. 69). Currently, 44 percent of New Jersey’s hardwood sawtimber is in grade 1.

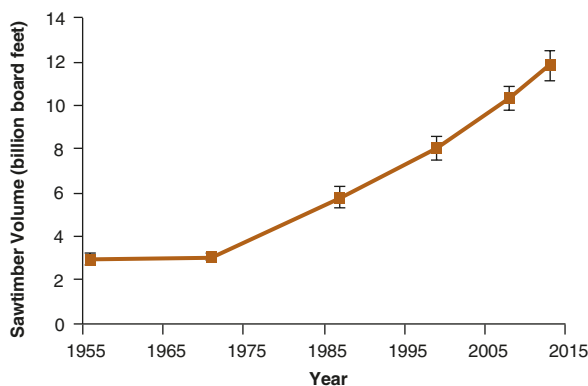


Figure 67.—Sawtimber volume on timberland by inventory year, New Jersey. Error bars represent a 68 percent confidence interval.

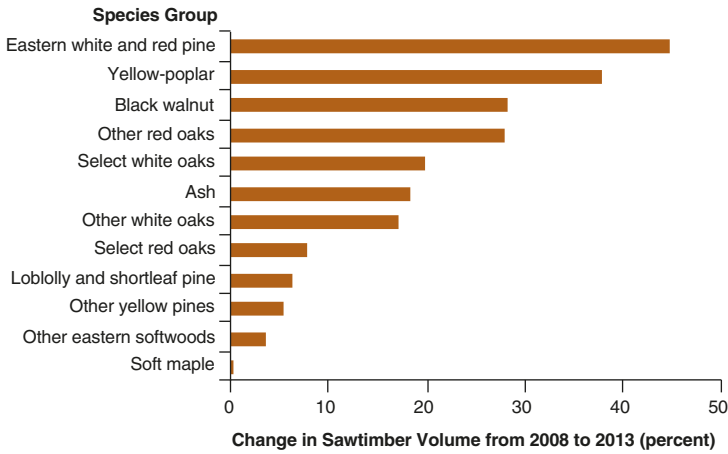


Figure 68.—Percent change in sawtimber volume on timberland for 12 selected species groups, New Jersey.

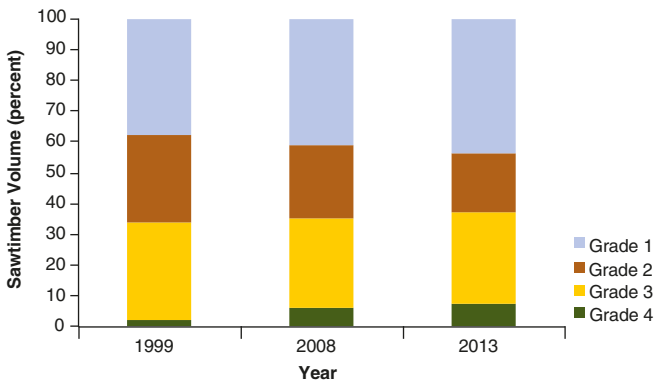


Figure 69.—Sawtimber volume for hardwood species on timberland by tree grade and inventory year, New Jersey.

What this means

New Jersey's sawtimber resource has been steadily increasing for decades. This is indicative of a stable and sustainable component of the forest ecosystem. If current trends continue, one would expect increasing sawtimber volumes into the foreseeable future. However, this assumption may not hold locally, or following unexpected forest disturbances (e.g., invasive pests, disease, or weather).

Timber Products

Background

The harvesting and processing of timber products produce a stream of income shared by timber owners, managers, loggers, marketers, truckers, and processors. Although the wood products and paper manufacturing industries (including primary and secondary processors) in New Jersey are relatively small, 9,659 people were employed in 2013, with an average annual payroll of \$485.8 million (U.S. Census Bureau 2015). To better manage the State's forests, it is important to know the species, amounts, and locations of timber being harvested.

Surveys of New Jersey's wood-processing mills are conducted periodically to estimate the amount of wood volume that is processed into wood products. This information is supplemented with the most recent surveys conducted in surrounding states that processed wood harvested from New Jersey. Five active primary wood-processing mills were surveyed to determine the volume of industrial roundwood processed in 2010, by species and by the state and county that the wood material came from.

What we found

New Jersey mills processed more than 5.7 million board feet (941,000 cubic feet), nearly all of which originated from forest land within the State. About 1.1 million cubic feet of industrial roundwood was harvested, including roundwood that was harvested in New Jersey but was exported to primary wood-processing mills in other states. Eighty-six percent of the industrial roundwood harvested was processed by sawmills, with the remainder processed by pulp and composite panel mills (Fig. 70). All timber harvested for pulp and composite panel production was exported to mills in other states. Sweetgum accounted for more than 40 percent (454,000 cubic feet) of the total industrial roundwood harvested (Fig. 71). Other important species groups harvested were the red oaks, white oaks, and pines. The processing of industrial roundwood by the State's primary wood-using mills generated 15,200 green tons of wood and bark residues. More than 95 percent of these mill residues were used for mulch. Mill residues were also used for pulp, residential fuelwood, animal bedding, and other miscellaneous uses. Less than 1 percent of the mill residues were not used for other products.

