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Indiana Forests 2018: Summary Report

Citation

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Abstract

This summary report provides an overview of findings from the fourth full annualized inventory of Indiana forests based on data collected from 2012 to 2018. Indiana has nearly 4.9 million acres of forest land with an average of 442 trees (at least 1.0-inch in diameter) per acre. Hardwoods are the dominant tree species in Indiana. Forest land is dominated by the oak/hickory forest-type group, which occupies 72 percent of the total forest land area (3.5 million acres). Live tree volume averages 2,240 cubic feet per acre. Growing-stock net growth exceeds removals resulting in a growth-to-removals ratio of 2.2, meaning that timberland is accumulating volume. Fragmentation and parcelization, aging forest cover, as well as threats from native and non-native plants and pests are major issues that will impact the future of Indiana's forests. Information from the National Woodland Owner Survey and the Timber Products Output studies are also presented in this summary document. A detailed interactive report is available at https://doi.org/10.2737/NRS-RB-132-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-132.

KEYWORDS: 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: A road ablaze with fall colors in Hoosier National Forest, Indiana. USDA Forest Service photo by Gary Courtney.

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Foreword

Welcome to Indiana Forests 2018, the latest results of our statewide forest inventory. This inventory is an ongoing joint venture between the Indiana Department of Natural Resources, Division of Forestry and the Forest Inventory and Analysis program of the U.S. Department of Agriculture, Forest Service. Results from this eighth inventory show that Indiana forests continue to grow more wood than is being harvested, providing an important and essential element to Indiana's economy, the wood industry, and individual woodland owners. Indiana forests have expanded to nearly 4.9 million acres with an average statewide volume of over 2,200 cubic feet per acre. These productive forests provide homes and food for wildlife; clean our water and air; protect soil that would otherwise disappear due to erosion; supply fine quality hardwood products, and provide diverse outdoor recreation opportunities for both today's citizens and the next generation of Hoosiers, Americans, and the world.

Indiana is fortunate to have productive and high-quality stands of forest land. Quality hardwood forests rank Indiana high in many categories of high value forest products. Indiana's forest products industry has an annual economic impact of over $10 billion and supports 70,000 jobs—44,000 in primary and secondary manufacturing and 26,000 in ancillary sectors. Eighty four percent or 4.1 of Indiana's 4.9 million forest acres are privately owned. Indiana's forests are growing more wood than is being harvested; statewide timberland growing-stock net growth exceeds growing-stock removals—by 2.3 times.

While Indiana forests continue to be resilient, there are concerns. Throughout Indiana and the entire Central Hardwood region, oak-hickory forests are maturing and, in many places, shifting to different forest types. As maturing oaks and hickories mature and die they often are replaced by other competing species such as sugar maple and yellow-poplar, rather than young oaks or hickories. Driving these trends are significant reductions or even failures in oak-hickory regeneration. The current trajectory away from dominance by oaks represents a long, slow change that has implications for biodiversity, wildlife, recreation, and the forest products industry. Average tract size continues to decrease with indications these holdings may also be changing ownership. Ash tree mortality resulted in a loss of 40.1 million cubic feet of volume per year, mostly attributed to the emerald ash borer, a nonnative insect accidentally introduced in Michigan that has spread to other states. There are a growing number of invasive plant species outcompeting native vegetation for sunlight and nutrients. In addition, white-nose syndrome is deadly to many of our beneficial forest- and cave-dwelling bats. All these issues need to be monitored, and future management decisions may need to be altered to address such concerns.

I invite you to read and interpret the results of Indiana Forests 2018. Hopefully you enjoy perusing the information. As a result, perhaps you will become more interested in our State's forests and then participate in the discussions about the future of forests and forestry in Indiana.

John Seifert

Indiana State Forester
Indiana Department of Natural Resources

Contents


Barred owl in the Hoosier National Forest, Indiana.
Courtesy photo by Ian Terrell.


Wildflowers of the Biden genus in bloom in Hoosier National Forest, Indiana.
USDA Forest Service photo by Terry Severson.


Traveling by kayak through Hoosier National Forest, Indiana.
USDA Forest Service photo by Robert Arnold.

Highlights

On the Plus Side

- Eighty-four percent of Indiana's forest land is privately owned by corporations and family forest owners. The vast majority, an estimated 3.6 million acres (76 percent) are family-owned forests. An estimated 85,000 family forest owners across Indiana own at least 10 acres of forest land.
- The statewide increase in timberland area between 1986 and 2018 may be attributed to farmland to forest reversion.
- Over the past 68 years, the area of Indiana timberland increased slightly from 4 to 4.9 million acres. Over that same period, the net volume of live trees on timberland quadrupled from 2.6 to 10.9 billion cubic feet.
- Yellow-poplar continues to be the most voluminous species followed by sugar maple and white oak. Black cherry had the greatest percentage increase in volume with 9 percent.

Issues to Watch

- Indiana forests are being affected by urbanization and fragmentation.
- Future changes in Indiana's forest land will depend on the pace of land development and, to a great extent, farming economics, since idle farmland has been the source of much of the increase in forest land.
- Invasive plant species were detected on more than 97 percent of the inventory plots—a 7 percent increase since 2013. The data suggest that these plants are present throughout the State and have become widespread.
- Emerald ash borer has had a major impact on ash resources in Indiana, particularly with respect to black ash.
- The current trajectory away from dominance by oaks represents a long, slow change that has implications for biodiversity, wildlife, recreation, and the forest products industry.
- Forest stands continue to shift to the sawtimber (large diameter) size class. In 2018, approximately 84 percent of the stands are in age classes greater than 40 years and 82 percent are in sawtimber-size stands. Indiana forests are maturing. Currently, over half (57 percent) of the stands are over 60 years of age.

Background

What is this Report?

This report summarizes the findings of the eighth inventory of the forest resources of Indiana conducted between 2012 and 2018. This report will refer to these years as the 2018 inventory. This report is broken into chapters that focus on forest features, forest resource attributes, health indicators, and socioeconomics. It includes graphics which summarize data to make comparisons as well as maps to reflect forest attribute estimates. The summary report and additional resource materials are available online at https://doi.org/10.2737/NRS-RB-132.

More detailed results are available in the Indiana Forests 2018: Interactive Report StoryMap collection (Fig. 1). It includes interactive maps, charts, and dashboards that summarize data and illustrate trends, making it easy for readers to compare between inventory periods, geographic locations, or ecological divisions. This document offers a summary of those results.

Indiana Forest Inventories

Information on the condition and status of forests in Indiana was obtained from the U.S. Department of Agriculture, Forest Service, Northern Research Station, Forest Inventory and Analysis (NRS-FIA) program. Previous inventories of Indiana's forest resources were completed in 1950 (Winters 1953), 1967 (Spencer 1969), 1986 (Smith and Golitz 1988; Spencer et al. 1990), 1998 (Schmidt et al. 2000), 2003 (Woodall et al. 2005), 2008 (Woodall et al. 2011), and 2013 (Gormanson et al. 2016).

FIA switched from periodic to annual inventories starting after the 1998 periodic inventory. Historically, periodic inventories were conducted for each state on a cycle that averaged every 12 years. Indiana began annual inventories in 1999. Under the annual inventory system, approximately one-fifth of all field plots are measured each year. This resulted in a completed inventory every 5 years, with estimates being produced using a 5-year moving average. In 2014, NRS-FIA changed to a 7-year inventory cycle, wherein one-seventh (14.3 percent) of the plots are measured annually. For the 2018 inventory, estimates such as forest area, volume, and biomass are based on 1,106 forested field plots collected from 2013 to 2018. The 2018 change variables, such as net growth, removals, and mortality, are based on plots collected in 2007 to 2013 and resampled in 2013 to 2018. Data used in this publication were accessed from the FIA database from May 2019 to May 2020. Information published in this report and in related tables is based on Forest Inventory and Analysis Database (FIADB), collected under NRS field guides 4.0 to 7.2 and compiled in the National Information Management System (NIMS). Version 7.2 of the FIA field methods guide was released October 2017. It describes the current set of nationally consistent core field procedures used by all FIA units for projects that begin after the date of release. This version of the field guide covers all core and core optional measurements collected on Phase 2 plots (the standard base FIA sample grid, each sample location represents approximately 6,000 acres). See Bechtold and Patterson 2005; Burrill et al. 2018; and Gormanson et al. 2023 for definitions and technical details. FIA estimates, tabular data, and maps may be generated using the various applications in the FIA Data and Tools page.

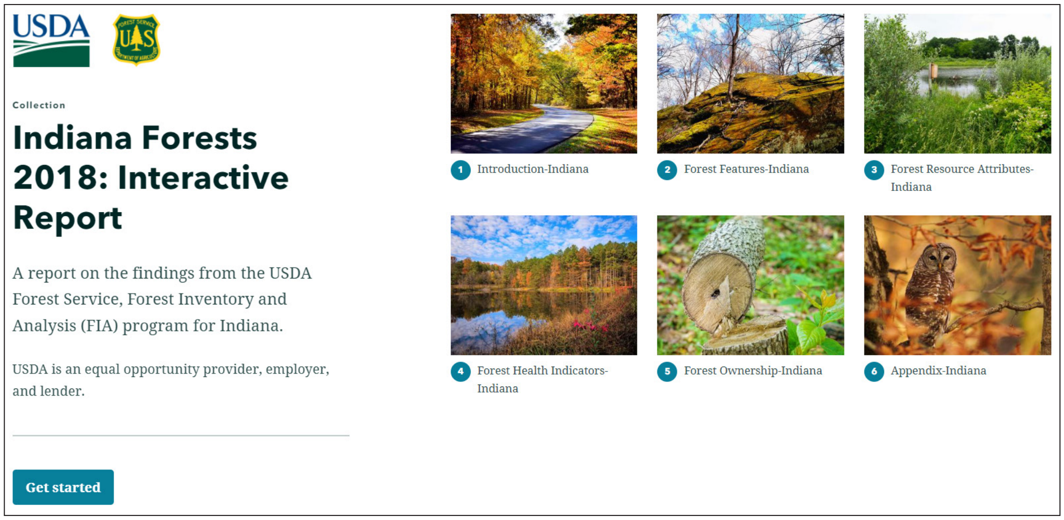

Figure 1.—The Indiana Forests 2018: Interactive Report contains a series of StoryMaps (collection) that focus on different forest aspects. Select the Get Started button or one of the photos to view an individual StoryMap within the collection.

Forest Features

Forest Area and Land Use

Forest area is an essential measurement standard for evaluating status and overall trends in a variety of assessments of natural resources. The quantity, quality, structure, composition, age, and general health of our forest and timber lands are key measures for assessing forest resources and making informed decisions about their management, recreational uses, and future. Trends in the forest land base serve as a barometer of forest sustainability, wetland and forest health, and land-use stewardship practices. Gains and losses in forest area directly affect the benefits forests provide, including clean air and water (watershed protection), wildlife habitat, prevention of fertile soil erosion, materials for medicines, renewable energy development, wood products, and outdoor opportunities like hiking, biking, camping, fishing, hunting, viewing wildlife, and enjoying nature.

The FIA program defines land use by several categories (cropland, developed, forest, pasture/rangeland, water, wetland, and other). Tracking changes in land use is important for analyzing factors affecting forest loss (diversion) and forest gain (reversion). To accomplish this, land use is compared on remeasured plots. This report section is based on plots measured during the 2018 inventory and previously measured during the 2013 inventory.

Indiana forests have increased in area by 800,000 acres since 1950 and now comprise nearly 4.9 million acres, with the percentage of land in forest cover increasing from north to south. The State is divided into four inventory or FIA units (Fig. 2), with timberland unevenly distributed among inventory units: Northern (1.3 million acres), Lower Wabash (929 thousand acres), Upland Flats (643 thousand acres), and Knobs (1.8 million acres). Forest reversions slightly exceeded forest diversions since the last inventory (Fig. 3).

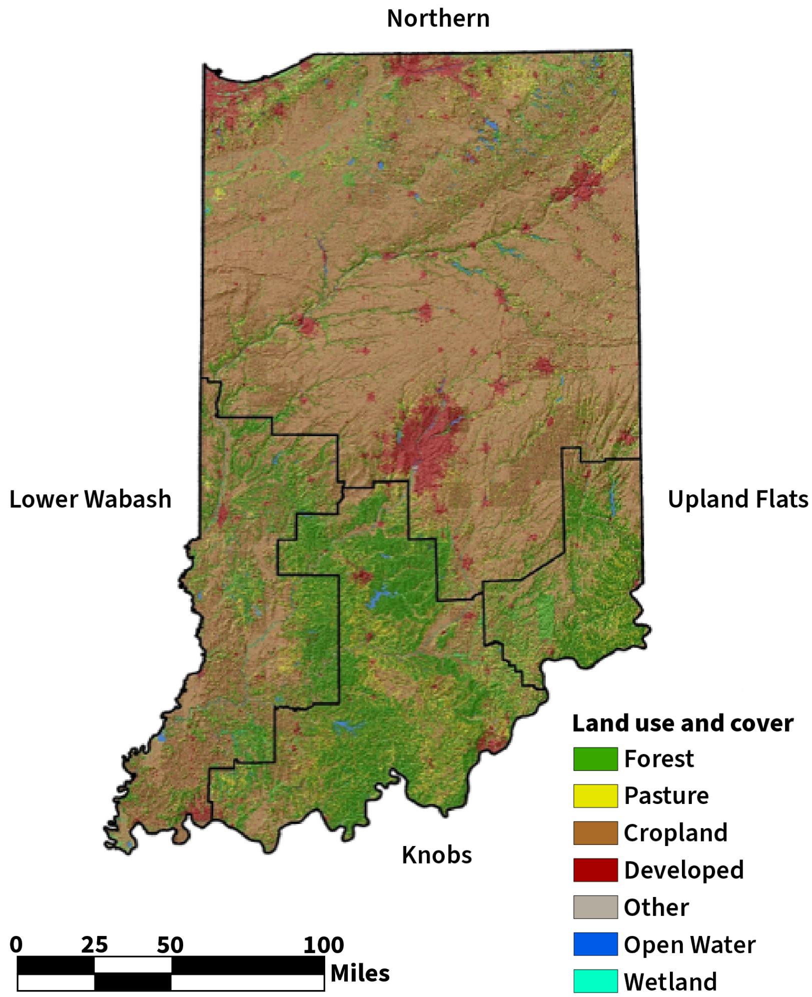

Figure 2.—Indiana land use and land cover (Jin et al. 2019). The four FIA units are outlined.

