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Missouri Forests 2018: Summary Report



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Abstract

This summary report provides an overview of findings from the fourth annualized inventory of Missouri forests based on data collected from 2012 to 2018. Forest land area remained stable at 15.4 million acres, and 80 percent of forest land is in the oak/hickory forest-type group. Forests in the State continue to mature with 64 percent in large diameter stands and 61 percent in stands older than 60 years of age. Live tree net volume on timberland totals 20.9 billion cubic feet, and 79 percent of that volume is in growing-stock trees. Mortality increased by 17 percent from 2013 to 2018 to 333 million cubic feet per year, resulting in a 7 percent decrease in annual net growth to 371 million cubic feet. Additional information on land-use change, fragmentation, ownership, urban forests, species composition, stand structure, forest carbon, down woody material, regeneration, invasive plants, forest pests, tree health, and timber products output are also presented. A detailed interactive report is available at <https://doi.org/10.2737/NRS-RB-122-INT>, and supplemental information, including (1) tables summarizing quality assurance, (2) a core set of tabular estimates for a variety of forest resources, and (3) user and database guides for P2 and P2+ protocols, can be accessed at <https://doi.org/10.2737/NRS-RB-122>.

KEY WORDS: inventory, land use, fragmentation, forest land, timberland, forest ownership, urban forests, volume, growth, removals, mortality, carbon, forest regeneration, invasive plants, forest health, forest products

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Cover photo: Spring Creek Gap Conservation Area. Photo by Missouri Department of Conservation, used with permission.

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Foreword

Welcome to the fourth 5-year report from the U.S. Department of Agriculture's Forest Service statewide forest inventory, "Missouri Forests 2018." This inventory is conducted as a cooperative program between the Missouri Department of Conservation and the Forest Inventory and Analysis program of the Forest Service. Results of the inventory show that Missouri forests have increased substantially since 1989. Missouri forests are growing more wood than is being harvested. Missouri forests support a forest products industry that contributes over \$10.3 billion annually to the Missouri economy (2017 dollars) through jobs, personal income, product sales, and sales tax. In addition, Missouri forests provide high quality wildlife habitat, clean and abundant water, clean air, and diverse outdoor recreation opportunities for both today's citizens and the next generation of Missourians.

Missouri forests are stable and in good health, but they also face a variety of concerns. For example, white oak is declining due to a complex mix of pathogens and environmental factors that are not fully understood, and a long list of invasive plant species are competing with native plants for space and nutrients. The impacts of emerald ash borer can clearly be seen, with annual mortality volume of ash on forest land increasing 57 percent since the 2013 report. Land ownership parcellation and forest land conversion to other land uses result in smaller, fragmented forests. Missourians expect and need responsible management of our forests that will result in abundant renewable resources and improve the quality of forests habitats. "Missouri Forests 2018" gives those who are interested in these issues a common set of scientifically gathered, statistically accurate numbers that we can use to make responsible management decisions.

I trust this document will be informative and inspire you to join us in our pursuit to sustain Missouri's treasured trees and forests.

Justine Gartner

State Forester

Missouri Department of Conservation

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Missouri Forests Summary Tables Online at <https://doi.org/10.2737/NRS-RB-122>

Additional Resources Online at <https://doi.org/10.2737/NRS-RB-122>



Ha Ha Tonka State Park. Photo by Missouri Department of Conservation, used with permission.

Highlights

On the Plus Side

- Forest land in Missouri remains relatively stable at 15.4 million acres.
- Aboveground live biomass increased by 2.6 percent since the 2013 survey to 658,074.4 thousand dry tons.
- Net volume of live trees on forest land increased 3.3 percent from 2013 to 2018 to 21.6 billion cubic feet.
- Statewide, the net growth to harvest removals ratio on timberland is 2.2, suggesting that the opportunity exists for more intensive management, especially for under-utilized species such as American sycamore, hackberry, and eastern redcedar.
- Browse incidence and the amount of competing vegetation in Missouri are much lower than most Northern Research Station (NRS) states, suggesting these factors are not impediments to successful regeneration of key species such as oak if proper silvicultural treatments are implemented.
- Only 4 percent of mill residues generated in the processing of industrial roundwood in the State's primary wood-using mills went unused for other secondary products.