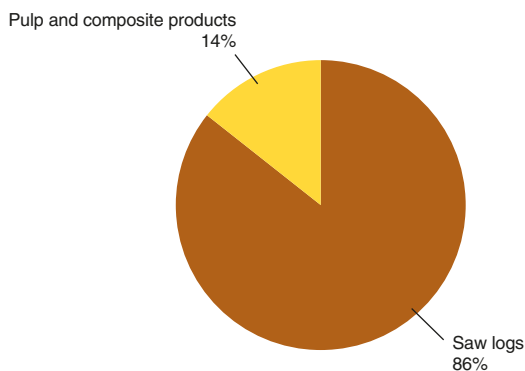


Figure 70.—Industrial roundwood production by product, New Jersey, 2010.

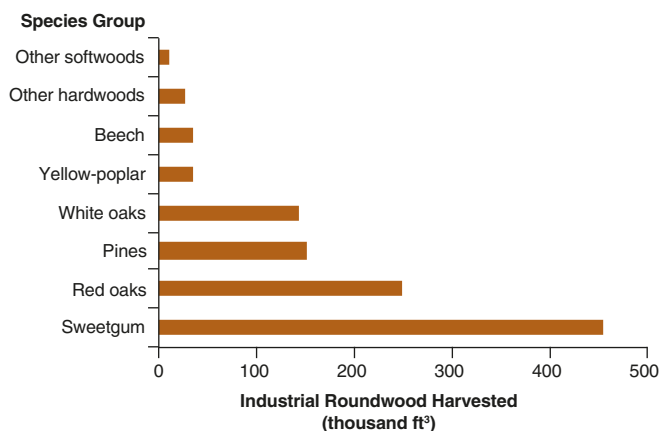


Figure 71.—Industrial roundwood harvested by species group, New Jersey, 2010.

What this means

An important consideration for the future of the primary wood-products industry is its ability to retain industrial roundwood processing facilities. The number of wood-processing mills has been steadily declining. The loss of processing facilities makes it harder for landowners to find markets for the timber harvested from management activities on their forest land.

Future Forests



View from Wildlife Drive at Edwin B. Forsythe National Wildlife Refuge. Photo by Chelsi Hornbaker, U.S. Fish and Wildlife Service.

Future Forest Projections

Background

Future forest change will largely be the result of normal forest growth, aging, natural regeneration, and species succession. External forces, such as the following examples, will also influence forest change:

- Population increases will cause roughly 0.5 million acres of forest land to be converted to urban land.
- Economic conditions will affect forest products consumption, production, and harvest rates.
- The spread of invasive species will affect forest composition.
- Changes in human population, the economy, energy consumption, and energy production will affect future climate change.
- Climate change will affect patterns of forest growth and species succession.

The Northern Forest Futures study focuses on anticipated changes to forests between 2010 and 2060 (Shifley and Moser 2016). This study examined several alternative futures covering a range of different assumptions about the economy, population, climate, and other driving forces that will affect the future conditions of forests. The assumptions were incorporated into seven scenarios that consider how different alternative future climate conditions, demographic changes, and economic policies will affect forests. Additional details on methods can be found in Shifley and Moser (2016).

The seven scenarios that were considered are briefly described below. Naming conventions relate to the more detailed scenario descriptions that originated from the Intergovernmental Panel on Climate Change (2000):

- 1) A1B-C—Moderate population growth and rapid economic growth.
- 2) A1B-C-BIO—Moderate population growth and rapid economic growth including the potential impact of increased harvest and utilization of woody biomass for energy.
- 3) A2-C—Rapid population growth and moderate economic growth.
- 4) A2-C-BIO—Rapid population growth and moderate economic growth including the potential impact of increased harvest and utilization of woody biomass for energy.

- 5) A2-C-EAB—Rapid population growth and moderate economic growth including the potential impact of continued spread of emerald ash borer with associated mortality of all ash trees in the affected areas.
- 6) B2-C—A trend toward low population growth and low economic growth.
- 7) B2-C-BIO—A trend toward low population growth and low economic growth including the potential impact of increased harvest and utilization of woody biomass for energy.

What we found

Over the next 50 years, forest land is predicted to decline under all scenarios, thus reversing the long-term trend of increasing forest area in New Jersey (Fig. 72). Specifically, these declines are approximated to be 31 percent under scenario A1B-C, 35 percent under scenario A2-C, and 20 percent under scenario B2-C. The greater the assumed increases in population and economic activity, the greater the projected loss of future forest land—thus the higher predicted loss of forest land in the A1B and A2 scenarios. Forest land, which made up 41 percent of New Jersey’s land base in 2010, is expected to fall to between 27 and 34 percent of total land area.

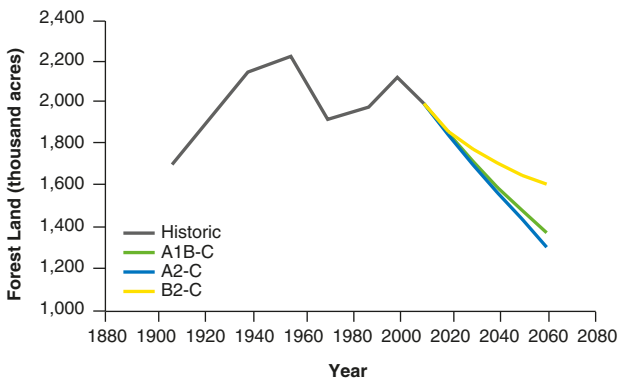


Figure 72.—Projected area of forest land by scenario, New Jersey, 2010-2060.