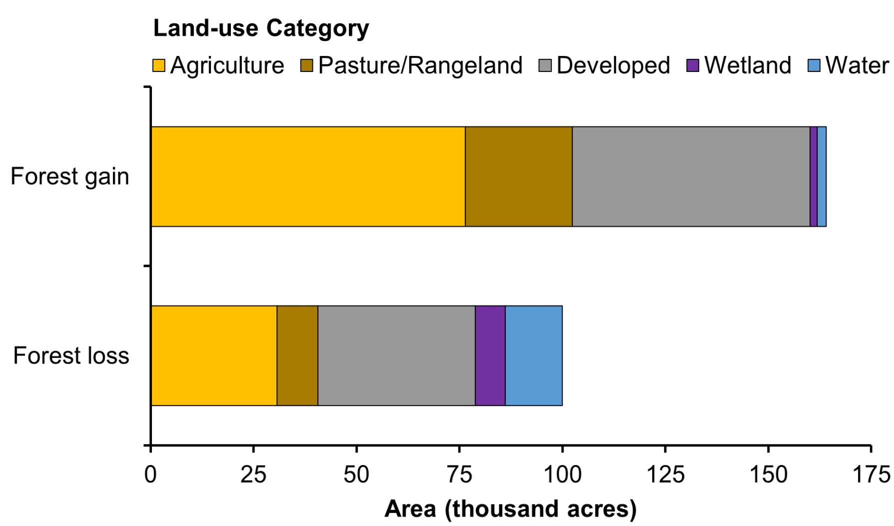

Figure 3.—Gross area of forest loss and forest gain by land use category in Indiana from 2013 to 2018.

The Knobs and Lower Wabash Units showed timberland losses between 1986 and 2003 but rebounded by 2013 and seem stable in 2018 (Fig. 4). The Upland Flats and Northern Units have experienced gains in forest land since 1986, and these gains combined with the units that have increased since 2003, account for the recent increase in forest land for the state.

Trends in forest land area resulting from land-use change can be more closely examined by limiting the comparison to only plots that were measured at both times. Most of the land in Indiana remained either nonforest (78.7 percent) or forest (20.2 percent), with the remaining land changing as forest reversion (0.7 percent gain) and diversion (0.4 percent loss) (Fig. 5).

Agricultural land use combined with Pasture/Rangeland accounted for 40.1 percent of forest loss, and 62.5 percent of forest gain. Developed land use and water accounted for 38.2 and 13.9 percent of forest losses, and 35.1 and 1.3 percent of forest gains, respectively, with wetland contributing remaining areas forest changes (Fig. 3).

Timberland area, which comprises a substantial majority of Indiana forest land, had been increasing for several decades but has since leveled off; forest area has exhibited a similar pattern. Most of the forest change in Indiana has been to and from agriculture and pasture/rangeland, which comprise the most prevalent land uses in the State. For now, it appears that forest loss and gain is largely offsetting.

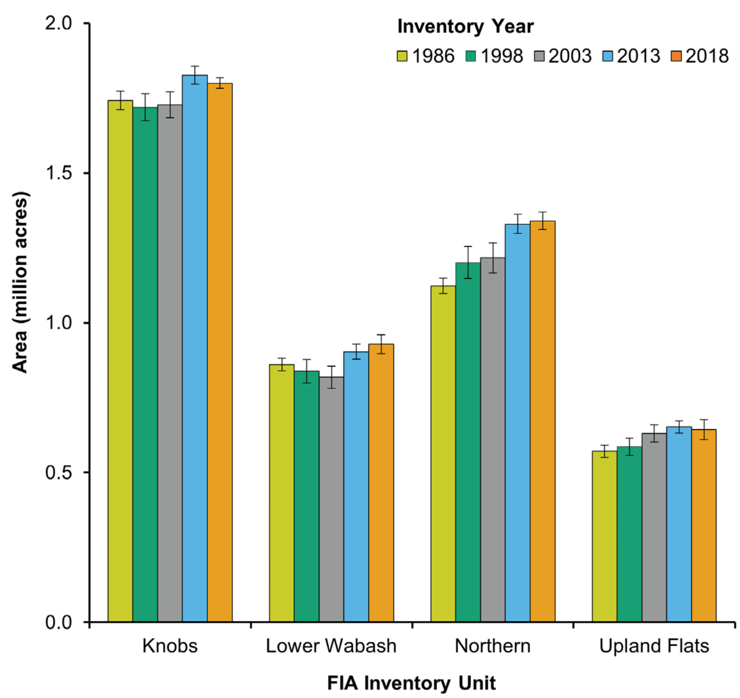

Figure 4.—Area of timberland in Indiana by inventory unit and year: 1986, 1998, 2003, 2013, and 2018. Error bars represent a 68 percent confidence interval around the estimate.

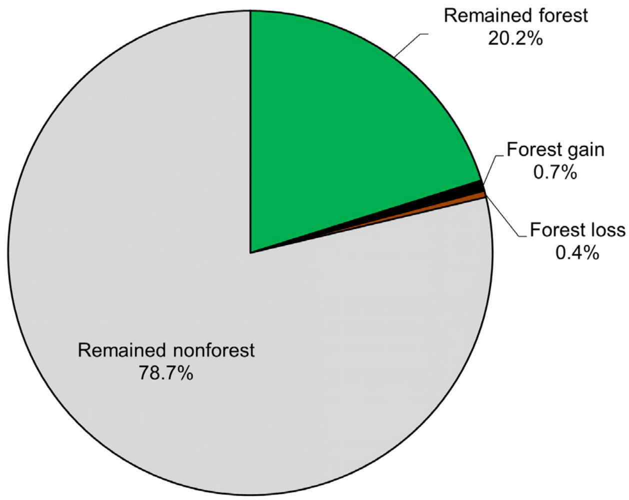

Figure 5.—Land use dynamics showing percentage of unchanged land, forest loss and forest gain in Indiana from 2013 to 2018.

Forest-Type Groups

The composition of forests can be described at varying levels from the numbers of individual species of seedlings, saplings, and larger trees to a broader view of the resource categorizing land based on shared characteristics. The broad-scale delineation of forest land is expressed as forest types which comprise tree species that generally coexist together in a forest setting. Similar forest types are collectively known as forest-type groups.

Over 85 percent of Indiana's 4.9 million forest land acres was composed of just two forest-type groups. Oak/hickory occupied 3.5 million acres, or 72 percent of total forest land base. Only one other forest-type group exceeded 500,000 acres; elm/ash/cottonwood accounted for nearly 14 percent of forested acres at 664,000. Though some regional differences in the composition of forest land exist across the State, they are relatively small. Oak/hickory ranged from 68 percent of the Lower Wabash inventory unit to 76 percent of Knobs in the south-central region of the State. Maple/beech/birch was just 5 percent of the Upland Flats unit and 9 percent of Knobs, averaging out to 7 percent statewide or 366,000 acres. Larger variations were evident in the elm/ash/cottonwood forest-type group which was 8 percent of Knobs but over 20 percent of the Northern unit.

Individual forest types identified in the State numbered 46 with 18 in the oak/hickory forest-type group alone. White oak/red oak/hickory was the single largest forest type with over 1.5 million acres of forest land. This acreage represented 43 percent of area within the oak/hickory forest-type group and 31 percent of total forest land in the State.

Changes in the extent of forest-type groups are generally slow, though some trends are evident when contrasting the first annual inventory in 2003 with the latest results. Oak/hickory's dominance decreased over that time as it dropped from 75 percent to 72 percent of the States forest land. It is interesting to note, though, that this loss in proportion did not represent a loss of actual acreage because of the increase in total forest land since

2003. The 300,000 acres increase from 2003 was split roughly evenly among the 3 main forest-type groups. The result was that while oak/hickory lost some proportion, elm/ash/cottonwood and maple/beech/birch gained in proportion of forest land across the state. Furthermore, the overall loss of dominance observed in oak/hickory did not affect all regions in the same way. For instance, the Northern inventory unit saw increased prevalence of oak/hickory, rising 2 percentage points to 69 percent over 15 years, while the Lower Wabash unit dropped 6 points to 68 percent of all forest land in the same time period. Both the Knobs and Upland Flats units lost oak/hickory acreage since 2013 even as each unit saw slight increases in overall forest land estimates.

Forest Resource Attributes

Forest Structure and Stand Size

Three classes are used to describe the stand size of forested conditions. They are commonly used by foresters and the wood product industries. The seedling/sapling (small) size class is assigned to stands where at least half of the total stocking present is in seedlings and saplings (trees less than 5.0-inch diameter at breast height, d.b.h.). The poletimber (medium) stand-size class describes stands where at least half of the stocking is of trees at least 5.0 inches d.b.h. and the stocking of poletimber size trees exceeds that of sawtimber. When most of the stocking in a stand is made up of large diameter trees (softwoods must be at least 9.0 inches d.b.h. and hardwood species at least 11.0-inch d.b.h.), the sawtimber (large) stand-size class is assigned. For timberland these simple classifications allow for easy comparisons of young, maturing, and mature forests.

Since 1986, the proportion of timberland classifying as large diameter stands has been steadily increasing (Fig. 6). Although the total area covered by timberlands has increased by only 414,332 acres, the acreage of large diameter stands has increased more than 2.5 times that amount (1,043,579 acres) as small and medium sized stands grow and shift into the larger class.

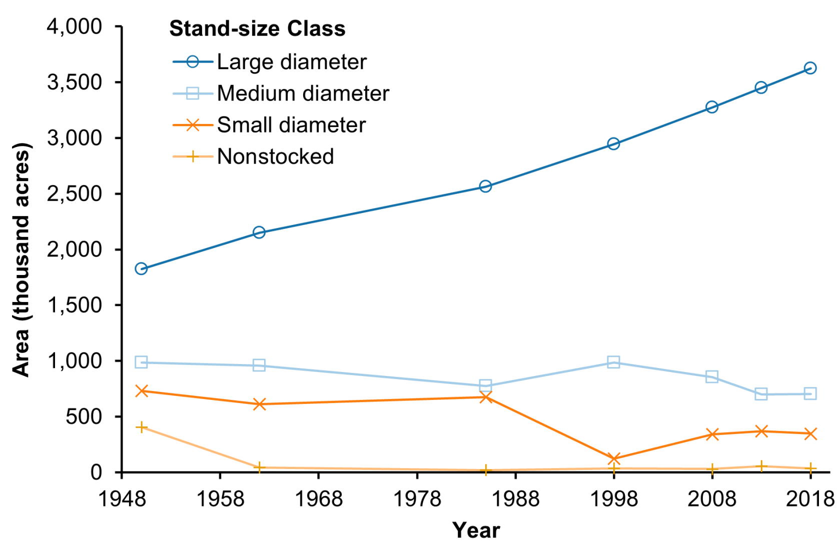

Figure 6.—Area of timberland by stand-size class and inventory year, Indiana.

Timberland acres throughout the state have continued to grow and shift from small and medium stands into the large stand-size category. Although these shifts suggest maturing forests, they alone do not indicate a lack of regeneration. Stands that classify as sawtimber can include trees of a full range of sizes and recruitment may be occurring in the understory resulting in dynamic, multi-aged and multi-sized stands. Further investigation of individual tree diameters, stocking and seedling data in these maturing stands could provide answers about whether these forests will sustain themselves in the years to come.

Standing Dead Trees

Specific habitat features like nesting cavities and standing dead trees 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." There are ongoing research efforts to determine the characteristics of dead trees that provide habitat for a given species. The Society of American Foresters defines the size threshold for a snag as being at least 10.0-inch d.b.h. and at least 6 feet tall (Helms 1998); however, standing dead trees of smaller size and diameter are also considered beneficial for some wildlife species. Standing dead trees serve as important indicators not only of wildlife habitat, but also of past mortality events and carbon storage. They are sources of down woody material (discussed further in Down Woody Materials section), which also provides 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 Indiana's forests.