Concerns

- Annual net growth on forest land decreased by 7 percent from 2013 to 2018, driven by a 19 percent increase in annual mortality.
- Average annual mortality of growing stock trees in the select white oak group (primarily white oak) increased 63 percent from 2013 to 2018.
- More than 60 percent of Missouri forests have a stand age over 60 years, making them more susceptible to insect and disease driven mortality.
- Average annual mortality of ash on forest land increased from 7.0 million cubic feet in 2013 to 11.1 million cubic feet in 2018.
- The proportion of total timberland volume that is in growing stock trees declined by 6 percent from 2008 to 2018.
- A majority of forest land (82 percent) in the State is privately owned, yet only 16 percent of private landowners with 10 or more acres received advice on forest management and less than 5 percent had a written management plan.
- Shortleaf pine, Missouri's only native pine species, ranked fifth in number of trees over 5 inches d.b.h. in 2018 with 79 million stems, but ranked 32nd and 41st in number of saplings and seedlings, respectively.
- Although invasive plant species are less frequently observed in Missouri than in neighboring states, observations of the top three species increased in the 2018 inventory. Observations of multiflora rose increased from 52 percent of P2+ plots in 2013 to 58 percent in 2018. Japanese honeysuckle and nonnative bush honeysuckle observations also increased, from 9 and 6 percent to 14 and 11 percent, respectively.

An Overview of Forest Inventory

What is this report?

This report summarizes findings of the 2018 survey of Missouri forest resources. Data for this survey were collected from 2012 through 2018 and are referred to as the 2018 inventory throughout this report. The inventory is conducted by the U.S. Department of Agriculture's Forest Service, Forest Inventory and Analysis program in cooperation with the Missouri Department of Conservation. More detailed results are available in an interactive digital collection available at <https://doi.org/10.2737/NRS-RB-122-INT>.

The results presented in the interactive report are divided into sections that focus on different forest aspects, including carbon, sustainability, health, and timber trends (Fig. 1). Graphics, including interactive maps, charts, and dashboards, summarize data and illustrate trends that make it easy for readers to compare between inventory periods, geographic locations, or ecological divisions. This document offers a summary of those results.