Although the elm/ash/cottonwood forest type is projected to decline by 24,000 acres between 2010 and 2060 under the A2-C-EAB scenario, it remains about 4 percent of total area (Fig. 73). Ash volume is predicted to fall under both the A2-C-EAB and A2-C scenarios; however, the greater decrease is predicted in the A2-C-EAB scenario, where it declines from 231 million cubic feet in 2010 to 0 cubic feet by 2030. Under the standard A2-C scenario, ash volume remains at 169 million cubic feet in 2060.

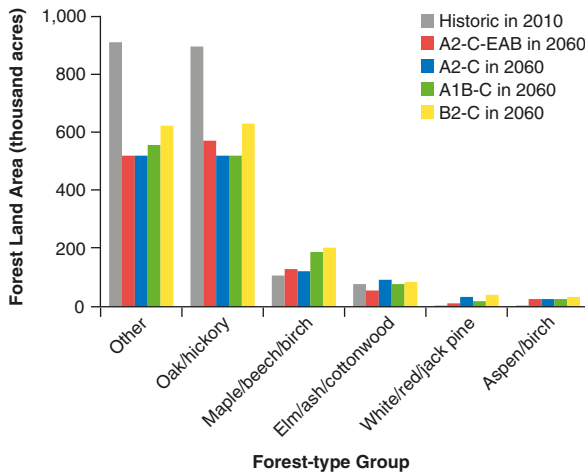


Figure 73.—Projected area of forest land by forest-type group and scenario, New Jersey, 2010-2060.

Due to the projected loss of forest land, live-tree volume on forest land in 2060 is expected to decrease under all scenarios. All three high biomass utilization scenarios (A1B-C-BIO, B2-C-BIO and A2-C-BIO) result in lower levels of live-tree volume in 2060 than do their corresponding normal biomass utilization scenarios (A1B-C, B2-C, and A2-C). Volume per acre is anticipated to increase by the following percentages for six of the seven scenarios: A1B-C (6 percent), A1B-C-BIO (1 percent), A2-C (3 percent), A2-C-BIO (11 percent), B2-C (10 percent), and B2C-BIO (3 percent) as forests continue to mature. Volume per acre is expected to drop by 4 percent for scenario A2-C-EAB. Average annual removals of growing stock on timberland are expected to increase under all scenarios, but removals rates may not be sustainable for the high biomass utilization scenarios (Fig. 74).

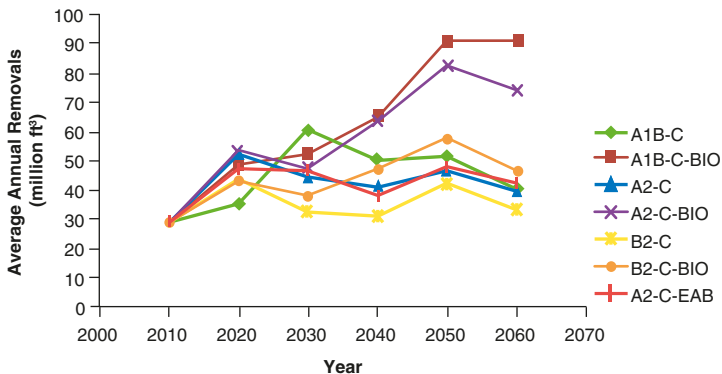


Figure 74.—Average annual removals of growing stock on timberland by scenario, New Jersey, 2010-2060.

What this means

Projected trends reflect the combined effects of population and economic growth, which are expected to lean heavily toward continually maturing forests with decreasing forest area. These projections are considered to be possible trends, and they will be influenced by actual future climate conditions, demographic changes, and economic policies relative to the assumptions. Knowledge of potential trends in future forest conditions helps elucidate the impacts to forest land given a variety of circumstances. This knowledge also provides valuable information on future directions of and associated impacts on long-term forest health and sustainability. An understanding of the implications of potential changes will allow managers to make informed decisions and manage for desired future conditions.

Data Sources and Techniques

Forest Inventory

Information on the condition and status of forests in New Jersey was obtained from the Northern Research Station's Forest Inventory and Analysis (NRS-FIA) program. Previous inventories of New Jersey's forest resources were completed in 1956 (Webster and Stoltenberg 1958), 1971 (Ferguson and Mayer 1974), and 1987 and 1999 (Griffith and Widmann 2001). Data from New Jersey's forest inventories can be found online at <http://www.nrs.fs.fed.us/fia>. For detailed information on inventory methods, see the Statistics, Methods, and Quality Assurance section online at <https://doi.org/10.2737/NRS-RB-109>.