FIA inventories standing dead trees by species and categorizes each tree into one of five stages of decay. Decay class 1 is used for freshly dead trees which still have fine branches present and intact, sound sapwood and heartwood. The categories describe increasingly decayed dead trees with class 5 describing a standing dead tree that has no branches remaining, more than 80 percent of the bark missing, no remaining sapwood present, and significant decay in the heartwood. Standing dead trees with a decay class of 1 or 2 will retain nearly all the carbon they stored while they were alive. Those trees which have decayed enough to be classified in category 4 provide the standing structure necessary for wildlife habitat. Decay class 5 can also provide critical habitat but may have only a short period of time before they fall to the ground and become down woody material. Forest Inventory and Analysis reports on standing dead trees 5.0-inch d.b.h. or greater.

There are currently over 70 million standing dead trees on Indiana's forest lands which equates to an average of 14.5 standing dead trees per forested acre. Overall, public lands have only a slightly greater density of standing dead trees per acre (16.7 trees/acre) than private land (14.0 trees/acre). Dead trees classified as decay class 1 or 2 make up 43 percent of total standing dead and 46 percent are within decay class 3 and 4 showing incipient to advanced decay. The remaining decay class 5 trees show severe decay and may soon fall. Nearly 75 percent of the standing dead trees are smaller than 11.0-inch d.b.h and only 6 percent are greater than 17.0-inch in diameter (Fig. 7).

Dead trees usually contain significantly more cavities per tree than occur in live trees (Fan et al. 2003), thereby providing habitat features for foraging, nesting, roosting, hunting perches, and cavity excavation for wildlife, from primary colonizers such as insects, bacteria, and fungi to birds, mammals, and reptiles. Snags and smaller standing dead trees result from a variety of potential causes, including diseases, insects, weather damage, fire, flooding, drought, and competition. Recommendations for the density, distribution, and size of snags to support wildlife in a region vary by the species of interest and the location and type of forest land. Some forest management guidelines recommend a minimum of four snags per acre forest land with one exceeding 24.0-inch d.b.h. and three exceeding 18.0-inch d.b.h. (Elliot 2008). The size distribution of standing dead trees in Indiana is heavily skewed toward smaller diameter trees. The density of large diameter snags (greater than 17.0-inch d.b.h.) is only 0.9 per acre. The availability of very large standing dead trees (snags) may be a limiting habitat feature for some species of wildlife. Providing a variety of forest structural stages and retaining specific features like snags on both private and public lands are ways that forest landowners and managers maintain the abundance and quality of habitat for forest-associated wildlife species.

Significant increases in the number of standing dead trees (5.0-inch d.b.h and larger) in Indiana can largely be attributed to the impacts of the emerald ash borer (*Agrilus planipennis*). The total number of live white ash and green ash is currently estimated to be just 80 percent of what it was in 2013. Although these trees do provide dead tree structure for wildlife, that they all died in a relatively brief period suggests that their benefits to wildlife will be lessened. As this influx of standing dead trees reach decay levels that provide necessary habitat, it is possible that more will be available than is required. The dead trees are then also likely to reach their final stages of decay at approximately the same time which may lead to a future shortage of standing dead trees as large numbers fall within the span of a few years.

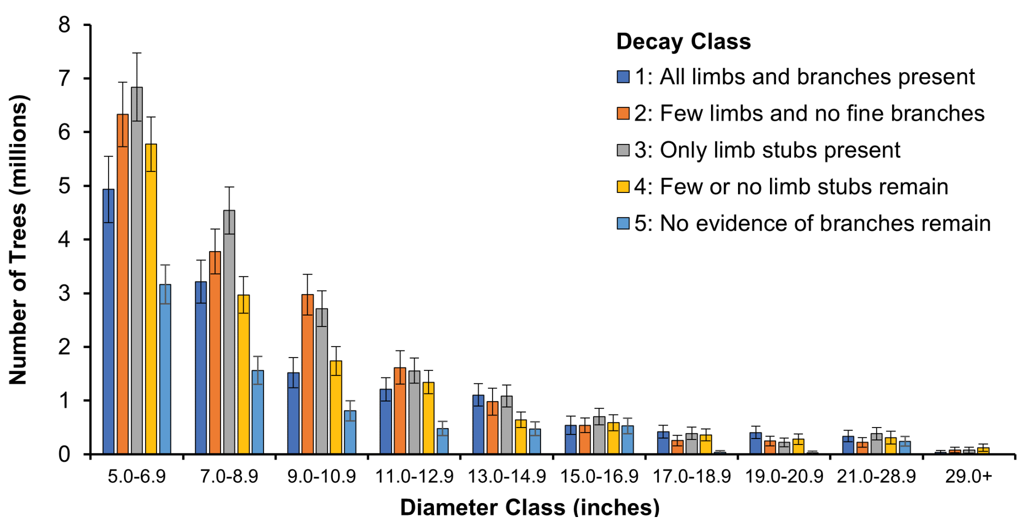

Figure 7.—Standing dead trees (5.0 inches d.b.h. or greater) by diameter class and decay class on forest land, Indiana, 2018. Error bars represent a 68 percent confidence interval around the estimated mean.

Number of Trees

A basic component of forest inventory is the number of trees; these estimates are simple, reliable, and comparable with estimates from past inventories. When combined with tree diameter data, estimates of numbers of trees are valuable for showing the structure of forests and changes that are occurring over time. Young forests generally have many more trees per acre than older forests, but the latter usually have much more wood volume (or biomass) than younger forests.

In Indiana, there are 2.2 billion live trees (at least 1.0-inch d.b.h.) on forest land. Past inventories have shown small fluctuations in the total number of trees and the 2018 estimate is no exception, with a 2 percent decrease since 2013. Seventy-one percent of trees in Indiana are saplings (1.0 to less than 5.0-inch d.b.h.), 18 percent are poletimber-size trees (5.0 to less than 9.0 inches d.b.h. for softwoods and 5.0 to less than 11.0 inches d.b.h. for hardwoods), and 11 percent are sawtimber-size trees (9.0 inches and 11.0 inches d.b.h. and larger for softwoods and hardwoods, respectively). There has been a consistent decrease in the number of trees in all diameter classes less than 5.0-inch d.b.h. since 2003, while the number of trees has increased in each successive inventory for trees 19.0-inch and larger during the same time period (Fig. 8).

Since 2013, the number of saplings decreased by 2 percent which is less than the 7 percent drop in sapling counts between 2003 and 2008. While increases in the number of sawtimber-size trees continues, the increase since 2013 was 2 percent compared to a 10 percent increase between 2003 and 2008. Poletimber-size trees decreased 6 percent since 2013, following a 4 percent increase from 2008 to 2013 (Fig. 9).

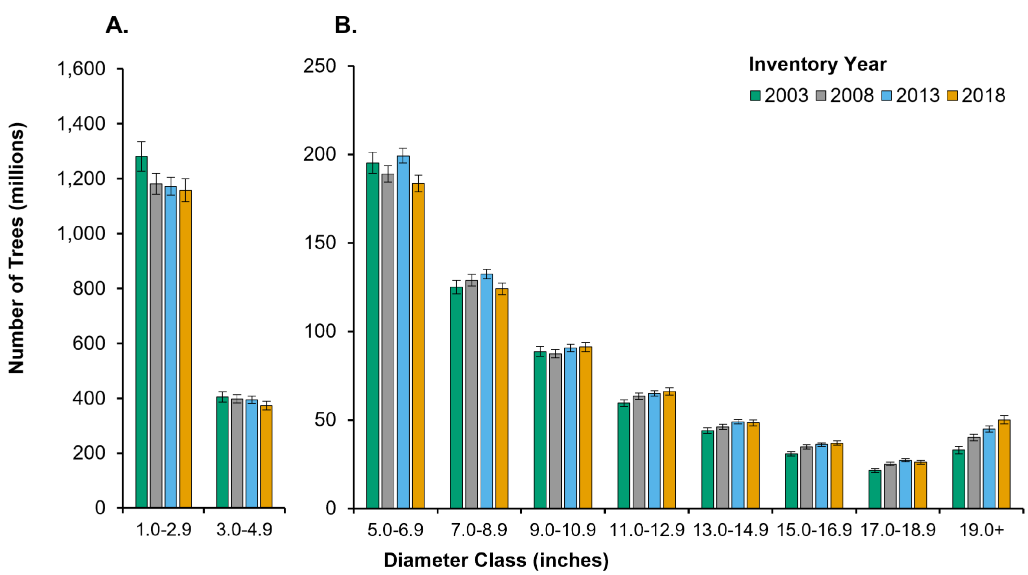

Figure 8.—Number of live trees on timberland by diameter class and inventory year for (A) saplings and (B) trees at least 5.0 inches d.b.h. , Indiana. Error bars represent 68 percent confidence intervals around the estimated means.

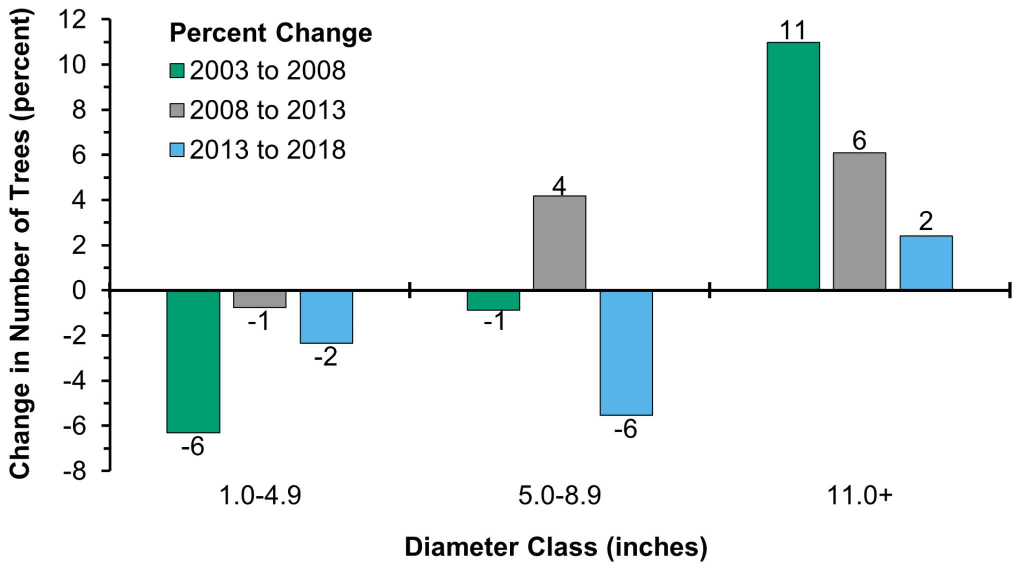

Figure 9.—Percent change in the number of live trees by diameter class and inventory year, Indiana.

The trend of increasing numbers of large diameter and decreasing numbers of small diameter trees suggests that Indiana's forests are continuing to mature. Generally, as forests mature and trees become larger, the number of trees per acre decreases. Since 2003, the overall number of trees per acre of forest land has decreased by 12 percent in Indiana. As forests continue to mature, maintaining a diverse range of size classes will become increasingly important in terms of overall forest health and sustainability. Maintaining a healthy balance of tree sizes will help ensure adequate regeneration and stable species composition, two topics that are discussed in greater depths in other sections of this report.

Tree Volume

Accurate measurement of volume on timberland can provide reliable estimates of the quantity, quality, and value of wood available for timber resources as well as project those attributes for the future. FIA reports volume for trees at least 5.0-inch in d.b.h. by several categories including: 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 calculated for the central stem from the 1-foot stump to the 4-inch top (diameter outside bark). Growing-stock volume excludes rough or rotten cull trees and non-commercial species. Volume estimates for sound, net, and growing stock are reported in cubic feet. Trees classified as rough cull either have two-thirds of their volume not meeting merchantable requirements with most of that volume being rough cull, or they are 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 provide critical wildlife habitat and carbon storage. Estimates of sawtimber volume are reported in board feet (International ¼ inch) for hardwoods greater than or equal to 11.0-inch d.b.h. to the 9-inch top, and softwoods greater than or equal to 9.0-inch d.b.h. to the 7-inch top.

Sound volume on forest land was estimated at 11.3 billion cubic feet in 2018, a 5 percent increase from 2013. Timberland accounted for 96 percent (10.9 billion cubic feet) of that volume, also up 5 percent. Sound volume on reserved lands increased 11 percent to 413 million cubic feet. Notably, no forest land was classified as unproductive (other forest) in the 2018 inventory. Net volume on timberland totaled 10.5 billion cubic feet, a 5 percent increase and 90 percent of that volume was in growing-stock trees (Fig. 10).

A total of 16 species had at least 2 percent of total growing-stock volume in 2018 (Fig. 11). At the individual species level, yellow-poplar[1] led the State in net volume with 1.3 billion cubic feet, a 6 percent increase from 2013. After decreasing from 2008 to 2013, black oak rebounded with a 14 percent increase to 589 million cubic feet. Eastern cottonwood also followed this trend but saw a much greater recent increase of 49 percent from 2013. White ash and silver maple had double digit volume losses over the same time, 22 percent and 11 percent respectively.

Net sawtimber volume on timberland totaled 26.8 billion board feet (Doyle log rule) in 2018, a 9 percent increase from 2013. A total of 17 species had at least 2 percent of total sawtimber volume in 2018, and all but two saw an increase in volume (Fig. 12).