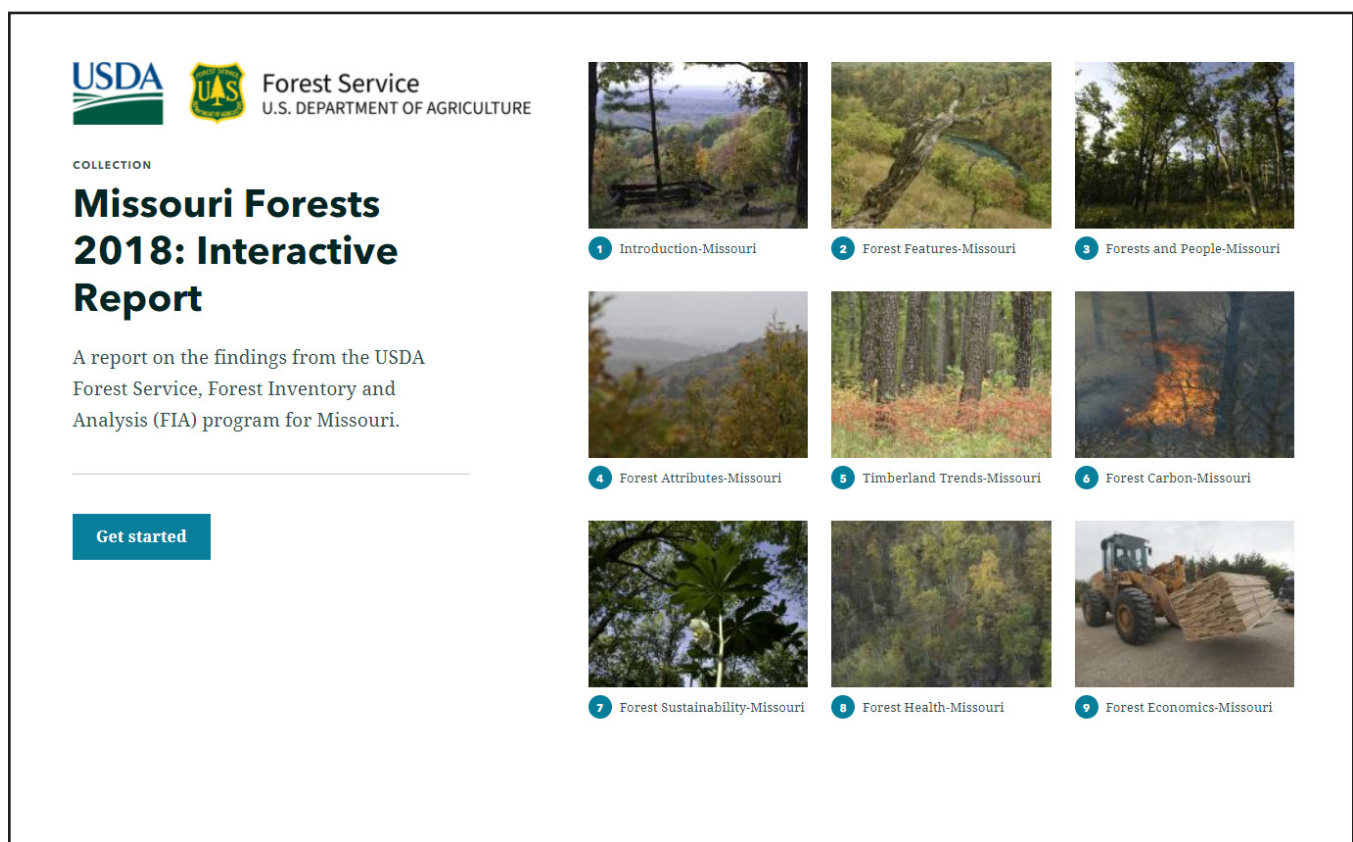


Figure 1.—The Missouri Forests 2018: Interactive Report is a digital collection that focuses on different forest aspects.

What is FIA?

The USDA Forest Service's Forest Inventory and Analysis (FIA) program is often referred to as the Nation's forest census. FIA is a national program that conducts and maintains a comprehensive inventory of forest resources in the United States and its territories. For detailed information on key definitions, data collection methods, and estimation procedures, see Gormanson et al (2018) and supplemental resources available online at <https://doi.org/10.2737/NRS-RB-122>.

Missouri Forest Inventories

FIA has been conducting inventories of Missouri forest resources since 1947. Prior to 1999, inventories were conducted periodically, or approximately once every 10-20 years. Periodic inventories were completed in 1947 (Central States Forest Experiment Station 1948), 1959 (Gansner 1965), 1972 (Spencer and Essex 1976), and 1989 (Hahn 1991). In 1999 an annual inventory system was implemented, wherein a percentage of plots were measured each year and an entire inventory cycle completed every 5 years. Previous annual inventories were completed in 2003 (Moser et al. 2007), 2008 (Raeker et al. 2011), and 2013 (Piva et al. 2016). In 2014, FIA went from a 5-year cycle completing 20 percent of the plots annually to a 7-year cycle completing 14 percent of the plots annually. FIA maintains a 5-year reporting period, and each report covers a full data cycle. This creates a yearly moving window of 5-year cycles, each composed of plots from up to 7 years, which is identified by the last year in a given full cycle.

For the 2018 inventory, 7,842 plots in Missouri were selected for measurement. From that selection, 3,189 contained forest land, 4,301 were nonforest, and 336 were not sampled due to various issues prohibiting access. Current estimates of forest area, composition, volume, and other statistics are based on the 7,506 sampled plots. Estimates of change (e.g., forest area change, growth, mortality, and removals) are based on 7,334 plots that were measured both during the 2018 cycle and the previous cycle that ended in 2013 (2009-2013).

Regional Analysis

In this report, references are made to FIA units or inventory units. These geographic delineations are aggregations of adjacent counties that facilitate analysis of FIA data on a more local scale. The State of Missouri is divided into five inventory units (Fig. 2).

Projection: Missouri State Plane Central, NAD 83. Source: USDA Forest Service, Forest Inventory and Analysis program, 2019. Geographic base data are provided by the National Atlas of the USA. FIA data and tools are available online at <https://www.fia.fs.fed.us/tools-data>. Cartography: T.A. Albright, USDA Forest Service, February 2020. Albright, USDA Forest Service February 2020.

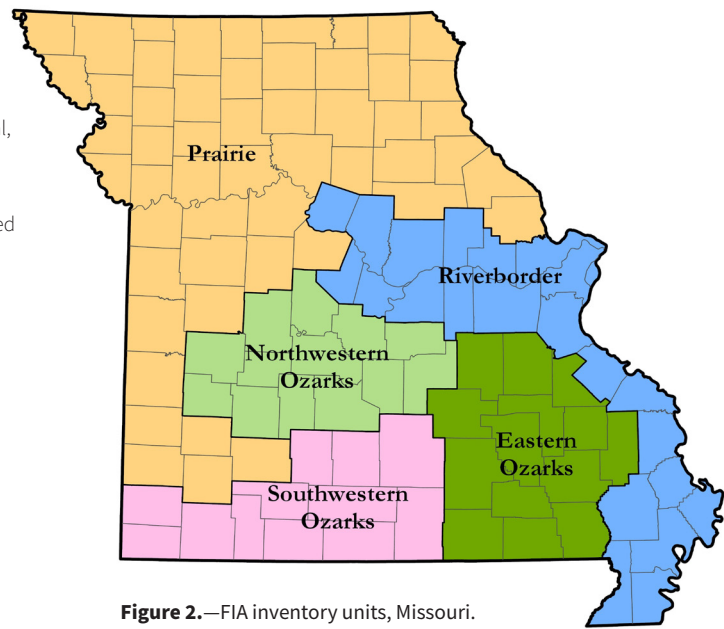


Figure 2.—FIA inventory units, Missouri.

