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Michigan Forests 2019: Summary Report



Citation

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Abstract

This summary report provides an overview of findings from the ninth inventory of Michigan forests based on visits to 4,367 forested plots from 2013 to 2019. Until the 2019 inventory, the base estimate of Michigan forest land had been increasing since the 1980 inventory. The 2019 inventory has 20.2 million acres of forest land. Timberland accounts for 95 percent of this forest land, and 61 percent is privately owned. The sugar maple/beech/yellow birch forest type accounts for 19 percent of Michigan forest land, followed by aspen (12 percent) and white oak/red oak/hickory (7 percent). Balsam fir (*Abies balsamea*) has the most saplings (18 percent), red maple (*Acer rubrum*; 15 percent) has the most poletimber-size trees, and northern white-cedar (*Thuja occidentalis*; 14 percent) has the most sawtimber-size trees. Growing-stock volume on timberland has continued to increase and now totals 30.7 billion cubic feet. The associated net growth, mortality, and removals were 604 million, 359 million, and 353 million cubic feet/year, respectively.

In addition to information on forest attributes, this report includes data on land use change, forest health, ecosystem services, family forest owners, timber product outputs, urban forests, and fragmentation. A detailed interactive report is available at <https://doi.org/10.2737/NRS-RB-130-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-130>.

KEYWORDS: inventory, carbon, forest area, timberland, forest land, sustainability, volume, mortality, harvest, growth, forest health, land use change, forest products, ecosystem services, urban forests, fragmentation, forest health, invasive plants, down woody materials, forest regeneration, forest ownership

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Cover photo: An older stand in the large stand-size class predominated by hemlock sawtimber, Michigan. Courtesy photo by David Kenyon, Michigan Department of Natural Resources, used with permission.

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Contact Author:

Scott A. Pugh

scott.a.pugh@usda.gov

906-482-6303

About the Authors

Scott A. Pugh is a forester with the Forest Inventory and Analysis (FIA) program, Northern Research Station, Houghton, MI.

Jagdish Poudel is a forest economist with the Forest Resources Division, Michigan Department of Natural Resources, Lansing, MI.

Thomas A. Albright is a forester with the FIA program, Northern Research Station, Williamsport, PA.

Brett J. Butler and Jesse Caputo are research foresters with the FIA program, Northern Research Station, Amherst, MA.

Susan J. Crocker and Mark D. Nelson are research foresters with the FIA program, Northern Research Station, St. Paul, MN.

Cassandra M. Kurtz, Ronald J. Piva, and Brian F. Walters are foresters with the FIA program, Northern Research Station, St. Paul, MN.

Tonya W. Lister and James A. Westfall are research foresters with the FIA program, Northern Research Station, York, PA.

Randall S. Morin is a research forester with the FIA program, Northern Research Station, York, PA.

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

Christopher W. Woodall is a research forester with the FIA program, Northern Research Station, Durham, NH.

Foreword

Michigan is a state like no other in the Nation with two peninsulas and a large latitudinal gradient. From the warmer agriculture and urban areas in the south to the colder wooded lands in the north, the State offers unique ecosystems, a wide variety of land uses, and one of the most diverse forests in the United States.

Michigan has more forest land than any other state in the Northeast or Midwest. Nearly all of its forest land was cut or burned (or both) during European settlement (Dickmann and Leefers 2003). The lumber boom and fires occurred primarily in the late 1800s and early 1900s. By 1920, the lumber boom had ended and secondary succession and recovery of the forests had begun.

Since then, these forests have been maturing and forest management has evolved. Michigan state forests and a number of large private ownerships are certified as practicing sustainable forestry through the [Forest Stewardship Council \(FSC\)](#) and the [Sustainable Forestry Initiative \(SFI\)](#). The U.S. national forests are managed under the National Forest Management Act of 1976 and the National Environmental Protection Act of 1969. There also are assistance programs to help small forest landowners. An active, diverse wood products industry exists which provides jobs and goods to meet consumer demand.

The status and trends of forest resources can indicate how Michigan forests are faring over time in the face of physical and social changes. The USDA Forest Service, through its [Forest Inventory and Analysis \(FIA\)](#) program and in partnership with the [Michigan Department of Natural Resources \(MI DNR\), Forest Resources Division](#), inventoried the Michigan forest resources periodically in 1935, 1955, 1966, 1980, and 1993. In 2000, the State's periodic inventory was replaced with an annual inventory in which a portion of the field plots are measured each year. The first full sample set of annually collected plots was completed in 2004 and has been annually updated ever since. Using the annual inventory, forest resource reports are created every 5 years with past reports for 2004, 2009, and 2014. The current 2019 report covers recent observations from 2013 to 2019 (6,667 plots) and change observations from 2008–2013 to 2013–2019 (6,074 plots).

In this report we describe and highlight the current status and trends observed within Michigan forests. We invite you to read and consider this report knowing that it will stimulate additional discussion, analysis, and education about one of the State's greatest treasures.

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Wet meadow and conifer swamp at the headwaters of the Manistee River, Michigan. Courtesy photo by Natural Features Inventory, Michigan Department of Natural Resources, used with permission.

Highlights

Many of the statements about status and trends listed here are not addressed in this summary report of Michigan forests, but are discussed in the interactive report, available at <https://doi.org/10.2737/NRS-RB-130-INT>. Please see the appendix for a list of common and scientific names of trees species in Michigan.

Forest Features

- The change in forest stand-size and stand-age class distributions indicates a maturing forest resource. Since the 2004 inventory, a disproportionate amount of acreage has been converting from the middle age classes and medium stand-size class to the older age classes and the large stand-size class, but the percentage of young forest has remained steady. Forest land increased 33 percent in the large stand-size class but decreased 19 percent in the medium stand-size class. The overall trend toward maturing forests is expected to continue.
- The high percentage of fully and medium stocked lands in Michigan is conducive to maintaining forest health, high-quality timber products, and efficient timber production. Seventy-eight percent of Michigan forest land is medium or fully stocked. Nine percent is overstocked and 12 percent is poorly stocked or nonstocked. At the State level, stocking levels have not changed appreciably over the last 15 years.
- The predominant forest type, sugar maple/beech/yellow birch, accounts for 19 percent of Michigan forest land, followed by aspen (12 percent) and white oak/red oak/hickory (7 percent). Northern white-cedar (7 percent) is the most abundant softwood forest type, followed by red pine (5 percent) and jack pine (3 percent).
- Relatively recent decreases in acreage for the black ash/American elm/red maple and sugarberry/hackberry/elm/green ash forest types may potentially be linked to ash mortality. Since the previous plot visits, 15 percent of the acreage in black ash/American elm/red maple and 18 percent of the acreage in sugarberry/hackberry/elm/green ash have converted to other types where ash is not prominent.
- The numbers of trees are fairly well distributed among species, with no species accounting for more than 15 percent of trees (saplings and larger). Balsam fir has more saplings (18 percent of saplings) than any other species in Michigan but accounts for only 2 percent of sawtimber-size trees. By number of saplings, red maple (13 percent), quaking aspen (9 percent), and sugar maple (8 percent) rank the highest after balsam fir. Red maple (15 percent), sugar maple (13 percent), northern white-cedar (13 percent), balsam fir (7 percent), quaking aspen (6 percent), and red pine (5 percent) make up nearly 60 percent of poletimber-size trees. Northern white-cedar (14 percent), sugar maple (13 percent), red maple (11 percent), red pine (11 percent), eastern white pine (5 percent), eastern hemlock (5 percent), and northern red oak (4 percent) account for over 60 percent of sawtimber-size trees. The oaks account for 20 percent of all trees greater than the 18-inch size class but only 4 percent of saplings. Red pine is the only species with more poletimber-size trees than saplings.