National Woodland Owner Survey

Information about family forest owners is collected annually through the U.S. Forest Service's National Woodland Owner Survey (NWOS). The NWOS was designed to increase our understanding of owner demographics and motivation (Butler et al. 2016). Individuals and private groups identified as woodland owners by FIA are invited to participate in the NWOS. Each year, questionnaires are mailed to 20 percent of private owners, with more detailed questionnaires sent out in years that end in 2 or 7 to coincide with national census, inventory, and assessment programs. Data presented here are based on survey responses from randomly selected families and individuals who own forest land in New Jersey. For additional information about the NWOS, visit www.fia.fs.fed.us/nwos.

Timber Products Output Inventory

Using a questionnaire designed to determine the size and composition of New Jersey's forest products industry, its use of roundwood (round sections cut from trees), and its generation and disposition of wood residues, NRS-FIA personnel contacted via mail and telephone all primary wood-using mills in the State. Completed questionnaires were sent to NRS-FIA for processing. As part of data processing, all industrial roundwood volumes reported were converted to standard units of measure using regional conversion factors.

Literature Cited

- Bechtold, W.A.; Patterson, P.L., eds. 2005. **The enhanced Forest Inventory and Analysis program—national sampling design and estimation procedures**. Gen. Tech. Rep. SRS-80. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 85 p.
- Breiman, L. 2001. **Random forests**. Machine Learning. 45: 15-32.
- Butler, B.J.; Hewes, J.H.; Dickinson, B.J.; Andrejczyk, K.; Butler, S.M.; Markowski-Lindsay, M. 2016. **U.S. Forest Service National Woodland Owner Survey: national, regional, and state statistics for family forest and woodland ownerships with 10+ acres, 2011-2013**. Resour. Bull. NRS-99. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 39 p.
- Cipollini, D. 2015. **White fringetree as a novel larval host for emerald ash borer**. Journal of Economic Entomology. 108(1): 370-375.
- Clarke, S.R.; Nowak, J.T. 2009. **Southern pine beetle**. Forest Insect and Disease Leaflet 49. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 8 p.
- Collins, B.R.; Anderson, K.H. 1994. **Plant communities of New Jersey: a study in landscape diversity**. New Brunswick, NJ: Rutgers University Press. 287 p.
- Conservation Biology Institute. 2010. **Protected areas database of the United States, PAD-US**. CBI edition. Available at <https://protectedareas.databasin.org> (accessed January 2014).
- Coulston, J.W.; Moisen, G.G.; Wilson, B.T.; Finco, M.V.; Cohen, W.B.; Brewer, C.K. 2012. **Modeling percent tree canopy cover: a pilot study**. Photogrammetric Engineering & Remote Sensing 78(7): 715-727.
- Crocker, S.J.; Nelson, M.D.; Barnett, C.J.; Brand, G.J.; Butler, B.J.; Domke, G.M.; Hansen, M.H.; Hatfield, M.A.; Lister, T.W.; Meneguzzo, D.M.; Perry, C.H.; Piva, R.J.; Wilson, B.T.; Woodall, C.W.; Zipse, W. 2011. **New Jersey's forests 2008**. Resour. Bull. NRS-59. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 52 p. [DVD included].
- Fan, Z.; Shifley, S.R.; Spetich, M.A.; Thompson, F.R., III; Larsen, D.R. 2003. **Distribution of cavity trees in midwestern old-growth and second-growth forests**. Canadian Journal of Forest Research. 33: 1481-1494. <http://dx.doi.org/10.1139/x03-068>.

- Ferguson, R.H.; Mayer, C.E. 1974. **The timber resources of New Jersey.** Res. Bull. NE-34. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 45 p.
- Griffith, D.M.; Widmann, R.H. 2001. **Forest statistics for New Jersey: 1987 and 1999.** Resour. Bull. NE-152. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 33 p.
- Harlow, W.M.; Harrar, E.S.; Hardin, J.W.; White, F.M. 1996. **Textbook of dendrology.** 8th ed. New York: McGraw-Hill. 534 p.
- Heath, L.S.; Hansen, M.H.; Smith, J.E.; Smith, W.B.; Miles, P.D. 2009. **Investigation into calculating tree biomass and carbon in the FIADB using a biomass expansion factor approach.** In: McWilliams, W.; Moisen, G.; Czaplewski, R., comps. 2008 Forest Inventory and Analysis symposium; 2008 October 21-23; Park City, UT. Proc. RMRS-P-56CD. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. [CD].
- Helms, J.A., ed. 1998. **The dictionary of forestry.** Bethesda, MD: Society of American Foresters. 210 p.
- Hermes, D.A.; McCullough, D.G. 2014. **Emerald ash borer invasion on North America: history, biology, ecology, impacts and management.** Annual Review of Entomology. 59(1): 13-30. <http://dx.doi.org/10.1146/annurev-ento-011613-162051>.
- Homer, C.G.; Dewitz, J.A.; Yang, L.; Jin, S.; Danielson, P.; Xian, G.; Coulston, J.W.; Herold, N.D.; Wickham, J.D.; Megown, K.A. 2015. **Completion of the 2011 National Land Cover Database for the conterminous United States—representing a decade of land cover change information.** Photogrammetric Engineering & Remote Sensing. 81 (5): 345-354. <http://dx.doi.org/10.14358/PERS.81.5.345>.
- Honnay, O.; Jacquemyn, H.; Bossuyt, B.; Hermy, M. 2005. **Forest fragmentation effects on patch occupancy and population viability of herbaceous plant species.** New Phytologist. 166(3): 723-736. <http://dx.doi.org/10.1111/j.1469-8137.2005.01352.x>.
- Hunter, W.C.; Buehler, D.A.; Canterbury, R.A.; Confer, J.L.; Hamel, P.B. 2001. **Conservation of disturbance-dependent birds in eastern North America.** Wildlife Society Bulletin. 29(2): 440-455.
- Intergovernmental Panel on Climate Change [IPCC]. 2000. **Summary for policymakers: emissions scenarios.** Geneva, Switzerland. 21 p. <https://www.ipcc.ch/pdf/special-reports/spm/sres-en.pdf> (accessed July 31, 2014).