Forest Features

Area and Land Use

FIA delineates land use into several categories, including but not limited to, forest land, pasture, cropland, idle farmland, developed, and water. Tracking changes in land use is important for analyzing factors affecting forest loss (diversion) and forest gain (reversion). This is accomplished by comparing land use on plots visited on two separate occasions. For this report, plots visited between 2007 and 2012 (hereafter referred to as 2013) and revisited between 2012 and 2018 (hereafter referred to as 2018) were evaluated.

Forest land area of Missouri in 2018 is estimated at 15.4 million acres, a one percent decrease from the 2013 estimate of 15.5 million acres (Fig. 3). Of the forest land, 96 percent is timberland, which totaled 14.8 million acres in 2018, a 1 percent decrease from

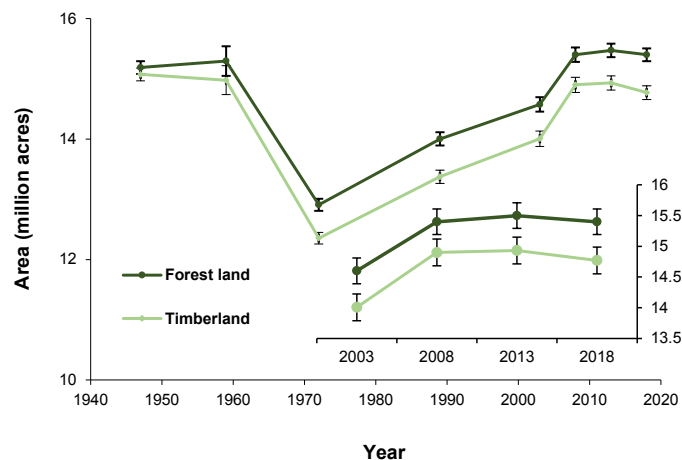


Figure 3.—Forest land and timberland area by inventory year, Missouri. Error bars represent a 68 percent confidence interval

the 2013 estimate of 14.9 million acres. For context, total area of land and water in Missouri is 44.6 million acres, making 34 percent of the State forested.

Trends in forest land area resulting from land-use change can be more closely examined by limiting the comparison to only plots that were visited at both times. A majority of the land in Missouri remained either nonforest (64.7 percent) or forest (33.6 percent), with the remaining split between reversion and diversion. There were 401,000 acres diverted from forest land and 362,000 acres reverted to forest land, leading to a slight net loss in forest land area (Fig. 4).

Agricultural land use accounted for 78 percent of forest loss and 79 percent of forest gain. Developed land use accounted for 13 and 18 percent of forest loss and gain, respectively, with other land uses contributing less area to forest changes.

After decades of increasing, forest land area in Missouri appears to have leveled off. Small fluctuations in forest land and timberland area since 2014 have been within the margin of error (Fig. 3). Historically, most of the land use change in Missouri has been to and from agriculture, the most prevalent land use in the State, and that trend continues. Commodity prices, landowner objectives, and land values all drive land use change and, therefore, affect forest land directly and indirectly. For now, it appears that the loss and gain of forest to and from agriculture continues to be largely offsetting.

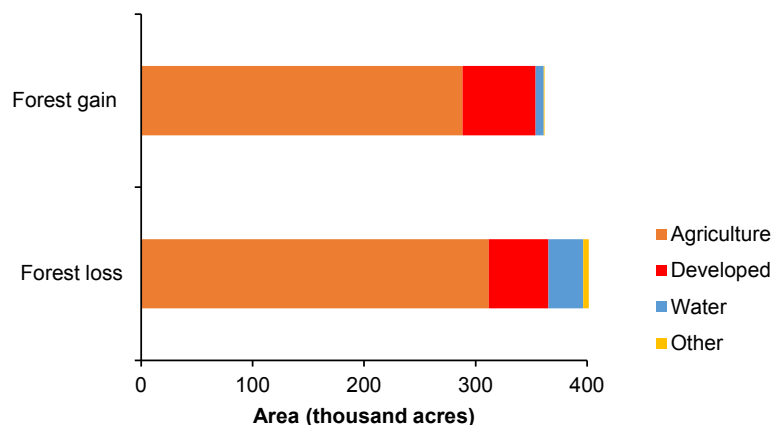


Figure 4.—Forest area loss and gain by land-use category, Missouri, 2013 to 2018

Forests and People

Forest Ownership

To a large extent, the availability and quality of forest resources are determined by landowners, including recreational opportunities, timber availability, and wildlife habitat. By understanding the priorities of forest land owners, the forest conservation community can better help owners meet their needs, and in so doing, help manage forests sustainably for future generations.