Yellow-poplar accounted for 16 percent of sawtimber volume statewide and increased 11 percent to 4.3 billion board feet. Black cherry and black walnut, two of the highest value per board feet species in the state, had double digit gains of 14 percent and 33 percent respectively. White ash and silver maple both endured substantial losses in volume over the same period, 26 percent and 11 percent respectively.

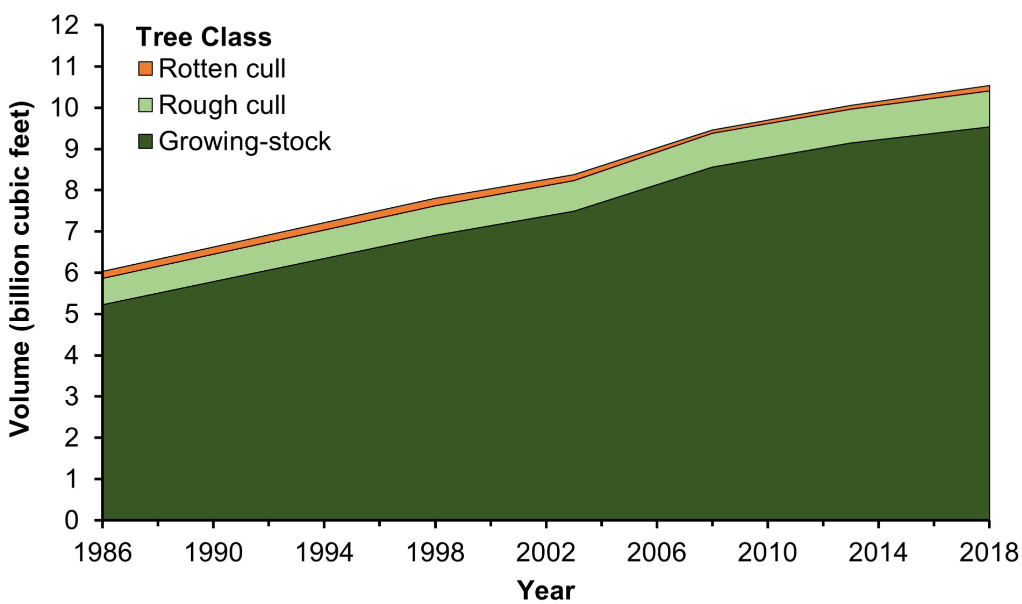

Figure 10.—Net volume on timberland by tree class and year, Indiana.

[1] See list of tree species, seedling and larger, found on FIA plots in Indiana in the 2018 inventory for a list of common and scientific names for each tree species.

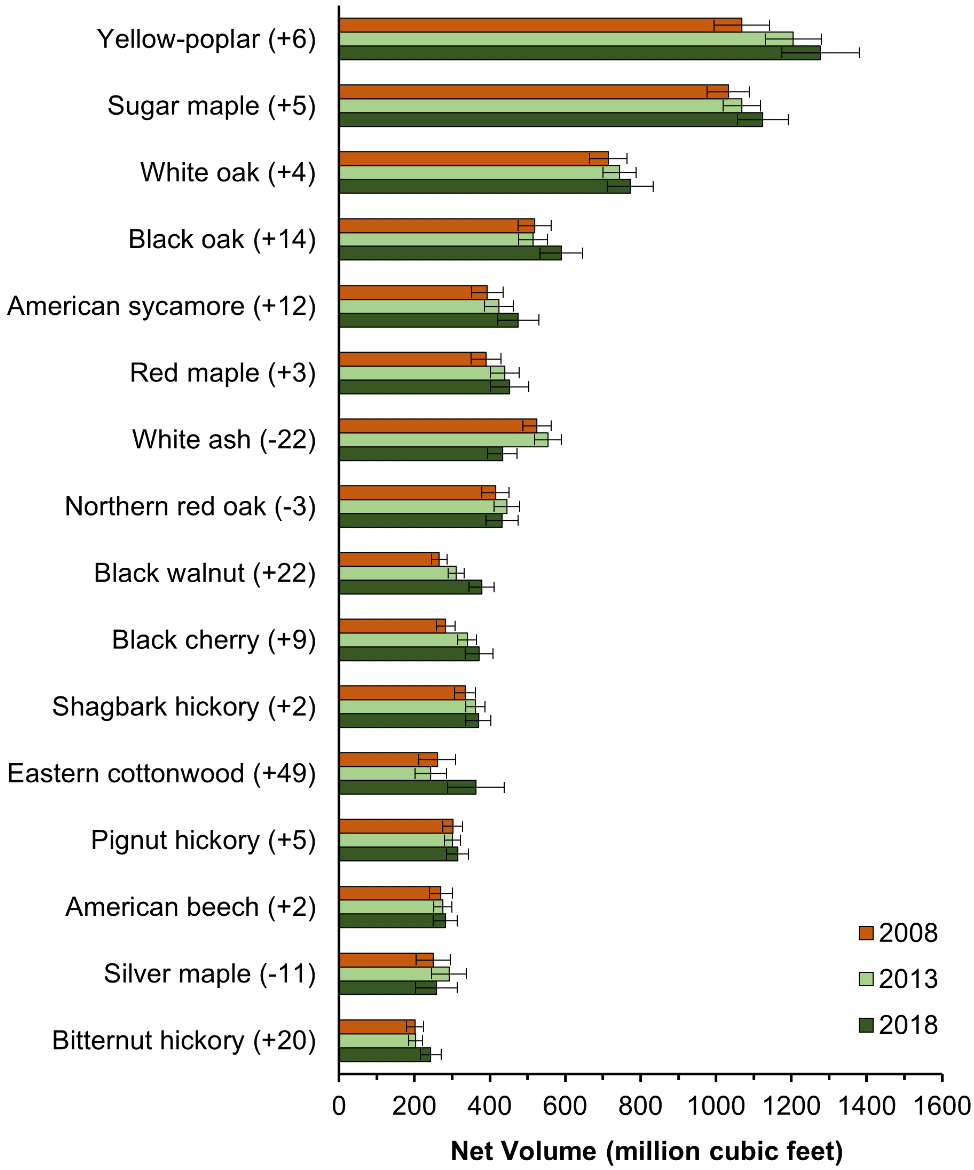

Figure 11.—Net volume on timberland for species having at least 2 percent of total net volume, by species and inventory year, Indiana. Percentage change between 2013 and 2018 is shown in parenthesis. Error bars represent a 68 percent confidence interval.

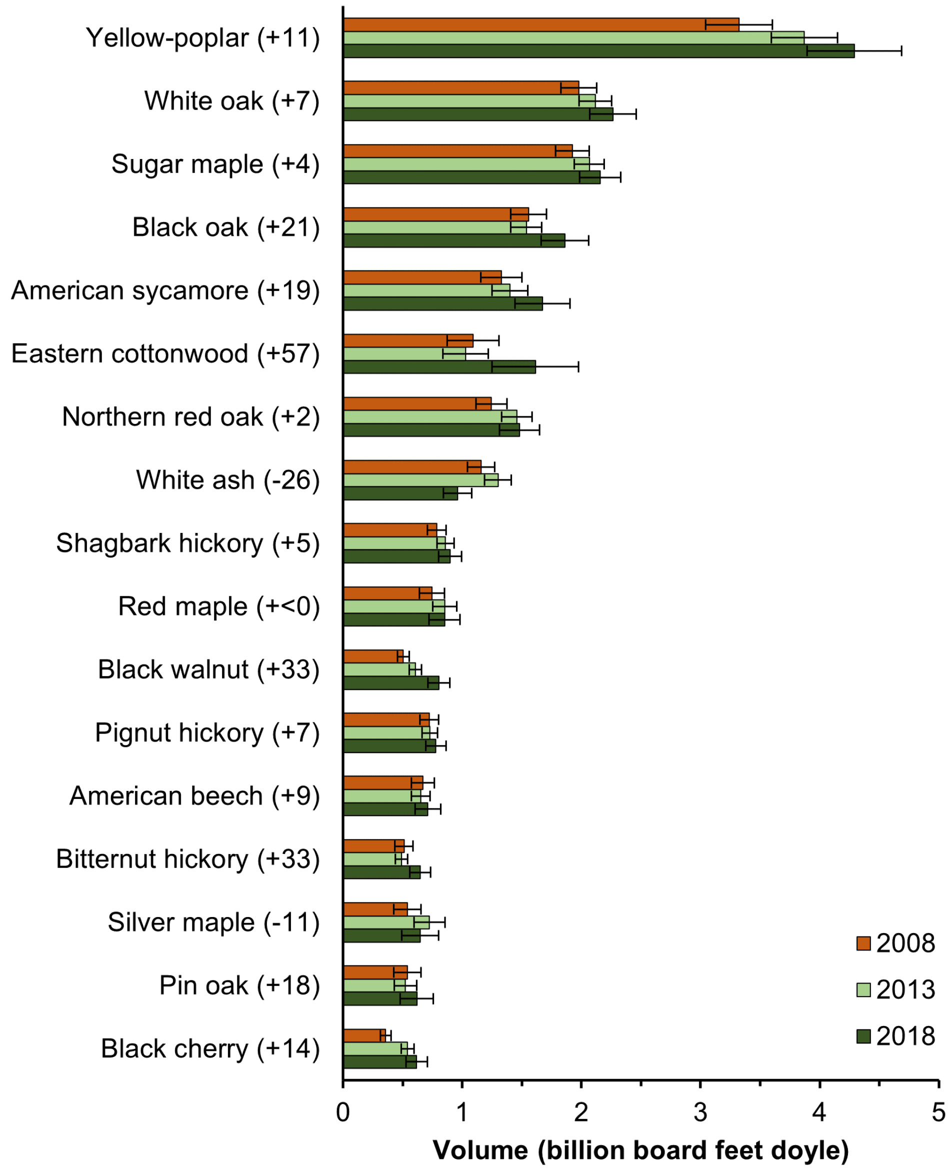

Figure 12.—Net volume of sawtimber trees on timberland for species having at least 2 percent of total sawtimber volume, by species and inventory year, Indiana. Percentage change between 2013 and 2018 is shown in parenthesis. Error bars represent a 68 percent confidence interval.

Hardwood sawtimber volume has also increased steadily since 2003 and proportional shifts in that volume between grades are apparent. Grade 1 volume increased 39 percent from 2013 to 2018 to 9.9 billion board feet (Doyle) and was 38 percent of the total compared to 30 percent in 2013 (Fig. 13). The proportion of volume in grade 1 has been increasing since 2008, while the proportion in grade 2 has decreased. Since hardwood tree grades are diameter dependent, some of this shift can be attributed to trees growing out of lower grades and into higher ones. Grade 3 volume decreased by 11 percent from 2013 to 2018 and its proportion of the total went from 24 percent to 20 percent over that same time.

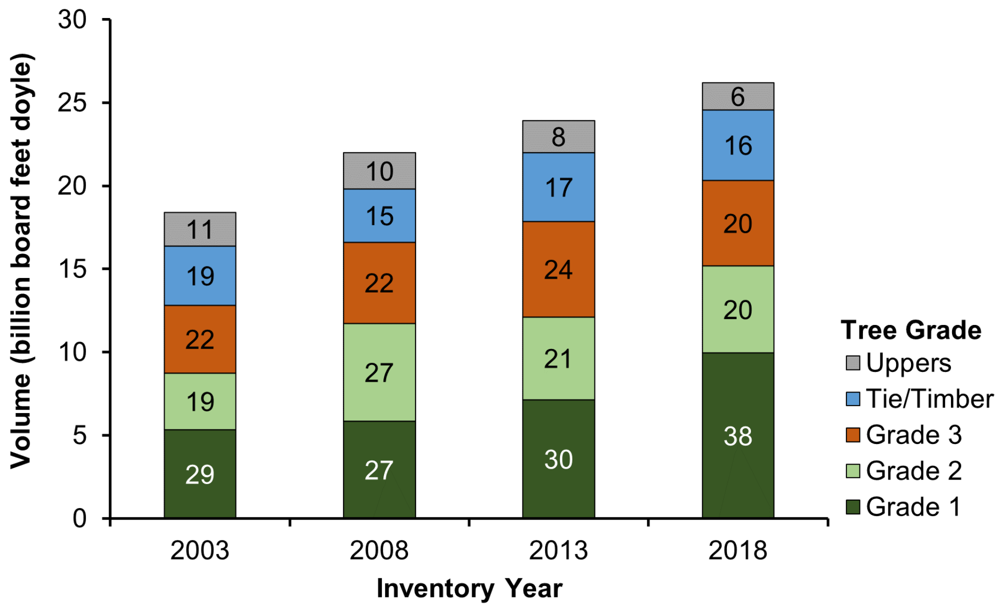

Figure 13.—Hardwood sawtimber volume on timberland, by tree grade and inventory year, with percentage of total hardwood sawtimber volume for each year, Indiana. "Uppers" refers to trees containing a qualifying saw log outside the butt section.

All major metrics of volume on both forest land and timberland in Indiana increased from 2013 to 2018. Sound volume increased 5 percent over that same time on forest land and timberland and net volume on timberland was 97 percent of sound volume due to a small amount of cull volume. Indiana's proportion of timberland live tree volume in growing-stock trees has been stable since 2003 at 90 percent.