- The increasing number of sawtimber-size trees is another sign of the maturing forest resource in Michigan. Since the 2004 inventory, the number of sawtimber-size trees increased by 19 percent (+14 percent in trees per acre) and the number of poletimber-size trees decreased by 2 percent (-6 percent in trees per acre). Shade-tolerant species such as eastern white pine are increasing in number and volume while shade-intolerant and short-lived species such as paper birch are declining. Currently, there are 14.1 billion and 13.4 billion live trees (at least 1 inch diameter at breast height or diameter at root collar) on forest land and timberland, respectively.
- Since 2014, there has been a sharp decrease in the number of live ash trees in the Lower Peninsula. Estimates for green ash decreased by 57 and 66 percent for poletimber- and sawtimber-size trees, respectively. Estimates for white ash decreased by 29, 47, and 65 percent for sapling-, poletimber-, and sawtimber-size trees, respectively. Estimates for black ash decreased by 32, 76, and 61 percent for sapling, poletimber-, and sawtimber-size trees, respectively. Ash has other health threats, but the relative change is stark and mostly attributed to emerald ash borer (EAB; *Agrilus planipennis*). Mortality is expected to increase as EAB spreads farther throughout Michigan.
- In the eastern Upper Peninsula since 2014, estimates for the number of American beech have decreased for poletimber-size (-14 percent) and sawtimber-size (-38 percent) trees. Beech bark disease (BBD) is suspected as the primary cause. Mortality is expected to increase as BBD continues to spread throughout Michigan.
- The regeneration indicator monitors the abundance of tree seedlings and browse impact over time (384 plots in 2019 inventory). Approximately 39 percent of forest land has at least moderate browse impact. This is an indication that browsing by deer is influencing composition of the regeneration component in some areas.
- There are about 30.7 billion cubic feet (ft³) of growing stock on timberland (1,606 ft³/acre) and about 37.5 billion ft³ of sound bole volume on forest land (1,859 ft³/acre). Increases in forest land area and the number of trees, particularly sawtimber-size trees, have led to increases in volume. Although Michigan is still experiencing an increase in volume, this increase has slowed, mostly due to EAB and other forest health issues, and partially due to the lower rate of growth that accompanies the maturing of Michigan forests. From 1955 to 1966 for growing stock on timberland, the increase was nearly 4 percent per year. The increase between the 2012 and 2019 inventory was approximately 0.2 and 1.1 percent per year for hardwoods and softwoods, respectively. The greatest effect is evident in the Lower Peninsula, where ash volume has peaked and continues to fall.
- Green and white ash had been gaining volume, but their growing-stock volume estimates dropped after the 2014 inventory by 59 and 46 percent, respectively. These State-level decreases are due to decreases in the Lower Peninsula where green and white ash volumes dropped by 66 percent for each species. Black ash volume also fell by 72 percent in the Lower Peninsula. At the State level, ash sound bole volume peaked in the 2009 inventory at 1,204 million ft³ and dropped to 375 million ft³ (69 percent decrease) in the 2019 inventory.

Forest Change

- Among the 50 states, Michigan ranks 21st in area but 10th in forest land area, accounting for 20.2 million acres. Timberland accounts for 95 percent of this forest land or 19.1 million acres.
- The majority of Michigan forest land is privately owned (12.4 million acres or 61 percent). Most of these private acres are in family forests (8.7 million acres). Corporate ownerships have 3.0 million acres across the State and other private owners, including conservation organizations and unincorporated clubs and partnerships, own an additional 705,299 acres. Other private ownership increased by 4 percent (215,870 acres) since the 2009 inventory. Public forest land (7.8 million acres or 39 percent) is owned by Federal, State, and local government agencies with the State (21 percent) and USDA Forest Service (14 percent) being the primary owners. County and other local governments manage an estimated 445,802 acres of forest land.
- Until the 2019 inventory, the base estimate of Michigan forest land had been increasing since the 1980 inventory. Forest land gains essentially offset forest land losses in the 2019 inventory. Approximately 1.5 percent of forest diverted to nonforest (297,000 acres) and 1.8 percent of nonforest reverted to new forest (308,000 acres).
- Average annual net growth of sound bole volume on forest land was 688.8 million ft³ and average annual net growth of growing stock on timberland was 603.8 million ft³. This is about 1.8 percent of live volume on forest land and 2.0 percent of growing-stock volume on timberland in 2019. Even with these moderate to high rates, the 2019 estimate for net growth of sound volume on forest land decreased by 10 percent compared to the 2014 estimate (758.3 million to 688.8 million ft³). The increasing mortality of ash trees is the primary factor driving net growth downward. Excluding ash, the estimate did not change between the 2014 and 2019 inventory (788.3 million ft³ in each inventory).
- Since 2014, average annual net growth of sound bole volume on forest land increased in the western Upper Peninsula (17 percent) where the region has benefited from little to no drought after 2012. Drought was routinely moderate to extreme from 2005 through 2012 in the western Upper Peninsula. Currently, the effects of EAB are not prominent in the western Upper Peninsula.
- The net growth-to-volume ratio remains moderate to high for most species, evidence of the vitality of Michigan forests. Species such as ash, American beech, paper birch, yellow birch, and white spruce suffer from high mortality and have low or negative ratios.
- Average annual mortality of sound bole volume on forest land was 461.8 million ft³ and average annual mortality of growing stock on timberland was 359.2 million ft³. This is about 1.2 percent of live volume on forest land and 1.2 percent of growing-stock volume on timberland. These are low rates even though the 2019 estimate rose 18 percent for sound bole volume on forest land (13 and 20 percent for softwoods and hardwoods, respectively). Mortality increased substantially in the northern Lower Peninsula for ash, American beech, and most other species. In this region, the effects of EAB are now widespread and BBD continues to spread and kill American beech. Usually moderate but sometimes severe drought (2013, 2016 through 2018) contributed to declines in

health for species such as oak, aspen, and maple. Disregarding ash, mortality remained stable in the southern Lower Peninsula. With or without ash, there was no notable change in the Upper Peninsula.

- Total average annual removals (all removals including land use change) of sound bole volume and growing-stock volume from timberland were 395.6 million ft³ and 353.0 million ft³, respectively. Ninety-seven percent of sound bole volume removals (381.8 million ft³) was average annual harvest removals (no land use change). This harvest estimate is essentially equivalent to the 350.5 million and 353.0 million ft³ of the 2009 and 2014 inventory, respectively. The ratio of average annual harvest removals to current volume (sound volume on timberland-to-timberland) is 1.0 percent, remaining stable with the ratios from the 2009 and 2014 inventory at 1.1 and 1.0 percent, respectively. Variability in the harvest estimates makes it difficult to identify change.
- For the 2019 inventory, the ratio of net growth to harvest removals for sound bole volume on timberland is 1.8 (no land use change), indicating that volume is increasing at a moderate rate. This ratio is consistent with the ratios of the 2009 and 2014 inventory at 1.8 and 2.0, respectively. From 1955 through 2004, the ratio of net growth to total removals for net merchantable bole volume of growing stock on timberland was 2.7 to 2.8 (includes land use change). The ratio has dropped to 1.7 for the 2019 inventory. Even with the small drop from historical levels, the ratio is still at a moderate to high level. At the State level, Michigan has had relatively low removals and mortality rates and high growth rates.

Forest Health Indicators

- Of the 44 invasive plant species (43 species and 1 undifferentiated genus) monitored on forest land, 27 were observed on 406 forested plots. Canada thistle (*Cirsium arvensa*) ranked first as the most commonly observed species (13 percent of plots) and was found throughout the State. Autumn olive (*Elaeagnus umbellata*; 11 percent) and nonnative bush honeysuckle (*Lonicera* spp.; 9 percent) ranked second and third, respectively. Each was primarily observed in the Lower Peninsula. Multiflora rose (*Rosa multiflora*) ranked fourth (9 percent) and was found predominantly in the southern Lower Peninsula.
- The number of standing dead trees for green and white ash has increased nearly elevenfold and sevenfold, respectively, since the 2004 inventory. Most of the change has been in the Lower Peninsula, where these ash trees occur in the largest numbers. For black ash in the Lower Peninsula and eastern Upper Peninsula, the number of standing dead trees increased over fivefold since the 2009 inventory. Most black ash trees exist in the Upper Peninsula. The increase is primarily attributed to EAB.
- In the eastern Upper Peninsula and the northern Lower Peninsula, the number of standing dead American beech trees has increased nearly fourfold since the 2009 inventory. American beech is mostly concentrated in the northern Lower Peninsula and eastern Upper Peninsula. The increase is primarily attributed to BBD.

- No major health problems are indicated in the crown data for most important species and most of the damage is a natural part of forest stand development. Green ash, American beech, and black ash have relatively high proportions of poor crowns at 25, 13, and 12 percent of trees, respectively. The remaining species have proportions below 10 percent. Given the limited sample size, it is difficult to discern temporal trends in crown data.