- Kapos, V.; Lysenko, I.; Lesslie, R. 2000. **Assessing forest integrity and naturalness in relation to biodiversity**. On behalf of FAO as part of the Global Forest Resources Assessment 2000. Working Paper 54. Rome, Italy: Food and Agriculture Organization of the United Nations/UNEP-World Conservation Monitoring Centre. 65 p.
- Liebhold, A.M.; Gottschalk, K.W.; Muzika, R.; Montgomery, M.E.; Young, R.; O'Day, K.; Kelley, B. 1995. **Suitability of North American tree species to the gypsy moth: a summary of field and laboratory tests**. Gen. Tech. Rep. NE-211. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 34 p.
- McRoberts, R.E. 1999. **Joint annual forest inventory and monitoring system, the North Central perspective**. Journal of Forestry. 97(12): 27-31.
- McRoberts, R.E. 2005. **The enhanced Forest Inventory and Analysis program**. In: Bechtold, W.A.; Patterson, P.L., eds. The enhanced Forest Inventory and Analysis program—national sampling design and estimation procedures. Gen. Tech. Rep. SRS-80. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 1-10.
- Miles, P.D.; Smith, W.B. 2009. **Specific gravity and other properties of wood and bark for 156 tree species found in North America**. Res. Pap. NRS-38. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 35 p.
- Montreal Process. 1999. **Criteria and indicators for the conservation and sustainable management of temperate and boreal forests: the Montreal process**. 2nd ed. Ottawa, ON: Natural Resources Canada, Canadian Forest Service. 19 p.
- Morin, R.S.; Randolph, K.C.; Steinman, J. 2015. **Mortality rates associated with crown health for eastern forest tree species**. Environmental Monitoring and Assessment 187: 87. <http://dx.doi.org/10.1007/s10661-015-4332-x>.
- Natural Resources Conservation Service. 2015. **The PLANTS database**. Greensboro, NC: U.S. Department of Agriculture, Natural Resources Conservation Service, National Plant Data Team. www.plants.usda.gov (accessed July 22, 2014).
- O'Connell, B.M.; LaPoint, E.B.; Turner, J.A.; Ridley, T.; Pugh, S.A.; Wilson, A.M.; Waddell, K.L.; Conkling, B.L. 2014. **The Forest Inventory and Analysis database: database description and user guide, ver. 6.0.1 for Phase 2**. Washington, DC: U.S. Department of Agriculture, Forest Service. 748 p. Available at <http://www.fia.fs.fed.us/library/database-documentation/>.

- O'Neill, K.P.; Amacher, M.C.; Perry, C.H. 2005. **Soils as an indicator of forest health: a guide to the collection, analysis, and interpretation of soil indicator data in the Forest Inventory and Analysis program.** Gen. Tech. Rep. NC-258. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 53 p.
- Pimentel, D.; Lach, L.; Zuniga, R.; Morrison, D. 2000. **Environmental and economic costs of nonindigenous species in the United States.** *Bioscience*. 50(1): 53-65. [http://dx.doi.org/10.1641/0006-3568\(2000\)050%0053:EAECON%5D2.3.CO;2](http://dx.doi.org/10.1641/0006-3568(2000)050%0053:EAECON%5D2.3.CO;2).
- Radeloff, V.C.; Hammer, R.B.; Stewart, S.I.; Fried, J.S.; Holcomb, S.S.; McKeefry, J.F. 2005. **The wildland urban interface in the United States.** *Ecological Applications*. 15: 799-805. <http://dx.doi.org/10.1890/04-1413>.
- Russell, M.B.; Woodall, C.W.; D'Amato, A.W.; Fraver, S.; Bradford, J.B. 2014a. **Linking climate change and downed woody debris decomposition across forests of the eastern United States.** *Biogeosciences*. 11(22): 6417-6425. <http://dx.doi.org/10.5194/bg-11-6417.2014>.
- Russell, M.B.; Woodall, C.W.; Fraver, S.; D'Amato, A.W.; Domke, G.M.; Skog, K.E. 2014b. **Residence time and rate of decay for downed woody debris biomass/carbon in eastern US forests.** *Ecosystems*. 17: 765-777. <http://dx.doi.org/10.1007/s10021-014-9757-5>.
- Schomaker, M.E.; Zarnoch, S.J.; Bechtold, W.A.; Latelle, D.J.; Burkman, W.G.; Cox, S.M. 2007. **Crown-condition classification: a guide to data collection and analysis.** Gen. Tech. Rep. SRS-102. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 78 p.
- Schulz, B.K.; Bechtold, W.A.; Zarnoch, S.J. 2009. **Sampling and estimation procedures for the vegetation diversity and structure indicator.** Gen. Tech. Rep. PNW-GTR-781. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 53 p.
- Scott, V.E.; Evans, K.E.; Patton, D.R.; Stone, C.P. 1977. **Cavity-nesting birds of North American forests.** *Agric. Handb.* 511. Washington, DC: U.S. Department of Agriculture, Forest Service. 112 p.
- Shifley, S.R.; Moser, W.K., eds. 2016. **Future forests of the Northern United States.** Gen. Tech. Rep. NRS-151. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 388 p.
- Smith, G.C.; Coulston, J.W.; O'Connell, B.M. 2008. **Ozone bioindicators and forest health: a guide to the evaluation, analysis, and interpretation of the ozone injury data in the Forest Inventory and Analysis program.** Gen. Tech. Rep. NRS-34. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 100 p.