While volume increased over this last survey interval, the rate of increase appears to be slowing. Net volume on timberland increased 13 percent from 2003 to 2008, 6 percent from 2008 to 2013, and 5 percent from 2013 to 2018. These trends have been observed for other states in the Northern region in recent years and can be attributed to an aging forest resource.

The sawtimber quality in Indiana is among the best in the region. The fact that grade 1 volume is increasing proportionally while overall stand sizes have increased suggests that higher quality trees are not being harvested at a disproportional rate, and rather are being left behind to grow and increase in value. No doubt some of the increase in grade 1 volume can also be attributed to the substantial increase in eastern cottonwood sawtimber volume, which also has the highest proportional grade 1 volume of Indiana's hardwoods. While overall sawtimber quality in Indiana is very good, differences between public and private ownership are apparent. The higher proportion of public timberland in growing stock and grade 1 trees suggests that privately owned timberland has room for improvement where management is concerned.

Growth, Removals, and Mortality

Forests are a renewable resource when managed to provide a constant supply of useful products without diminishing long-term productivity. Growth rate is an indicator of the overall condition of a stand as well as forest health, successional stage, and tree vigor. Average annual net growth (gross growth minus mortality) is calculated by measuring trees at two points in time and determining the average annual change over the time period. Negative net growth occurs when mortality exceeds gross growth and is indicative of a serious forest health issue resulting in a reduction of total inventory volume. Average annual net growth estimates are based on the change in volume of growing stock on timberland between inventories. The terms average annual net growth and net growth are used interchangeably. A useful measure to assess growth is the ratio of annual net growth to current inventory volume.

Mortality is a natural part of stand development in healthy forest ecosystems. Many factors contribute to mortality, including competition, succession, insects, disease, fire, human activity, and severe weather events. Mortality is often initiated by one causal agent (inciting factor) that is followed by other contributing stress factors, making it difficult to identify the underlying cause. Although mortality is a natural event in a functional forest ecosystem, dramatic increases in mortality can be a sign of forest health problems. Average annual growing-stock mortality estimates represent the average cubic-foot volume of wood that dies each year between inventories.

Since 2008, average annual net growth of growing stock on timberland has decreased in Indiana while average annual removals remained stable and average annual mortality increased. Net growth of growing-stock trees on timberland averaged 185 million cubic feet annually as of 2018, and the ratio of net growth-to-removals (including land-use change) (2.2:1.0) decreased from what was reported for 2008 (3.8:1.0) (Fig. 14).

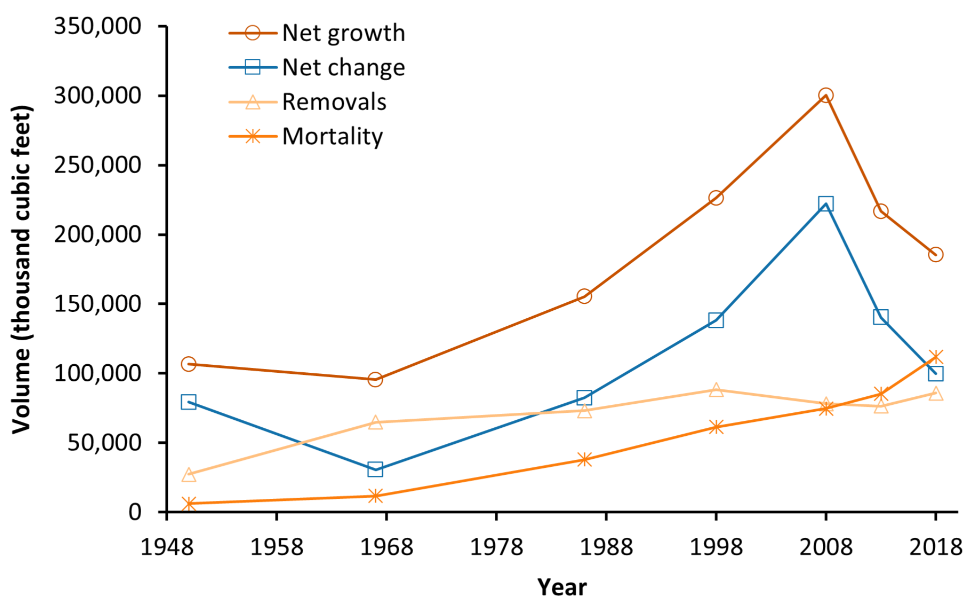

Figure 14.—Net growth, total removals, mortality, and net change of growing stock on timberland, Indiana. Includes land-use change.

In comparison to previous inventories, annual net growth of growing stock on timberland as a percentage of growing-stock volume has been generally decreasing since 2008. By contrast, annual mortality of growing stock on timberland averaged 112 million cubic feet as of 2018 and as a percentage of growing-stock volume mortality has been generally increasing since 2008. However, net growth still outpaces removals by more than two to one annually.

Down Woody Materials

Down woody materials, in the various forms of fallen trees and shed branches, play a critical role in the forests of Indiana. Down woody materials provide valuable wildlife habitat, seedling browse protection, stand structural diversity, a store of carbon/biomass, and contribute towards forest fire hazards via surface woody fuels.

The total carbon stored in down woody materials (fine and coarse woody debris and residue piles) on Indiana's forest land was nearly 24 million short tons in 2018 which is roughly 34 percent greater than what was estimated in 2010 (Fig. 15). Down woody debris carbon is loosely related to the amount of live tree basal area with forests with greater than 80 square feet per acre of live tree basal area having the highest amounts of downed dead wood carbon (14.9 million tons). The down dead wood biomass within Indiana's forests is dominated by coarse woody debris (Fig. 16) at approximately 32 million tons with fine woody debris representing 34 percent of statewide totals (16.5 million tons).

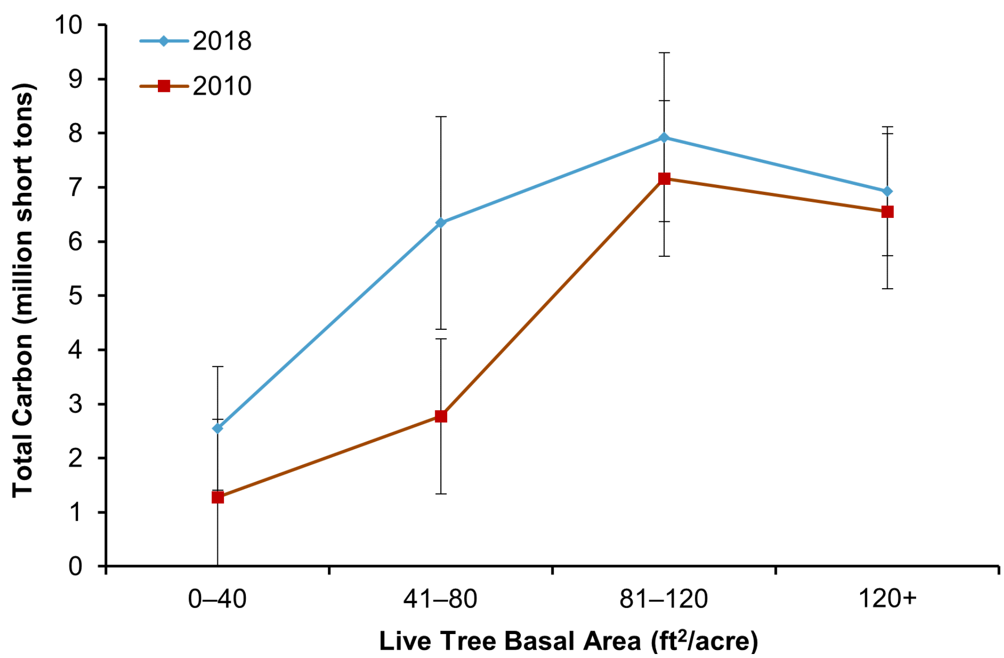

Figure 15.—Total carbon (short tons) in down woody materials (fine and coarse woody debris and residue piles) by basal area (square feet per acre) on forest land in Indiana, 2010 and 2018. Error bars represent a 68 percent confidence interval.

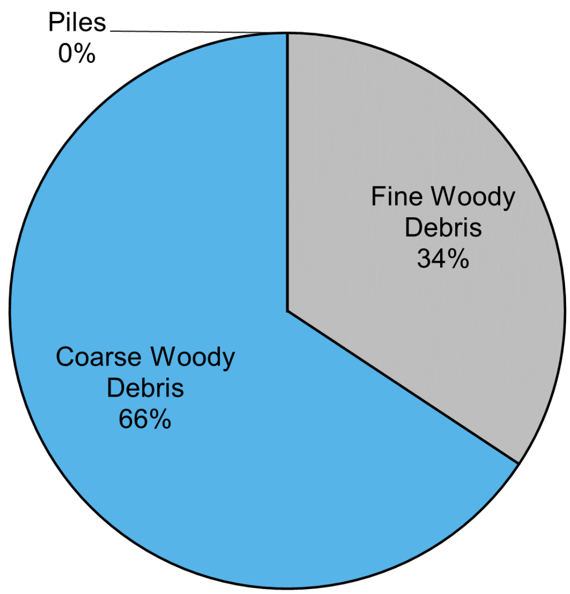

Figure 16.—Proportion of down woody material statewide biomass by dead wood component (fine and coarse woody debris and residue piles) on forest land in Indiana, 2018.

Given the temperate forests across Indiana, only in times of drought would the biomass of down woody materials be considered a fire hazard particularly the fine woody debris biomass identified in this recent inventory. There was a slight increase in the volume and biomass of down woody materials since the 2010 inventory, although relatively high levels of sampling error and differences in measurements at the plot-level exclude further conclusions (Woodall et. al. 2019). Although the carbon stocks associated with Indiana's down woody materials are relatively small compared to those of soils and standing live biomass, it is still a critical component of the carbon cycle as a transitory stage between live biomass and other detrital pools such as the litter (Russell et al. 2015). Given that most of the coarse woody debris volume was estimated to be in private and state/local ownership, the decisions of numerous stakeholders will determine the future of down woody material contributions to statewide forest carbon stocks and wildlife habitat (i.e., stand structure). Overall, because fuel loadings are estimated to not be exceedingly high across the State, possible fire dangers may be outweighed by the numerous ecosystem services provided by down woody materials.

Forest Health Indicators

Urbanization 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. 2017). Although originally created to identify the area where wildfires pose the greatest risk to people, the WUI is associated with a variety of consequential human-environment conflicts.

With the recent completion of a temporally consistent census block-level dataset capable of accurately comparing block-level change in housing densities from 1990 to 2010 (Mockrin et al. 2019; Radeloff et al. 2017), changes in housing density and forest land can now be analyzed at a finer spatial resolution and with more accuracy than previously possible. The data is used to identify FIA forest land and changes in WUI levels of housing density via the following categories: forest land in census blocks that have had housing densities above established WUI thresholds for 30 years or more (from 1990 or before), forest that first reached WUI house density levels in the 1990s, forest that first reached WUI house density levels in the 2000s, forest that underwent change in WUI house density both decades, and forest land that still remained in non-WUI census blocks in 2010 (Fig. 17). Forest land is depicted in the map using the 2011 National Land Cover Dataset to mask out nonforest areas, however all forest land statistics reported are summarized from the FIA plot data. Both the acres and proportion of forest that is non-WUI is continuing to decrease, from 3.5 to 3.0 million acres in Indiana (73 to 62 percent of the total forest land) between 1990 and 2010 (Fig. 18).

Urbanization is affecting an increasing amount of forest area in Indiana, including unfragmented forest land in otherwise core or high spatial integrity situations. Over 1.2 million acres (26 percent of Indiana's forest land) was in WUI conditions by 1990, and between 1990- and- 2010 forest land was still being converted to WUI conditions at rates averaging greater than 5 percentage points per decade in 40 counties.

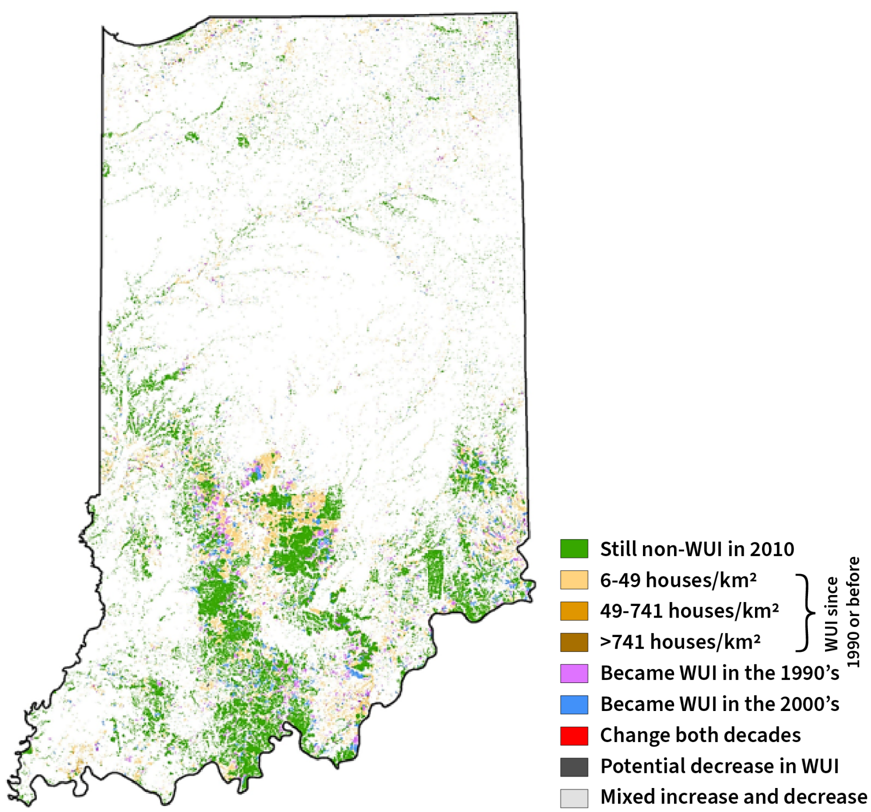

Figure 17.—National Land Cover Dataset forest by census block-level change in wildland-urban interface (WUI) status (1990–2010), Indiana.