Ecosystem Services

- Michigan forests provide ecosystem services that directly improve human well-being. These include wood products and nontimber forest products, recreation and other cultural services, and important regulating services (critical ecological functions). In 2020, regulating services such as carbon sequestration, air pollution removal, and runoff avoidance produced benefits worth an estimated \$2.0 billion across Michigan.
- According to the 2017 “Impact Analysis for Planning,” forest products industries in Michigan directly employed 41,000 workers with an output of approximately \$12.2 billion annually. The total number of jobs supported was 91,176 with a total output close to \$20.2 billion annually.
- In 2018, 505 million ft³ of woody material was harvested from Michigan forests as identified by the Timber Products Output survey. Seventy-six percent of the woody material removed was used for industrial roundwood, 6 percent was logging residues (merchantable material left on-site), and 18 percent was logging slash (unmerchantable material left on-site). By product, pulpwood accounted for 46 percent (33 percent as pulp and 14 percent as composite panels) of all the roundwood produced, saw logs represented 41 percent, and veneers, industrial fuelwood, and other miscellaneous items accounted for 13 percent.
- The Timber Products Output survey of 2018 shows that Michigan is processing most of its own wood resources. More than 91 percent of the roundwood harvested in Michigan is processed by Michigan mills. The number of active mills, production, and total mill output have all increased since 2010. The number of mills increased from 260 to 302 and production increased from 339 million to 386 million ft³. Aspen is the most commonly harvested species in the State, accounting for 17 percent of the total industrial roundwood produced in 2018.
- There is an abundance of sustainable wood resources in the State based on the ratio of net growth to removals and current volumes. Net growth, removals, and volume indicate that an increase in the harvest of timber products in Michigan would be biologically sustainable. This opportunity to increase harvest is influenced by difficult-to-measure factors such as landowner objectives, accessibility, parcelization, stumpage price, and market volatility, all of which make it challenging to increase the harvest level in Michigan.
- Forest ecosystem carbon stocks and density have remained stable in Michigan between 2014 and 2019. Soil organic carbon stocks represent the largest pool in the State and are important for long-term carbon storage. The carbon stocks in live biomass

also represent a substantial amount of the total carbon and there are opportunities to increase carbon stocks in the near term, as this pool is most affected by forest management. Soil organic carbon and live trees account for 89 percent of forest carbon stocks.

- According to the National Woodland Owner Survey of 2018, 72 percent of the family forest ownerships, which control 78 percent of the family forest land, participated in activities such as hiking or hunting on their land. Commercial timber harvesting in the previous 5 years was done by 23 percent of the family forest ownerships, which control 33 percent of the family forest land. Eighteen percent of the family forest ownerships, which control 30 percent of the family forest land, have received advice in the last 5 years and 5 percent of the family forest ownerships, which control 19 percent of the family forest land, have a written forest management plan. The average size of family forest holdings is 45 acres. Given the average age of family forest owners in the State, 65 years, many acres of land will be passing on to the next generation in the not too distant future.

Urban Forests and Fragmentation

- FIA established a national urban forest inventory program in 2014 and began monitoring in urban areas, focusing on the most populous cities. The urban FIA inventory in Michigan is still being established, but data will soon be available to provide sample-based estimates of urban forest structure and associated ecosystem services and to provide a means to monitor resource changes through time.
- The wildland-urban interface (WUI) is the zone where human development meets or intermingles with undeveloped wildland vegetation. We identified WUI areas with at least 15.5 houses per square mile. By 1990, 3.7 million acres of forest land (18 percent) was in WUI conditions. From 1990 to 2010, the percentage of forest land in WUI increased to 25 percent. Over these two decades, area of WUI forest land in 31 counties, including most counties in the southeastern Lower Peninsula and clusters of counties in other parts of the State, increased by more than 10 percentage points. The change from WUI to non-WUI forest was 114,815 acres state-wide.

An Overview of Forest Inventory

What is FIA?

The U.S. Department of Agriculture's Forest Service (hereafter, Forest Service) [Forest Inventory and Analysis \(FIA\) program](#) is often referred to as the Nation's forest census. The program was established by the U.S. Congress to "make and keep current a comprehensive inventory and analysis of the present and prospective conditions of and requirements of the forest and range lands of the United States" ([Forest and Rangeland Renewable Resources Planning Act of 1974](#)). For detailed information on forest inventory methods, data, and quality control estimates, see "Statistics and Quality Assurance for the Northern

Research Station Forest Inventory and Analysis Program, version 3” (Gormanson et al. 2023). For additional information on the FIA program, visit: <https://www.fs.usda.gov/research/nrs/programs/fia>.

What is this report?

This report summarizes findings of the ninth FIA inventory for Michigan, the 2019 inventory. Data for this survey were collected from 2013 through 2019 and are referred to as the 2019 inventory throughout this report. The inventory was conducted by FIA in cooperation with the Michigan Department of Natural Resources (MI DNR), Forest Resources Division.

More-detailed results and additional resource materials are provided in an interactive digital StoryMap collection available online at <https://doi.org/10.2737/NRS-RB-130-INT>. 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-130>.

The results presented in the interactive StoryMap are divided into sections that focus on different forest aspects, such as change, health, ecosystem services, urban forests, and fragmentation (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, major ownership groups, geographic locations, or ecological divisions. This document offers a short summary of select results.

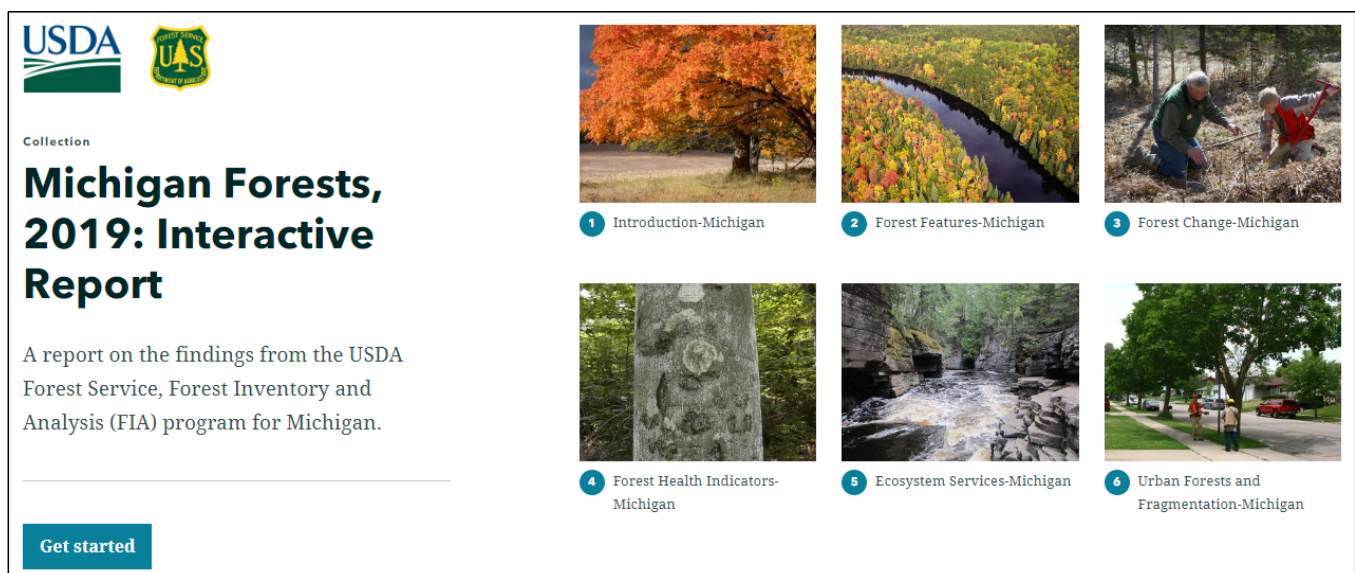


Figure 1.—The Michigan Forests 2019 StoryMap collection contains a series of StoryMaps that focus on different forest aspects. Click on “Get started” to enter the collection or click on one of the photos to view an individual StoryMap within the collection.

Michigan Forest Inventories

FIA has been conducting inventories of Michigan forest resources since 1935. Prior to 1999, inventories were conducted periodically, or approximately once every 10 to 20 years. Periodic inventories were completed in 1935 (USDA Forest Service 1936), 1955 (Findell et al. 1960), 1966 (Chase et al. 1970), 1980 (Raile and Smith 1983, Spencer 1983), and 1993 (Leatherberry and Spencer 1996, Schmidt et al. 1997).

Areas and volumes were estimated only for total forest land in the 1935 inventory. The 1935 estimates were revised in 1945 to include timberland (USDA Forest Service 1946). Subsequent inventories have included estimates for forest land and timberland.

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. The annual inventory includes observations from all forest land types, whereas observations on reserved and other forest land were limited in periodic inventories. Previous annual inventories were completed in 2004 (Pugh et al. 2009), 2009 (Pugh et al. 2012), and 2014 (Pugh et al. 2017). 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, composed of plots from up to 7 years, which are identified by the last year in a given full cycle. For this report, plots measured from 2013 through 2019 are collectively referred to as the 2019 inventory.

For the 2019 inventory, 7,299 plots in Michigan were selected for measurement. That is approximately one plot for every 5,608 acres of land, noncensus water, and inland census water (Great Lakes excluded). From that selection, 4,367 plots contained forest land, 2,300 were nonforest, and 632 were not sampled due to various reasons preventing access. Current estimates of forest area, composition, volume, and other statistics are based on 6,667 sampled plots. Estimates of change (e.g., forest area change, growth, mortality, and removals) are based on 6,074 plots that were measured during both the 2019 cycle (2013 through 2019) and the previous cycle (2008 through 2013).