- Smith-Fiola, D.; Hamilton, G.C.; Lashomb, J. 2004. **The hemlock woolly adelgid: life cycle, monitoring, and pest management in New Jersey**. New Brunswick, NJ: Rutgers, The State University of New Jersey, Cooperative Research and Extension. 2 p. <http://njaes.rutgers.edu/pubs/publication.asp?pid=FS751> (accessed April 25, 2011).
- Steinman, J. 2000. **Tracking the health of trees over time on forest health monitoring plots**. In: Hansen, M.; Burk, T., eds. Integrated tools for natural resources inventories in the 21st century; 1998 August 16-20; Boise, ID. Gen. Tech. Rep. NC-212. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station: 334-339.
- Thatcher, R.C.; Searcy, J.L.; Coster, J.E.; Hertel, G.D., eds. 1980. **The southern pine beetle**. Tech. Bull. 1631. Pineville, LA: U.S. Department of Agriculture, Forest Service. 265 p.
- U.S. Census Bureau. 2015. **Annual survey of manufactures**. Washington, DC: U.S. Department of Commerce, Census Bureau. Available at <http://www.census.gov/manufacturing/asm/index.html> (accessed October 1, 2015).
- U.S. Environmental Protection Agency. 2015. **Inventory of U.S. greenhouse gas emissions and sinks: 1990-2013**. EPA 430-R-15-004. Washington, DC: U.S. Environmental Protection Agency, Office of Atmospheric Programs. <http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html>.
- U.S. Forest Service. 2005. **Forest inventory and analysis field methods for forest health (Phase 3) measurements, ver. 3.0**. Washington, DC: U.S. Department of Agriculture, Forest Service. Available at <http://fia.fs.fed.us/library/field-guides-methods-proc/docs/2006/Version-3.0.pdf> (accessed October 28, 2010).
- U.S. Forest Service. 2010a. **Forest Inventory and Analysis national core field guide: field data collection procedures for Phase 2 plots, ver. 5.0**. U.S. Department of Agriculture, Forest Service. [http://www.fia.fs.fed.us/library/field-guides-methods-proc/docs/Complete FG Document/NRS FG 5.0-Oct 2010-Complete Document.pdf](http://www.fia.fs.fed.us/library/field-guides-methods-proc/docs/Complete%20FG%20Document/NRS%20FG%205.0-Oct%202010-Complete%20Document.pdf) (accessed April 11, 2016).
- U.S. Forest Service. 2010b. **Hemlock woolly adelgid**. NA-PR-09-05. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry. 2 p.
- U.S. Geological Survey. 2011. **1997-2014 edition of the National Atlas of the United States**. Reston, VA: U.S. Department of the Interior, Geological Survey. Archived at <http://catalog.data.gov/harvest/1997-2014-edition-of-the-national-atlas-of-the-united-states>. [Note that the homepage for the new National Map is www.nationalmap.gov/small_scale (accessed August 17, 2016)].

- Webster, H.H.; Stoltenberg, C.H. 1958. **The timber resources of New Jersey. A report on the Forest Survey made by the U.S. Forest Service.** Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 45 p.
- Westfall, J.A.; Frieswyk, T.; Griffith, D.M. 2009. **Implementing the measurement interval midpoint method for change estimation.** In: McRoberts, R.E.; Reams, G.A.; Van Deusen, P.C.; McWilliams, W.H. eds. Proceedings of the eighth annual Forest Inventory and Analysis symposium; 2006 October 16-19; Monterey, CA. Gen. Tech. Rep. WO-79. Washington, DC: U.S. Department of Agriculture, Forest Service: 231-236.
- Wilcox, B.A.; Murphy, D.D. 1985. **Conservation strategy: the effects of fragmentation on extinction.** *American Naturalist*. 125(6): 879-887.
- Wilson, B.T.; Lister, A.J.; Riemann, R.I. 2012. **A nearest-neighbor imputation approach to mapping tree species over large areas using forest inventory plots and moderate resolution raster data.** *Forest Ecology and Management*. 271: 182-198. <http://dx.doi.org/10.1016/j.foreco.2012.02.002>.
- Woodall, C.W.; Amacher, M.C.; Bechtold, W.A.; Coulston, J.W.; Jovan, S.; Perry, C.H.; Randolph, K.C.; Schulz, B.K.; Smith, G.C.; Tkacz, B.; Will-Wolf, S. 2011. **Status and future of the forest health indicators program of the USA.** *Environmental Monitoring and Assessment*. 177(1): 419-436. <http://dx.doi.org/10.1007/s10661-010-1644-8>.
- Woodall, C.W.; Monleon, V.J. 2008. **Sampling protocols, estimation, and analysis procedures for the down woody materials indicator of the FIA program.** Gen. Tech. Rep. NRS-22. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 68 p.
- Woodall, C.W.; Walters, B.F.; Oswalt, S.N.; Domke, G.M.; Toney, C.; Gray, A.N. 2013. **Biomass and carbon attributes of downed woody materials in forests of the United States.** *Forest Ecology and Management*. 305: 48-59. <http://dx.doi.org/10.1016/j.foreco.2013.05.030>.