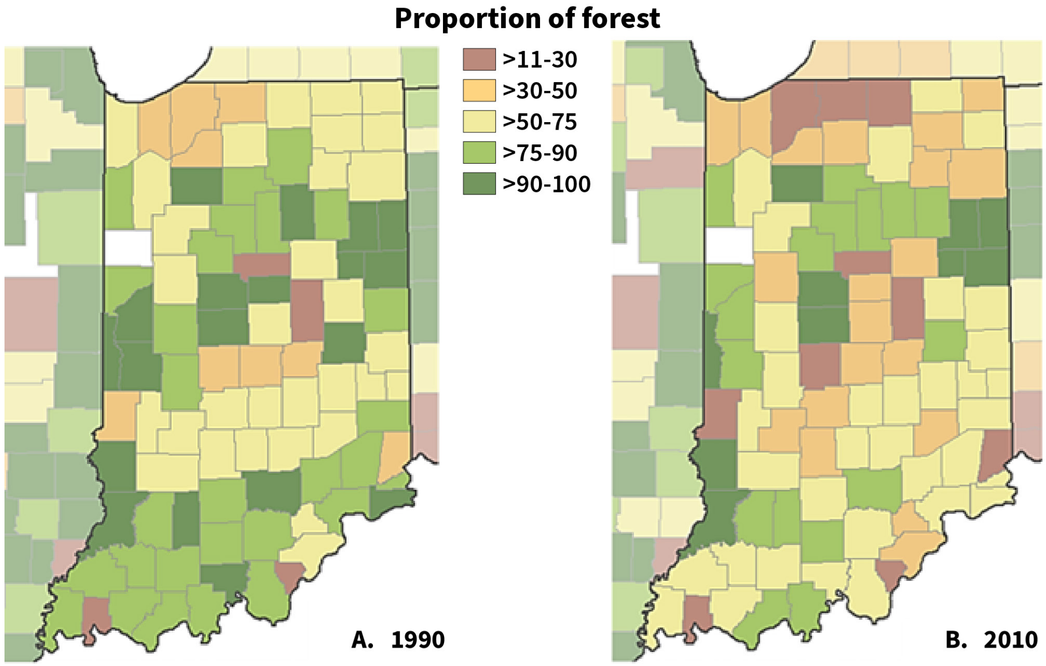

Figure 18.—Proportion of forest that is non-wildland-urban interface in (A) 1990 and (B) 2010, Indiana.

Increasing urbanization has the potential to change how forests function, affecting their vulnerability to threats such as insect pests and diseases, non-native 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. Given the well-documented negative effects of residential development on forest land and the amount of forest land occurring in WUI conditions in some areas, it matters how we manage those residential areas and strategies to reduce the effects of those residential land uses on surrounding forest land should be pursued (Kramer 2013). In addition, planning interventions can be used to maintain remaining forest connectivity in these areas.

Tree Regeneration

Throughout Indiana and the entire Central Hardwood region, oak/hickory forests are maturing and, in many places, converting to different forest types (Gormanson et al. 2016). Driving these shifts are significant reductions or even failures in oak/hickory regeneration. As maturing oaks and hickories die they often are replaced by other competing species such as sugar maple and yellow-poplar, rather than young oaks or hickories. Given forest type compositional shifts and a lack of regeneration, the persistence of oak and hickory in Indiana's future forests is becoming increasingly uncertain.

To address the need for more detailed information on regeneration, the Northern Research Station, Forest Inventory and Analysis program has added advanced tree seedling regeneration (ATSR) sampling protocols to collect data on a subset of NRS-FIA sample plots measured during the leaf-on growing season (McWilliams et al. 2015). The procedures measure all established tree seedlings less than 1.0-inch in d.b.h. by height class and include a browse assessment for the area surrounding the sample location.

Over the past 15 years the percent of Indiana forest land classified as young (less than 20 years in age) has slightly decreased from 7 to 5 percent (Fig. 19). At the same time, the abundance of advanced tree seedlings (less than 1.0-inch d.b.h and at least 6.0 inches in length for softwoods and 12.0 inches in length for hardwoods) has also decreased to about 1,878 seedlings per acre, but the changes vary considerably across the State. In contrast, saplings have remained stable with a slight increase to 442 per acre. From 2012 to 2018, over 53 percent of Indiana's forest land was assessed as having very low to low ungulate browse impact on seedlings. In contrast, only 1 percent of Indiana's forest land was identified as suffering from high to very high impact of seedling browse.

Additional regeneration assessments on a subset of inventory plots classify seedlings by height and estimate the total number of all established seedlings in Indiana at over 29 billion with an average of nearly 6,000 seedlings per acre. Sugar maple, white ash, and red maple were the most abundant tree seedlings of the most abundant 15 species across all height classes (Fig. 20). Similarly, sugar maple, white ash, and eastern hophornbeam were the most abundant species in the largest seedling height class (at least 5.0 feet in height). Expectations for white ash should be tempered with information on the demise of ash due to impacts of the emerald ash borer. In terms of the difference between the abundance of the smallest versus largest seedling size classes, red maple had the greatest disparity with an average of over 400 small seedlings per acre (2.0 inches to less than 12.0 inches in height) across all of Indiana's forest land but approximately 10 per acre for the largest height class (at least 5.0 feet). In contrast, eastern hophornbeam had over 42 small seedlings compared to 23 per forest land acre that were five feet or taller.

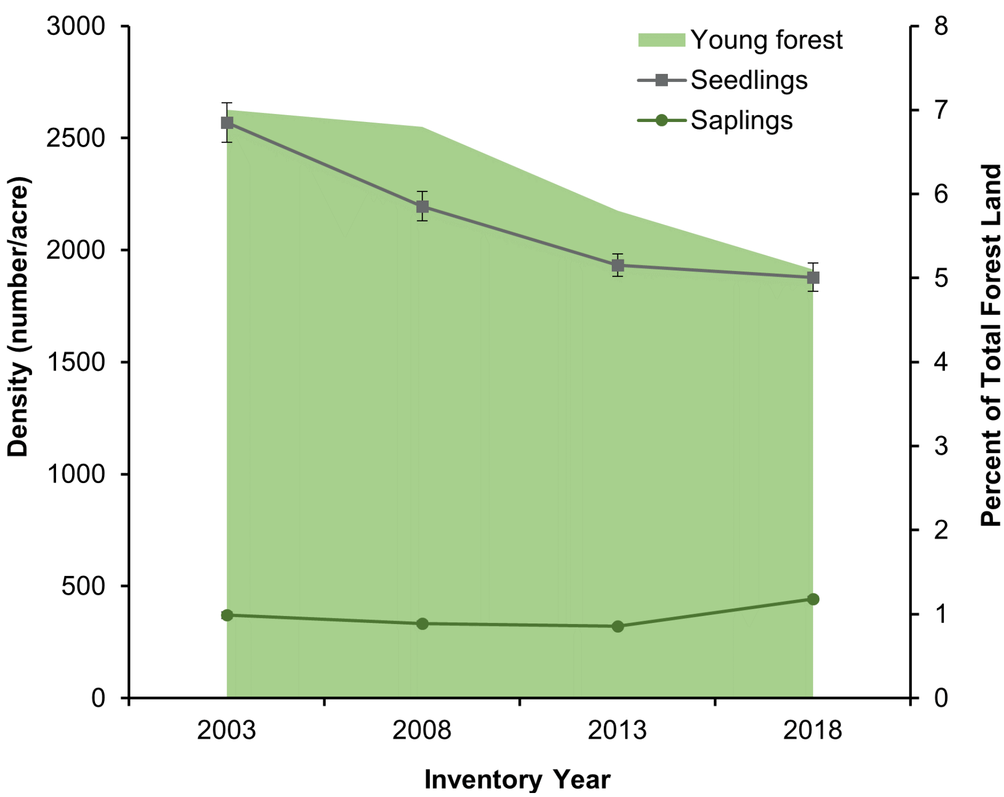

Figure 19—Percent young forest (less than 20 years in age) and density (numbers per acre) of seedlings and saplings by inventory year, Indiana.

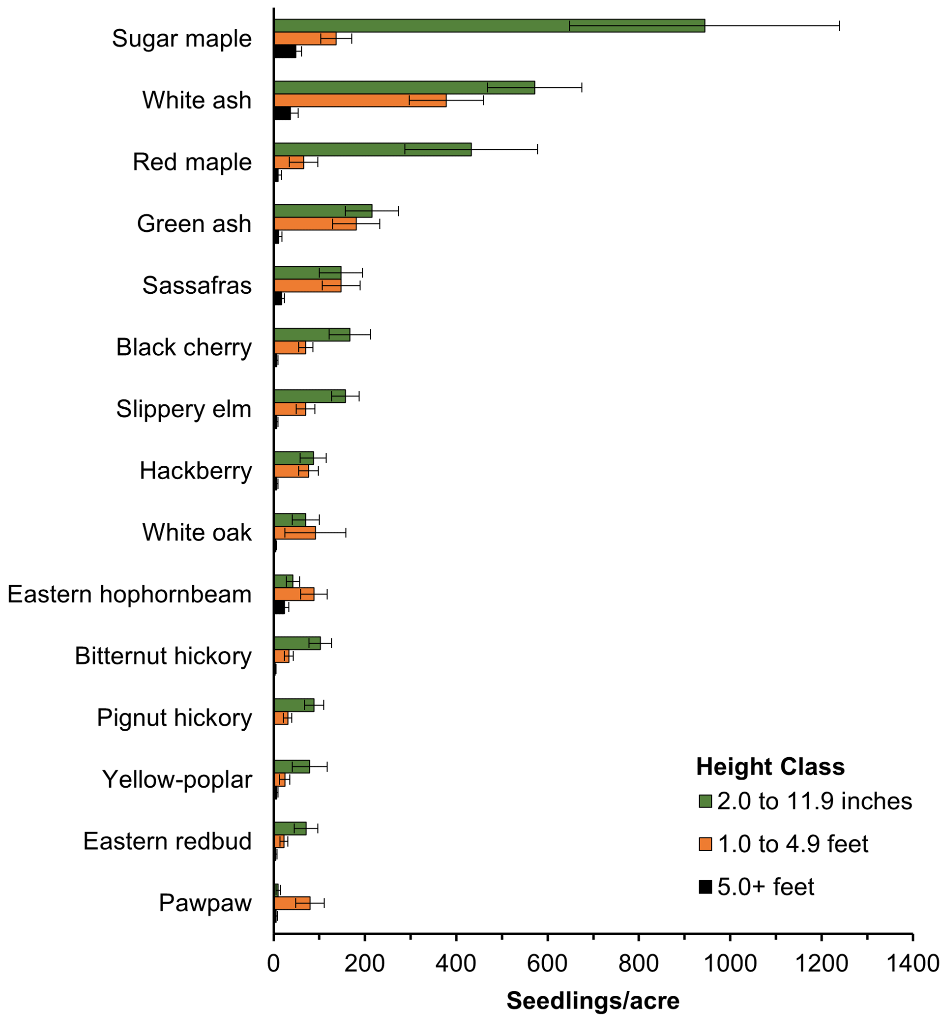

Figure 20—Seedlings per acre for height class by tree species in Indiana, 2018.

Like many states in the eastern U.S., there is a lack of younger aged forests across Indiana despite a relatively abundant understory of seedlings. Early successional forest habitat is critically important for providing unique plant biota, wildlife food and cover, and landscape diversity.

Oak and hickory regeneration are a well-known documented regional issue (Abrams 1992; Gormanson et al. 2016; Holt and Fischer 1979; Lorimer 1993) and management techniques for successful regeneration have been described (Brose et al. 2008; Dey et al. 2010; Weigel et al. 2012). Another concern is the impact that regeneration has on the future of species important for spring, summer, and fall roosting of Indiana bats (*Myotis sodalis*), particularly in proximity to hibernation locations. Along with the oaks mentioned, shagbark hickory is preferred by Indiana bats for maternity colonies (Menzel et al. 2001; Pruitt and TeWinkel 2007) and is underrepresented in the regeneration component. Loss of habitat has been listed as an important factor in Indiana bat population reductions in the past so forest management will need to consider these and other preferred species during the regeneration phase of forest development.