Forest Features

Volume

Increases in forest land and timberland area (see Forest Change section starting on p. 10) and the number of trees, particularly sawtimber-size trees, have led to increases in volume (Fig. 2). Since the 2004 inventory, the number of sawtimber-size trees increased by 19 percent (+14 percent in trees per acre) and the number of poletimber-size trees decreased by 2 percent (-6 percent in trees per acre). Overall volume has slowly increased since 1980 with a substantial climb starting in 2004 for hardwoods and in 2009 for softwoods. Jack pine, balsam fir, yellow birch, paper birch, white ash, balsam poplar, and American elm are notable exceptions to the increase in sawtimber-size trees, having lost a substantial number since 1980. Although Michigan is still experiencing an increase in volume, this increase has slowed, mostly due to mortality caused by the emerald ash borer (EAB;

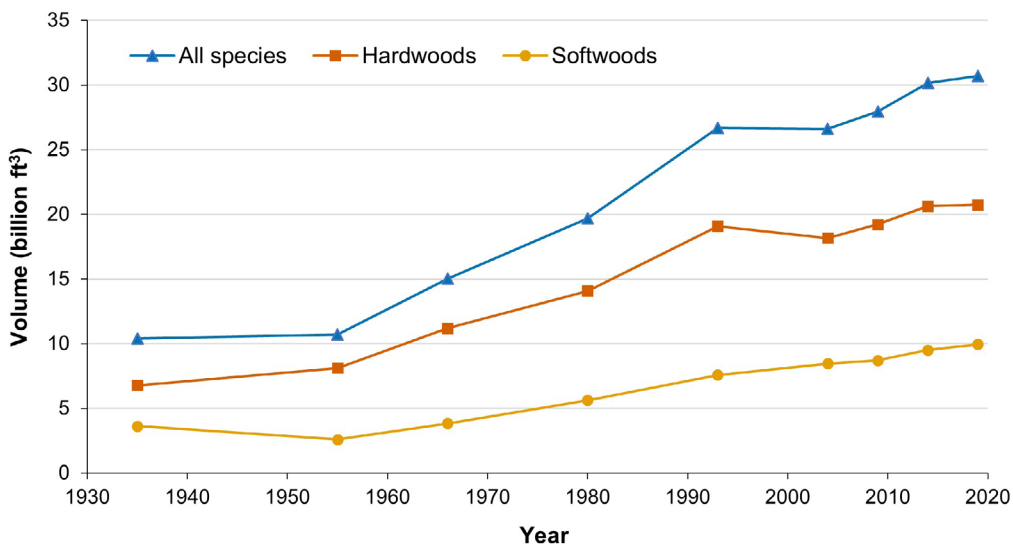


Figure 2.—Distribution of growing-stock volume on timberland by species category and inventory year, Michigan.

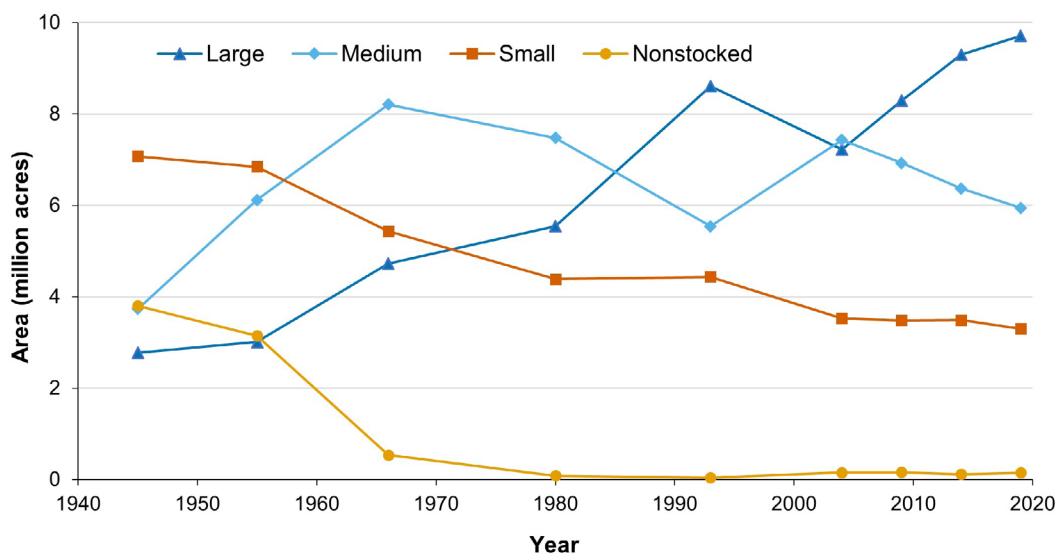


Figure 3.—Area of timberland by stand-size class and inventory year, Michigan.

Agilus planipennis) and other forest health issues, and partially due to the lower rate of growth that accompanies the maturing of Michigan forests (see Forest Change section).

Stand Size

The increase in the number of sawtimber-size trees and volume is concurrent with the change in forest stand size (Fig. 3). Discounting the 1993 inventory, acreage has been steadily increasing in the large stand-size class since the 1935 inventory. The 1993 inventory includes modeled and nonmodeled plots, which results in an overestimation of volume (Pugh et al. 2009). This bias contributed to the substantial increase in the large stand-size class and the substantial decrease in the medium stand-size class from 1980 to 1993. Acreage in the small stand-size class was declining until the 2004 inventory and has since leveled off. Acreage in the medium stand-size class has been variable but has been dropping since the 2004 inventory.

Forest Change

Forest Area and Land Use Change

Changes in amount of forest land and timberland can be indicative of natural factors or human-caused changes in land use, sustainability, and forest health. These changes directly affect the ability of the forest to provide goods and services. Area of forest land in Michigan decreased from the 1955 to 1980 inventory (-6 percentage points) and from the 1980 to 1993 inventory (-2.2 percentage points) and increased from the 1993 to 2009 inventory (4.3 percentage points) for the eastern Upper Peninsula (Fig. 4). The western Upper Peninsula had an increase between the 1993 and 2009 inventory (2.4 percentage points). In the northern Lower Peninsula, there was a decrease from the 1955 to 1980 inventory (-9.7 percentage points) and an increase from the 1980 to 1993 inventory (3.9 percentage points). The southern Lower Peninsula had an increase between the 1980 and 1993 inventory (3.4 percentage points) and between the 1993 and 2009 inventory (2.1 percentage points). The other changes ranged from -1.2 to +0.6 percentage points.

Until the 2019 inventory, the base estimate of Michigan forest land had been increasing since the 1980 inventory. Forest land gains essentially offset forest losses in the 2019 inventory (Fig. 5). Approximately 1.5 percent of forest diverted to nonforest (297,000 acres) and 1.8 percent of nonforest reverted to new forest (308,000 acres). At the State level, forest land diverted to agriculture (33 percent), wetland (31 percent), developed (28 percent), pasture/rangeland (4 percent), water (3 percent), and other (1 percent). Nonforest land reverted from developed (34 percent), agriculture (27 percent), wetland (20 percent), pasture/rangeland (12 percent), other (4 percent), and water (2 percent). Losses in forest land may occur as diversions increase, but the current amount of forest land remains at the highest level since the 1930s.

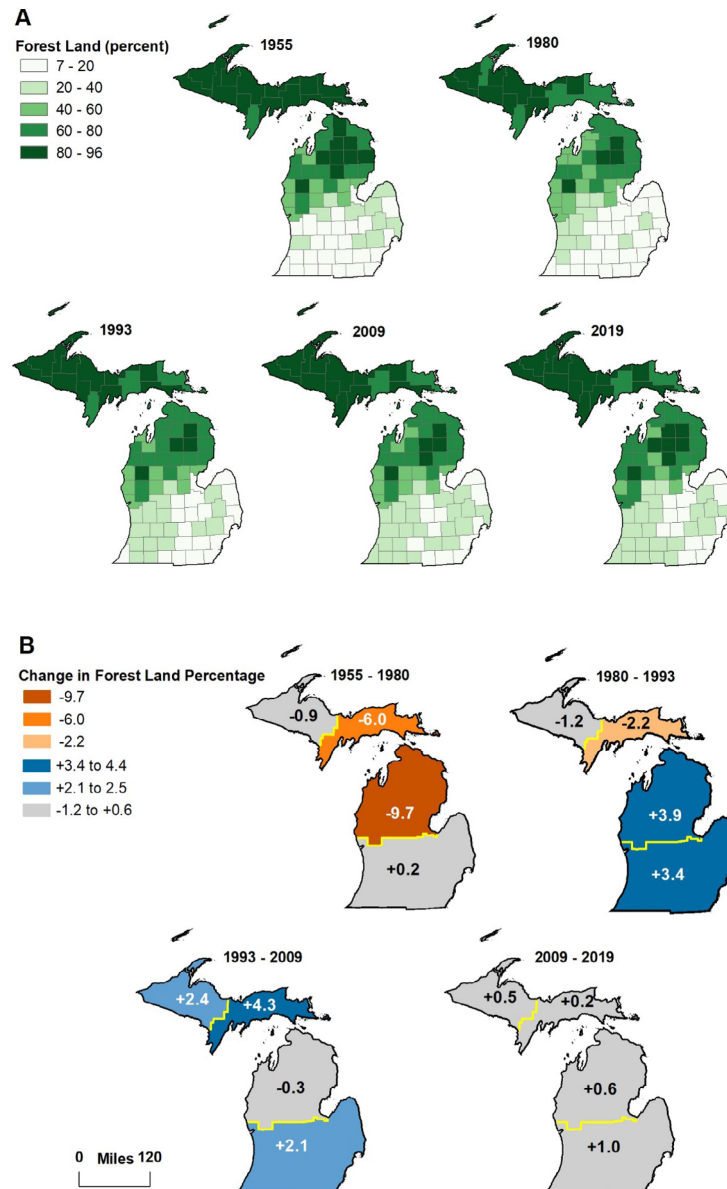


Figure 4.—Percentage of forest land by county (A) and change in forest land by region (B), by inventory year, Michigan.