The dominant category of forest ownership in Missouri is private ownership, particularly family forest ownership. An estimated 12.6 million acres, or 81.9 percent of Missouri forest land, is privately owned (Fig. 5). The vast majority of these acres, an estimated 11.3 million acres (73.8 percent of all forest land in the state), are owned by families, individuals, trusts, estates, and family partnerships, collectively referred to as family forest ownerships. Corporations own an estimated 1.0 million acres (6.8 percent) across the State, and other private owners, including conservation organizations and unincorporated clubs and partnerships, own an additional 200,000 acres (1.3 percent).

Public agencies control the other 18.1 percent of the State's forest land. The federal government has jurisdiction over an estimated 1.9 million acres (12.2 percent of all forest land in the State), most of which is in the Mark Twain National Forest. Forest, park, and wildlife agencies in the State manage an estimated 810,000 acres (5.3 percent). An additional 88,000 acres (<1 percent) are controlled by local governments.

Family forest ownerships, the group that is the least understood and the fate whose land is arguably the most uncertain, own their land primarily for amenity reasons, but many are actively doing things with their land. The percentages of ownerships who have received advice and who have written forest managements is relatively low, so there are significant opportunities to help these owners increase their engagement and stewardship of their lands. Another important trend to watch is the aging of the family forest owners. Given that 18.9 percent of the family forest owners (10+ acres), who control 20.4 percent of the family forest land, are 75 years of age or older, many acres of land will be passing on to the next generation in the not too distant future.

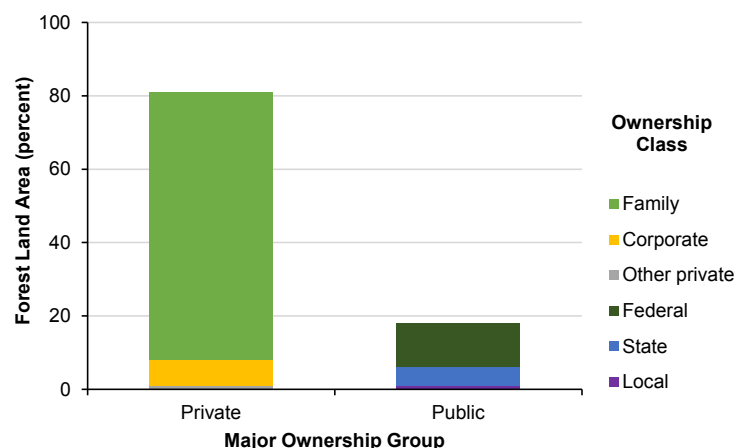


Figure 5.—Forest land area by ownership category, Missouri, 2018.

Forest Attributes

Species Composition and Stand Structure

Species composition, stand size, stocking, and stand age are the attributes most commonly used to describe a forest. Several factors contribute to the species composition of a forest. Site characteristics such as slope, aspect, soil type, and water availability determine what species grow where. Management practices such as timber stand improvement and harvesting as well as disturbances like fire, weather events (e.g., flooding, drought, high winds), insects, and disease all play a role in shaping forest composition. The frequency and severity of these events, over time, created the forests that we see today. FIA describes the overall composition of a forest by assigning forest types and forest-type groups. A forest-type is a collection of species that commonly grow together, and similar forest types are aggregated to make up forest-type groups. Forest types are delineated by determining the most common species present in the overstory.

The most common forest-type group in Missouri is the oak/hickory group, which occupies 80 percent of all forest land statewide. The oak/hickory group has seen a 3 percent (375,746 acres) decline since 2008, with a majority of the land changing to a nonforest land use. Elm/ash/cottonwood group, the second most common (7 percent) forest-type group in 2018, has increased 16 percent (156,677 acres) since 2008.. Eastern redcedar, represented by the other eastern softwoods group, has seen an increase of 5 percent (19,527 acres) since the 2008 inventory, and represents 3 percent of total forest land in 2018.

Five of the top eight most voluminous forest-types had more than 50 percent of their area in large diameter stands (Fig. 6), and four of those five forest types include an oak component. Conversely the eastern redcedar and eastern redcedar/hardwood forest-types had a majority of their area in medium diameter stands, at 53 percent and 46 percent, respectively.