On a positive note, most Indiana forests have experienced a low level of tree seedling browse which can impede effective tree regeneration. In addition, the increasing abundance of saplings suggests a positive trend of increasing recruitment of seedlings into larger tree size classes irrespective of species. The abundance of seedling species across height classes can indicate a variety of forest stand dynamics such as stand senescence or changing successional directions. Only eastern hophornbeam and pawpaw appear to have abundant populations of the smallest seedlings with recruitment into the larger height classes. In contrast, important commercial species such as oaks, hickories, and yellow-poplar have appreciable abundance of the smallest sized seedlings but hardly any larger sized seedlings. Although not as commercially important nor critical for ensuring future sustainability, red maple had the largest number of the smallest seedlings among all tree species. The lack of young forest, lack of commercial species recruitment, prevalence of red maple in the understory, and abundance of ash species regeneration (i.e., future emerald ash borer mortality) should be monitored for its future effects on Indiana forest species diversity, forest industry, and resiliency.

Invasive Plants

Invasive plant species (IPS) are both native and nonnative species that can negatively affect ecosystems. Several factors contribute to the success of IPS such as rapid growth, prolific seed production, survival in harsh environments, and vegetative propagation. Humans, hoofed mammals, fragmentation, and disturbance promote the spread of IPS. Once established, they can quickly take over an area, displacing native species. IPS often form dense monocultures and alter light, nutrient, and water availability. Invasive plants can affect the suitability of wildlife habitat. In forests, infestations may increase runoff and limit food, cover, and nesting sites. For example, infestation by nonnative bush honeysuckles can shade out understory plants. If these plants gain hold in the stand initiation stage, they can create monocultures, eliminating tree species. This impacts the suitability for a variety of wildlife. Cavity dwellers dependent on snags are displaced. By reducing trees, IPS impact the carbon cycle. Additionally, they affect aesthetic beauty which can influence tourism and local economies. In 2018 there were 118 plots monitored for IPS in Indiana. Of the 20 species of invasive plants recorded (Table 1), multiflora rose was the most commonly found.

When looking at these trends it is important to remember that about half as many plots were monitored for IPS in this inventory versus 2013. Additionally, since this inventory only covers forested areas, areas with less forest land have fewer plots. These species can cause vast ecosystem and economic consequences. The presence of IPS is concerning and future monitoring is important. Invasive presence is influenced by time since introduction, forest fragmentation, and propagule pressure. Changes in the percentage of plots with IPS in the state, percentage of plots with a given species, newly observed invasives, and an increase in the number of invasive plants per plot are all key metrics to monitor. Further analysis may help to reveal important site and regional trends.

Table 1.—Number of invasive plant species observed on Forest Inventory and Analysis plots and the percentage of total plots in Indiana, 2018 and 2013

Species	Observances, 2018	Percentage of plots, 2018	Observances, 2013	Percentage of plots, 2013
Multiflora rose (*Rosa multiflora*)	101	85.6	239	74.5
Nonnative bush honeysuckle (*Lonicera* spp.)	45	38.1	120	37.4
Japanese honeysuckle (*Lonicera japonica*)	43	36.4	103	32.1
Garlic mustard (*Alliaria petiolata*)	41	34.7	63	19.6
Japanese stiltgrass, Nepalese brown top (*Microstegium vimineum*)	40	33.9	95	29.6
Autumn olive (*Elaeagnus umbellate*)	21	17.8	55	17.1
Oriental bittersweet (*Celastrus orbiculatus*)	15	12.7	20	6.2
Creeping jenny (*Lysimachia nummularia*)	14	11.9	20	6.2
Reed canarygrass (*Phalaris arundinacea*)	11	9.3	32	10.0
Black locust (*Robinia pseudoacacia*)	10	8.5	38	11.8
European privet (*Ligustrum vulgare*)	10	8.5	22	6.9
Common buckthorn (*Rhamnus cathartica*)	7	5.9	3	0.9
Tree of heaven (*Ailanthus altissima*)	7	5.9	7	2.2
Japanese barberry (*Berberis thunbergii*)	6	5.1	6	1.9
Canada thistle (*Cirsium arvense*)	5	4.2	12	3.7
Bull thistle (*Cirsium vulgare*)	3	2.5	10	3.1
Common barberry (*Berberis vulgaris*)	1	0.8	5	1.6
Dames rocket (*Hesperis matronalis*)	1	0.8	12	3.7
English ivy (*Hedera helix*)	1	0.8	1	0.3
Silktree (*Albizia julibrissin*)	1	0.8	--	--
Glossy buckthorn (*Rhamnus frangula*)	--	--	3	0.9
Japanese meadowsweet (*Spiraea japonica*)	--	--	2	0.6
European cranberrybush (*Viburnum opulus*)	--	--	2	0.6
Siberian elm (*Ulmus pumila*)	--	--	1	0.3
Japanese knotweed (*Polygonum cuspidatum*)	--	--	1	0.3
Russian olive (*Elaeagnus angustifolia*)	--	--	1	0.3

Forest Insect and Disease Activity

Insects and disease pathogens help shape the structure and composition of forest ecosystems. Monitoring their status provides a measure of forest health and is crucial in assessing the current state and changing trends in Indiana's forests. Mortality caused by insect and disease activity can be hard to differentiate from other causes and natural senescence. The ratio of mortality-to-gross growth has been used as a national indicator of mortality; ratios above 0.6 are considered high and may be indicative of an acute forest health issue if forests are not senescing (Ambrose 2019). Further, a high mortality-to-gross growth ratio, in combination with high average annual mortality as a percentage of live volume suggests an increased likelihood of a serious threat to forest health. Over the 2018 inventory cycle, Indiana's forests have been impacted by a variety of insects and diseases, including emerald ash borer (*Agrilus planipennis*, EAB), oak wilt (*Bretziella fagacearum*), and spongy moth (*Lymantria dispar*).

Now found in every county in the State, EAB, a wood-boring beetle native to Asia, was first detected in Indiana in 2004. All North American ash (*Fraxinus* spp.) species are hosts of EAB; however, host preference appears to vary by species, with consistently high observations of green ash and black ash mortality and variable white ash mortality (Herms and McCullough 2014; McCullough 2020).

Ash trees represent 6 percent of total species abundance on Indiana forest land. Since 2003, the total number of ash trees (greater than or equal to 1.0-inch d.b.h.) has decreased by 12 percent, from 141.5 million ash trees in 2003 to 124.9 million ash trees in 2018. Of the total decline in tree abundance, there has been a 9 percent reduction in saplings, a 26 percent reduction in poletimber trees, and a 1 percent increase in trees greater than 11.0 inches in diameter. Since 2008, the Northern inventory unit, which formerly had the largest proportion of ash, had the greatest decrease (38 percent) in the number of ash trees greater than 5.0 inches in diameter (Fig. 21).

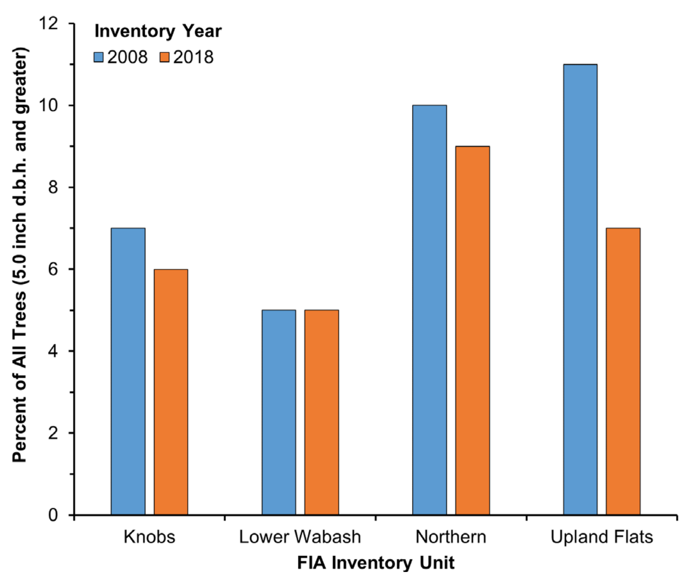

Figure 21.—Number of live ash trees as a proportion of all trees (5.0-inch d.b.h. and greater) by inventory unit, Indiana 2008 and 2018.

By species, white ash is most prevalent of trees 1.0-inch d.b.h. and greater (71 percent), followed by green ash (25 percent), blue ash (4 percent), and black ash (less than 1 percent). Black ash has been hit the hardest, with a 93 percent reduction in abundance since 2003.

Emerald ash borer has had a major impact on ash resources in Indiana, particularly with respect to black ash. Declining abundance of ash saplings and poletimber will lead to reduced abundance of ash in the overstory. Species composition and forest structure are likely to undergo continued change as ash trees give way to forests that are increasingly dominated by maples. Continued monitoring will help to identify the long-term impacts of EAB.

Forest Carbon

Among terrestrial ecosystems, forests contain the largest reserves of sequestered carbon. The accumulation of carbon in forests helps to mitigate emissions of carbon dioxide to the atmosphere from sources such as wildfire or 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; approximately 50 percent of tree biomass is carbon (based on dry weight). Over time, this stored carbon also accumulates in standing dead trees, down woody materials, litter, and forest soils. The FIA program uses a combination of field measurements and models to estimate forest carbon stocks. Procedures for the estimation of carbon are detailed in the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017 (U.S. EPA 2019). Forest carbon is often broken down into storage pools. The carbon pools and their components discussed here are defined as: live biomass (live trees at least 1.0-inch d.b.h. and live understory vegetation), dead wood (standing dead trees at least 1.0-inch d.b.h. and down dead wood), forest floor litter, and soil organic matter estimated to a depth of 1-meter (39 inches).

Total forest ecosystem carbon stocks in Indiana are an estimated 335 million tons. This represents an increase of two percent in total forest carbon stocks since 2013, and an increase of nearly seven percent since 2008. Carbon density is an estimated 69.7 tons per acre of forest land. Soil organic carbon and live trees are the largest components; combined, these account for 91 percent of forest carbon stocks (Fig. 22).

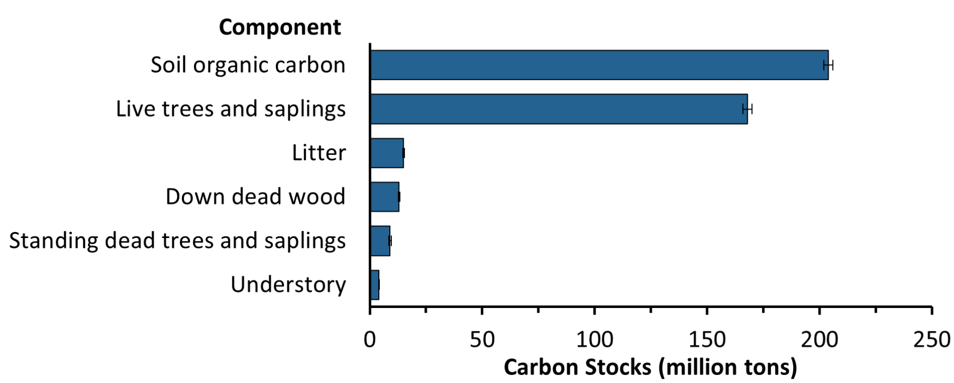

Figure 22.—Carbon stocks on forest land by component, Indiana, 2018. Error bars represent a 68 percent confidence interval.

Carbon density can vary among forest-type groups with the live biomass pool being most affected by tree species composition (e.g., forest-type groups dominated by long-lived species can have a higher proportion of live biomass carbon). Among the forest-type groups that account for at least 1 percent of Indiana's forest carbon, total density was highest in the elm/ash/cottonwood forest-type group (90 tons per acre). Both the elm/ash/cottonwood and oak/hickory forest-type group had the greatest density of live biomass at 36 tons per acre each (Fig. 23).

Forest carbon stocks continue to rise in Indiana as a result of maturing stands accumulating carbon, particularly in the live biomass pool. Soil organic carbon stocks represent the largest pool in Indiana and are important to long-term carbon storage. The carbon stocks in live biomass also represent a substantial amount of the total carbon and there are opportunities to increase those stocks in the near term, as this pool is most affected by forest management. As mitigating U.S. greenhouse gas emissions becomes increasingly important, an understanding of trends in carbon sequestration and storage will be an essential tool for forest managers.