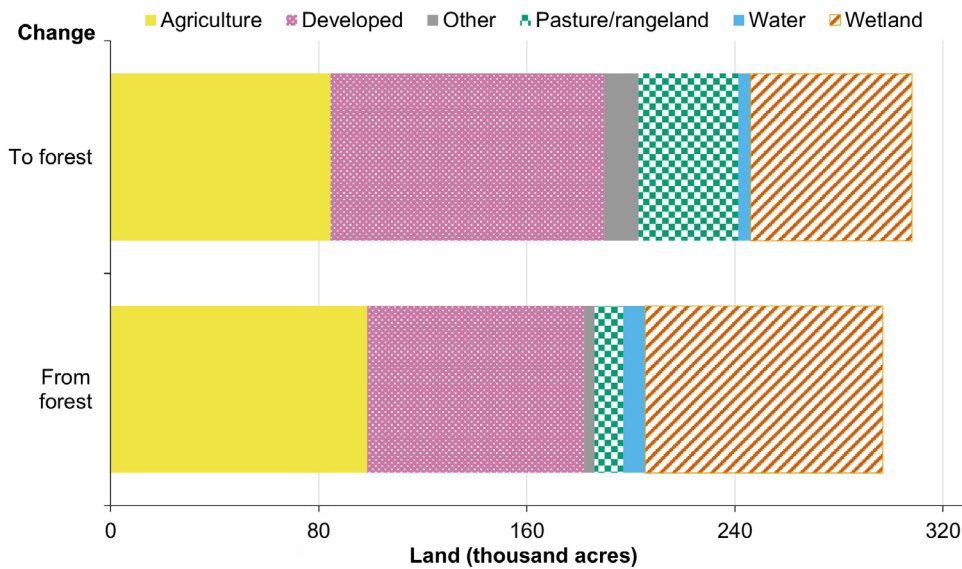


Figure 5.—Forest loss and forest gain by land use category, Michigan, 2008 through 2013 and 2013 through 2019.

Net Growth, Mortality, and Removals

Changes in tree volume (Fig. 6) provide information on forest succession, forest health, disturbance, sustainability, species growth rates, and ecosystem services such as timber production and carbon sequestration. The ratio of change to current live volume (expressed as a percentage) is a useful measure for analysis (Fig. 7). In general, a lower rate will be indicated by a percentage less than or equal to 1.0. Moderate rates are about 1.0 to 3.0; high rates exceed 3.0.

Mortality is a natural part of forest stand development and Michigan has been fortunate to have low rates of mortality. Since the 2009 inventory, the statewide estimate has increased primarily due to the nearly sixfold increase in ash mortality caused by EAB.

Average annual net growth (growth including ingrowth minus mortality and cull) is computed by measuring trees at two points in time and determining the average annual change in volume over the period. A lower rate of net growth has occurred as the forests have matured. Net growth to current volume peaked in the 1955 inventory and total net growth peaked in the 1980 inventory. Even though net growth has slowed, net growth to current volume remains moderate to high for most species. Disregarding ash, net growth on forest land did not change between the 2014 and 2019 inventory (788.3 million ft³ of sound bole volume in each inventory), primarily due to an increase in the western Upper Peninsula, where survivor tree growth increased substantially.

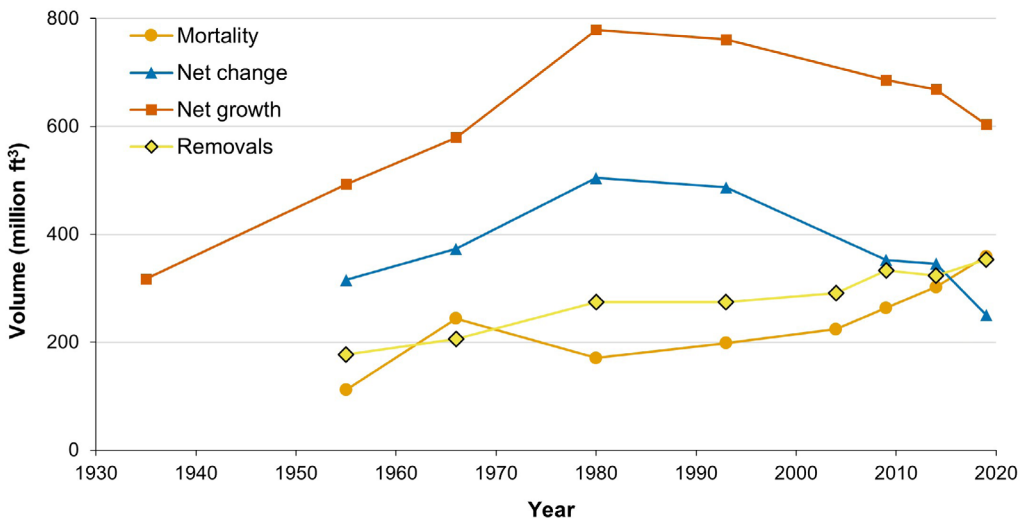


Figure 6.—Net growth, total removals, mortality, and net change of growing stock on timberland by inventory year, Michigan. Estimates include land use change.

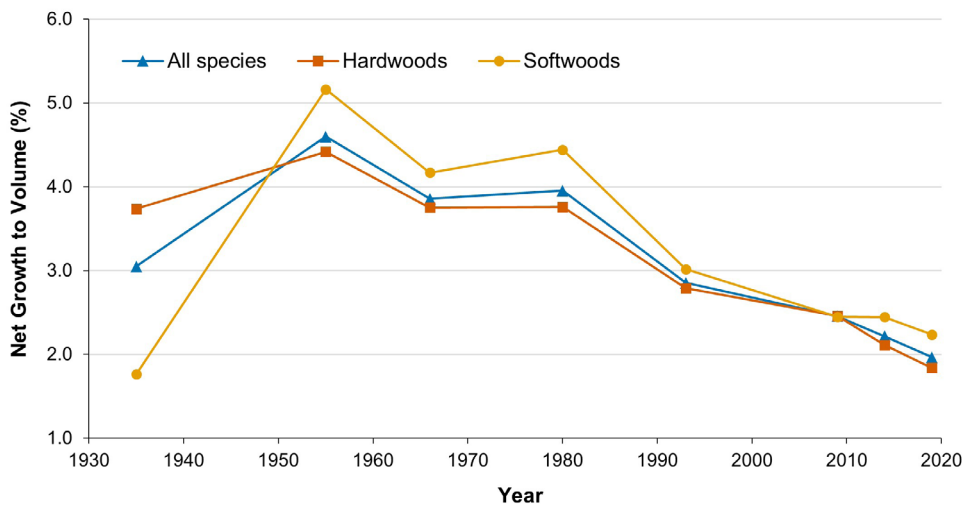


Figure 7.—Ratio (percent) of net growth to current volume for growing stock on timberland by species category and inventory year, Michigan. Estimates include land use change.

The total removals estimate consists of harvest removals (utilized and not utilized) and diversion removals. Harvest removals include utilized trees and trees killed (cut or not cut) as a result of harvest operations (including land clearing) but not utilized. Diversion removals associated with timberland occur when living trees are removed from the timberland base due to land use change (trees are not killed). Removals are affected by biological and social factors. Changes in demand for wood play a key role in removals. Harvesting is not a top priority for most private owners or for public owners like the Forest Service. Since the 1955 inventory, total removals have slowly risen. There has been no discernable change since the 2009 inventory.

Forest Health Indicators

Standing Dead Trees

Specific habitat features like nesting cavities and standing dead trees provide critical habitat components for many wildlife species across Michigan forest land. Standing dead trees are important indicators not only of wildlife habitat, but also of past mortality events and carbon storage. There are currently an estimated 429 million standing dead trees (at least 5 inches diameter at breast height [d.b.h.] or diameter at root collar [d.r.c]) on Michigan forest land. This estimate equates to an average of 21 standing dead trees per acre or approximately 12 standing dead trees for every 100 live trees (at least 5 inches d.b.h. or d.r.c.).