Appendixes

Appendix 1.—List of tree species, New Jersey, 2013

Common name	Genus	Species
boxelder	<i>Acer</i>	<i>negundo</i>
striped maple	<i>Acer</i>	<i>pensylvanicum</i>
Norway maple	<i>Acer</i>	<i>platanoides</i>
red maple	<i>Acer</i>	<i>rubrum</i>
silver maple	<i>Acer</i>	<i>saccharinum</i>
sugar maple	<i>Acer</i>	<i>saccharum</i>
ailanthus	<i>Ailanthus</i>	<i>altissima</i>
serviceberry spp.	<i>Amelanchier</i>	spp.
yellow birch	<i>Betula</i>	<i>alleghaniensis</i>
sweet birch	<i>Betula</i>	<i>lenta</i>
river birch	<i>Betula</i>	<i>nigra</i>
gray birch	<i>Betula</i>	<i>populifolia</i>
American hornbeam, musclewood	<i>Carpinus</i>	<i>caroliniana</i>
mockernut hickory	<i>Carya</i>	<i>alba</i>
bitternut hickory	<i>Carya</i>	<i>cordiformis</i>
pignut hickory	<i>Carya</i>	<i>glabra</i>
shagbark hickory	<i>Carya</i>	<i>ovata</i>
American chestnut	<i>Castanea</i>	<i>dentata</i>
hackberry	<i>Celtis</i>	<i>occidentalis</i>
Atlantic white-cedar	<i>Chamaecyparis</i>	<i>thyoides</i>
flowering dogwood	<i>Cornus</i>	<i>florida</i>
common persimmon	<i>Diospyros</i>	<i>virginiana</i>
Russian-olive	<i>Elaeagnus</i>	<i>angustifolia</i>
American beech	<i>Fagus</i>	<i>grandifolia</i>
white ash	<i>Fraxinus</i>	<i>americana</i>
black ash	<i>Fraxinus</i>	<i>nigra</i>
green ash	<i>Fraxinus</i>	<i>pennsylvanica</i>
American holly	<i>Ilex</i>	<i>opaca</i>
black walnut	<i>Juglans</i>	<i>nigra</i>
eastern redcedar	<i>Juniperus</i>	<i>virginiana</i>
sweetgum	<i>Liquidambar</i>	<i>styraciflua</i>
yellow-poplar	<i>Liriodendron</i>	<i>tulipifera</i>
Osage-orange	<i>Maclura</i>	<i>pomifera</i>
sweetbay	<i>Magnolia</i>	<i>virginiana</i>
apple spp.	<i>Malus</i>	spp.
red mulberry	<i>Morus</i>	<i>rubra</i>
blackgum	<i>Nyssa</i>	<i>sylvatica</i>

(Appendix continued on next page.)

(Appendix continued)

Common name	Genus	Species
eastern hophornbeam	<i>Ostrya</i>	<i>virginiana</i>
Norway spruce	<i>Picea</i>	<i>abies</i>
shortleaf pine	<i>Pinus</i>	<i>echinata</i>
red pine	<i>Pinus</i>	<i>resinosa</i>
pitch pine	<i>Pinus</i>	<i>rigida</i>
pond pine	<i>Pinus</i>	<i>serotina</i>
eastern white pine	<i>Pinus</i>	<i>strobus</i>
Scotch pine	<i>Pinus</i>	<i>sylvestris</i>
loblolly pine	<i>Pinus</i>	<i>taeda</i>
Virginia pine	<i>Pinus</i>	<i>virginiana</i>
American sycamore	<i>Platanus</i>	<i>occidentalis</i>
eastern cottonwood	<i>Populus</i>	<i>deltoides</i>
bigtooth aspen	<i>Populus</i>	<i>grandidentata</i>
cottonwood and poplar spp.	<i>Populus</i>	spp.
quaking aspen	<i>Populus</i>	<i>tremuloides</i>
sweet cherry, domesticated	<i>Prunus</i>	<i>avium</i>
black cherry	<i>Prunus</i>	<i>serotina</i>
white oak	<i>Quercus</i>	<i>alba</i>
swamp white oak	<i>Quercus</i>	<i>bicolor</i>
scarlet oak	<i>Quercus</i>	<i>coccinea</i>
southern red oak	<i>Quercus</i>	<i>falcata</i>
scrub oak	<i>Quercus</i>	<i>ilicifolia</i>
laurel oak	<i>Quercus</i>	<i>laurifolia</i>
blackjack oak	<i>Quercus</i>	<i>marilandica</i>
swamp chestnut oak	<i>Quercus</i>	<i>michauxii</i>
chinkapin oak	<i>Quercus</i>	<i>muehlenbergii</i>
pin oak	<i>Quercus</i>	<i>palustris</i>
willow oak	<i>Quercus</i>	<i>phellos</i>
chestnut oak	<i>Quercus</i>	<i>prinus</i>
northern red oak	<i>Quercus</i>	<i>rubra</i>
post oak	<i>Quercus</i>	<i>stellata</i>
black oak	<i>Quercus</i>	<i>velutina</i>
black locust	<i>Robinia</i>	<i>pseudoacacia</i>
black willow	<i>Salix</i>	<i>nigra</i>
sassafras	<i>Sassafras</i>	<i>albidum</i>
American basswood	<i>Tilia</i>	<i>americana</i>
basswood	<i>Tilia</i>	spp.
eastern hemlock	<i>Tsuga</i>	<i>canadensis</i>
American elm	<i>Ulmus</i>	<i>americana</i>
slippery elm	<i>Ulmus</i>	<i>rubra</i>