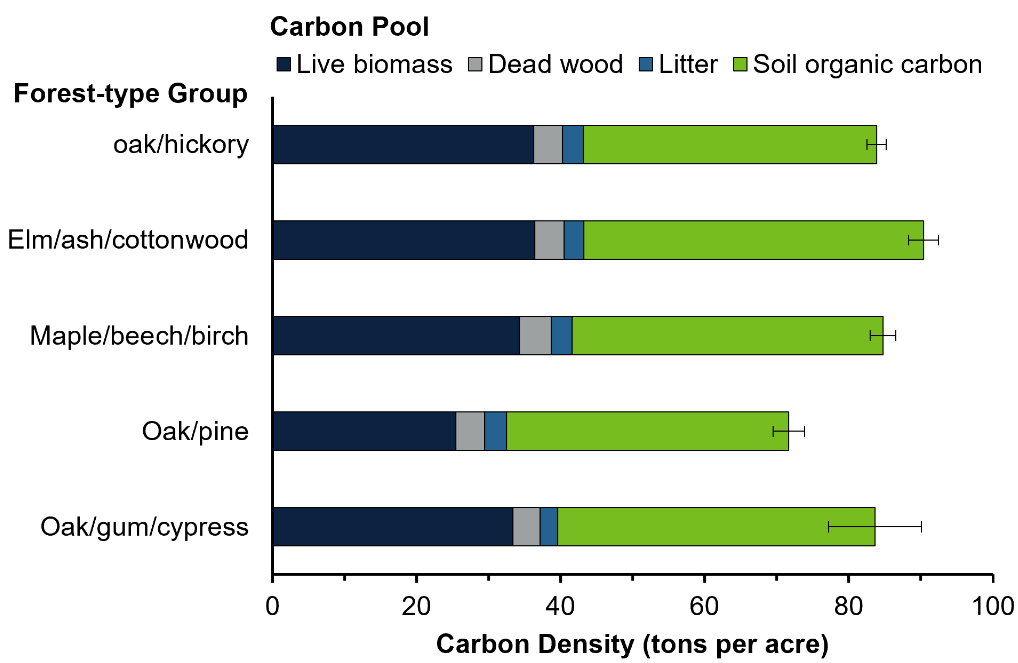

Figure 23.—Carbon density by forest-type group and carbon pool, Indiana, 2018. Error bars represent a 68 percent confidence interval around the total carbon density estimate (all pools).

Forest Ownership

To a lare extent, the quantity and quality of forest resources are determined by landowners, including recreational opportunities, timber supply, and wildlife habitat. By understanding the priorities of forest landowners, the forest conservation community can better help owners meet their needs, and in so doing, help conserve the State's forests for future generations. 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 NWOS results reported here are from studies completed in 2006 (Butler 2008), 2013 (Butler et al. 2016), and 2018 (Butler et al. 2021). The results presented are for family forest ownerships with 10 or more acres of forest land.

Eighty-four percent of Indiana's forest land is privately owned. The vast majority of these private acres, an estimated 3.6 million acres, are family forests. Corporate ownerships have an estimated 389,000 acres across the State and other private owners, including conservation organizations and unincorporated clubs and partnerships, own an additional estimated 103,000 acres. Federal, state, and local governments are responsible for 16 percent of the State's forest land. Much of the 383,000 acres of Federal forest land is in Hoosier National Forest. The 349,000 acres of state forest land are controlled by a combination of state forestry, parks, and wildlife agencies. The area of forest land by ownership group has stayed relatively consistent since 2006, with the biggest change being an increase in the area of family forest land (Fig. 24).

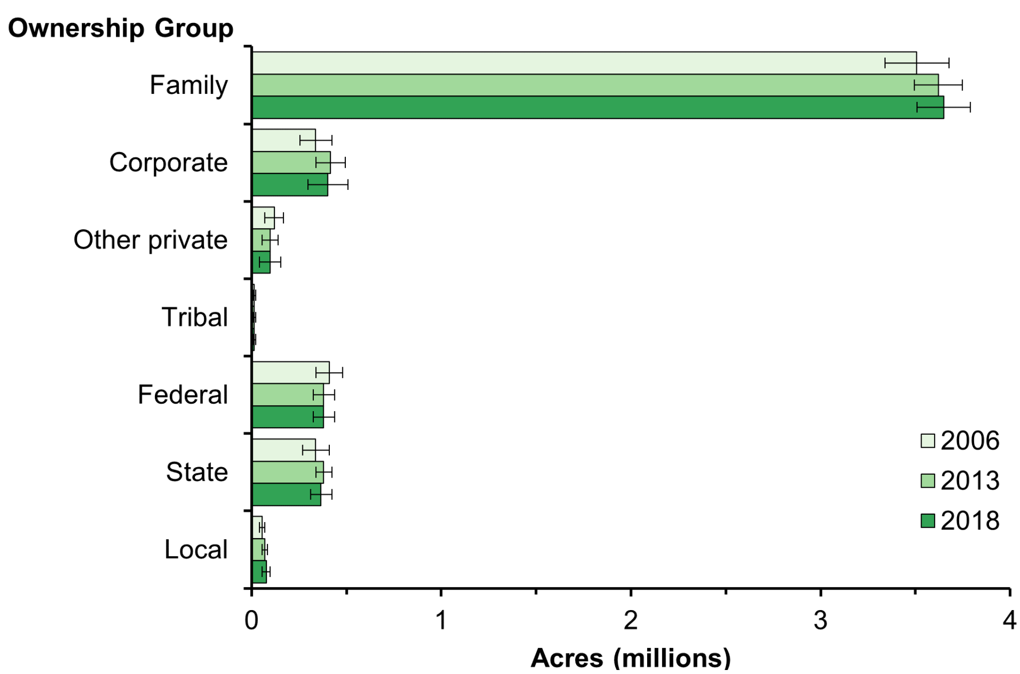

Figure 24.—Area of forest land by ownership group, Indiana, 2006, 2013, and 2018. Error bars represent a 95 percent confidence interval.

The primary reasons for owning family forests are related to amenity values, such as aesthetics, nature, and wildlife (Fig. 25). Objectives related to financial values, including timber production and land investment, are rated as dominant ownership reasons much less frequently. The overall order of reasons for owning did not changed substantially between 2013 and 2018, but the percentages rating items as important or very important are markedly higher for most objectives.

The fate of the forests lies primarily in the hands of those who own and control the land. It is therefore critical to understand forest owners and what policies and programs can help them conserve the forests for current and future generations. Looking particularly at family forest ownerships, the group that is the least understood and the fate whose land is arguably the most uncertain, they own their land in Indiana primarily for amenity reasons, but many are actively doing things with their land. A low to moderate number of ownerships have received advice and have written forest managements plans. 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 in Indiana. Given the average age of family forest owners in the State, 69 years (Fig. 26), many acres of land will be passing on to the next generation in the not-too-distant future.

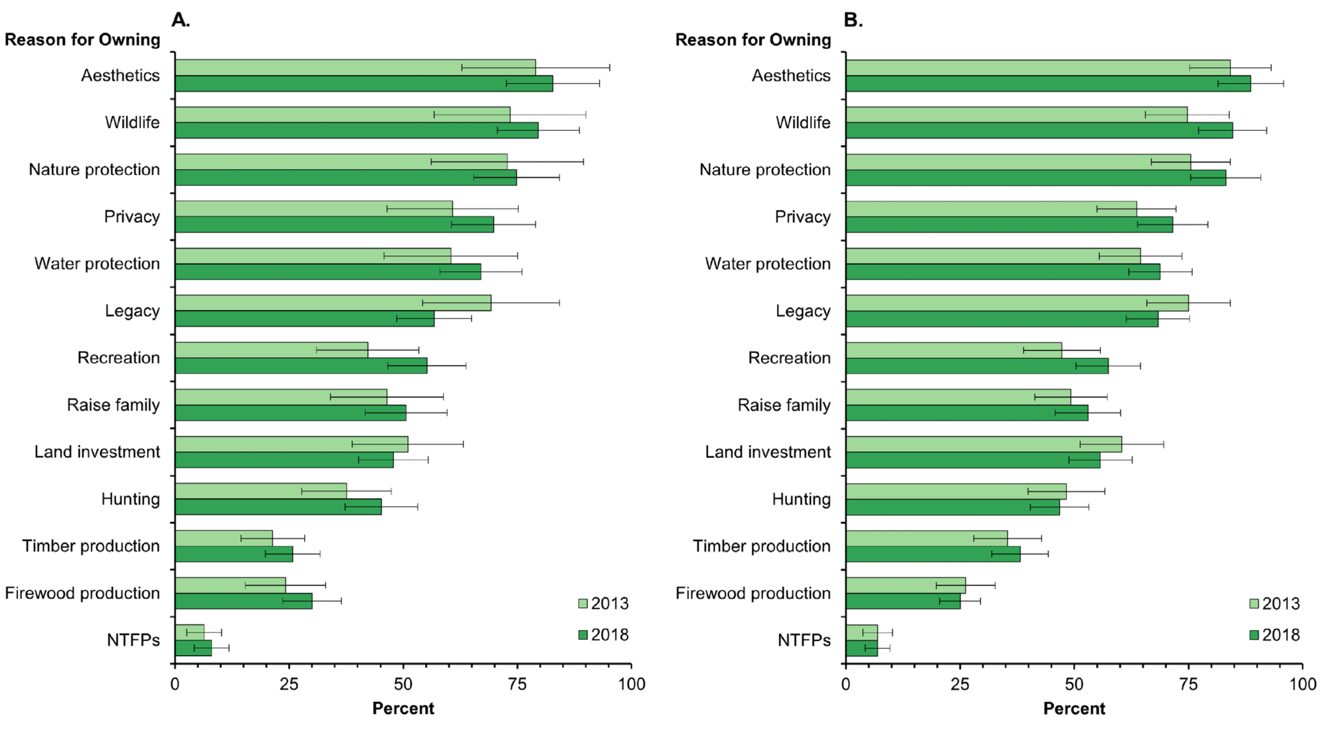

Figure 25.—Family forest (10+ acres) (A) ownerships and (B) acreage by reasons for owning for the survey years of 2013 and 2018, Indiana. Percentages include those who responded a specific reason was important or very important on a 5-point Likert scale. Error bars represent a 95 percent confidence interval. Due to differences in the survey options offered to respondents, data from 2006 are excluded. NTFP's are non-timber forest products.

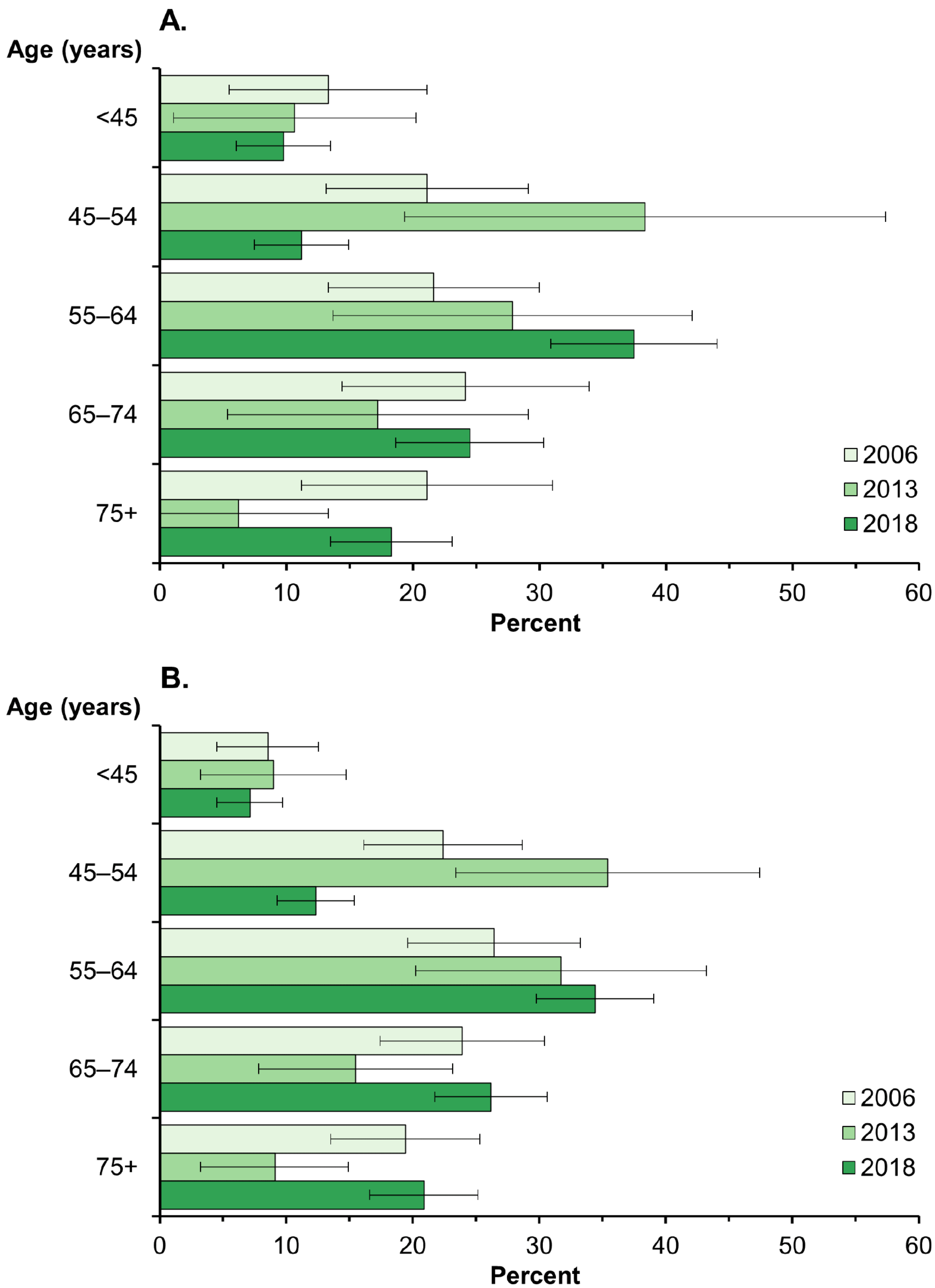

Figure 26.—Family forest (10+ acres) (A) ownerships and (B) acreage by age of primary decision maker for the survey years of 2006, 2013, and 2018, Indiana. Error bars represent a 95 percent confidence interval.

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