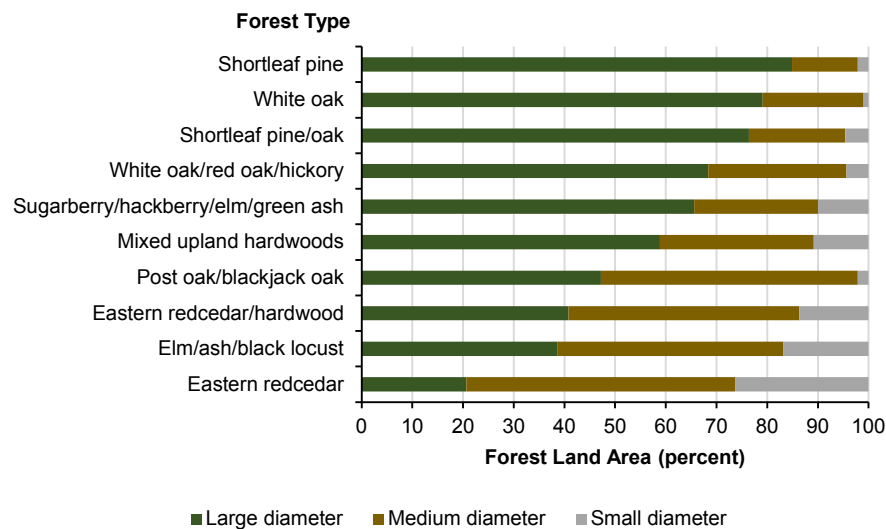


Figure 6.—Percentage of forest land area by forest type and stand-size class, Missouri, 2018.

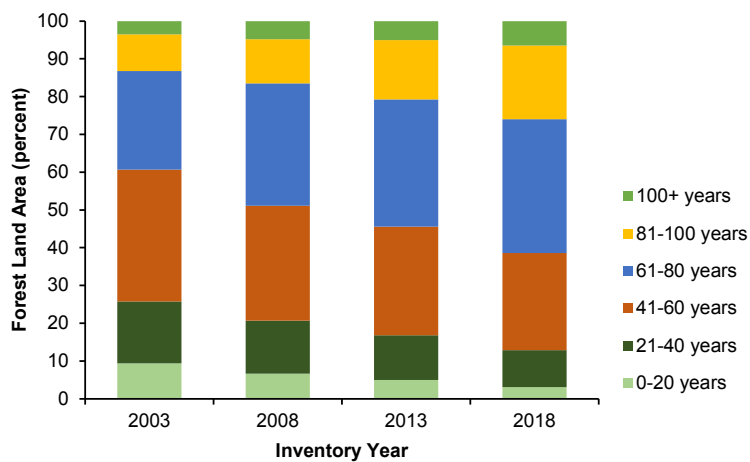


Figure 7.—Percentage of forest land area by stand-age class and inventory year, Missouri.

More than 60 percent of Missouri forests have a stand age over 60 years (Fig. 7). Since 2003, forests with stand ages over 60 years have increased by 65 percent. Proportionally, stands in the 81-100 year age class had the largest increase (112 percent), while stands in the 0-20 year age class had the largest decrease (65 percent).

Timberland Trends

Volume on Timberland

The assessment of the volume of live trees provides information on trends in the resource, the potential uses of that wood, and its economic value. Current volume and changes in volume over time can characterize forests and reveal important resource trends. FIA uses several categories to report volume for trees that are at least 5 inches in diameter: sound, net, growing-stock, and sawtimber. Sound volume is the total volume less deductions for rotten and unsound wood. Net volume is sound volume minus additional deductions for roughness and form defects and is computed for the central stem from the 1-foot stump to a 4.0-inch top diameter. Growing-stock volume excludes rough or rotten cull trees and noncommercial species. Volume estimates for sound, net, and growing-stock are reported in cubic feet. For trees classified as rough cull, either two-thirds of their volume does not meet merchantable requirements, with the majority of that volume being rough cull, or it is not a commercial species. Rotten cull trees have two-thirds of their volume as cull, and the majority is unsound or rotten cull. While rough and rotten cull trees may not be available for timber utilization, they do provide critical wildlife habitat and carbon storage. Estimates of sawtimber volume are reported in board feet (International ¼-inch rule) for the useable saw log portion of the tree that meets minimum size requirements. For hardwoods, this includes a minimum d.b.h. of 11.0 inches measured from stump to a 9-inch top diameter; for softwoods this includes a minimum d.b.h. of 9.0 inches

measured from stump to a 7-inch top diameter.

The 2018 inventory for Missouri estimates 20.9 billion cubic feet of live tree net volume on timberland, an increase of 7 percent since 2008 (Fig. 8). Growing-stock volume comprised 79 percent (16.5 billion cubic feet) of that, with the balance in rough (20 percent) and rotten cull (1 percent).