Tree Species

ailanthus (*Ailanthus altissima*)
black locust (*Robinia pseudoacacia*)
chinaberry (*Melia azedarach*)
Norway maple (*Acer platanoides*)
paulownia, princess tree (*Paulownia tomentosa*)
punktree, melaleuca (*Melaleuca quinquenervia*)
Russian-olive (*Elaeagnus angustifolia*)
saltcedar (*Tamarix ramosissima*)
Siberian elm (*Ulmus pumila*)
silktree, mimosa (*Albizia julibrissin*)
Chinese tallowtree (*Triadica sebifera*)

Shrub Species

autumn-olive (*Elaeagnus umbellata*)
common barberry (*Berberis vulgaris*)
common buckthorn (*Rhamnus cathartica*)
European cranberrybush (*Viburnum opulus*)
European privet (*Ligustrum vulgare*)
glossy buckthorn (*Frangula alnus*)
Japanese barberry (*Berberis thunbergii*)
Japanese meadowsweet (*Spiraea japonica*)
multiflora rose (*Rosa multiflora*)
nonnative bush honeysuckles (*Lonicera* spp.)

Vine Species

English ivy (*Hedera helix*)
Japanese honeysuckle (*Lonicera japonica*)
Oriental bittersweet (*Celastrus orbiculatus*)

Herbaceous Species

black swallow-wort (*Cynanchum louiseae*)
bull thistle (*Cirsium vulgare*)
Canada thistle (*Cirsium arvense*)
creeping jenny (*Lysimachia nummularia*)
dames rocket (*Hesperis matronalis*)
European swallow-wort (*Cynanchum rossicum*)
garlic mustard (*Alliaria petiolata*)
giant knotweed (*Polygonum sachalinense*)
Japanese knotweed (*Polygonum cuspidatum*)
leafy spurge (*Euphorbia esula*)
Bohemian knotweed (*Polygonum xbohemicum*)
purple loosestrife (*Lythrum salicaria*)
spotted knapweed (*Centaurea stoebe* ssp. *micranthos*)

Grass Species

common reed (*Phragmites australis*)
Nepalese browntop (*Microstegium vimineum*)
reed canarygrass (*Phalaris arundinacea*)



Oak/pine stand with an understory of blueberry. Photo by Rich Widmann, U.S. Forest Service.

Crocker, Susan J.; Barnett, Charles J.; Butler, Brett J.; Hatfield, Mark A.; Kurtz, Cassandra M.; Lister, Tonya W.; Meneguzzo, Dacia M.; Miles, Patrick D.; Morin, Randall S.; Nelson, Mark D.; Piva, Ronald J.; Riemann, Rachel; Smith, James E.; Woodall, Christopher W.; Zipse, William. 2017. **New Jersey Forests 2013**. Resour. Bull. NRS-109. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 90 p.

The second full annual inventory of New Jersey's forests reports more than 2.0 million acres of forest land and 77 tree species. Forest land is dominated by oak/hickory forest types in the north and pitch pine forest types in the south. The volume of growing stock on timberland has been rising since 1956 and currently totals 3.3 billion cubic feet. Average annual net growth of growing stock from 2008 to 2013 was about 65.7 million cubic feet per year. This report includes additional information on forest attributes, land-use change, carbon, timber products, and forest health. The following information is available online at <https://doi.org/10.2737/NRS-RB-109>: 1) detailed information on forest inventory statistics, methods, and quality assurance of data collection, 2) a glossary of terms, 3) tables that summarize quality assurance, 4) a core set of tabular estimates for a variety of forest resources, and 5) a Microsoft® Access database that represents an archive of data used in this report, with tools that allow users to produce customized estimates.

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

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at http://www.ascr.usda.gov/complaint_filing_cust.html and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by: (1) mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, SW, Washington, D.C. 20250-9410; (2) fax: (202) 690-7442; or (3) email: program.intake@usda.gov.



Northern Research Station

www.nrs.fs.fed.us