Among prominent species, ash (green, white, and black) have the highest ratios of standing dead to live trees. These ratios are found throughout the Lower Peninsula (ratio of 175 standing dead ash to 100 live trees) in contrast with the Upper Peninsula (6 dead ash to 100 live trees), where the effects of EAB are currently much less pervasive. The number of standing dead trees for green and white ash has increased nearly elevenfold and sevenfold, respectively, since the 2004 inventory (Fig. 8). Most of the change has been in the Lower Peninsula, where most green and white ash occur. For black ash, the number of standing dead trees (more than fivefold increase) has risen dramatically since the 2009 inventory in the Lower Peninsula and eastern Upper Peninsula. Most black ash trees exist in the Upper Peninsula.

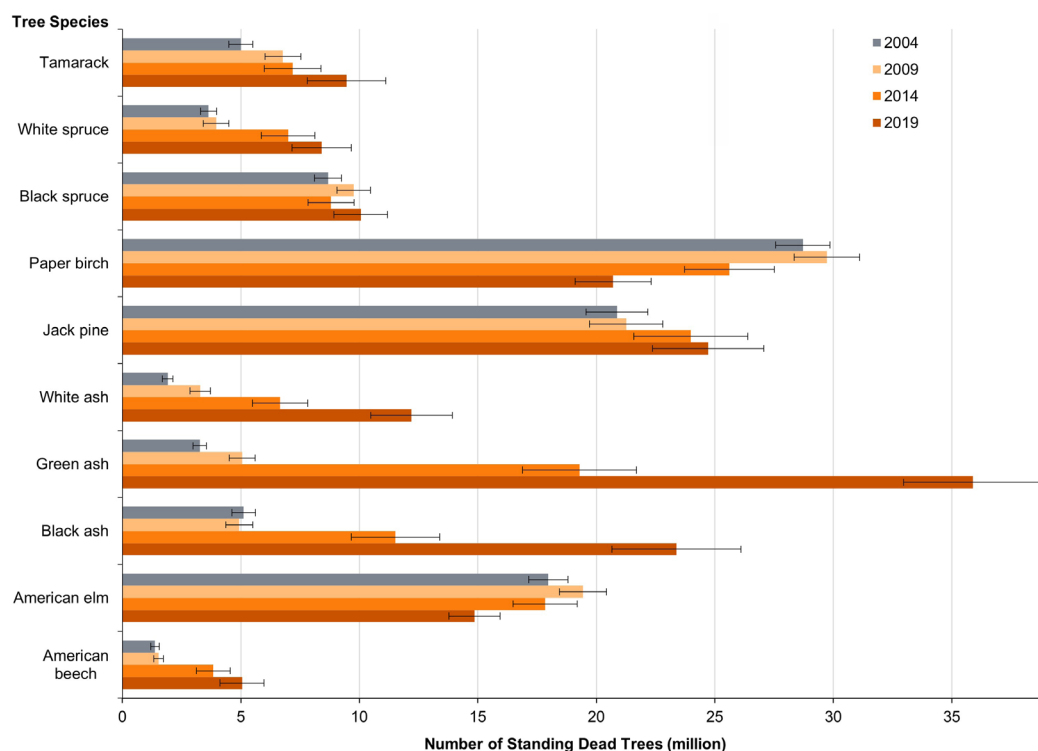


Figure 8.—Number of standing dead trees (at least 5 inches d.b.h. or d.r.c.) on timberland by select species and inventory year, Michigan. Error bars show a 68 percent confidence interval.

In the eastern Upper Peninsula and the northern Lower Peninsula, the number of standing dead trees (nearly fourfold increase) and the ratio of standing dead trees to live trees have risen for American beech since the 2009 inventory. American beech is concentrated mostly in the northern Lower Peninsula and eastern Upper Peninsula. Again, in the eastern Upper Peninsula and the northern Lower Peninsula, the number of standing dead trees (over twofold increase) and the ratio of standing dead trees to live trees have risen for tamarack since the 2004 inventory. Tamarack occurs most frequently in the Upper Peninsula and the northern Lower Peninsula. Tamarack has been affected by the larch casebearer (*Coleophora laricella*), eastern larch beetle (*Dendroctonus simplex*), and changes in fluctuating water levels.

The number of standing dead trees relative to live trees increased for ash and American beech due primarily to EAB and beech bark disease (a complex of the scale insect *Cryptococcus fagisuga* and the fungus *Nectria* spp.), respectively. When the number of standing dead trees of these species finally begins to decrease, it will likely be due to depleted numbers of live trees. Widespread and species-specific tree mortality such as that resulting from EAB may provide an overabundance of habitat while the trees are standing. But the dead trees are likely to fall within a short time of one another, again eliminating available habitat.

Ecosystem Services

The forests of Michigan provide multiple benefits—also called ecosystem services—to people living in the region and beyond. Ecosystem services can be defined as “the aspects of ecosystems utilized (actively or passively) to produce human well-being” (Fisher et al. 2009). These include wood products and nontimber forest products, recreation and other cultural services, and important regulating services.

Regulating Services

Regulating services (sometimes called critical ecological functions) improve well-being by acting as buffers and drivers of energy and matter flows that constitute the human environment, such as climate and hydrology. We used i-Tree Landscape 4.2 (i-Tree® 2020), a component of the i-Tree suite of tools, to estimate the provision of three regulating services on Michigan forests. In 2020, carbon sequestration (\$1.8 billion or 91 percent), avoided runoff (\$106.7 million or 5.3 percent), and pollution removal (\$75.7 million or 3.7 percent) produced benefits worth an estimated \$2.0 billion across Michigan. The removal of pollutants by forests reduces the annual number of disease cases and health incidents. The largest share of these avoided incidents were acute respiratory symptoms (5,339 cases) and asthmatic episodes (3,004 cases).

Product and Cultural Services

Michigan forests have always supported local and State economies, generating employment and income (Leefers 2014, 2015). Knowing the economic contribution of forestry and forest products industries (FPI) is essential to fostering sustainable forest management. According to the 2017 “Impact Analysis for Planning,” FPI in Michigan directly employed 41,000 workers with an output of approximately \$12.2 billion annually (Leefers et al. 2020). The total number of jobs supported was 91,176 with a total output close to \$20.2 billion annually.

Timber Product Output

To properly manage and sustain Michigan forests, it is essential to have information on the location and species of timber that supply FPI. The Forest Service and the MI DNR conduct surveys of all primary and wood-using mills in the Timber Product Output (TPO) study identifying the volume of industrial roundwood products produced.

According to the 2018 study, 505 million ft³ of woody material was harvested from Michigan forests. The northern Lower Peninsula was the largest producer of roundwood with more than 157.9 million ft³ (41 percent of total); the western Upper Peninsula, ranked second, produced 105.9 million ft³ (27 percent of total). The northern Lower Peninsula and western Upper Peninsula account for the majority of timberland with 7.2 million and 4.6 million acres, respectively. Roundwood production has been fairly steady since 2010 (Fig. 9). However, there appears to have been an increase in 2014 and then a decrease in 2018 for the northern Lower Peninsula. An increase occurred in 2018 for the southern Lower Peninsula. The southern Lower Peninsula has consistently produced the least amount of roundwood.

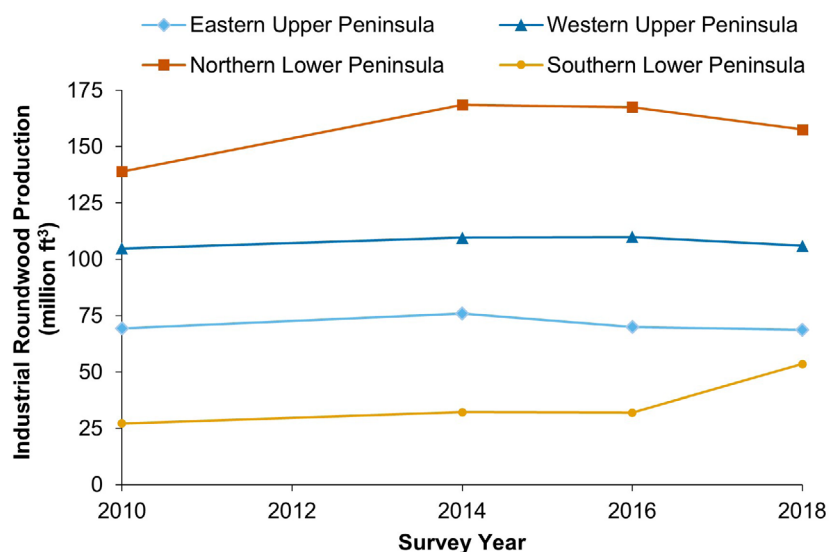


Figure 9.—Industrial roundwood production by region and survey year, Michigan.