Net volume on timberland has increased since the first annual survey in 2003, but the rate of increase is declining. Between 2003 and 2008, net volume rose 13 percent, but between 2013 and 2018 it only increased 3 percent. The declining rate of volume accumulation can be largely attributed to a long-term trend of annual increases in mortality volume.

Growing-stock volume on timberland in Missouri appears to have leveled off. The majority of timberland volume is in growing-stock trees, but that percentage is also declining. The decreasing proportion of volume in growing-stock along with an increase in net volume indicates that the volume that is being added is primarily in cull trees. Members of the red oak group, which are most susceptible to oak decline driven mortality, experienced significant decreases in growing-stock volume.

Timber on public lands is overall of better quality than that of private land, but an overwhelming majority of the timberland in Missouri is privately owned. The higher proportional volume in high quality tree grades as well as the greater proportion of growing-stock trees on public lands suggest that there is room for improvement where the management of private timberland is concerned.

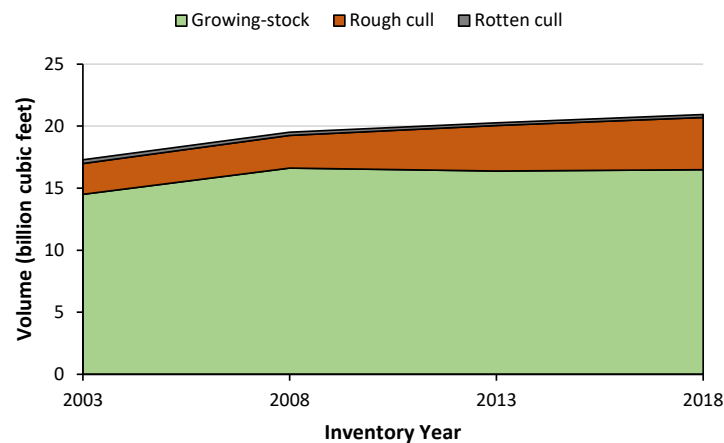


Figure 8.—Net volume of live trees on timberland by tree class and inventory year, Missouri.

Timberland Growth, Removals, and Mortality

Sustainably managed forests provide a continuous supply of goods and services without compromising long-term productivity. One way to judge the sustainability of a forest is to examine the components of annual change in inventory volume: growth, removals, and mortality. Gross growth includes growth (accretion) on trees measured previously as well as the volume of ingrowth trees on existing samples and newly forested plots. Net growth is the volume of gross growth less deductions for mortality. Mortality includes trees that died from natural causes, insect and disease infestations, fire and animal damage, and damage from weather. Removals include trees cut during harvests, silvicultural treatments, and land clearing (harvest removals), as well as previously measured trees now on nonforest land (other removals). Analysis of these individual components can help us better understand changes in volume.

Gross growth on timberland totaled 704 million cubic feet per year in 2018, a 3 percent increase from the 2013 per year estimate of 682 million cubic feet (Fig. 9). Mortality increased by 17 percent to 333 million cubic feet per year over the same period, resulting in a 7 percent decrease in annual net growth to 371 million cubic feet. The decrease in net growth was offset by decreases in both harvest removals (13 percent) and other removals (36 percent), resulting in a 3 percent increase in net change from 2013 to 2018 to 200 million cubic feet.

Net volume change on timberland in Missouri was estimated to be 200 million cubic feet per year in 2018, but this may be misleading. Gross growth increased slightly from 2013 to 2018, but the preceding 5 years saw a significant drop in annual gross growth. Future monitoring of this trend is critical to ensure that it has indeed reversed. Net growth decreased overall and among the most common species groups due to an increase in mortality, but in this last survey interval, it was partially offset by a decrease in removals. Removal rates are solely human driven and influenced largely by timber values and the value of land for other uses (e.g., agriculture and development).

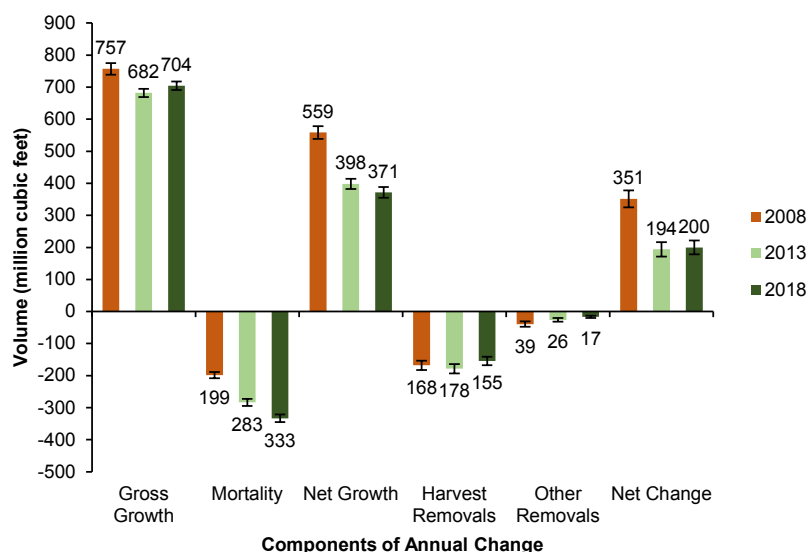


Figure 9.—Components of volume change on timberland by inventory year, Missouri. Error bars represent a 68 percent confidence interval.

Forest Health

Ash and Emerald Ash Borer

It has been 10 years since emerald ash borer (*Agrilus planipennis*), a wood-boring beetle native to Asia, was first detected in southeastern Missouri. Continued spread has resulted in emerald ash borer (EAB) detections across the majority of the State. Average annual ash mortality on forest land increased from 7.0 million cubic feet in 2013 to 11.1 million cubic feet in 2018, and represented 3 percent of total mortality in 2018. Given the length of time that EAB has been present in Missouri, it is likely that increases in ash mortality are due to EAB activity. Ash mortality is expected to increase as EAB persists and populations grow. The loss of ash in forested ecosystems will affect species composition and alter community dynamics. Continued monitoring will help to identify the long-term impacts of EAB in forested settings.

Rapid White Oak Mortality

The term rapid white oak mortality (RWOM) was coined following 2011 reports of significant mortality of white oak (*Quercus alba*) that could not be attributed to known causes (Reed et al. 2017). Central and southeastern Missouri, which are covered by the Eastern Ozarks and Riverborder units, as well as portions of the Northwestern Ozark unit, had the highest incidents of reported RWOM mortality.

In Missouri, 86 percent of the 699.3 million white oak trees occur in the Eastern Ozarks, Southwestern Ozarks, and Northwestern Ozarks units. White

oak accounts for 4.2 billion cubic feet of total volume (trees greater than 5 inches d.b.h.) and 13.8 billion board feet of sawtimber volume. In contrast to tree number, white oak volume is concentrated in the Eastern Ozarks and Riverborder units, representing a combined total of 58 percent of bole volume and 59 percent of sawtimber volume. Between 2008 and 2018, mortality of white oak bole volume significantly increased from 19.6 million cubic feet to 53.4 million cubic feet. In each inventory since 2008, approximately 60 percent of white oak mortality has occurred in the Eastern Ozarks and Riverborder units. The mortality-to-growth ratio for white oak has gradually increased across all units since 2008 (Fig. 10). The Riverborder unit continues to have the highest mortality-to-growth ratio, totaling 0.84 in 2018.

White oak is an ecologically and economically valuable species, and it makes up a major component of Missouri's statewide forest resource. As a result, RWOM has the potential to greatly affect forest dynamics and the timber products industry. Continuation of ongoing research and monitoring will assist land managers in making decisions on how best to manage Missouri's white oak resource and mitigate or reduce the impacts of RWOM.

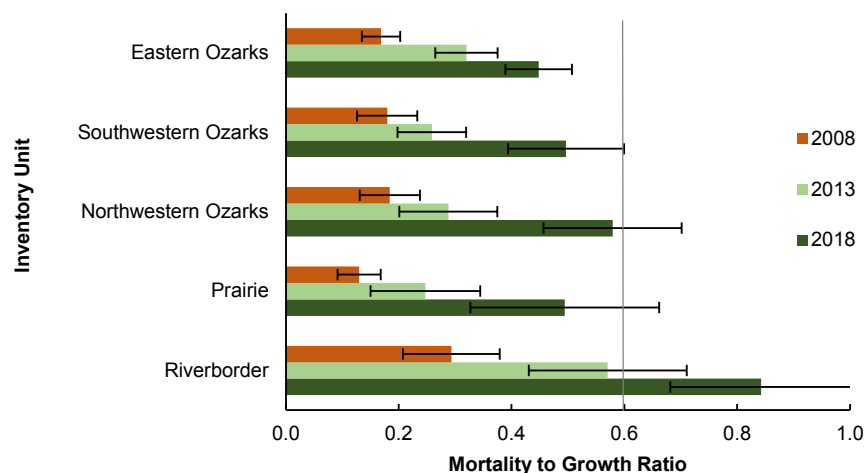


Figure 10.—Ratio of average annual mortality volume to gross growth volume for white oak on forest land by inventory unit and inventory year, Missouri. Error bars represent a 68 percent confidence interval. Vertical line indicates 0.6 threshold for potential acute health issue (Conkling et al. 2005).

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