Aspen accounted for almost 17 percent of the total industrial roundwood produced in 2018. Aspen is the most commonly harvested species in the State, in part because of the strong competitive nature of the pulp, paper, and oriented strand board and panel industries. Other important species or species groups harvested were red pine (10 percent), red oaks (9 percent), hard maple (9 percent), soft maple (8 percent), and white pine (3 percent).

Net growth, removals, and volume indicate that an increase in the harvest of timber products in Michigan would be biologically sustainable. For the 2019 inventory, the ratio of net growth to harvest removals for sound bole volume (trees at least 5 inches d.b.h. or d.r.c.) on timberland is 1.8, indicating that volume is increasing at a moderate rate. This opportunity to increase harvest is influenced by difficult-to-measure factors such as landowner objectives, accessibility, parcelization, stumpage price, and market volatility, all of which make it challenging to increase the harvest level in Michigan.

Family Forest Ownership

To a large extent, landowners determine the quantity and quality of forest resources, including ecosystem services such as recreation opportunities, timber supply, 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 conserve the State's forests for future generations.

FIA's National Woodland Owner Survey (NWOS) studies private forest owners' attitudes, management objectives, and concerns with a focus on the families, individuals, and other unincorporated groups collectively referred to as "family forest ownerships." The latest NWOS survey is for 2018 (Butler et al. 2021) and the results are for family forest ownerships with 10 or more acres of forest land.

For the 2018 inventory, 43 percent of the forest land in Michigan is owned by family forest owners. There are an estimated 182,000 family forest ownerships with 10 or more acres of forest land in the State. The average age of family forest owners is 65 years and the average size of family forest holdings is 45 acres.

The primary reasons for owning family forests are related to amenity values, such as aesthetics, wildlife, and nature (Fig. 10). The most common activity on family forest land in Michigan in the previous 5 years is personal recreation; 72 percent of the family forest ownerships, which control 78 percent of the family forest land, participated in activities such as hiking or hunting on their land.

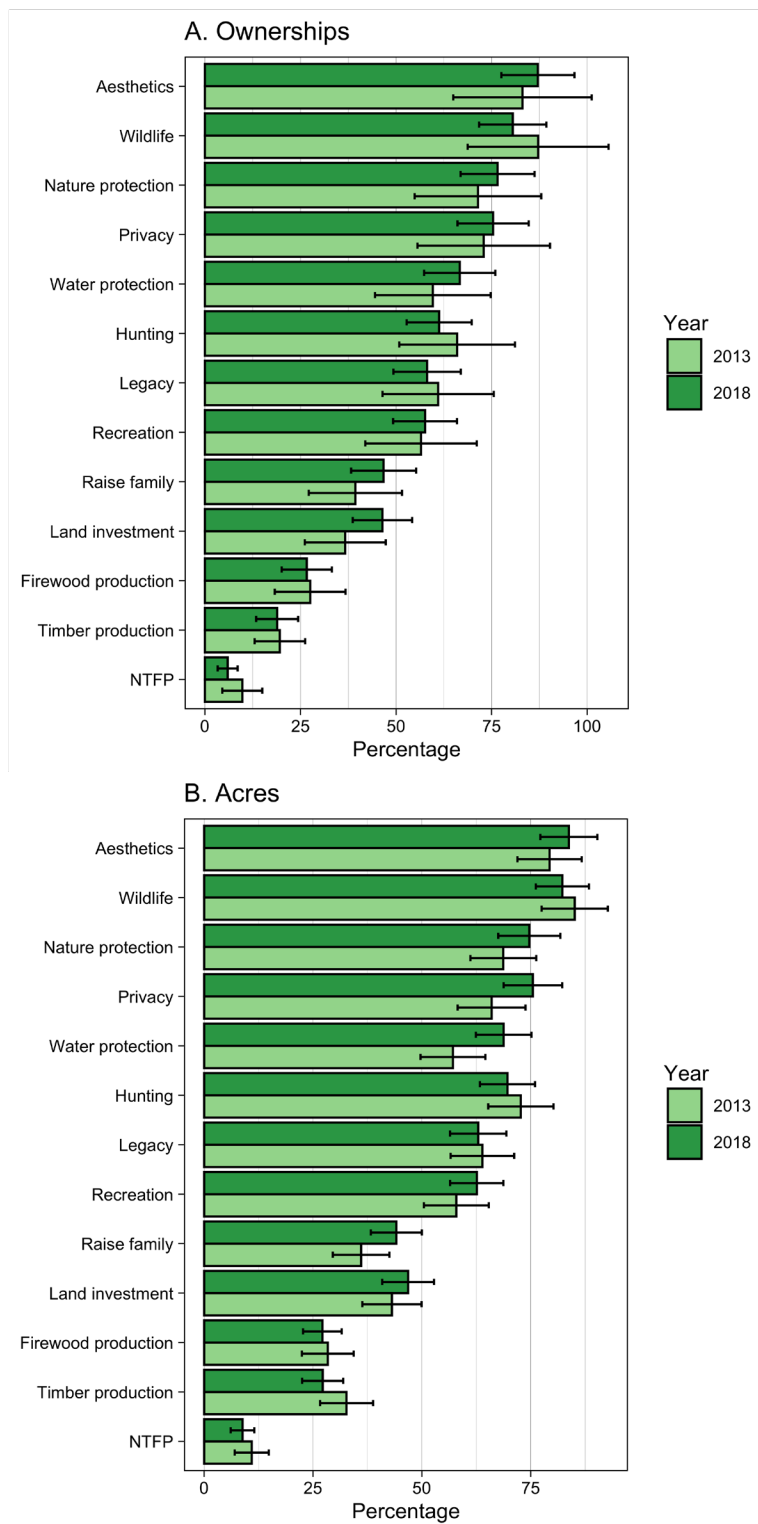


Figure 10.—Family forest (10+ acres) ownerships (A) and acreage (B) by reasons for owning and survey year, Michigan, 2013 and 2018. Percentages include those who responded a specific reason was important or very important on a 5-point Likert scale. NTFP: nontimber forest products. Error bars show a 95 percent confidence interval.

Commercial timber harvesting in the previous 5 years was done by 23 percent of the family forest ownerships, which control 33 percent of the family forest land. Eighteen percent of the family forest ownerships, which control 30 percent of the family forest land, have received advice in the last 5 years and 5 percent of the family forest ownerships, which control 19 percent of the family forest land, have a written forest management plan.

When we look particularly at family forest ownerships—the group that is the least understood and the fate of whose land is arguably the most uncertain—we see that they own their land primarily for amenity reasons, but many are actively doing things with their land. The percentage of ownerships that have received advice and that have written forest management plans is fairly low. There are significant opportunities to help these owners increase their engagement and stewardship of their lands through methods outlined by the Tools for Engaging Landowners Effectively program ([TELE](#)) and other projects.

Urban Forests and Fragmentation

The wildland-urban interface (WUI) is the zone where human development meets or intermingles with undeveloped wildland vegetation, and it is the fastest-growing land use type in the conterminous United States (Mockrin et al. 2019, Radeloff et al. 2018). The WUI is associated with a variety of consequential human-environment conflicts. For example, the WUI impacts water quality and quantity from impervious surfaces and increased pollution (Bar-Massada et al. 2014, Gonzalez-Abraham et al. 2007). The 2014 report from the Northwoods Climate Change Response Framework on Michigan forest ecosystem vulnerability (Handler et al. 2014) identified fragmentation and land use change as one of the top five current major stressors and threats to forest ecosystems.

We studied WUI areas with at least 15.5 houses per square mile. By 1990, 3.7 million acres of Michigan forest land (18 percent) was in WUI conditions. From 1990 to 2010, the percentage of forest land in WUI increased to 25 percent. Over these two decades, area of WUI forest land in 31 counties, including most counties in the southeastern Lower Peninsula and clusters of counties in other parts of the State, increased by more than 10 percentage points (Fig. 11). In six counties scattered throughout the State, that conversion rate was even more rapid, averaging greater than 20 percentage points per two decades. The change from WUI to non-WUI forest was 114,815 acres state-wide.

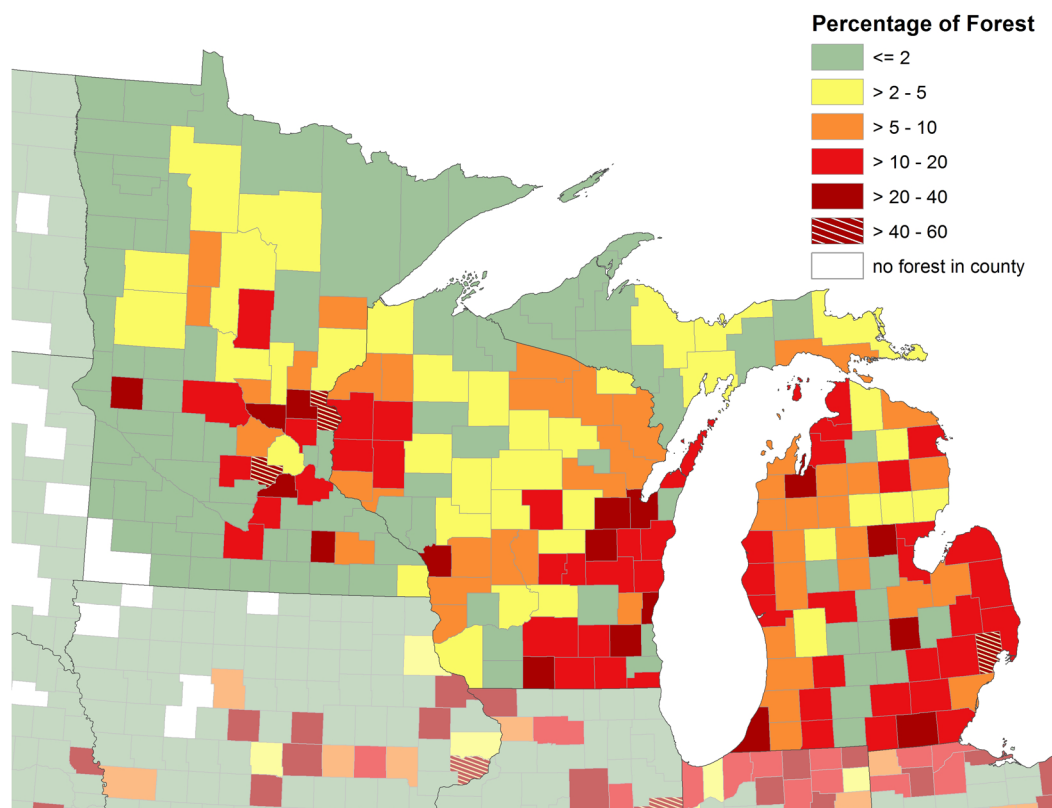


Figure 11.—Percentage of forest land that changed from nonwildland-urban interface (non-WUI) to WUI by county, primarily Minnesota, Wisconsin, and Michigan, 1990 to 2010. Source: WUI 2010 (Radeloff et al. 2017).

Increasing urbanization has the potential to change how forests function, affecting their vulnerability to threats such as insect pests and disease, nonnative species proliferation, and loss of native species, all of which hinders their overall resilience in the face of both these threats and the additional changes and disturbances expected due to climate change. Such changes also affect the inherent ecosystem services provided by forest land, such as clean water, clean air, flood protection, opportunities for recreation, wildlife habitat, and forest products (e.g., Vermont Department of Forests, Parks and Recreation 2015). Many of these forest ecosystem changes happen over time, and thus forest land that has only recently become WUI may not look any different yet. Forest land which has been in WUI conditions for over 30 years is more likely to exhibit changes.

The well-documented negative effects of residential development on forest land and the amount of forest land occurring in WUI conditions underscore the importance of management decisions and strategies to mitigate the effects of residential land use on surrounding forest land (Kramer 2013). In addition, land-use planning interventions can be used to maintain remaining forest connectivity.

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Appendix

Table 1.—Tree species, seedlings (P2) and larger, found on FIA plots, Michigan, 2019

Species common name	Genus	Species
Balsam fir	<i>Abies</i>	<i>balsamea</i>
White fir	<i>Abies</i>	<i>concolor</i>
Eastern redcedar	<i>Juniperus</i>	<i>virginiana</i>
Larch species	<i>Larix</i>	spp.
Tamarack	<i>Larix</i>	<i>laricina</i>
Norway spruce	<i>Picea</i>	<i>abies</i>
White spruce	<i>Picea</i>	<i>glauca</i>
Black spruce	<i>Picea</i>	<i>mariana</i>
Blue spruce	<i>Picea</i>	<i>pungens</i>
Jack pine	<i>Pinus</i>	<i>banksiana</i>
Red pine	<i>Pinus</i>	<i>resinosa</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>
Austrian pine	<i>Pinus</i>	<i>nigra</i>
Douglas-fir	<i>Pseudotsuga</i>	<i>menziesii</i>
Northern white-cedar	<i>Thuja</i>	<i>occidentalis</i>
Eastern hemlock	<i>Tsuga</i>	<i>canadensis</i>
Boxelder	<i>Acer</i>	<i>negundo</i>
Black maple	<i>Acer</i>	<i>nigrum</i>
Striped maple	<i>Acer</i>	<i>pensylvanicum</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>
Mountain maple	<i>Acer</i>	<i>spicatum</i>
Norway maple	<i>Acer</i>	<i>platanoides</i>
Ohio buckeye	<i>Aesculus</i>	<i>glabra</i>
Ailanthus	<i>Ailanthus</i>	<i>altissima</i>
European alder	<i>Alnus</i>	<i>glutinosa</i>
Serviceberry species	<i>Amelanchier</i>	spp.
Pawpaw	<i>Asimina</i>	<i>triloba</i>
Yellow birch	<i>Betula</i>	<i>alleghaniensis</i>
Paper birch	<i>Betula</i>	<i>papyrifera</i>
Gray birch	<i>Betula</i>	<i>populifolia</i>
American hornbeam, musclewood	<i>Carpinus</i>	<i>caroliniana</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>
Mockernut hickory	<i>Carya</i>	<i>alba</i>

continued on next page

Table 1.— Tree species, seedlings (P2) and larger, found on FIA plots, Michigan, 2019

Species common name	Genus	Species
American chestnut	<i>Castanea</i>	<i>dentata</i>
Northern catalpa	<i>Catalpa</i>	<i>speciosa</i>
Hackberry	<i>Celtis</i>	<i>occidentalis</i>
Flowering dogwood	<i>Cornus</i>	<i>florida</i>
Hawthorn species	<i>Crataegus</i>	spp.
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>
Honeylocust	<i>Gleditsia</i>	<i>triacanthos</i>
Kentucky coffeetree	<i>Gymnocladus</i>	<i>dioicus</i>
Butternut	<i>Juglans</i>	<i>cinerea</i>
Black walnut	<i>Juglans</i>	<i>nigra</i>
Yellow-poplar	<i>Liriodendron</i>	<i>tulipifera</i>
Apple species	<i>Malus</i>	spp.
White mulberry	<i>Morus</i>	<i>alba</i>
Red mulberry	<i>Morus</i>	<i>rubra</i>
Blackgum	<i>Nyssa</i>	<i>sylvatica</i>
Eastern hophornbeam	<i>Ostrya</i>	<i>virginiana</i>
American sycamore	<i>Platanus</i>	<i>occidentalis</i>
Balsam poplar	<i>Populus</i>	<i>balsamifera</i>
Eastern cottonwood	<i>Populus</i>	<i>deltoides</i>
Bigtooth aspen	<i>Populus</i>	<i>grandidentata</i>
Quaking aspen	<i>Populus</i>	<i>tremuloides</i>
Pin cherry	<i>Prunus</i>	<i>pennsylvanica</i>
Black cherry	<i>Prunus</i>	<i>serotina</i>
Chokecherry	<i>Prunus</i>	<i>virginiana</i>
American plum	<i>Prunus</i>	<i>americana</i>
Sweet cherry	<i>Prunus</i>	<i>avium</i>
Sour cherry	<i>Prunus</i>	<i>cerasus</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>
Northern pin oak	<i>Quercus</i>	<i>ellipsoidalis</i>
Shingle oak	<i>Quercus</i>	<i>imbricaria</i>
Bur oak	<i>Quercus</i>	<i>macrocarpa</i>
Pin oak	<i>Quercus</i>	<i>palustris</i>
Northern red oak	<i>Quercus</i>	<i>rubra</i>
Shumard oak	<i>Quercus</i>	<i>shumardii</i>

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Table 1.— Tree species, seedlings (P2) and larger, found on FIA plots, Michigan, 2019

Species common name	<i>Genus</i>	<i>Species</i>
Black oak	<i>Quercus</i>	<i>velutina</i>
Black locust	<i>Robinia</i>	<i>pseudoacacia</i>
Willow species	<i>Salix</i>	spp.
Peachleaf willow	<i>Salix</i>	<i>amygdaloides</i>
Black willow	<i>Salix</i>	<i>nigra</i>
Bebb willow	<i>Salix</i>	<i>bebbiana</i>
White willow	<i>Salix</i>	<i>alba</i>
Sassafras	<i>Sassafras</i>	<i>albidum</i>
Mountain-ash species	<i>Sorbus</i>	spp.
American mountain-ash	<i>Sorbus</i>	<i>americana</i>
Northern mountain-ash	<i>Sorbus</i>	<i>decora</i>
American basswood	<i>Tilia</i>	<i>americana</i>
American elm	<i>Ulmus</i>	<i>americana</i>
Siberian elm	<i>Ulmus</i>	<i>pumila</i>
Slippery elm	<i>Ulmus</i>	<i>rubra</i>
Rock elm	<i>Ulmus</i>	<i>thomasi</i>

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